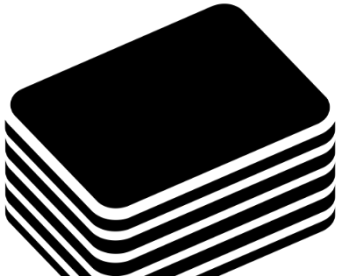
DESIGN FOR RE-USE

CARD DECK GUIDING THROUGH THE DESIGN PROCESS

Scottish Institute for
REMANUFACTURE
Reuse, Repair and Reconditioning



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PROCESS CATEGORIES

IDENTIFICATION	DISASSEMBLY	CLEANING	INSPECTION	REWORK	REASSEMBLY	TEST
Visual	Manual	Manual	Manual	Cosmetic Retouch	Manual Build without Tools	Manual Verification
Expert	Manual Tools	Power Wash	Assisted	Replacement	Manual Build with Tools	Verified with Equipment
Common Equipment	Power Tools & Force required	Automatic	Non Destructive Testing	Bespoke Manufacture	Specialist Tools	Automatic Test
Specialist Equipment	Specialist Tools	Chemical	Self Reporting	Localised Repair	Automatic Assembly	Endurance Testing
	Cutting Tools		Self Reporting with Equipment		Permanent Joints	
	Automated					

Identification

DEFINITION

Identification is the process where the whole product is reviewed to determine its make and model

Identification is important for DfR because

Efficiency of initial identification determines how quickly the feasibility of reuse is decided.
Accurate identification assists in ascertaining the cost effectiveness of carrying out the reuse process.

Identification of Product

SPECIFICATIONS

There are four generic identification processes:
- Visual
- Expert
- Common Equipment
- Specialist Equipment

Design tips for easy inspection

- Make part/serial numbers acessible
- Choose non wearing labelling systems

Identification

Identification
VISUAL

Visually identification without cleaning or taking apart

Advantages
- Components are easily identified
- No tools required

Disadvantages
- Competitors could easily identify the product
- Subject to human error
- Dependent on resilience of identification

Example
VISUAL

PRINTER CARTRIDGES

Product component is labelled with product numbers

Enable visual identification using:
- Embossing
- Engraving
- Casting

Identification
EXPERT

Visual identification without cleaning or taking apart but requires expert judgement

Advantages
- No equipment needed

Disadvantages
- Dependent on available expert
- Could be susceptible to inconsistencies & human error
- Potentially slow

Example
EXPERT

MOBILE DEVICE

An expert from SIMS Recycling Solutions identifies the make and model of a mobile device

Enable expert identification by considering:
- Visual differences
- Tactile differences
- Surface finish
- Mass

Identification
COMMON EQUIPMENT

Common equipment is used to identify the product

Advantages
- Quick procedure
- No specialised staff needed
- Equipment used to identify is widely available
- Low cost

Disadvantages
- Must conform to international standards
- Dependent on resilience of identification

Example
COMMON EQUIPMENT

QR CODE

Machine readable code accessible through common devices. QR codes provide fast readability and greater information storage capacity compared to standard barcodes

Enable identification with common equipment using:
- Bar codes
- Radio frequency identification (RFID) tags

Identification
SPECIALIST EQUIPMENT

Specialist equipment is used to identify the product

Advantages
- Provides a detailed in-depth analysis
- Access to extremely small or complex components

Disadvantages
- Specialist equipment can be expensive
- Equipment might not be easy to acquire or access.

Example
SPECIALIST EQUIPMENT

HANDHELD MASS SPECTROMETER

Handheld Mass Spectrometer is used to identify the product materials

Enable identification with specialist equipment by using:
- Distinct materials
- Distinctive internal features

Front

Identification

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Visually identification without cleaning or taking apart

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Back

Example

VISUAL

PRINTER CARTDRIGES

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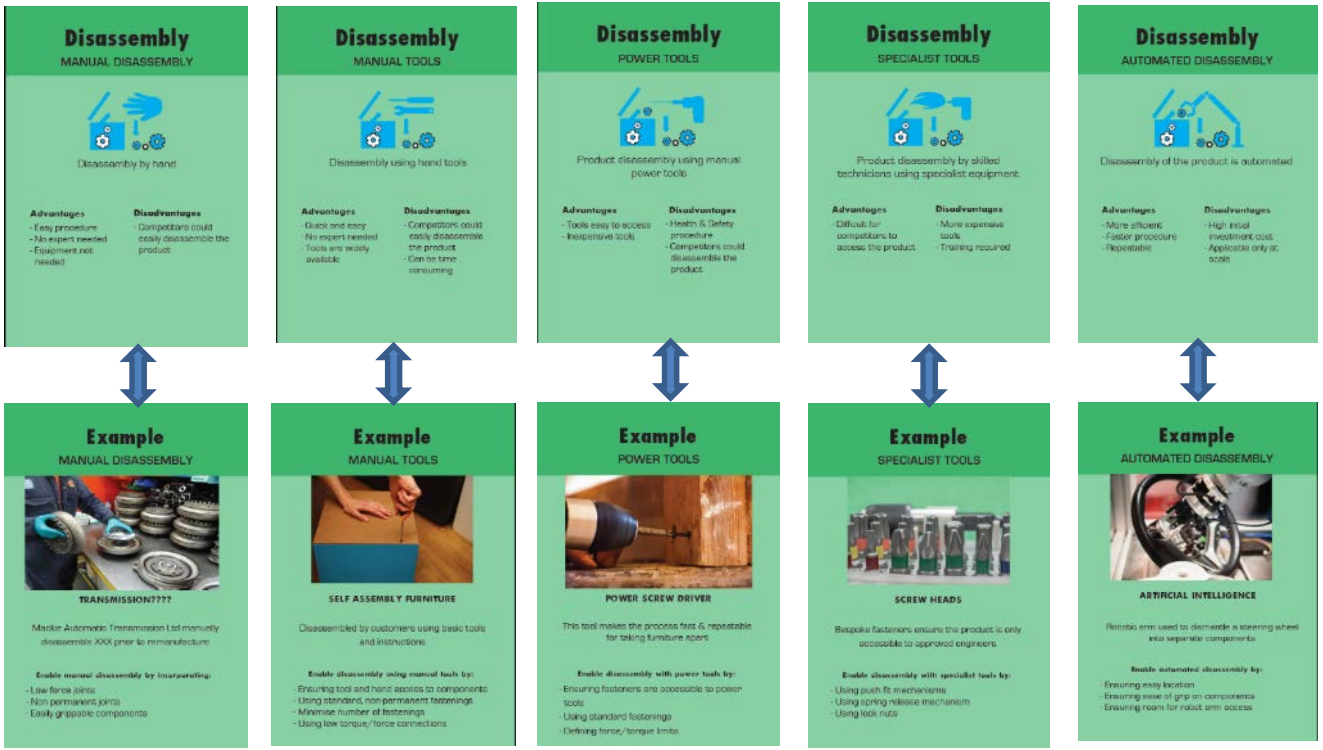
Disassembly



Cleaning

Cleaning
MANUAL

Cleaning by hand

Advantages
- No expert needed
- Cleaning equipment easy to use and access

Disadvantages
- Time consuming
- Quality can be inconsistent

Example
MANUAL

BRUSH CLEANING ELECTRONICS

A delicate brush is used to clear debris from electronic sensors and parts

Enable manual cleaning by:
- Ensuring visability of dirty areas
- Removing sharp corners
- Avoiding narrow features
- Using materials that are cleanable

Cleaning
POWER TOOLS

Cleaning with manually operated tools

Advantages
- Cleaning tools easy to access

Disadvantages
- Manual labour required
- Quality could be variable

Example
POWER WASH

JET CLEANING

Parts are jet cleaned at a petrochemical plant

Enable power washing by:
- Ensuring visability of surface for cleaning
- Ensuring features allow easy run off of debris

Cleaning
AUTOMATIC

Automated cleaning with equipment/machinery

Advantages
- Safe to use Automated process
- Efficient

Disadvantages
- Initial equipment cost

Example
AUTOMATIC

STEAM CLEANING

Mackie Automatic Transmissions Ltd use high temperature steam to remove oily grease. The products are placed on a moving surface that carries them though the steam.

Enable automation in cleaning by:
- Choosing materials that can withstand automated processes such as sand blasting & ultrasonic baths

Cleaning
CHEMICAL

Cleaning with chemicals

Advantages
- Removes resistent dirt and grease
- Efficient

Disadvantages
- Regulations COSHH
- Specially trained staff
- Environmental impact
- Disposal can be difficult and costly

Example
CHEMICAL

CHEMICAL CLEANING OF MECHANICAL COMPONENTS

Removing carbon deposits on automotive parts

Enable chemical cleaning by:
- Choosing robust materials that will withstand detergent, surfactants and organic acid

Inspection

Inspection
MANUAL

Visual assessment using hand tools

Advantages
- Easy
- No expert needed
- Cheap

Disadvantages
- Enables competitors
- Prone to error

Inspection
ASSISTED

Measurement involving specialist equipment and skilled operator

Advantages
- Harder for competitors to replicate

Disadvantages
- Qualified person needed for this process
- Prone to error

Inspection
NON-DESTRUCTIVE TESTING

Assessment of internal material

Advantages
- Non-intrusive
- Enables identification of internal flaws

Disadvantages
- Equipment might be difficult or expensive to access

Inspection
SELF REPORTING

Parts incorporate electronic or visual measures of its condition

Advantages
- Automated process
- Fast procedure
- Time saving
- Remote access
- Sensors can also store historical data

Disadvantages
- Built-in cost

Inspection
SELF REPORTING WITH EQUIPMENT

Parts can report their condition using plug in meters

Advantages
- Automated process
- Fast processure
- Sensors can also store historical data

Disadvantages
- Specialist skills
- Cost of equipment

Example
MANUAL

TYRE TREAD

The tread on tyres can be assessed with a measuring device

Enable easy manual inspection by:
- Using patterns on materials to highlight worn areas
- Ensuring known wearing components are visible

Example
ASSISTED

MICROMETER

Used to measure shaft diameter for push fit assembly of bearings

Enable assisted inspection by:
- Ensuring tools are readily available
- Ensuring ease of access to components

Example
NON-DESTRUCTIVE TESTING

INDUSTRIAL ENDOSCOPE

Used for inspecting the internal surface of pipe work

Enable non-destructive testing by
- Ensuring critical components are accessible
- Defining acceptable material properties

Example
SELF REPORTING

BATTERY LEVEL

Power tool displays remaining charge

Enable self reporting inspection by:
- Adding visual and audio indicators
- Including smart components with embedded sensors
- Use wireless standards

Example
SELF REPORTING WITH EQUIPMENT

PLUG-IN CAR DIAGNOSTIC TOOL

Unit when connected allows a garage to download performance log

Enable self reporting with equipment by:
- Designing sensing into the product
- Defining normal parameters
- Providing clear and accurate tolerance measurements

Re-work

Rework
COSMETIC RETOUCH

Refresh the external appearance

Advantages
- Ideal for functioning components needing only an appearance upgrade
- Fast procedure
- Easy to perform
- Enhances customer acceptance

Disadvantages
- It does not solve functional or performance issues
- Process must account for any pigmentation changes

Example
COSMETIC RETOUCH

REAPPLYING PROTECTIVE FINISH

Technician from Eurospray Ltd applies a protective finish to a piece of equipment

Enable cosmetic retouching by:
- Using materials which allow painting, polishing, powder coating and colour restoration

Rework
REPLACEMENT

Replacement with a functionally equivalent or upgraded component

Advantages
- Easy
- Same level or better functionality than original product

Disadvantages
- Requires sourcing of components

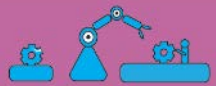
Example
REPLACEMENT

HARD DRIVE

Replacement of a laptop hard drive with an upgraded solid state hard drive (SSD) to improve performance

Enable replacement of components by:
- Creating modular design with well defined and standard interfaces
- Designing for standard size components

Rework
BESPOKE MANUFACTURE



No commercial source of replacement parts, repair requires bespoke manufacture

Advantages
- Enables an upgrade of the component

Disadvantages
- Waste of materials
- Costly
- Time consuming

Example
BESPOKE MANUFACTURE

3D PRINTING OF REPLACEMENT PART

Creation of metal or plastic clone components from 3D scans

Enable bespoke manufacture by:
- Providing 3D printing instructions for download

Rework
LOCALISED REPAIR

Removal and/or addition of material to repair worn areas

Advantages
- Avoids waste of reusable components
- Preserves value

Disadvantages
- Added material must be compatible
- Requires skilled labour or bespoke automation

Example
LOCALISED REPAIR

PRECISION GRINDING

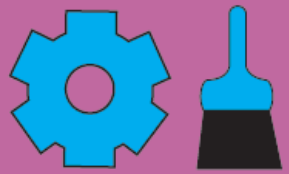
SIMS Recycling Solutions use precision grinding and polishing in the refurbishment of electronic devices.

Enable localised repair by:
- Choosing materials that allow patching, welding etc
- Ensuring visibility of and access to worn surface

Front

Rework

COSMETIC RETOUCH



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Re-assembly

Reassembly
MANUAL BUILD WITHOUT TOOLS

Reassemble by hand

Advantages
- Practical for products which require frequent disassembly

Disadvantages
- Enables competitors

Reassembly
MANUAL BUILD WITH TOOLS

Reassembly using hand and power tools

Advantages
- Quick and easy
- Readily available tools
- Low cost

Disadvantages
- Enables competitors

Reassembly
SPECIALIST TOOLS

Reassembly by skilled technicians using specialist equipment

Advantages
- Competitors cannot replicate assembly

Disadvantages
- Skilled person required
- Cost of tools

Reassembly
AUTOMATIC ASSEMBLY

Reasassembly can be automated

Advantages
- More efficient
- Repeatable quality

Disadvantages
- High initial investment cost
- Applicable only at scale

Reassembly
PERMANENT JOINTS

Reassembly requires creation of permanent joints

Advantages
- Harder for competitors to remanufacture the product
- Low cost

Disadvantages
- Force required to deassemble
- Risk of damaging the components
- Makes future remanufacture harder

Example
MANUAL BUILD WITHOUT TOOLS

TRANSMISSION

Mackie Automatic Transmission Ltd build part of a remanufactured transmission by hand

Enable manual building without tools by:
- Using standard fasteners
- Using snap fit

Example
MANUAL BUILD WITH TOOLS

REBUILD

Turner Aviation use a variety of tools to reassemble a generator

Enable manual build with tools by:
- Using components compatible with standard tools such as screwdrivers, spanners, allen keys
- Ensuring access to component for tool

Example
SPECIALIST TOOLS

BIKE ASSEMBLING

Assembly of a refurbished bicycle chain requires a specialist tool to join the links

Enable reassembly using specialist tools by:
- Concurrently designing of component and tool
- Supplying tools with product

Example
AUTOMATIC ASSEMBLY

ROBOTIC ASSEMBLY OF ENGINE BLOCKS

Use of robot with special fixtures and grippers to hold the components

Enable automatic reassembly by:
- Ensuring components are grippable by robotic arm
- Ensuring ease of access for robotic arm

Example
PERMANENT JOINTS

WELDING

Turner Aviation weld fuse nozzles to ensure a permanent joint is created

Enable reassembly with permanent joints by:
- Ensuring material can be welded or glued
- Creating one way snap fit joints

Test

Test
MANUAL VERIFICATION

Functions that can be manually checked

Advantages
- Easy procedure
- Fast procedure

Disadvantages
- Skilled staff
- Prone to human error

Test
VERIFIED WITH EQUIPMENT

Function requires measurement equipment to verify

Advantages
- Accuracy and speed
- Consistent

Disadvantages
- Trained staff
- Calibration required

Test
AUTOMATIC TEST

Function(s) can be automatically assessed

Advantages
- Efficient
- Consistent
- Automatic reporting

Disadvantages
- Requires bespoke equipment
- May only be applicable at scale

Test
ENDURANCE TESTING

Functions that require prolonged testing

Advantages
- Ensures quality
- Validates the performance specification

Disadvantages
- Longer procedure
- Requires bespoke equipment

Example
MANUAL VERIFICATION

MOBILE DEVICE TESTING

SIMS Recycling Solutions technicians manually test the functionality of mobile devices after refurbishment

Enable manual verification by:
- Incorporating visible "health" indicators (eg green light)

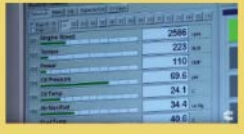
Example
VERIFIED WITH EQUIPMENT

PRESSURE TESTING

Turner Aviation verify the performance and functionality of bearings using pressure

Enable verification with equipment by:
- Developing test equipment in parallel with products
- Identifying a small number of critical parameters

Example
AUTOMATIC TEST



ENGINE PEFORMANCE TESTING

Automatic measurement of different aspects of engine performance for fast and clear assessment

Enable testing and certification by:
- Providing one plug access to a number of sensors
- Providing app or documentation to aid understanding of results

Example
ENDURANCE TESTING

ENDURANCE TESTING OF PROSTHETIC LEG

This medical product is repeatedly flexed over 1 million cycles

Enable endurance testing by:
- Developing automated test equipment in parallel with products

DESIGN FOR RE-USE

HOW TO USE THE DECK: EXAMPLES

Arrange the coloured generic process cards from left to right.

a) **A new product designed for reuse.**
- Discuss and select the most appropriate design options for your product for each step of the reuse process

b) **Assessment of an existing product.**
- Select the design steps that are applicable to your products
- Discuss possible improvements to make the reuse process more efficient