How part pairing is jeopardising the independent repair of smartphones

This paper explains how the increasing trend towards software pairing of smartphone parts limits repair options for consumers, threatens the repair ecosystem, and invalidates proposed ecodesign regulations aimed at resource efficiency.

Repair barriers cause short-lived products

77% of EU citizens would rather repair their goods than buy new ones[1], yet **when a smartphone breaks, only around 11% of consumers will follow through with a repair[2].** The likelihood of smartphone repair is influenced by i) economic factors, for example labour and spare part costs, and ii) feasibility, in terms of the ability to remove parts, the ability to access repair information and diagnostics, and the level of parts pairing.

Independent repair: an essential part of the repair ecosystem

Original equipment manufacturers (OEMs) are limited in the number of locations they operate, and the repairs that they will undertake. For example, in store repair options offered at one large smartphone OEM were limited to the repair of only four key parts[4]. **Consumers may be told by OEMs that other repairs are simply not feasible, which may drive them to purchase a new product in preference to repair[5].** A subgroup of independent repair shops are authorised by OEMs to make repairs (around 12% for smartphones[6]). These might still be a long distance away from many consumers, and they might be restricted in the repair options that they are permitted to provide. **A recent survey found that 78% of independent smartphone repair technicians offer additional repairs over those offered by a large OEM, and 41% of their repairs are the kind of repair that the OEM would not do in store[4]**, for example board-level repairs. Smartphones can also be repaired by consumers themselves, often with the help of online tutorials or assisted by volunteers at community events.

Serialisation and pairing restrictions

There is an increasing trend in some phone brands (and other electronic products) towards part serialisation. Serial numbers encoded in the firmware of spare parts enable smartphone manufacturers to confirm if a part is a genuine OEM part or not. However, some smartphones are being designed with part pairing restrictions so that new parts will not be accepted into the phone without their serial numbers being paired anew. This can create major barriers to independent and self-repair, through:

- **Restricted access to OEM parts:** Access to genuine OEM parts may be restricted to only OEM authorised repairers, forcing independent repairers to use aftermarket parts or reused parts from other smartphones.
- **Restricted access to serial entry functionality**: Whilst it could be made possible to enter serial numbers for new parts via a menu in the smartphone, it is often only possible using external tools – for example, a proprietary app to enable OEM authorisation and configuration of parts. Access to such apps can be restricted to OEM authorised technicians.
- **Rejection of aftermarket and reused parts:** If the serial number is not that of a genuine OEM spare part, it can be rejected by the OEM, regardless of the quality of the part, which could even be a genuine part recovered from another phone.
- **Functionality downgrading or loss for non-OEM and/or non-paired parts:** Replacement without authorisation may be possible in some cases, but smartphone functionality may be reduced or lost completely. This may even be triggered by software updates taking place long after the repair[8].
- **Intrusive notifications on non-OEM and/or non-paired parts:** Even if a part is successfully installed, smartphone owners may be inundated with intrusive alerts that their part is not genuine if the pairing process cannot be completed. This can even be the case with genuine parts recovered from identical models. It is useful for the user to provide informed consent once if a replacement part is not a genuine OEM part (especially if that part is implicated in security functionality), and to be able to verify this whenever needed. However, multiple alerts can change a positive repair experience to a negative one.

Pairing is not necessary for security

Security is often quoted as a rationale for the pairing approach, however pairing is not technically necessary to achieve adequate security. Alternative design approaches include:

- **Central storage of authentication data:** Whether authentication data is stored within the authentication part or within, for example, the CPU is a design choice, with central storage representing a more secure design with no need for pairing.
- **Multi-step authentication for informed consent to accept new parts:** When parts are replaced, multi-step authentication can be used via non-hardware means (e.g. pin, password etc) before the functionality of a new part, such as touch or face ID, is activated.

It is the device owner who should be empowered to choose how their product is repaired, rather than repair options being dictated to them by the manufacturer via remote part pairing decisions. It makes sense for users to be responsible for the decision on whether a new part should be accepted or not taking into account the diversity in the way that phones are used - for example, what is considered a critical function for some phone owners may not even be functionality that is used by others.

The magnitude of the pairing problem

Whilst there is a high risk that the issue of pairing becomes more widespread over time and across manufacturers, the main data currently available focus on the smartphones of the OEM Apple, although there have also been pairing instances observed in Samsung smartphones[9,10]. The chart in Figure 1 shows the increasing tendency towards part pairing in Apple iPhones over time (see Appendix 2 for more details).

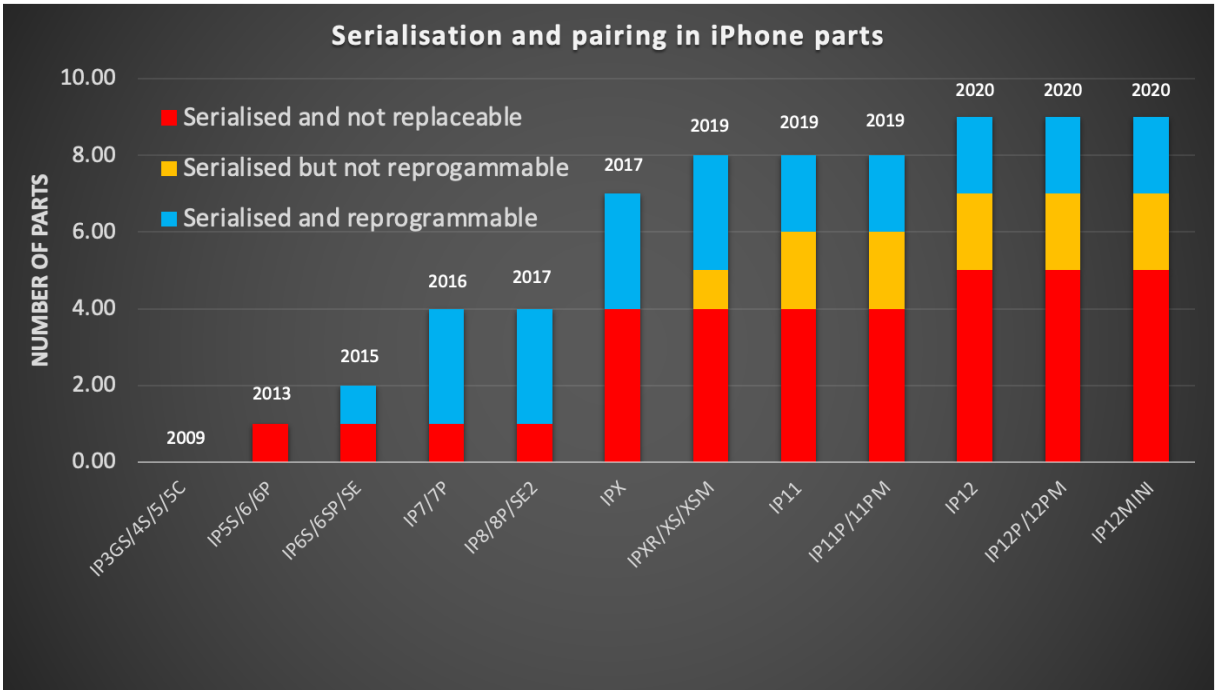

Figure 1: Evolution of part pairing in Apple iPhones (excluding CPU / baseband board)[11]

Parts that are shown in red, are serialised and cannot be replaced without loss of functionality by anyone but the OEM (unless the part itself is modified by means of very high precision microsoldering). Parts that are shown in yellow are serialised and can only be replaced without loss of functionality or error messages if they are reprogrammed using equipment that is only available within the manufacturer's authorised network. Parts that are blue are serialised but can be replaced provided that they are reprogrammed with equipment that is available outside of the manufacturer's authorised network. The parts most commonly paired were:

- **Serialised and not replaceable:** Touch ID / home button (where present), rear camera (newer models), face ID / facial recognition sensor (usually included in the front camera assembly), ambient light sensor, proximity sensor, built-in speakers.
- **Serialised and reprogrammable:** Screen (older models), wifi chip, vibration motor ('taptic engine').
- **Serialised but not reprogrammable:** Screen (newer models), batteries (newer models)

Pairing invalidates proposed ecodesign requirements

The serialisation and pairing of parts presents significant challenges for successful implementation of the proposed Ecodesign regulation for smartphones. Both the screen and battery should be user-reparable according to the regulation, and represent a high number of the multiple fault types addressed in community repair events (41% and 16% respectively[3]), yet are serialised in all recent models, and not programmable. The front-facing camera assembly frequently needs replacing (cameras are 3% of faults[3]), and should be repairable by independent (professional) repairers according to the regulation, but the Face ID functionality within this assembly is serialised and non replaceable. Likewise, the built in speakers (2% of faults are due to speakers and amplifiers[3]) should be repairable by independent (professional) repairers according to the regulation, but are serialised and non replaceable. Occasional defects occur due to the home button / touch ID (when present) and this should be repairable by independent (professional) repairers according to the regulation, but these are serialised and non replaceable.

Urgent action needed to prevent premature obsolescence and protect EU repair jobs

Pairing has a major influence on the likelihood of smartphone repair due to both economic factors and feasibility. In economic terms, low-cost independent repairs will not be possible for many defects if pairing is allowed, particularly as pairing also rules out the use of more affordable (potentially equivalent quality) aftermarket parts. This means that consumers are likely to pay greater repair costs due to OEMs having a monopoly on repair and spare part provision. In feasibility terms, device owners should be the ones to make an informed decision on where to source a repair and whether or not to accept a replacement part into their device. **Conversely part-pairing restricts the consumer's right to repair. It establishes the OEM as the sole decision maker, and enables them to dictate which repair operations they want to be possible, and which defects they want to result in the consumer buying a replacement product. Not only does this go against the intention of the draft regulatory requirements to ensure more widespread user and professional repair, it also represents a serious competition concern.** If left unchallenged, there is a risk of the number of unsuccessful repairs increasing considerably, and the rate at which phones become e-waste accelerating. If the trend continues, the volume of independent smartphone repairs is likely to reduce until the industry can no longer sustain itself. Companies working in independent smartphone repair could cease to operate, and many repair jobs would be lost in Europe as a result. There is no time to delay. **Urgent action is necessary to protect consumer's right to repair and prevent a slump in the independent repair industry in Europe. It is essential that the issue of pairing is addressed in the draft legislation**, see our recommendations in the appendix.

Notes and references

1. Montalvo, C., Peck, D. & Rietveld, E., for DG Internal Policies, European Commission (2016), *A Longer Lifetime for Products: Benefits for Consumers and Companies*, accessed on 10/05/2020 at https://www.europarl.europa.eu/news/en/press-room/20170530IPR76313/making-durable-reparable-goods-for-consumers-and-tackling-planned-obsolescence
2. Results from a German survey by OHA - Obsoleszenz als Herausforderung für Nachhaltigkeit (2019) cited in Schischke, K., Clemm, C., Berwald, A., Proske, M., Dimitrova, G., Reinhold, J., Prewitz, C., Durand, A., & Beckert, B., (2021) *Ecodesign preparatory study on mobile phones, smartphones and tablets - Final Report*, Fraunhofer IZM, Fraunhofer ISI, VITO and European Commission DG Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, pp 197
3. Analysis of 1900 repairs from Open Repair Alliance (2021), *Repair Database*, containing open data on repairs at community repair events worldwide, accessed 11 May 2020, https://openrepair.org/news/our-open-repair-dataset-grows-to-42000-records/
4. Proctor, N. (2020) *The Fix is In: How our smartphones get fixed, why it's harder than it should be, and why that matters,* U.S. PIRG Education Fund and iFixit
5. Pierini, D (2019) *Tenacious repair tech combats misinformation in Apple support forum,* Cult of Mac, accessed 10/05/2021 at https://www.cultofmac.com/620124/apple-support-forum-jessa-jones/
6. Extrapolated from example of Germany provided in Schischke, K., Clemm, C., Berwald, A., Proske, M., Dimitrova, G., Reinhold, J., Prewitz, C., Durand, A., & Beckert, B., (2021) *Ecodesign preparatory study on mobile phones, smartphones and tablets - Final Report,* Fraunhofer IZM, Fraunhofer ISI, VITO and European Commission DG Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs pp. 159
7. Extrapolated from example of Germany provided in Schischke, K., Clemm, C., Berwald, A., Proske, M., Dimitrova, G., Reinhold, J., Prewitz, C., Durand, A., & Beckert, B., (2021) *Ecodesign preparatory study on mobile phones, smartphones and tablets - Final Report*, Fraunhofer IZM, Fraunhofer ISI, VITO and European Commission DG Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs pp. 159
8. In 2015, an iOS 9 upgrade disabled all iPhones with a touch ID sensor that had their home button replaced by an unauthorised repair provider – a part that is often replaced by default together with a broken screen. As the update made the phones as useful as a brick, inoperable devices have since been referred to as 'bricked'. In 2017, the upgrade to iOS 11 broke the touchscreen input on iPhone 6s displays that were not serviced with genuine Apple parts. In 2018, similarly an upgrade to iOS 11.3 bricked iPhone 8s phones repaired with aftermarket screens, until the problem was addressed in IOS 11.3.1 released four weeks later. In all of these cases, a software update made devices effectively unusable, while all of its components were entirely functional. See https://www.ifixit.com/News/9917/11-3-update-breaking-iphone-screens.
9. Rossmann, L (2020), *Serializing parts will destroy independent repair - Samsung leads the trend*, accessed 15/06/2021 at https://www.youtube.com/watch?v=fz2R7-zTdKk
10. An issue was observed in the A70 and A50. If the original fingerprint sensor was moved over to a new screen without the July 2020 security update being implemented, the fingerprint sensor software function would work without problems. However, once the July 2020 security update was implemented, the fingerprint sensor function would fail.
11. Data gathered in the course of 2021 by The Repair Academy, a French expertise and training center specialised in board-level repair of portable ICT https://therepairacademy.com

Appendix 1: Legislative recommendations

The current text in the draft regulation that addresses this aspect is shown below:

1.1 Design for repair and reuse
(2) access to repair and maintenance information
From 6 months after placing on the market the first unit of a model and until seven years after placing the last unit of the model on the market, the manufacturer, importer or authorised representative shall provide access to the repair and maintenance information to professional repairers for parts concerned by point 1(a) in the following conditions:

(a) the manufacturer's, importer's or authorised representative's website shall indicate the process for professional repairers to register for access to information;
[…]
(c) manufacturers, importers or authorised representatives may charge reasonable and proportionate fees for access to the repair and maintenance information or for receiving regular updates of this information. 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;
[…]
e) the repair and maintenance information referred to in (a) shall include:
[…]
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.
[…]
g) for access to information and tools referred to in (e, xi) the manufacturer, importer or authorised representative might require the owner of the device to notify the manufacturer, importer or authorised representative of the intended repair case

We consider it essential that:

I. Clause xi is retained
II. There are no exemptions made to this clause.

Further, we recommend that the wording of clauses xi) and g) is refined as shown below:

xi) software ***or hardware*** *tools, firmware and similar auxiliary means* ***to permit professional repairers to enable*** ~~*required for*~~ *full functionality of the spare part and device after repair,* ~~*such as remote*~~ ***through independent*** *authorisation* ***or pairing*** *of serial numbers* ***with informed end-user consent****.*

g) ***to complete the process of part acceptance*** ~~*for access to information and tools referred to in (e, xi)*~~ *the manufacturer, importer or authorised representative might* ***inform the end-user of the authenticity of the parts via a single notification and/or information in the device settings for verification purposes, and may require the owner of the device to re-authenticate by other means prior to full part functionality being made available****.* ~~*notify the manufacturer, importer or authorised representative of the intended repair case*~~

Appendix 2: Serialisation and pairing in iPhone parts

The table below shows the results of experimental investigations on a range of iPhone models in reference to serialisation of parts[11].

Model	Number of serialised parts	screen	battery	home button / touch ID	charging connector	front camera	back camera	face ID (front camera)	wifi chip	vibration motor ('taptic engine').	speaker	ambient light sensor
IP3GS/4S/5/5C	0	OK	OK	OK	OK	OK	OK	NA	OK	OK	OK	OK
IP5S/6/6P	1	OK	OK	HS	OK	OK	OK	NA	OK	OK	OK	OK
IP6S/6SP/SE	2	OK	OK	HS	OK	OK	OK	NA	REP	OK	OK	OK
IP7/7P	4	REP	OK	HS	OK	OK	OK	NA	REP	REP	OK	OK
IP8/8P/SE2	4	REP	OK	HS	OK	OK	OK	NA	REP	REP	OK	OK
IPX	7	REP	OK	NA	OK	OK	OK	HS	REP	REP	OK	HS
IPXR/XS/XSM	8	REP	NON REP	NA	OK	OK	OK	HS	REP	REP	OK	HS
IP11	8	NON REP	NON REP	NA	OK	OK	OK	HS	REP	REP	OK	HS
IP11P/11PM	8	NON REP	NON REP	NA	OK	OK	OK	HS	REP	REP	OK	HS
IP12	9	NON REP	NON REP	NA	OK	OK	HS	HS	REP	REP	OK	HS
IP12P/12PM	9	NON REP	NON REP	NA	OK	OK	HS	HS	REP	REP	OK	HS
IP12MINI	9	NON REP	NON REP	NA	OK	OK	HS	HS	REP	REP	OK	HS

Model	proximity sensor	built-in speakers	internal speaker	flash memory	power button	volume button	vibration button	microphones	Antenna	Induction coil	Casing
IP3GS/4S/5/5C	OK	OK	OK	OK	OK	OK	OK	OK	OK	NA	OK
IP5S/6/6P	OK	OK	OK	OK	OK	OK	OK	OK	OK	NA	OK
IP6S/6SP/SE	OK	OK	OK	OK	OK	OK	OK	OK	OK	NA	OK
IP7/7P	OK	OK	OK	OK	OK	OK	OK	OK	OK	NA	OK
IP8/8P/SE2	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
IPX	HS	HS	OK	OK	OK	OK	OK	OK	OK	OK	OK
IPXR/XS/XSM	HS	HS	OK	OK	OK	OK	OK	OK	OK	OK	OK
IP11	HS	HS	OK	OK	OK	OK	OK	OK	OK	OK	OK
IP11P/11PM	HS	HS	OK	OK	OK	OK	OK	OK	OK	OK	OK
IP12	HS	HS	OK	OK	OK	OK	OK	OK	OK	OK	OK
IP12P/12PM	HS	HS	OK	OK	OK	OK	OK	OK	OK	OK	OK
IP12MINI	HS	HS	OK	OK	OK	OK	OK	OK	OK	OK	OK

- Serialised and not replaceable
- Serialised but not reprogammable
- Serialised and reprogrammable
- Replaceable