Introduction to
Digital Twin for Products &
Digital Product Passport (DPP)

trace

a transition towards
circular economy
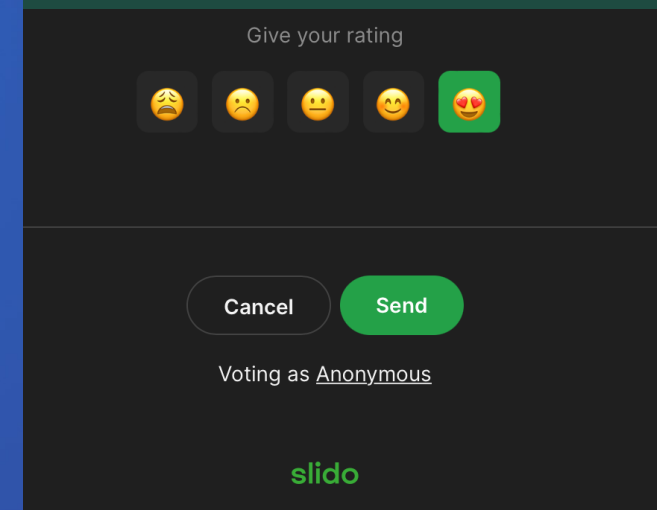
What's Digital Twin?

What's meaning of a twin in general?

What's meaning of a digital twin?

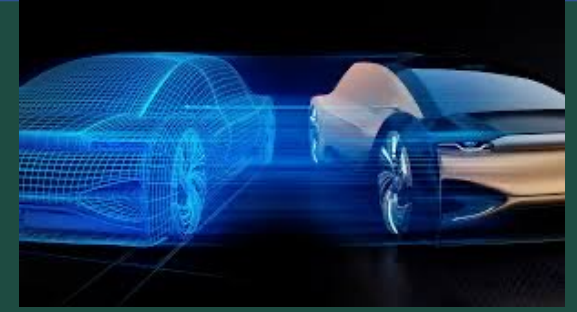What's meaning of a digital twin for a physical product?

Which level would you consider your experience with digital twins on a scale from 0 to 5?

Join at
slido.com
#2946 105

Digital twin

- Twin – human, profile on social media, avatar*
  - Oxford Dictionary/Languages: A 'twin' is: 1) one of two children or animals born at the same birth 2) something containing or consisting of two matching or corresponding parts (distinct from a pair)

- Digital twin for a physical product,
  - Initially part of Product Lifecycle Management in 2002 and NASA used it in 2010 within the Apollo program according to Grieves and Vickers, 2017
  - Expanded into aircraft industry, later into more industries and within the Industry 4.0** - Production/origin/provenance (herkomst)
  - Expanded to include the whole lifecycle of the product from before the physical product exists through its design and production until its disposal phase - Curcular Economiy's 9-10 R strategies

- Digital twin, definition, multiple examples**:
  a) Grieves (2014, p. 1): "The Digital Twin concept model [...] contains three main parts: a) physical products in Real Space, b) virtual products in Virtual Space, and c) the connections of data and information that ties the virtual and real products together."
  b) Boschert and Rosen(2016, p. 59): "The vision of the Digital Twin itself refers to a comprehensive physical and functional description of a component, product or system, which includes more or less all information which could be useful in all—the current and subsequent— lifecycle phases."
  c) Tao et al. (2018, p. 2): "[...A] complete DT [Digital Twin] should include five parts: physical part, virtual part, connection, data, and service."
  d) Kritzinger et al. (2018, p. 1017): "Based on the given definitions of a Digital Twin in any context, one might identify a common understanding of Digital Twins, as digital counterparts of physical objects."
  e) Zheng et al. (2018, p. 2): "In a broad sense, DT [Digital Twin] is an integrated system that can simulate, monitor, calculate, regulate, and control the system status and process."
  f) Singh et al, 2021: "A Digital Twin is a dynamic and self-evolving digital/virtual model or simulation of a real-life subject or object (part, machine, process, human, etc.) representing the exact state of its physical twin at any given point of time via exchanging the real-time data as well as keeping the historical data. It is not just the Digital Twin which mimics its physical twin but any changes in the Digital Twin are mimicked by the physical twin too." Examples of virtual or digital model includes layout, counterpart, doppelganger, clone, footprint, software analogue, representation, information construct, and simulation of its physical counterpart.

      There is no consensus regarding a definition of digital twin. One thing that binds most definitions of DT other than being a virtual representation of a physical object is the bidirectional transfer or sharing of data between the physical counterpart and the digital one, including quantitative and qualitative data (related to material, manufacturing, process, etc.), historical data, environmental data, and option for real-time data.

- Relation between physical product and digital twin
  - 1:n – size of n?; 1:1; n:1

* Oxford Dictionary: An 'avatar' is 'a picture of a person or an animal that represents a particular computer user, on a computer screen, especially in a computer game or on social media'
** Enders, M.R.; Hoßbach, 2019
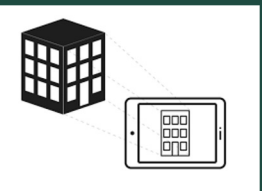
Digitalization - Your life on the web

- Prior the Internet - did you had a digital life then?

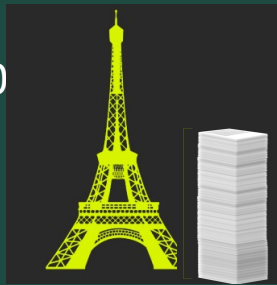- Today – surely you have a digital life & one or more digital twins
  - Dataetisk-råd's survey: 9 times more data about you on the web than you think – between 1-100.00 files equal to > 10 GB or if printed > 100 m high stack of paper
    https://nationaltcenterforetik.dk/nyheder/2023/befolkningsundersoegelse
    https://nationaltcenterforetik.dk/Media/638115380643624471/En%20hverdag%20af%20data%20-%20Executive_summary.pdf
    https://www.dr.dk/nyheder/indland/otte-forsoegspersoner-fik-vide-hvor-meget-internettet-egentlig-ved-om-dem-det-var
  - Check your self e.g. Me on the Web https://www.google.com/alerts?displaytype=1
  - You might have several digital profiles and avatars, accordingly people can have multiple digital lives wherefore if each digital life represents a digital twin but with different aspects in content then digital twins aren't identical. For some the avatar represents chance for a tiny boy to become great powerful warrior.
  - Digital Twin of customers, good idea? (Taking GDPR into consideration.)
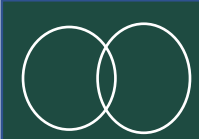
Digitalization of products,
- today, some product types transitioned to be only on the web
- is a digital twin of a digital product meaningful?

- Prior the Internet - did your product had a digital life then?

- Today – surely your product is on the web 1.0 & 2.0
  - Company webpage
  - e-commerce platform(s)
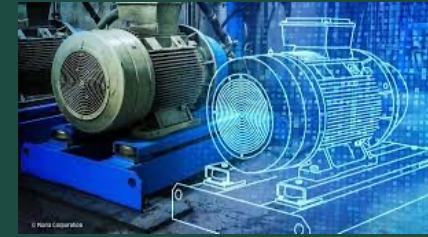 - Social media(s)
  - Resale platform(s)
  - ..

Digital twins of digital products, is that simply a digital copy?
Easy and nearly cost-free to copy digitally!
The endless number of copies, then Digital Twin doesn't make sense.
How to protect rights and businesses for digital products?

- Some products has digitalized fully into the digital world
  - Books
  - Newspapers
  - Magazines
  - Journals
  - Letters, telegrams, telex, telefax, etc..
  - Music
  - Photos
  - Films
  - Videos
  - Games
  - Maps
  - Meetings
  - Chats
  - Conferences
  - Shopping
  - Money via credit cards, apps, and crypto currencies
  - Expert knowledge
  - Designing, Architecting, ..
  - Art
  - Call centers, ..
  - Etc..

20 Years Later

All of these things fit in your pocket

Physical products' digital twin on the web
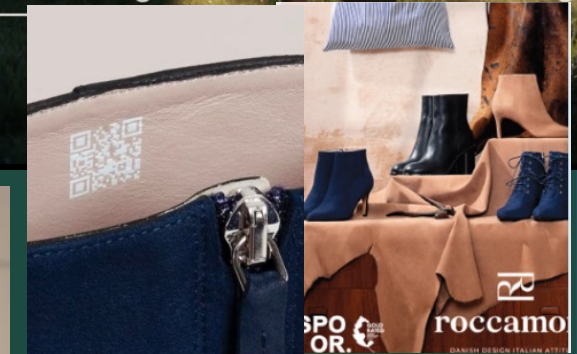## - today, some product types are sparsely on the web
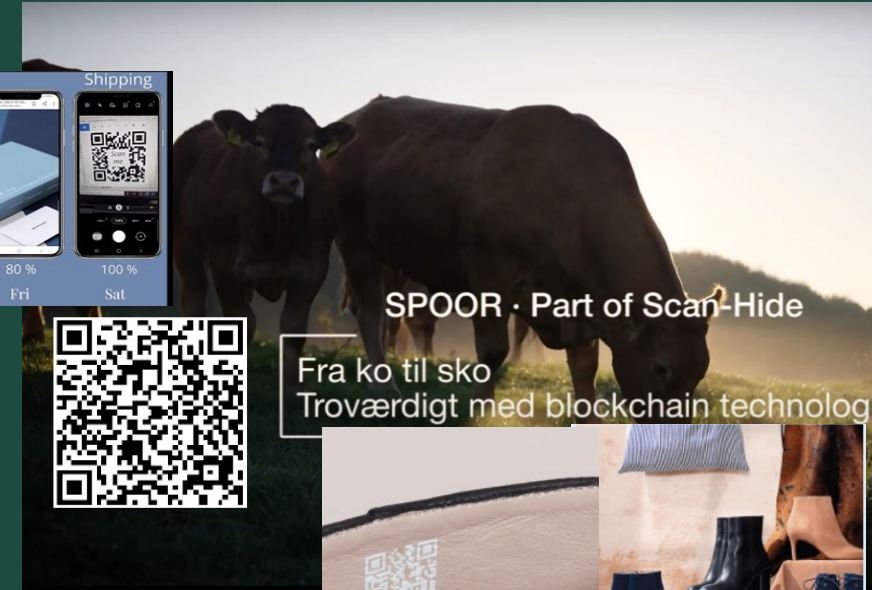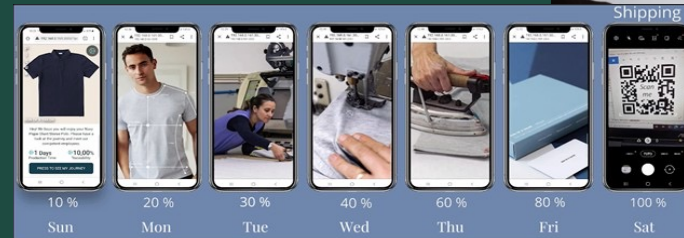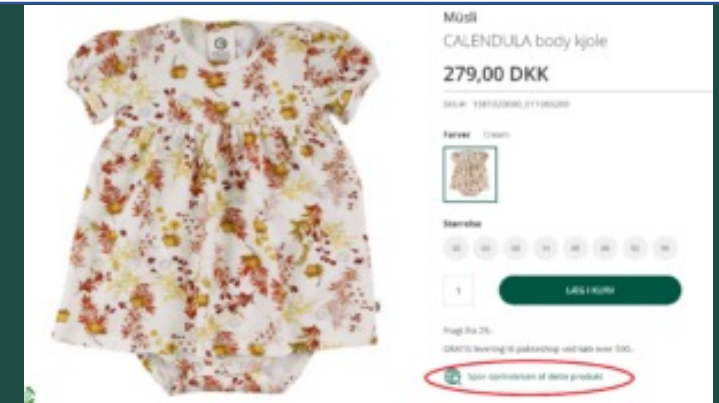## - the future?

- Prior the Internet - did your product had a digital life then?

- Today – surely your product is on the web 1.0 & 2.0
  - Company webpage
  - e-commerce platform(s)
  - Social media(s)
  - Resale platform(s)
  - ..

- Future – digital twin of physical product is on the web 3.0, use case scenarios:
  - Product information for consumers
  - Guaranty/Warranty
  - Campaign
  - Traceability and provenance from cradle to cradle
  - Authentication and origin
  - Counterfeit
  - Transparency
  - Sustainability and circularity
    - Measures
    - 9-10 R's as reuse, resale, repair/service, refurbishment, return/take-back, recycle, etc.

    …
  - Product information and instructions for service providers
  - Enriched use/consume experience
  - Digital collection …
  - Digital Product Passport
  - …..

Prototypes of digital twins for products

- Green Cotton web shop shows from farm with sustainable cotton fields to fashion for kids

- Son of a tailor from order to shirt
  https://blockchainbusiness.dk/wp-content/uploads/Son-of-a-tailor-final.mp4

- Roccamore & Spoor video of a shoe with a passport
  https://blockchainbusiness.dk/wp-content/uploads/Roccamoredemo.mp4

- Wehlers video, from 2 kg plastic garbage to sustainable design chair

  https://blockchainbusiness.dk/wp-content/uploads/Wehlers-final.mp4

Digital Twins for Products – What's it?

Digital twin for physical products is not well defined!

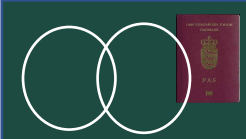|	
What	❖ Digitalisation of information about something/someone from its "birth" that in any way relevant for people, organisations, institutions, etc now, from the past and in the future
Why	❖ The digital information can be enormous wherefore it can become a challenge to filter the relevant information which can depend on e.g. for whom, when, and situation. Examples of digital information can be related to product safety, its use, its sustainable footprint, its content, how to recycle it, etc.
Which products	❖ Given the physical product a unique identity that's persistent and last will reduce confusion and risk of mistakes. However, the granularity or coverage of the identity is subject to clarification, does the identity cover a product type, a serial or a batch of products. Digital information is created via a digital device wherefore its good practices to record the identity of the device along with the time/date and possible location that have given the name/identity or "birth certificate" to the physical product. However, that demand the the identity of devices are registered with unique identity and including information about its user and/or owner.
Responsible whom	❖ Similarly
Aspects	❖ The digital information is stored digitally but where? As starting point where its created is the first source, sometimes/often the information is copied to other devices than the source whereby validity of information becomes a challenges especially if multiple versions exists, accordingly leaving information at the source and avoid copying information can be an approach. However, some
How	
for Who	❖ The access to the digital information about a physical product can be public available or governed by the owner/holder of the information e.g. registered trademark or other rights, ownership, of product/asset, NFT. For publicly available information the internet/the web is generally the channel. For governed information the owner/holder of the information. or public depend on the persons access rights
What information	❖ How is the information created? Depend on the life phase of the product. The designer might be the first, the manufacture and suppliers the next, the user or IoT devices attached to the product, certification bodies and institutions provides information related to or about the product.
	❖ Etc.

Digital Twins for Products
– What's Digital Product Passport?
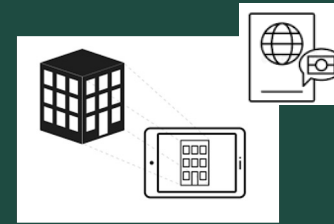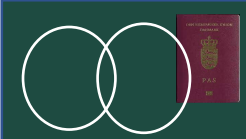

EU's Digital Product Passport:

What
- ❖ 'product passport' means a set of data specific to a product that includes the information specified in the applicable delegated act adopted pursuant to Article 4 and that is accessible via electronic means through a data carrier in accordance with Chapter III

Why
- ❖ The Commission is empowered to adopt delegated acts in accordance with Article 66 to supplement this Regulation by establishing ecodesign requirements for, or in relation to, products to improve their environmental sustainability. *Ecodesign requirements, Article 2*

Which products
- ❖ Products shall only be placed on the market or put into service if they comply with the ecodesign requirements set out in the delegated acts adopted pursuant to Article 4 applicable to those products. *Ecodesign requirements, Article 3*

Responsible whom
- ❖ requiring manufacturers, their authorised representatives or importers to make parts of the technical documentation related to the relevant product digitally available to the Commission or market surveillance authorities without request *Ecodesign requirements, Article 4*

Aspects
- ❖ The Commission shall, as appropriate to the relevant product groups and with due consideration for all stages of their life cycle, establish ecodesign requirements to improve the following product aspects: (a) durability; (b) reliability; (c) reusability; (d) upgradability; (e) reparability; (f) possibility of maintenance and refurbishment; (g) presence of substances of concern; (h) energy use or energy efficiency; (i) resource use or resource efficiency; (j) recycled content; (k) possibility of remanufacturing and recycling; (l) possibility of recovery of materials; (m) environmental impacts, including carbon and environmental footprint; (n) expected generation of waste materials. *Ecodesign requirements, Article 5*

How
- ❖ The requirements related to the product passport laid down in the delegated acts adopted pursuant to Article 4 shall, as appropriate for the product groups covered, specify the following: (a) the information to be included in the product passport pursuant to Annex III; (b) the types of data carrier to be used; (c) the layout in which the data carrier shall be presented and its positioning; (d) whether the product passport is to correspond to the model, batch, or item level; (e) the manner in which the product passport shall be made accessible to customers before they are bound by a sales contract, including in case of distance selling; (f) the actors that shall have access to information in the product passport and to what information they shall have access, including customers, end-users, manufacturers, importers and distributors, dealers, repairers, remanufacturers, recyclers, competent national authorities, public interest organisations and the Commission, or any organisation acting on their behalf; (g) the actors that may introduce or update the information in the product passport, including where needed the creation of a new product passport, and what information they may introduce or update, including manufacturers, repairers, maintenance professionals, remanufacturers, recyclers, competent national authorities, and the Commission, or any organisation acting on their behalf; (h) the period for which the product passport shall remain available.

for Who
- ❖ (a) ensure that actors along the value chain, in particular consumers, economic operators and competent national authorities, can access product information relevant to them; (b) facilitate the verification of product compliance by competent national authorities; and (c) improve traceability of products along the value chain. *Ecodesign requirements, Article 8*

What information
- ❖ What information shall or may be included in the product passport? AnnexIII

REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a framework for setting ecodesign requirements for sustainable products https://environment.ec.europa.eu/system/files/2022-03/COM_2022_142_1_EN_ACT_part1_v6.pdf
Annex https://environment.ec.europa.eu/system/files/2022-03/COM_2022_142_1_EN_annexe_proposition_part1_v4.pdf

What's Digital Product Passport?

Digital Product Passport **Purpose:**

❑ To enable sustainable consumer decision-making

❑ To demonstrate a sustainable business practice

❑ To explain how to handle/operate the product

❑ To demonstrate sustainable product design values

❑ To demonstrate sustainable processes and policy

❑ To facilitate collaborative multi-stakeholder sustainability efforts

❑ To monitor value extraction from resources

❑ To document the whole life cycle of the product

❑ To itemise the resources contained within a product

❑ To classify the source of resources used within a product

❑ To explain how to reuse, dismantle, and dispose of the product

❑ To monitor resource use and (total) availability

❑ To describe a product's performance against criteria

❑ To classify a product's ecological footprint

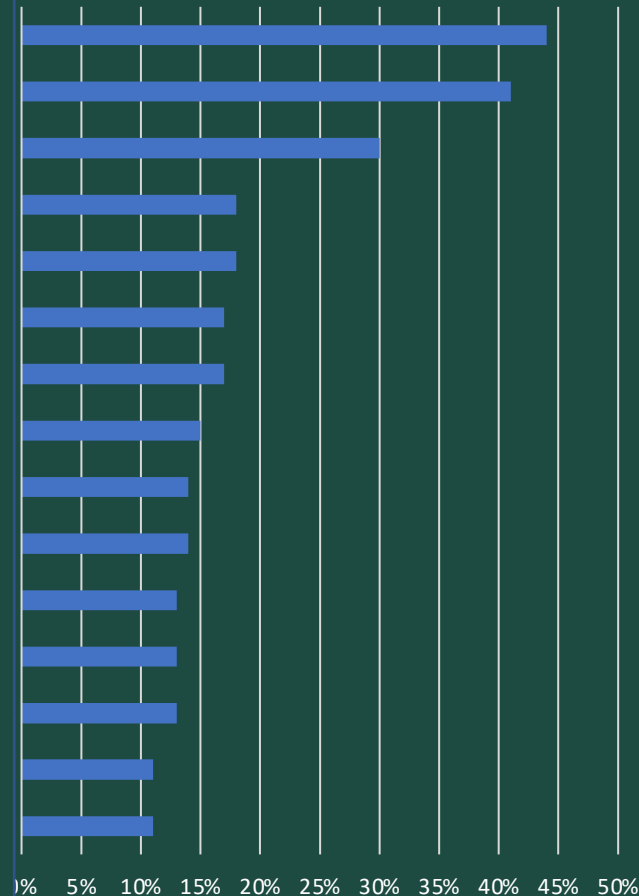❑ To explain how to maintain, repair, and refurbish the product

King et al., 2023: A proposed universal definition of a Digital Product Passport Ecosystem (DPPE): Worldviews, discrete capabilities, stakeholder requirements and concerns

What's Digital Product Passport?

Digital Product Passport Purpose:

- ❑ To enable sustainable consumer decision-making
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DDP purpose precentage

King et al., 2023: A proposed universal definition of a Digital Product Passport Ecosystem (DPPE): Worldviews, discrete capabilities, stakeholder requirements and concerns

EPREL — Det europæiske produktregister

EPREL's offentlige w

Klik her for nær

Opvaskemaskiner -	Vaske
Fjernsyn, monitorer og andre skærme	Køleskab vink
Dæk	Ly
Ovne til husholdningsbrug	Emhætter

ENERG

ECG   EFT 10855 WE

A
B
C
D
E
F
G

E

156 kWh/annum

❄

60 L

41dB

AB**C**D

2019/2016

Produkter til lokal rumopvarmning

Professionelle lagerkøleskabe/ lagerfryseskabe

Ventilationsaggregater til boliger

Kedler til fast brændsel

Pakker med kedel til fast brændsel

Anlæg

Energiklasser for produktsystem

	Energiklasse	Mærkning
$0 \leq E_{ref}$	A	A
$-17 \leq E_{ref} < 0$	B	
$-33 \leq E_{ref} < -17$	C	
$-55 \leq E_{ref} < -33$ *	D	
$-60 \leq E_{ref} < -55$	E	
$E_{ref} < -60$ *	F	

Energistyrelsen og Vinduesindustriens

EPREL — Det europæiske produktregister for energimærkning

Køleskabe og frysere, der anvendes til salg, flaskekølere og iscremefrysere

KOMMISSIONENS DELEGEREDE FORORDNING (EU) 2019/2018 for så vidt angår energimærkning af køle/fryseapparater, der anvendes til direkte salg

ARNEG s.p.a.
OSK3LX-96419809.0WDB040001

— Generelle oplysninger

B A↑G **GENERELLE PRODUKTPARAMETRE**

Årligt energiforbrug	5 232,95	kWh/år
Energieffektivitetsindeks (EEI)	17,8	

LYSKILDER

LYSKILDEPARAMETRE

Anvendt lysteknologi
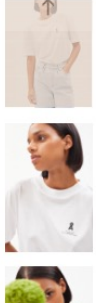
ENERG

ARNEG s.p.a.   OSK3LX-96419809.0WDB 040001

A
B
C
D
E
F
G

B

5233 kWh/annum

circularity.ID®

Product information | Materials | Extend the life | Product care | Brand

AW
Year
2021
Colourwa
White
Size
XS-XL

ZIGN

circularity.ID®

Product information | Materials | Extend the life | Product care | Brand

Sewing Thread

100% Nylon 6.6 biodegradable

Category
Yarn

Certification
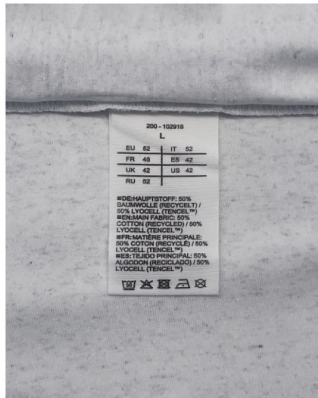
OEKO-TEX Standard 100

Colour

White

Components

100% nylon
Country of raw material production:
Italy

Production

Italy
Country of Production

Carelabel loop

Category
Trim

Certification

OEKO-TEX Standard 100

Colour

White

Components

100% organic_cotton
Country of raw material production:
United States

Production

China
Country of Production
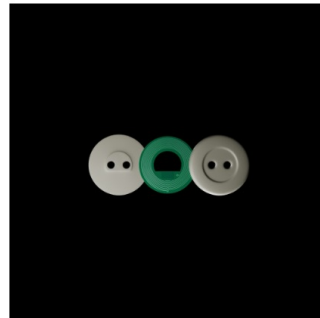
NFC tag

Category
Trim

Colour

Light Tan

Components

100% other

Production

Malaysia
Country of Production

Product information | Materials | **Extend the life** | Product care | Brand

Services

Return for Re-Use or Recycling
Take back for Reuse

In case you no longer want your Circular Tee, we recomme
usable and wearable for you, we partnered up with aktion
but also part of the solution. Ready?! And this is how you
hoffnung and they scan and select if the Circular Tee is re-
you will get a 5-Euro voucher. Follow the login: Takeback-

circularity.ID®

ARMEDANGELS
TARAA CIRCULAR LOGO

Product information | Materials | Extend the life | **Product care** | Brand

30° mild fine wash
DO NOT BLEACH.
DO NOT DRY-CLEAN.
IRON AT LOW TEMPERATURE.
DO NOT TUMBLE DRY.
USE MILD DETERGENT

# Digital Product Passport – lessons learned

- Political decided that Digital Product Passport means a set of data specific to a product that includes the information specified in the applicable delegated act adopted pursuant to Article 4 and that is accessible via electronic means through a data carrier in accordance with Chapter III

- Expect that the above means that

  1. Each product need a Digital Product Passport to "pass" through the "port" to the European Union market (which will result in that all sold products must have a Digital Product Passport)
  2. Each product need to be assigned a persistent digital identity e.g. EAN, GTIN or equivalent
  3. Each product need a persistent identifier attached, _____ted or other ways accessible by consumers including potential buyers e.g. an QR code accessible via the camera of a smartphone to ____ citizens to have access to relevant and verified information related to the characteristics of the products they own or are cons_____ to buy/rent (e.g. using apps able to read the identifier)"
  4. The final objective is for the DPP to become the "one entry point" to have access to all existing information related to a product during its entire life cycle.
     Each product's Digital Product Passport has to be accessible on the web e.g. via a persistent url (permalink)
  5. For each product the Digital Product Passport will collect, organize and store information in effici__ ___ information about at least

     a. the economic operator's name e.g. the manufacture, the registered trade name if any, authorized represe___
     b. information that enable potentia__ _____ _____ _____ _____ _____ ____ a pr_____ consumption
     c. Safety information or substance__
     d. product-specific information rele___
     e. Additional information is subject

- Many perspectives wherefore political

IoT

DB/BC
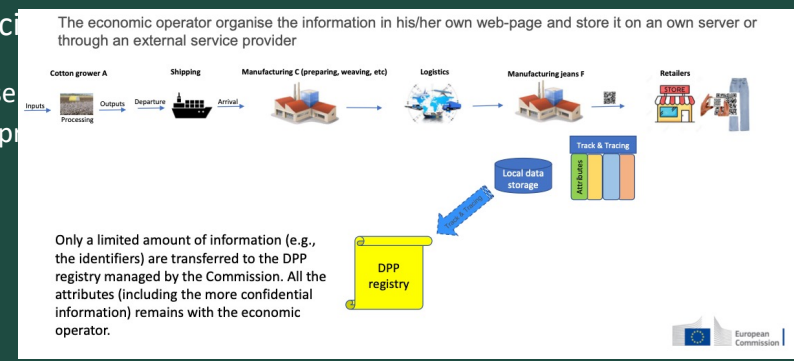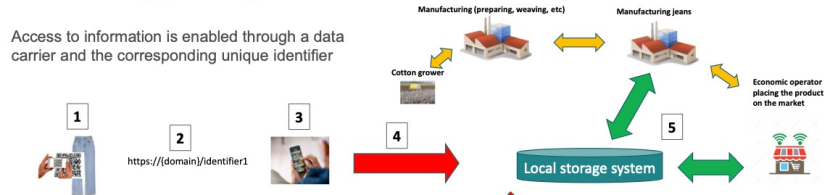
Appendix

1. EU Digital Product Passport - learning from frontrunners, July 2022

2. Ecodesign for Sustainable Products Regulation & Digital Product Passport presented by Galatola, Green and Circular Economy Unit, European Commission 19th November and 6th December 2022, selected slides

3. CIRPASS: Shaping the future of the Digital Product Passport 1st public event 13th December 2022

4. CIRPASS: The Digital Product Passport as defined in the Proposal for Eco-design for Sustainable Product Regulation (ESPR) The ESPR Proposal was published on March 30, 2022)