Made-to-measure unit-1 on-demand manufacturing of physical and digital apparel

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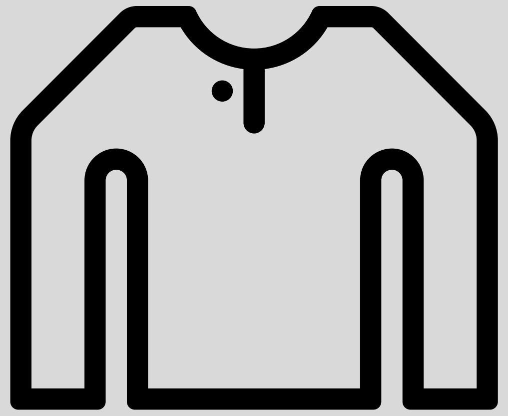
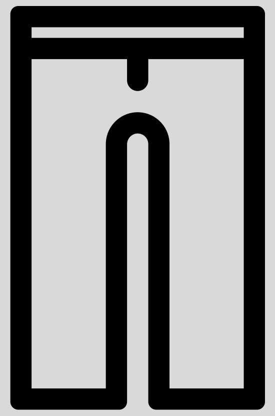
Why should I participate?

The workshop will guide you in creating a pipeline for unit-1 manufacturing of two unisex products.



Shirt



Jeans

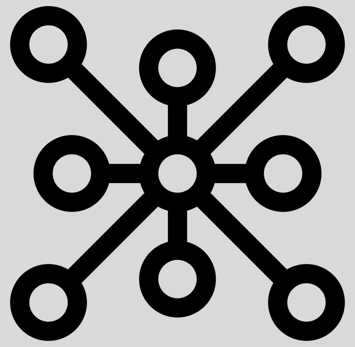
Development stages

Unit 1 refers to the same garment, yet different for each customer for optimum fit.

1

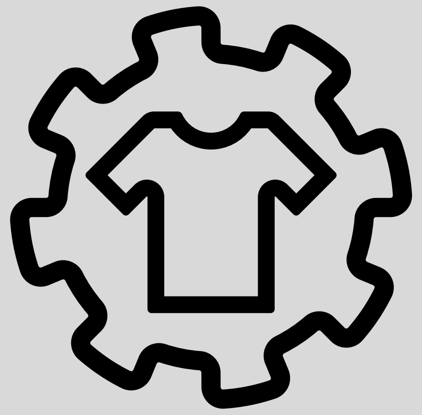
What user data to capture and process.

2



How to absorb data from all different sources.

3



What technology and processes are needed for manufacturing production.

Our Motivation

We want to establish a dialogue between retail companies that use data and manufacturers that supply various information on digital avatars and materials. In doing so, we want to:

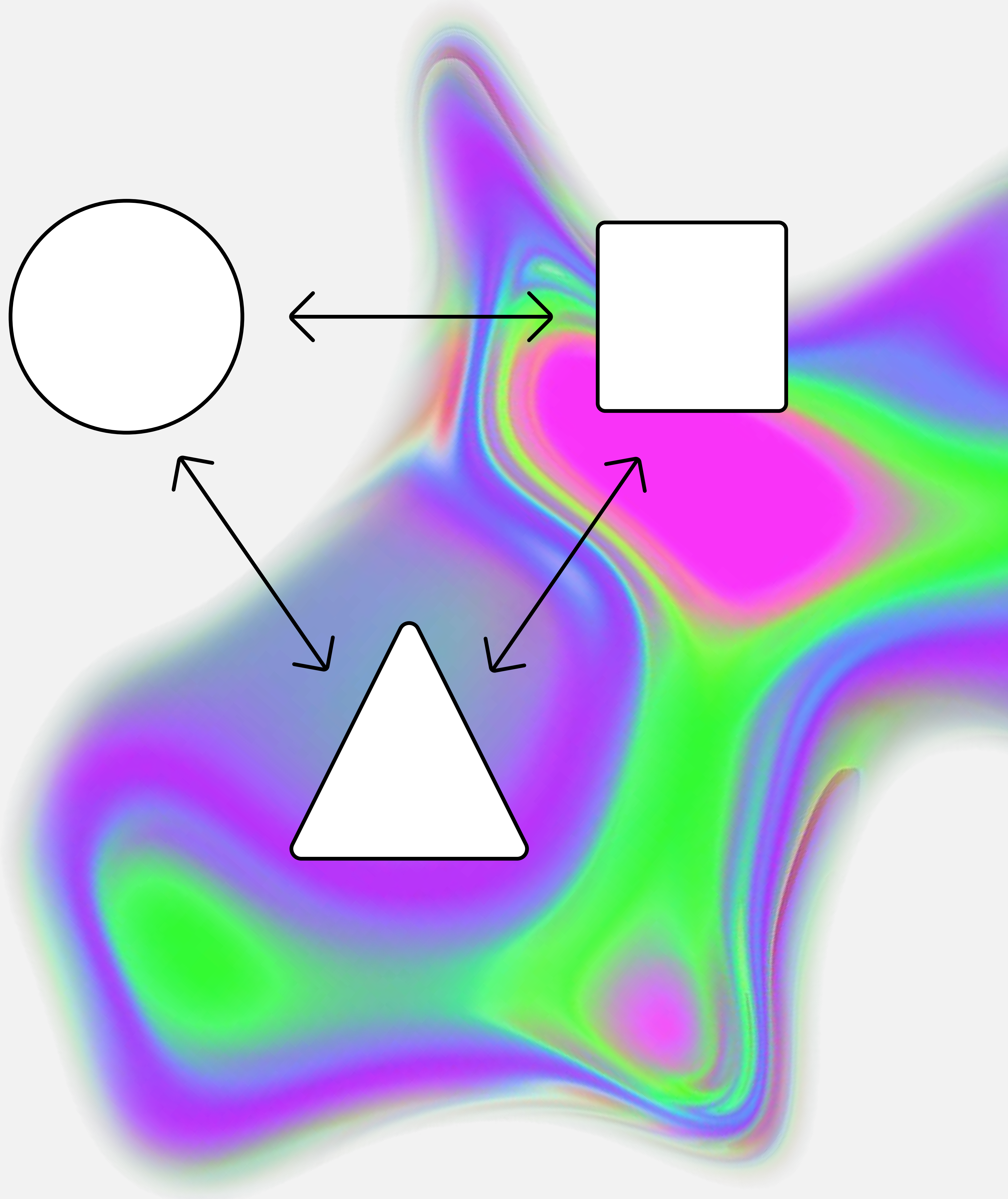
Propose a framework for scalable, modular unit-1 manufacturing to produce made-to-measure apparel.

Synthesize and identify research and technology gaps that inhibit the progress of unit-1 manufacturing.

Provide a theoretical basis for experimental validation to evaluate the performance of the proposed solutions.

Interoperability

The ability of two or more software or hardware components to cooperate despite differences in language, interface, execution platform, blockchain and distributed ledger.

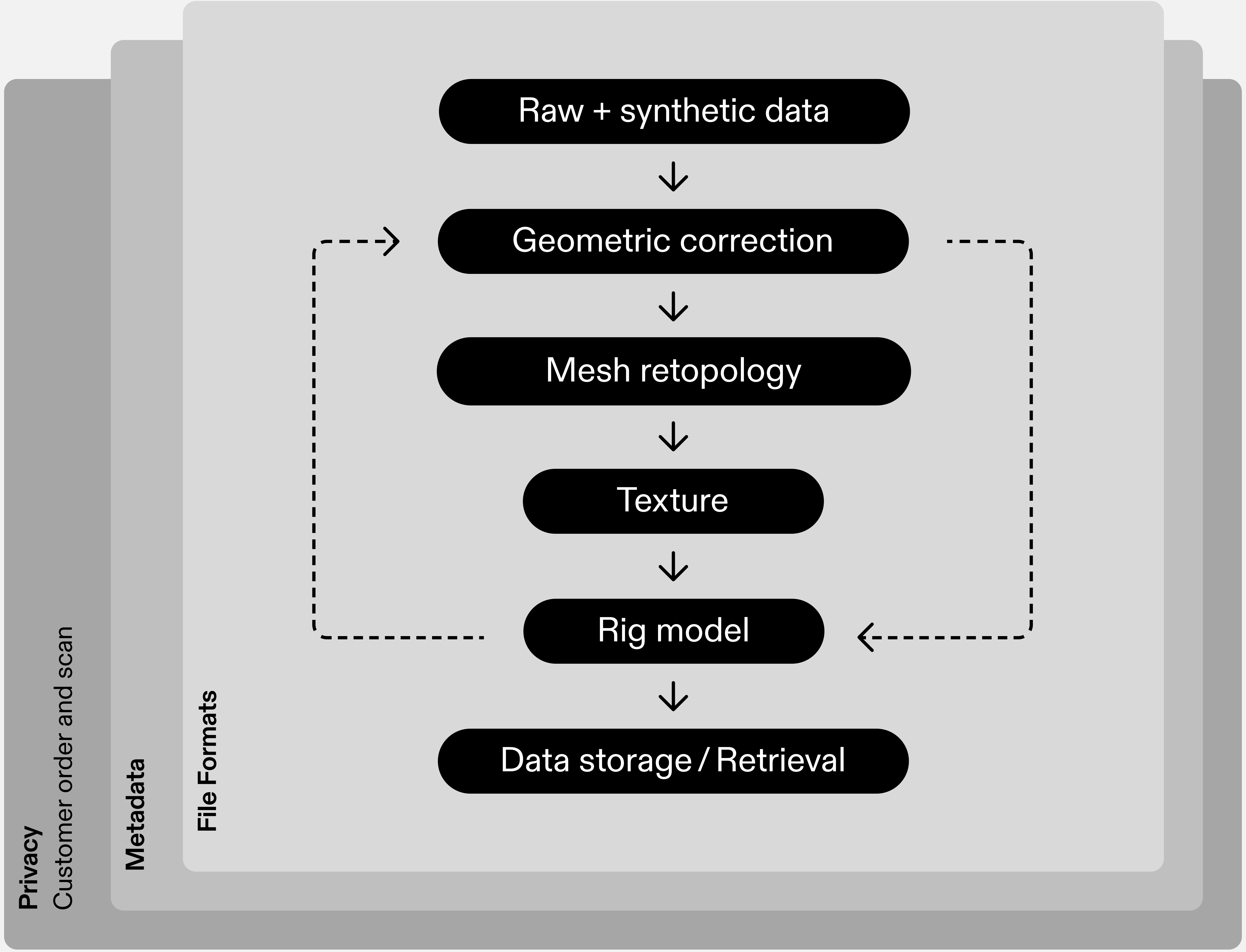


Stage 01

Data capture and processing

From raw scan mesh to animation ready avatar for virtual fit and size applications.

Modules


Raw + synthetic data
Geometric correction
Mesh retopology
Texture
Rig model
Data storage / Retrieval
Privacy
Customer order and scan
Metadata
File Formats

1 Raw legacy data from 3D body scan

Goal To extract anthropometrics with the surface geometry and texture.

Input
- Scan methods
- Depth algorithms
- The x-, y-, and z-axes in 3D body scan

Demand
- A raw scan in a common, non-proprietary format
- Ability to combine scans

Output
- Raw mesh, consisting of the point cloud, topographic surface and depth maps to determine anthropometrics and body shape

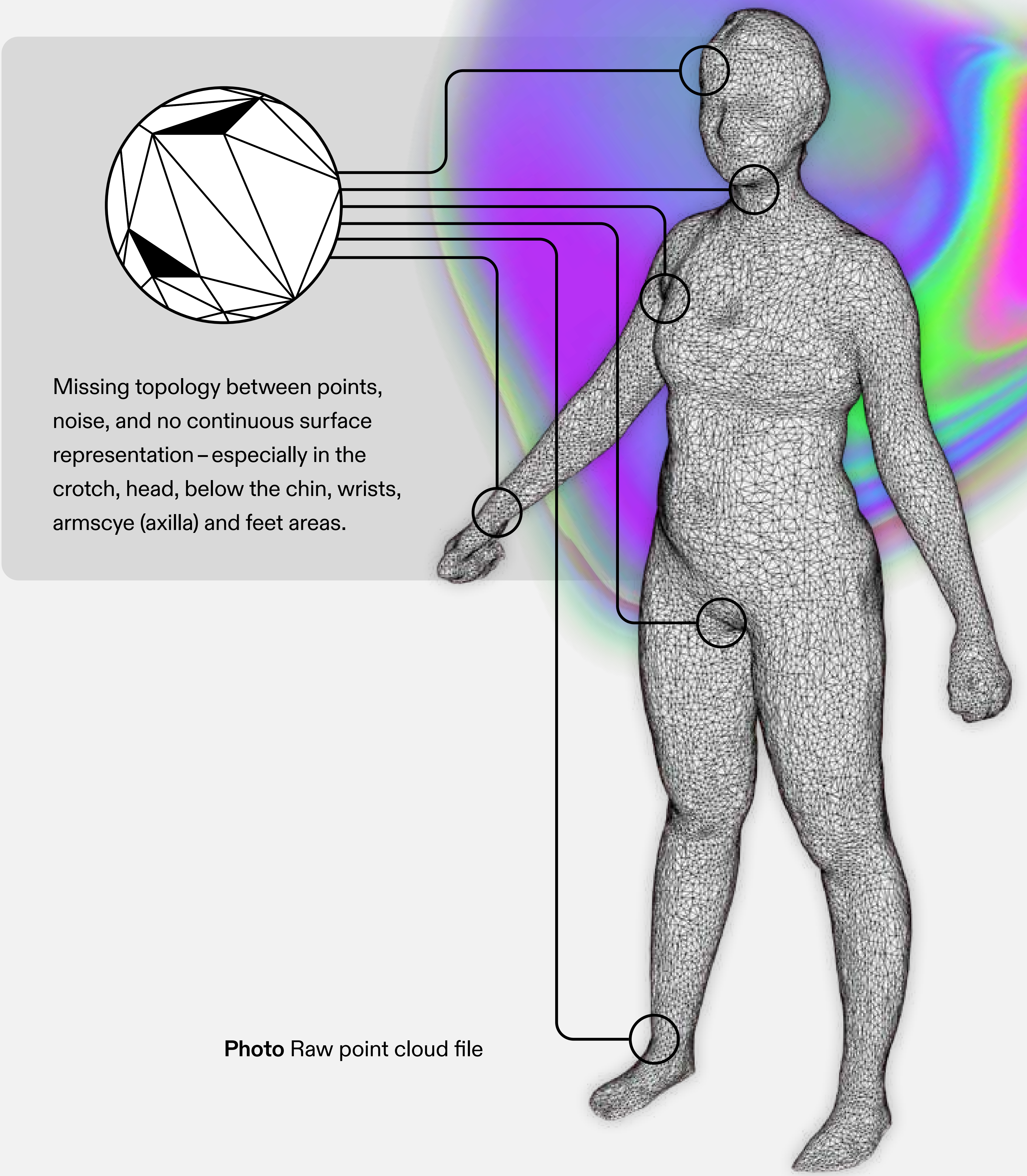


Photo Raw point cloud file

② Geometric correction of surface

Goal Watertight scan with closed holes and no floating noise.

Input
- Raw mesh
  Example: Fit3D 50K.obj poly.file

Demand
- Mesh templates from population datasets
- Tests to automatically identify potential errors in datasets
- De-identify the person from the scan in the workflow

Output
- The mesh topology output is watertight and connects to adjacent surfaces, and the volume is fully enclosed

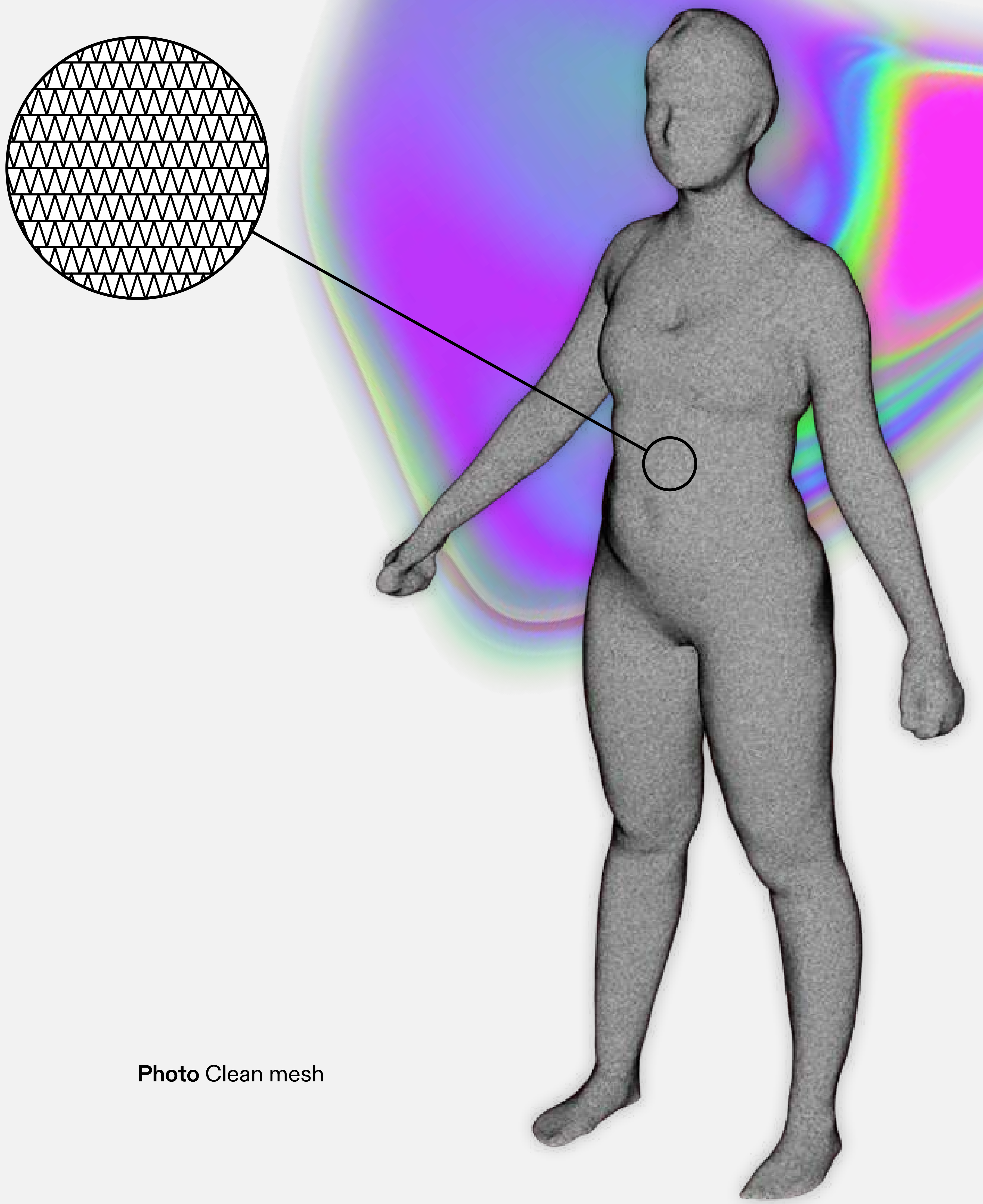


Photo Clean mesh

③ Mesh retopology

Goal Reduce the polygon count to improve 3D performance and structure the polygon edges for better deformation.

Input
- Watertight avatar with an outline of what is real and what is synthetically generated

Demand
- Smooth small data points, inexact surfaces and properties related to "moon-like" surfaces for the skin
- Conver triangles to quads in mesh structure and layout
- Reduce the density via the normal map

Output
- Mesh that preserves the silhouette with edge flow resembling the underlying muscle structure of a human

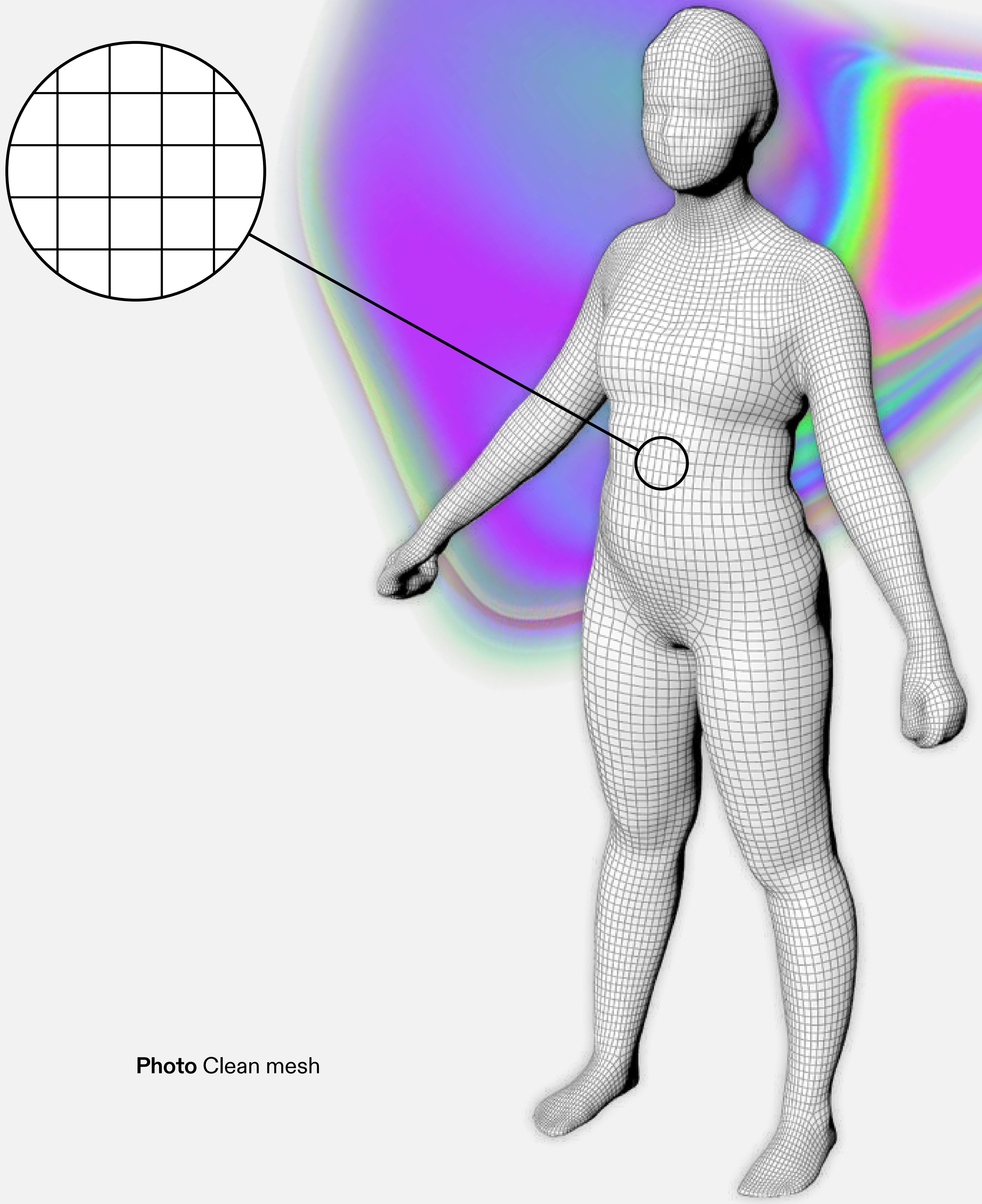


Photo Clean mesh

4

Texture (UV Maps & Normals)

Goal
Wrap a 2D image on a 3D object and reconstruct mesh normals and UV coordinates.

Input
- Retopologized avatar

Demand
- Organise UV islands to avoid surface gaps and create “texture seams”
- Set normals to determine a surface's orientation toward a light to avoid irregularities in the surface

Output
- Optimized mesh with a normal map texture

Photo Textured mesh

5

Rig & Animation (timing of implementation)

Goal	Additional step in the process for digital applications that will bring 3D avatars to life.
Input	• Avatar with texture maps • 3D rig and control methods
Demand	• Skeleton rig of a polygon mesh for animation • The rig composed based on the hierarchy of bones or body segments • A ready-made set of motion captured animations
Output	• Avatar with the rig

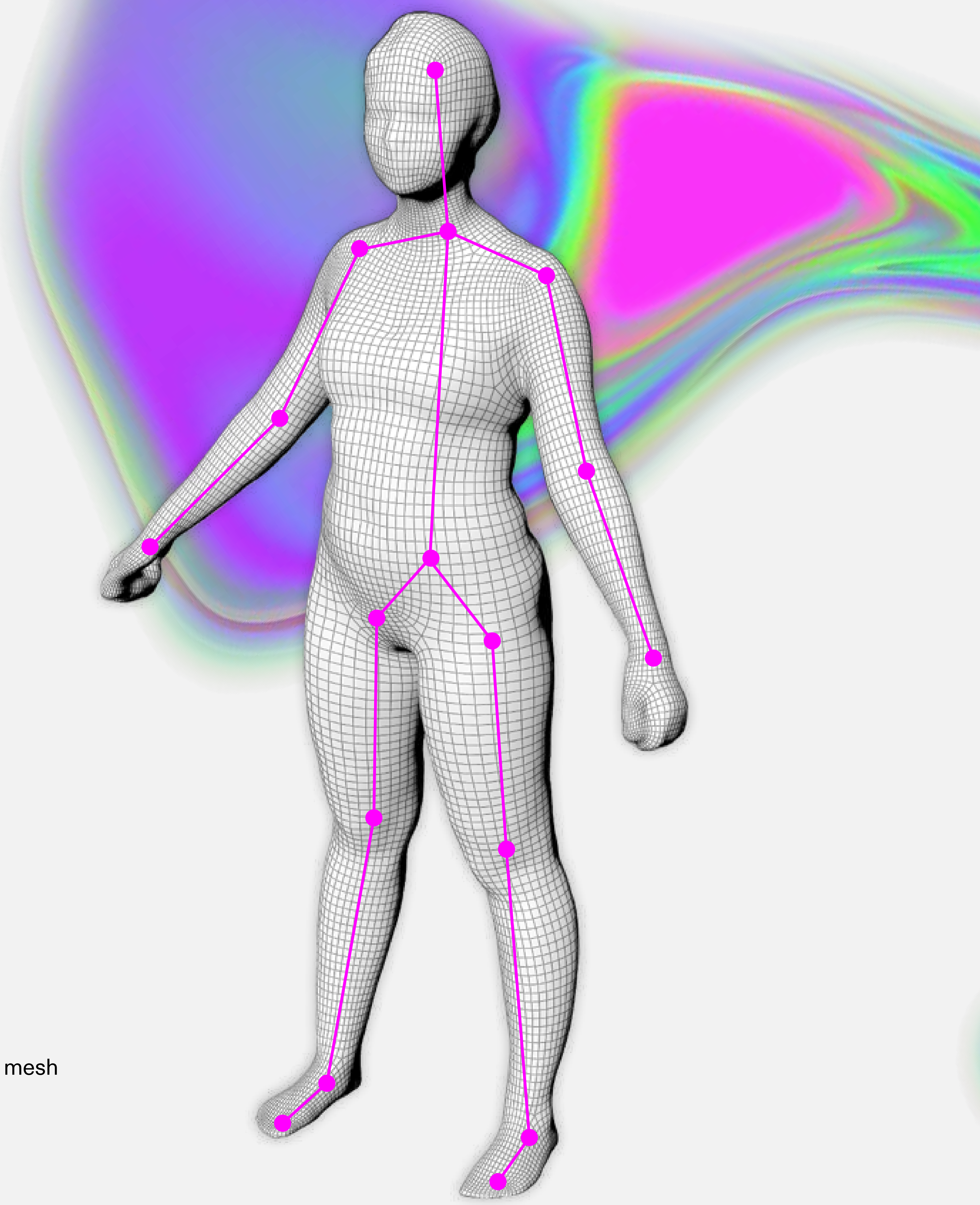


Photo Rigged mesh

6

Metadata: context, searchability and usability

Mandatory

- Use case (full body or segment)
- Origin
- Copyright
- Timestamp of data creation
- Technical equipment used
- File type / format to open data
- Components
- Scan vs. synthetic avatar

Optional

- Part of a set (larger population survey)
- A number of photos (when using photogrammetry)
- Editing process (sizes, origin, voxel spacing and space directional cosines)
- Scanee demographic data (gender, age, ethnicity, occupation)

Summary

Gap analysis

- Universal format for binary data
- Access to the population dataset
- Different file formats to get all layers of necessary data (.wrl, .obj, .fbx, .rig and .bip)
- Various software tools have rigging or auto-rigging capabilities, but interoperability can be an issue as the rig is irreversibly transformed

Requirements

- Binary data in non-proprietary format
- Uniform x-, y-, and z-axes in scan file
- Mesh templates from population
- Statistical tests for data alignment
- Data-identity confidence
- Access to metadata
- Privacy standards for different layers of data

Planning for future

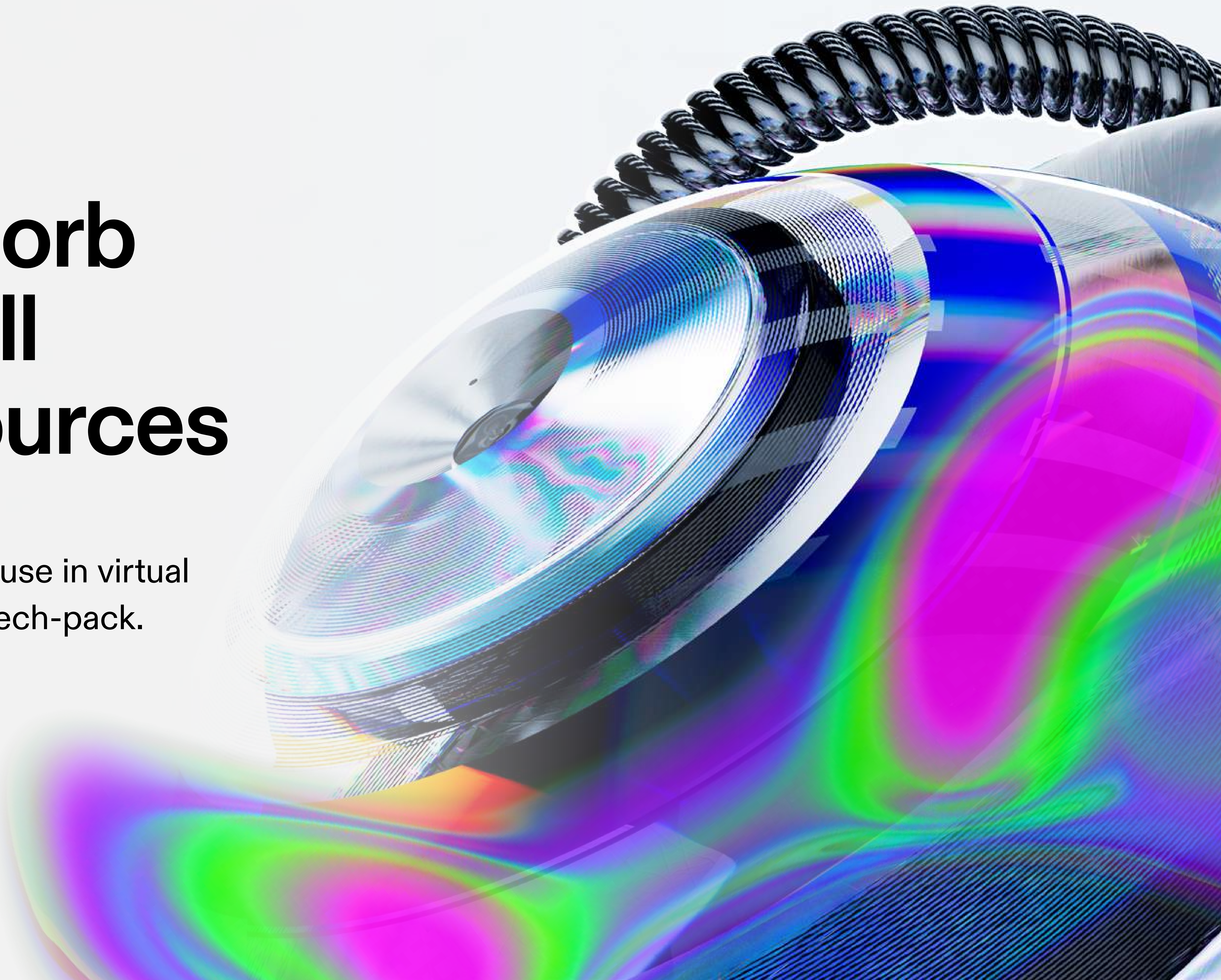
Exercise

How to implement the workflow for shirt and jeans?

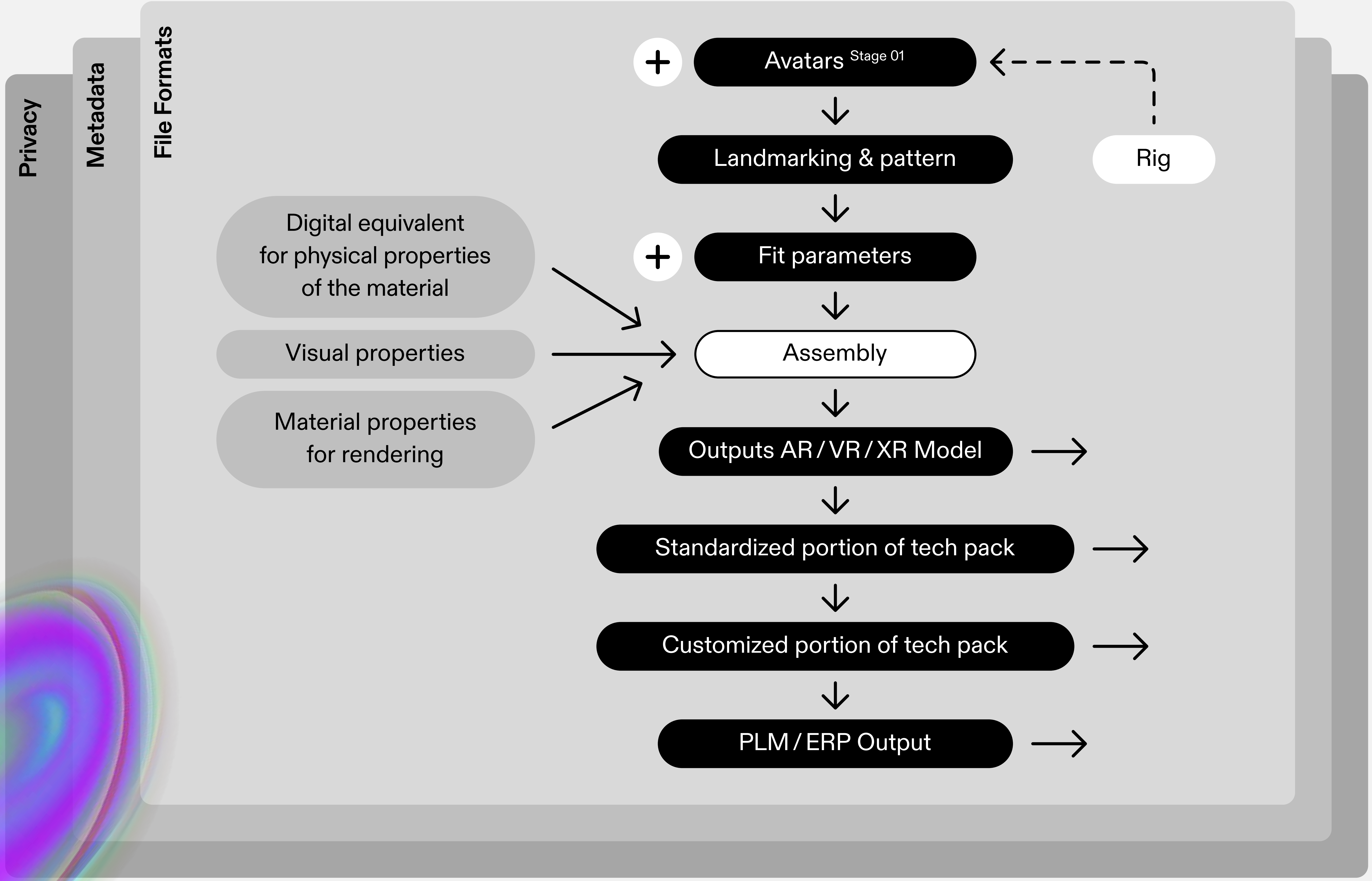
Stage 02

How to absorb data from all different sources

How to model clothing for the use in virtual applications and design for a tech-pack.



Modules


Privacy
Metadata
File Formats
Avatars Stage 01
Landmarking & pattern
Rig
Fit parameters
Digital equivalent for physical properties of the material
Visual properties
Material properties for rendering
Assembly
Outputs AR / VR / XR Model
Standardized portion of tech pack
Customized portion of tech pack
PLM / ERP Output

1 Digital equivalent for physical properties of the material

Goal

Build a material exchange database from physical properties that reference fiber-yarn-fabric varieties.

Demand

- Fiber type, yarn structure, arrangement and twist, fabric structure and cover
- Mechanical properties:
  bending, stretching, shearing, friction, straightening, weight, wrinkling, aerodynamic effects, inter-ply & intra-ply slippage and collisions

Output

- Fabric mechanical parameters in an open format to help developers create realistic simulations

Photo Blue jeans fabric

② Visual & aesthetic part of the material

Goal An open repository to provide aesthetic and visual data for textile technologists and 3D artists / designers.

Input
- Material exchange database about fabric composition and behaviors
- Lighting
- Camera orientation

Demand
- Drape, along with color, luster, and texture data of fabrics, influence the aesthetics and dynamic functionality of fabrics.
- Texture data could include diffuse, normal, AO, roughness scale, gradation, capacity, and ID number for each polygon

Output
- Visual and aesthetic information combined with cloth's encoded mechanical properties

Photo Digital jeans fabric

3 Material properties for rendering

Goal	A digital fabric that has been rendered to look 'exactly' like real cloth
Input	• Material exchange database for mechanical properties • Specifications for information on drape, color and texture. • Sync with printing devices and digital material for the production
Demand	• Non-linear deformations to mix stretching, shearing, and bending • Non-Elastic Properties of cloth • Range of colour adjustability of brightness, contrast and shade
Output	• Digital fabric for assembly and fitting

Photo Closeup of digital jeans

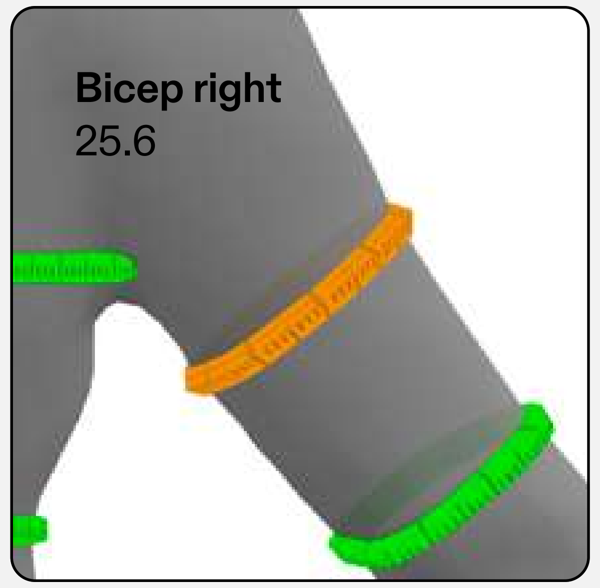
④ Definition of landmark to the actual pattern

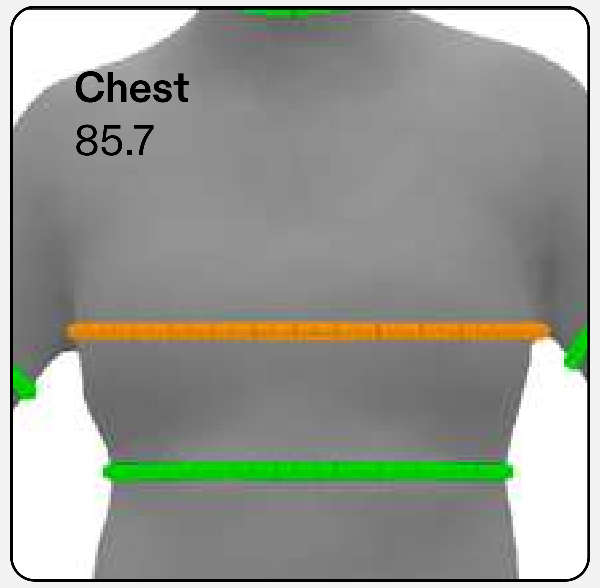
Goal Transform anthropometric data from a body scan to a garment based on a pattern-drafting method.

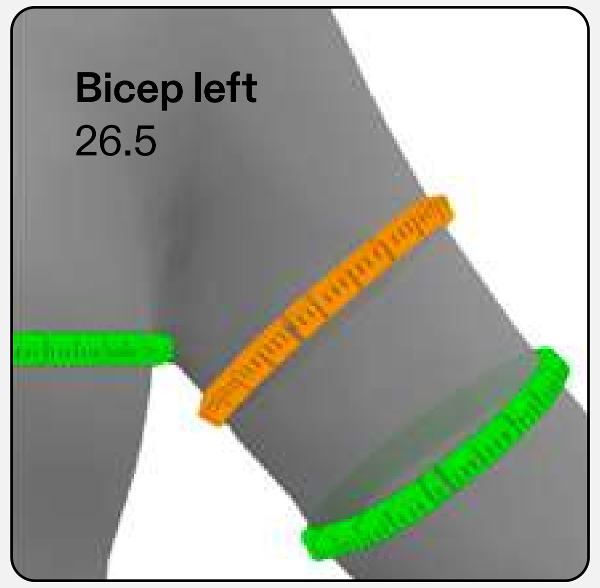
Input
- Avatar with or without a rig
- Material properties for rendering

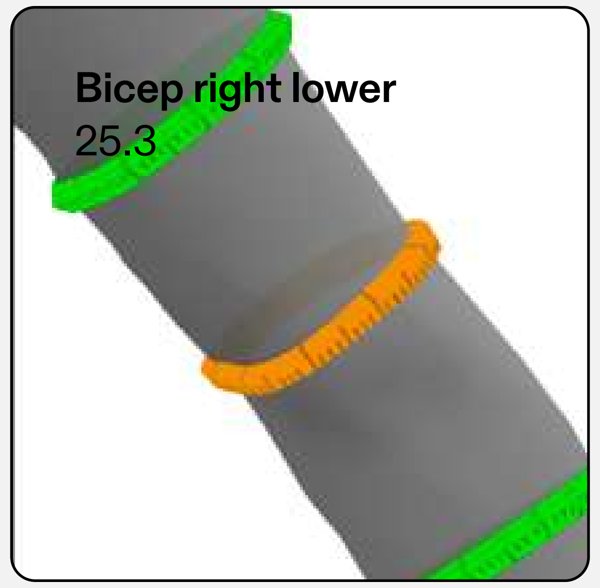
Demand
- Landmark placement and a list of required measurements to generate automatic pattern blocks from body scan data

Output
- Pattern blocks for garment assembly









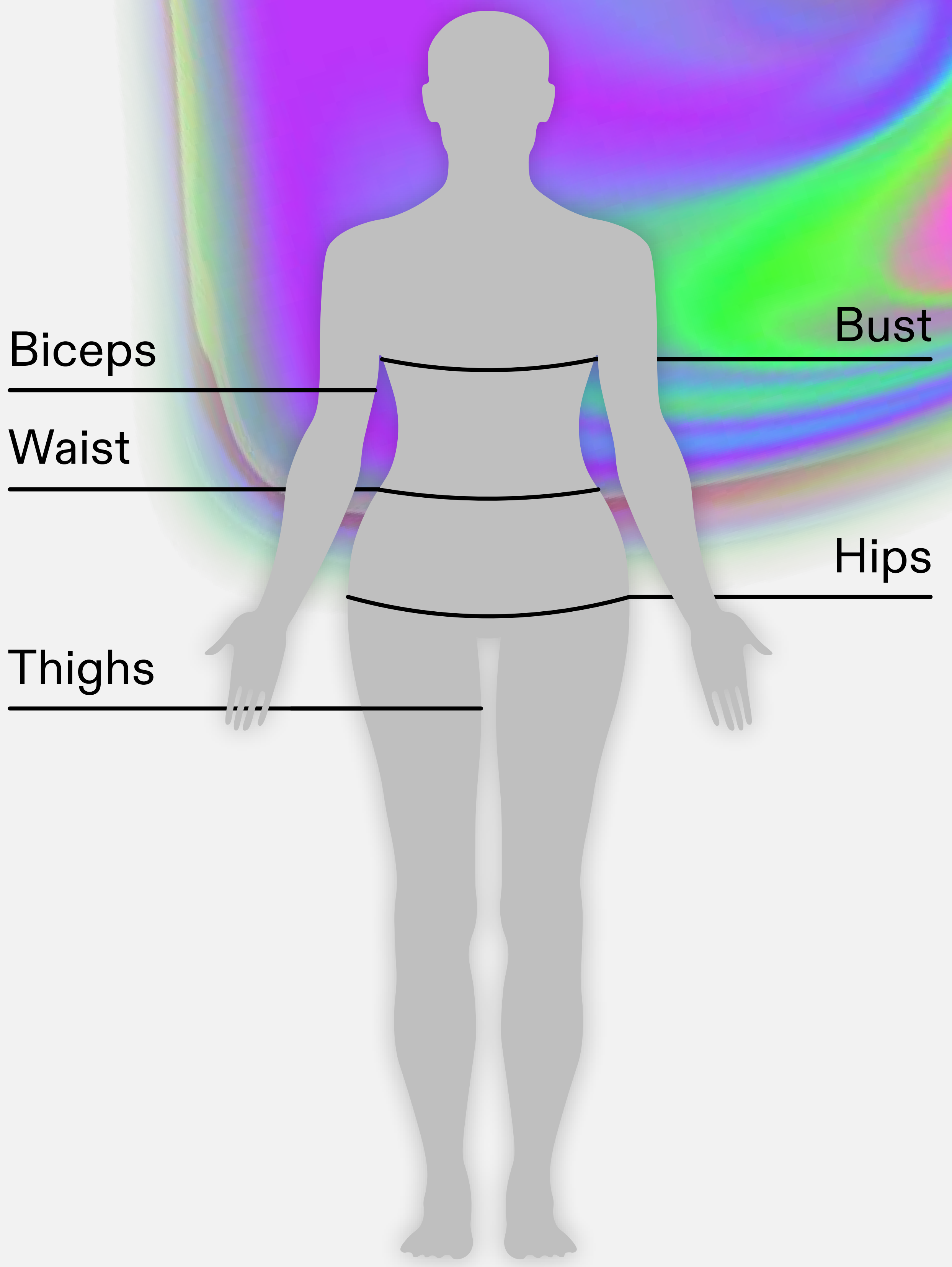


Photo Avatar and garments

5 Fit parameters

Goal
Pattern blocks with different levels of ease to visualize different styling options per garment.

Input
- Material Properties
- Pattern blocks
- 3D Model
- Animation with rig structure

Demand
- Quantify space for ease
- Definition of ease per garment
- Fabric properties in movement

Output
- 3D fitted garment on avatar body
- 3D animation for digital catwalk
- Adjusted assembly instruction
- Customer visualization for order confirmation

Video Floating animation of jeans fabric

6 Assembly

Goal Blend and combine the cloth with the pattern and design elements such as seams, trims and embroidery components.

Input
- 3D avatar
- Rendered material
- Customized pattern blocks
- Design components

Demand
- Grain direction for fabric behavior and drape
- Seam assembly information
- 2D piece geometry and 3D space alignment
- Mesh integrity maintained irrespective of rig

Output
- AR, VR, and XR avatar with the fitted garment
- Standardized tech pack with all components and assembly instructions for PLM and ERP order and inventory management
- Customized tech pack for unit-1 manufacturing

Video Floating animation of jeans fabric

Summary

Gap analysis

- Quantify aesthetic data to accurately capture garment characteristics
- Deformations should be non-linear, with stretching, shearing and blending occuring simultaneously
- Apply non-elastic properties for garment simulation

Requirements

- Reference material exchange database for different physical properties
- Open database to store and retrieve garment mechanical and visual data
- Clear definition of what to include in the assembly instruction for a portion of standardized and customized tech pack
- Consistent vocabulary for fit and ease per garment

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Exercise

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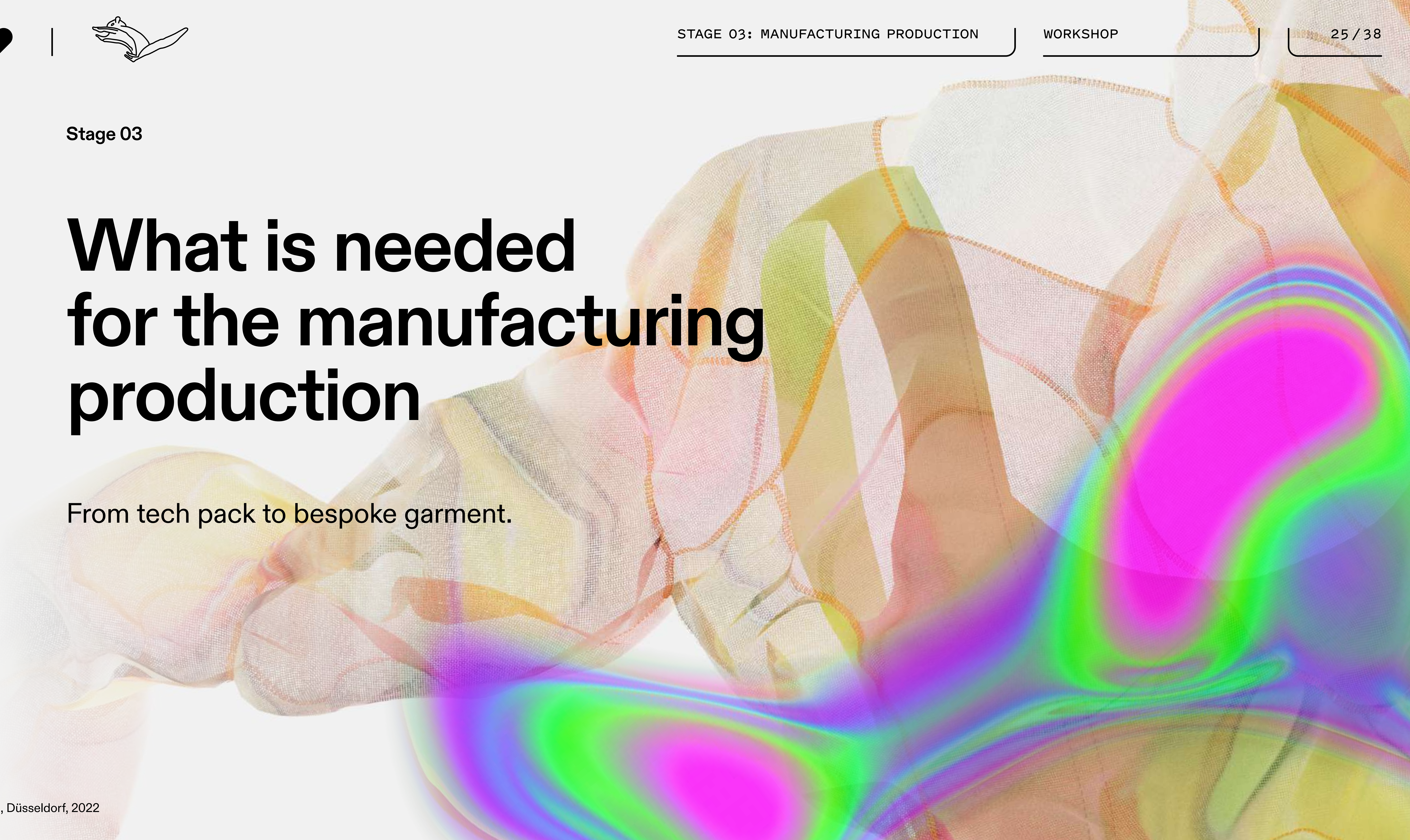
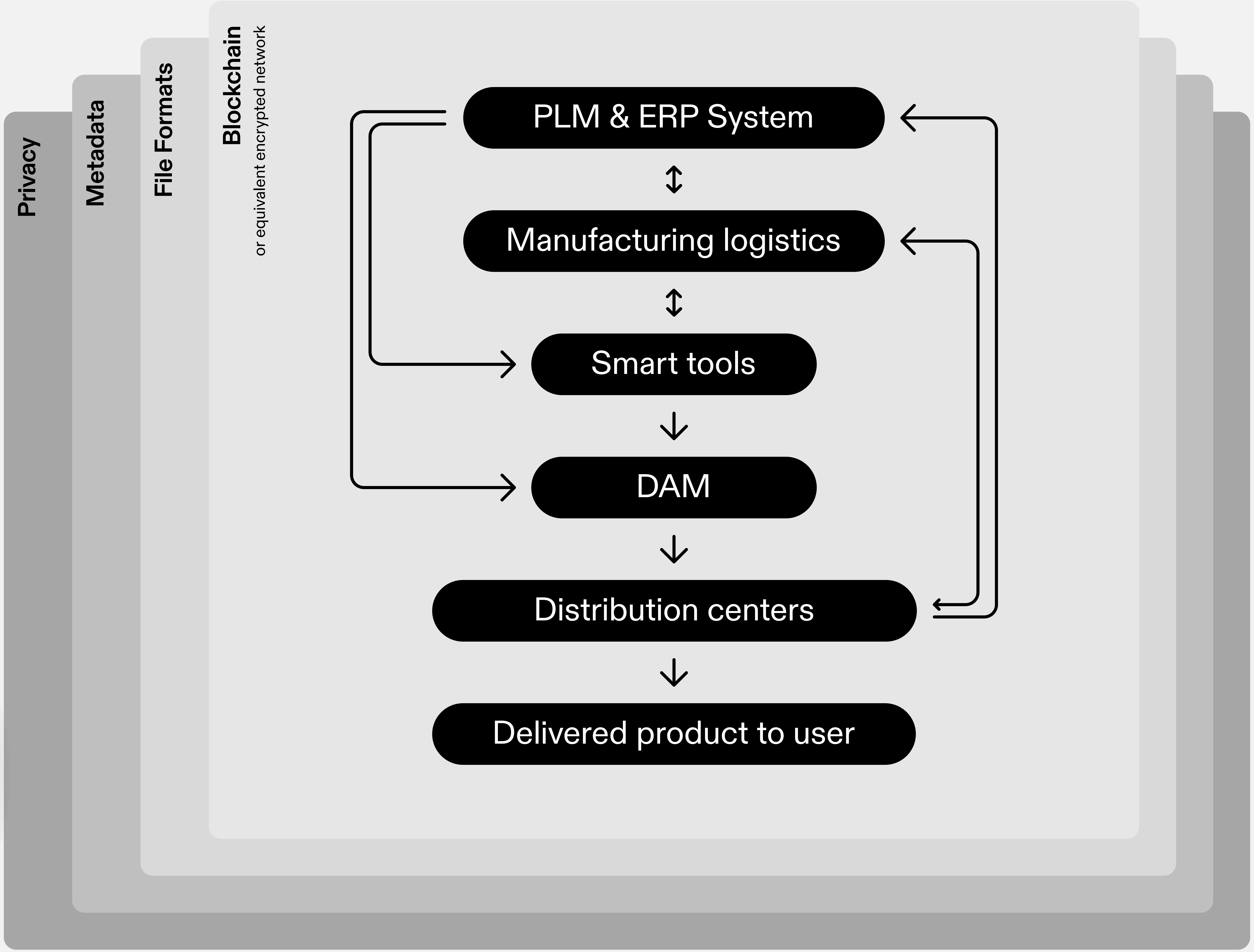
Stage 03

What is needed for the manufacturing production



From tech pack to bespoke garment.

Modules


Privacy
Metadata
File Formats
Blockchain
or equivalent encrypted network
PLM & ERP System
Manufacturing logistics
Smart tools
DAM
Distribution centers
Delivered product to user

1

PLM and ERP system in blockchain

Goal

Integrate data from tech pack into the manufacturing process and supply chain for the product usage context.

Input

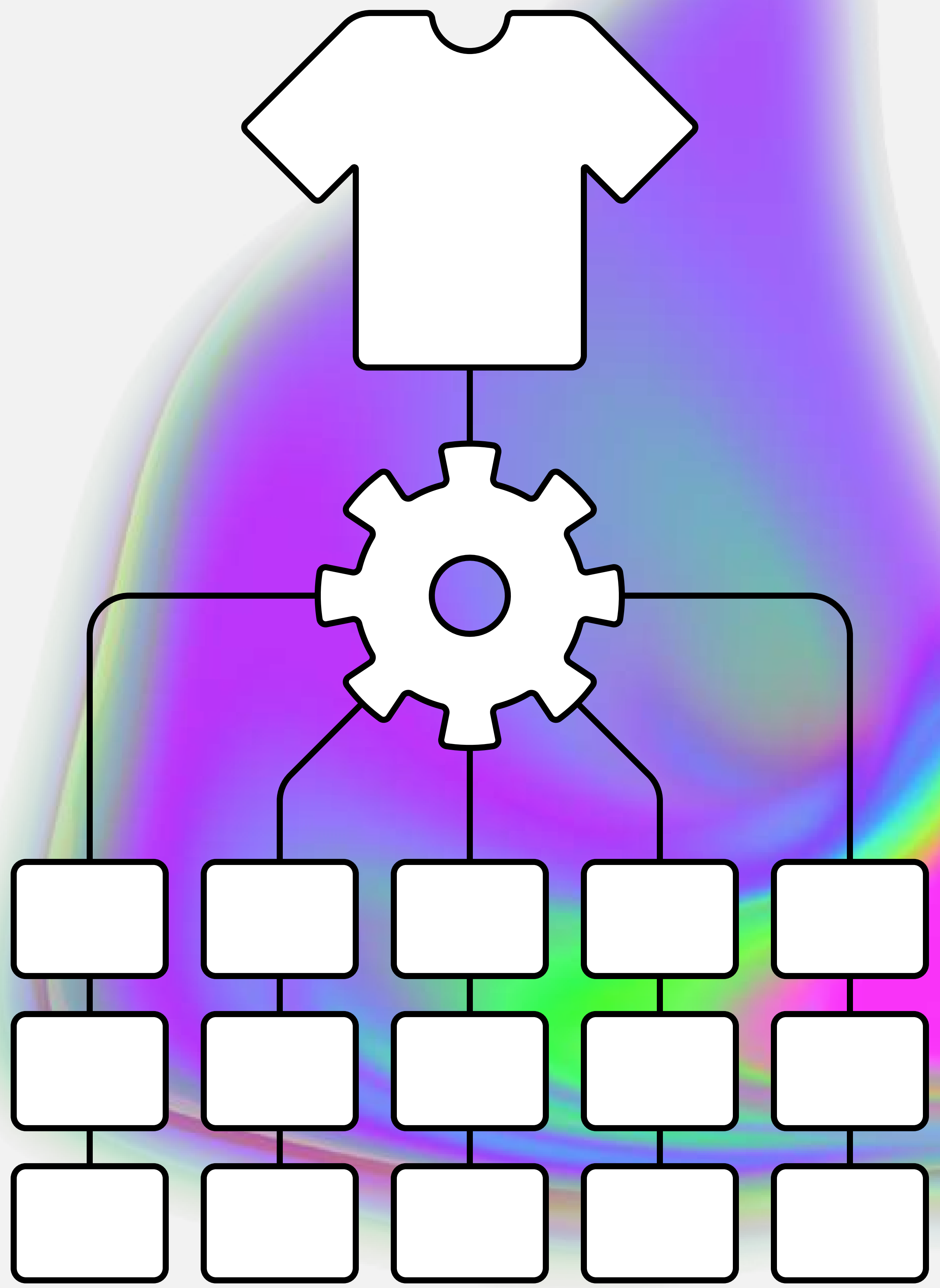
- Customized tech pack information
- Blockchain and smart contract that digitally facilitates and verifies contract negotiation and performance

Demand

- Arrange panels for products and assign metadata i.e. unique identifiers
- Synchronize data across the supply chain
- The production fees could be automatically calculated and settled by smart contracts

Output

- Examine production requirements for tools / localization
- BOM data with a variable quantity
- Assembly instructions for smart tools



② Logistics (global design → local manufacturing)

Goal

Manage and synchronise decision-making with supply-chain stakeholders and local production.

Input

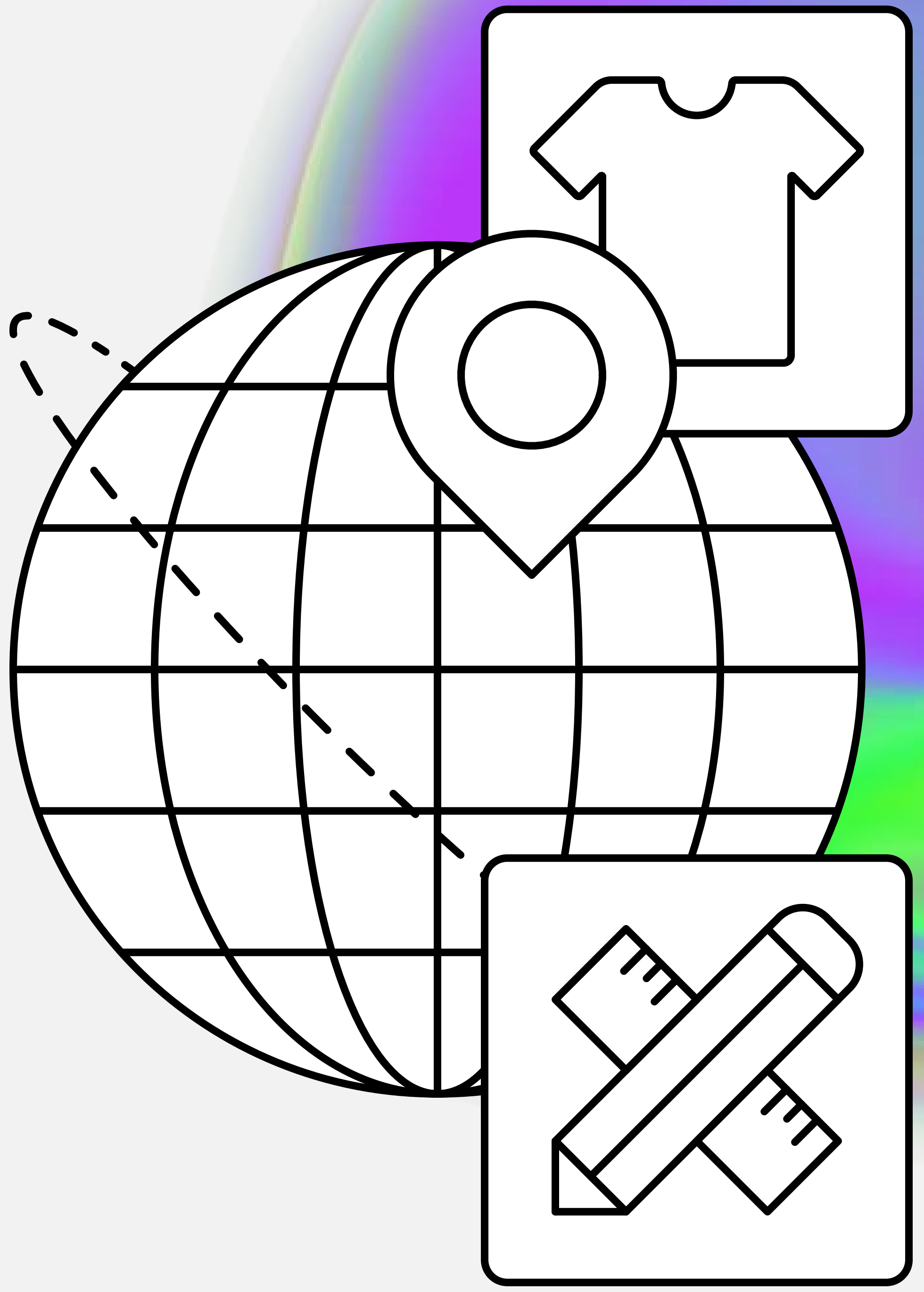
- PLM data for skills & resources requirement
- BOM data with variable quantity
- Inventory and resource management
- Logistics for product route

Demand

- Computing infrastructure:
  traceability, security, decentralized consensus, and decentralized process execution

Output

- Data sharing and copyright protection
- Logistics requirements:
  production, distribution and servicing



3 Smart tools on demand

Goal

Each smart tool can act as a node in the blockchain network or own a blockchain address, and each node has a private key to encrypt data and a public key for other nodes to verify data.

Input

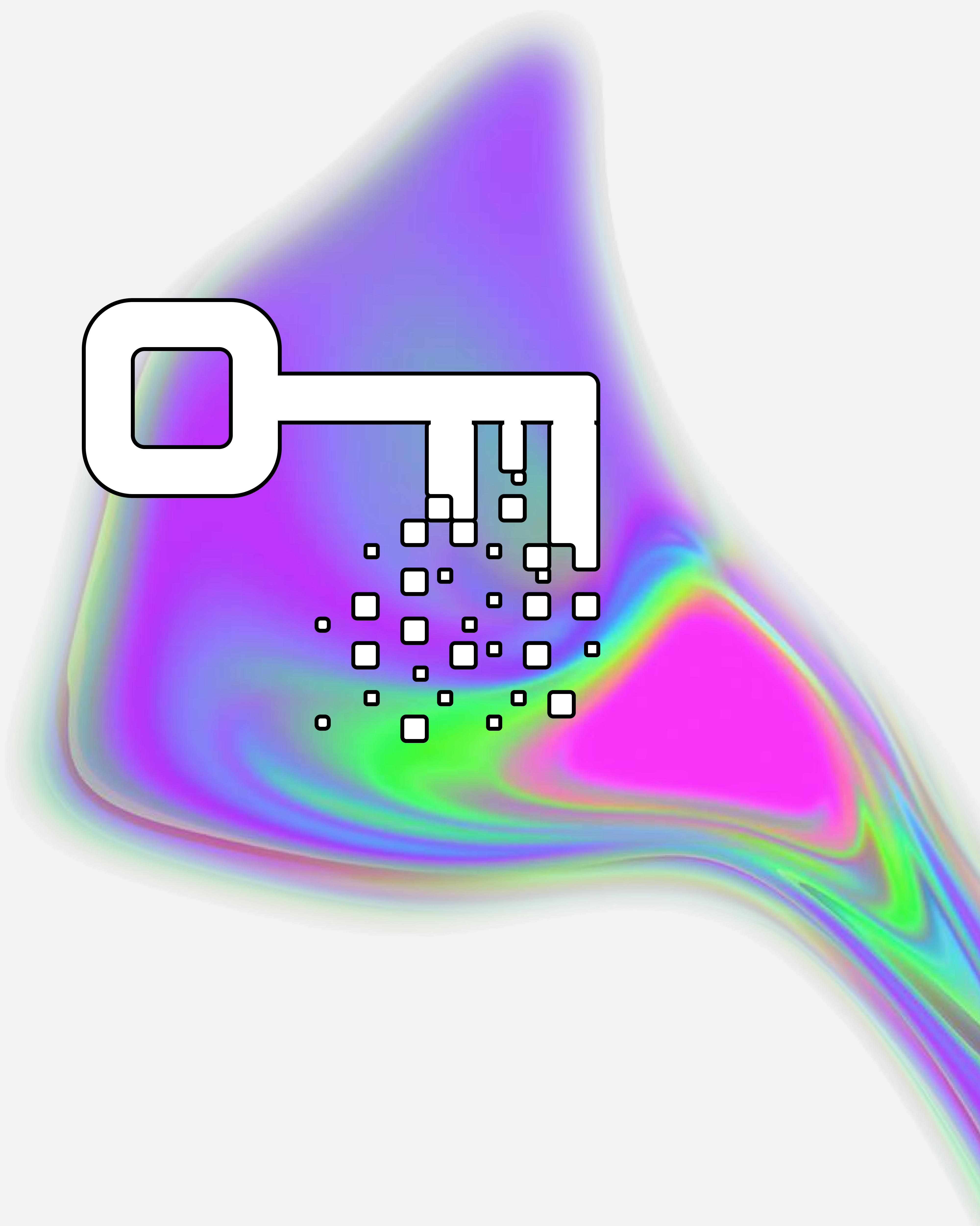
- Fabrication: Textile printer, dryer, cutter, assembly engine and coordinating computing environment or device
- Customized portion of a tech pack

Demand

- Inventory management for smart tools automated by smart contracts
- Cutter: How to account for manufacturing floor tweaks when it is an individual product
- Identify factors to control the cut of the textile sheet from cut control instruction and panel image

Output

- Finished unit-1 manufacturing garment
- Product Maintenance instructions
- Material quantities utilized by location



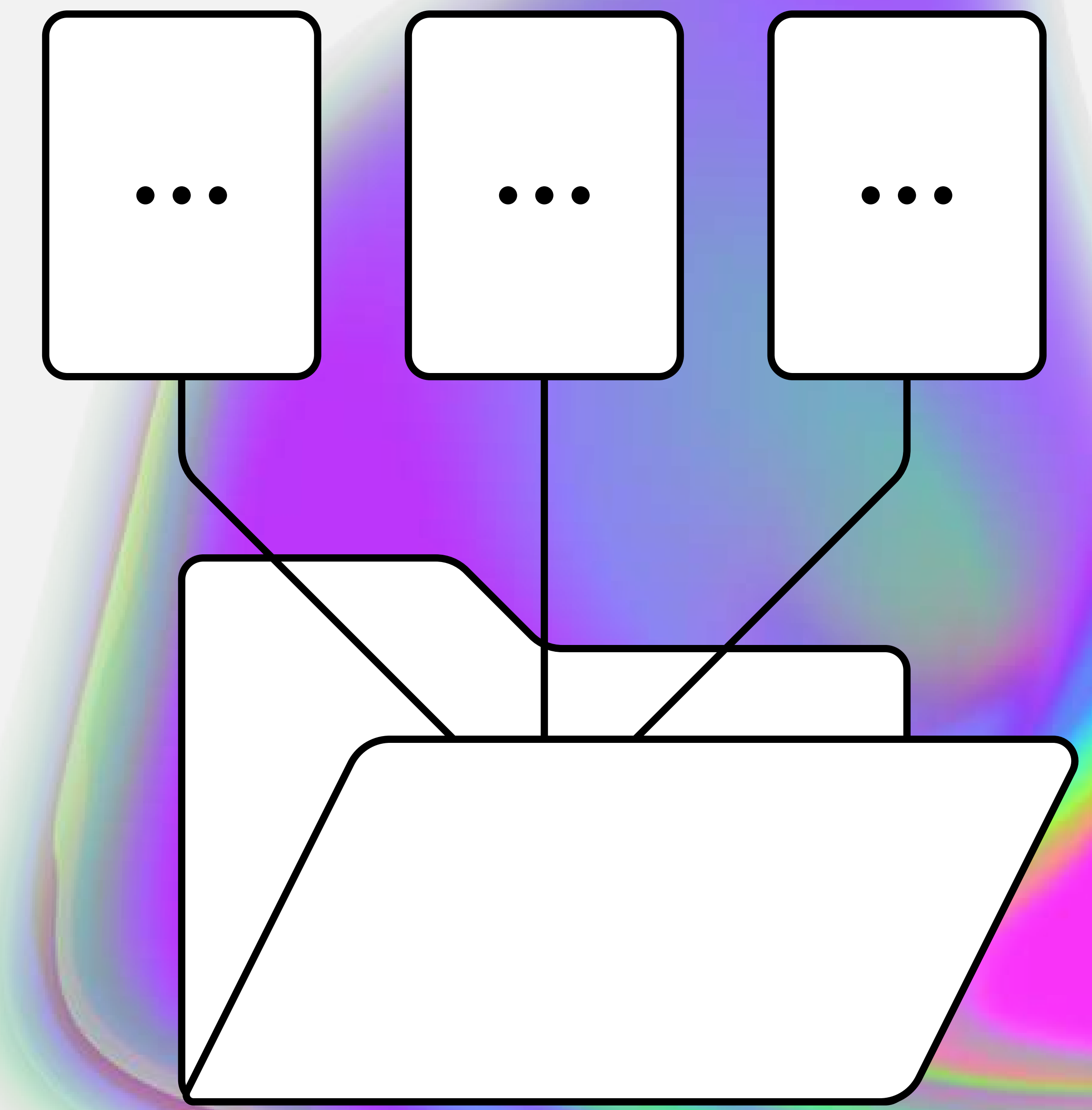
4 Digital Assets Management (DAM)

Goal
Blockchain or equivalent network can record lead time, minimum order quantity and end-of-life management.

Input
- PLM, BOM, Smart tools

Demand
- Agree on quality and analyze materials and components to develop more sustainable end-of-life disposal plans
- Identify productivity factors (shape range, delivery location, manufacturing location)
- Identify products that contain defective components and issue target recalls

Output
- The smart contract automatically calculates a quality score based on the agreed terms with client & supplier
- Store workflow data: Variable quantity for BOM, PLM & ERP and Smart Tools



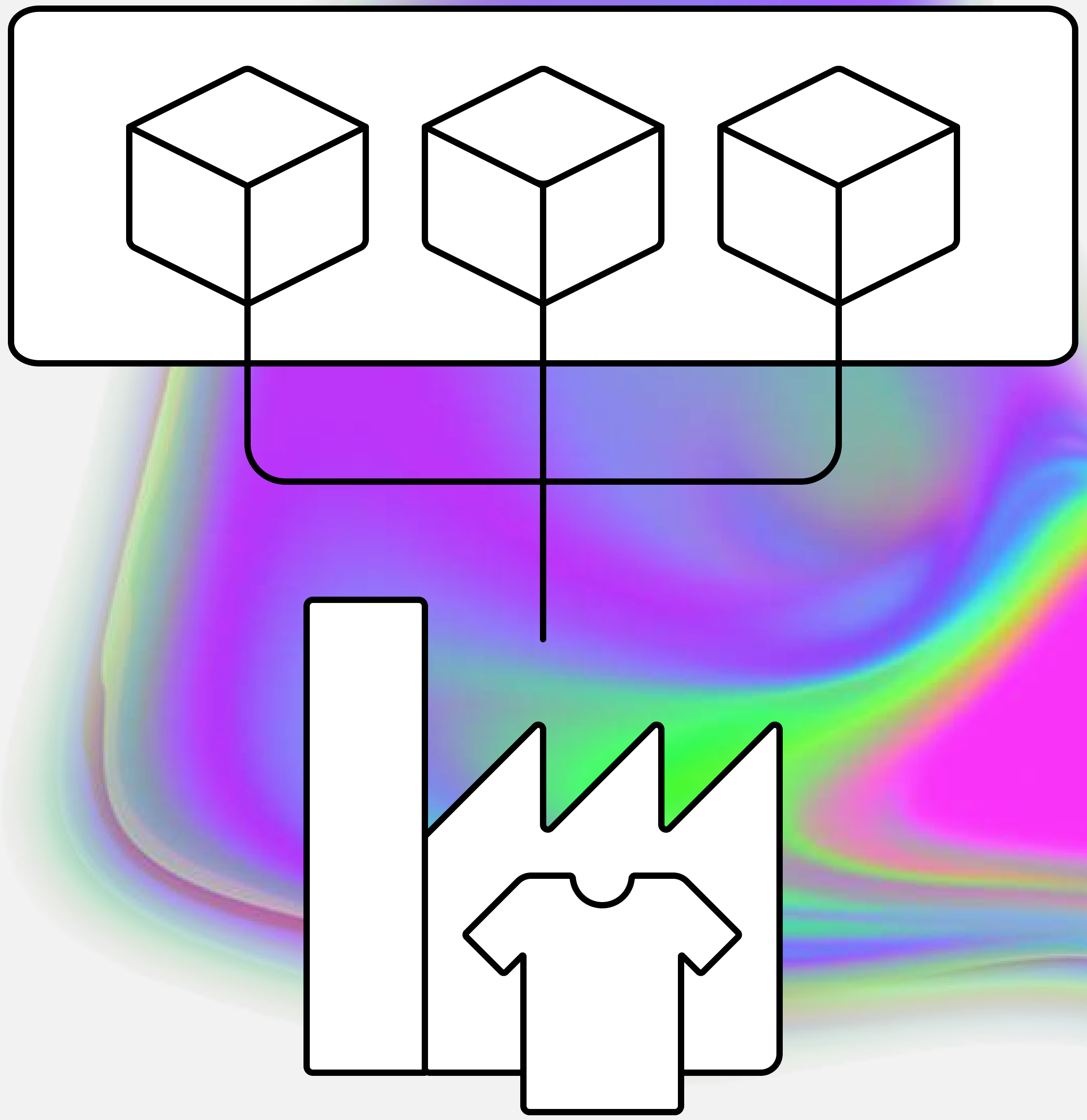
5 How to link Distribution Centre Hubs with manufacturing plants

Goal Mapped to different location parts through smart contracts. Identify the product origin as well as to develop informed reverse logistics.

Input
- Smart contract
- Unit-1 manufacturing garment

Demand
- Streamlined product exchange where data cannot be lost or altered
- In product sharing, the utilization fees should be automatically calculated and settled by smart contracts
- Blockchain and computing environment can be geographically dislocated from the facilities

Output
- Product route for distribution from plant to customer



Consolidation of data to various providers to one output of finished garments

Goal

Store avatar, garment, logistic data and all associated metadata and workflows with analytics for future purchase.

Input

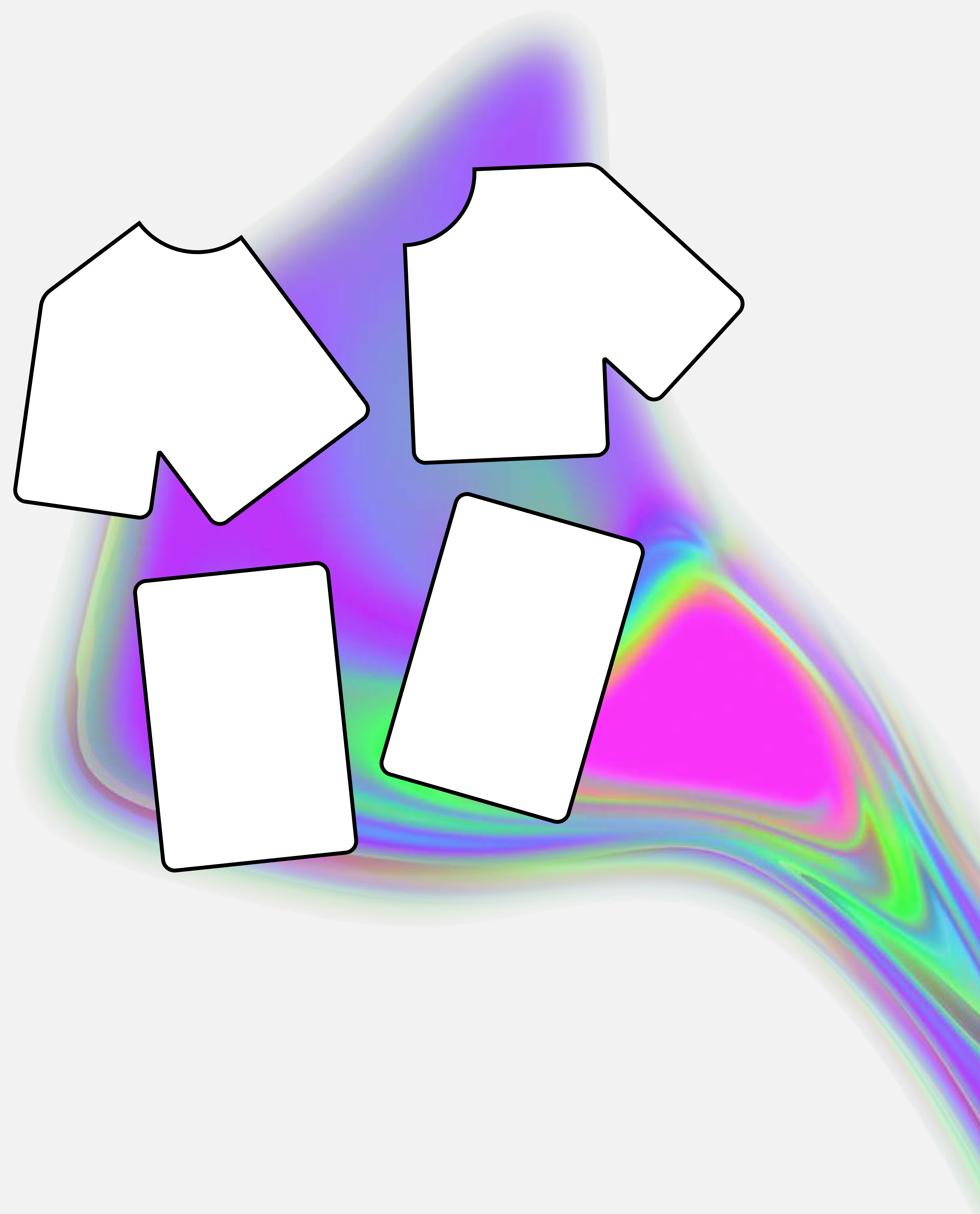
- 3D Avatar
- Garment tech pack
- PLM / ERP / BOM
- Smart tools instructions / QA feedback
- Metadata

Demand

- Collaboration among multiple manufactures to jointly establish and maintain a functioning manufacturing platform

Output

- A full product journey through different stages on unit-1 manufacturing



Summary

Gap analysis

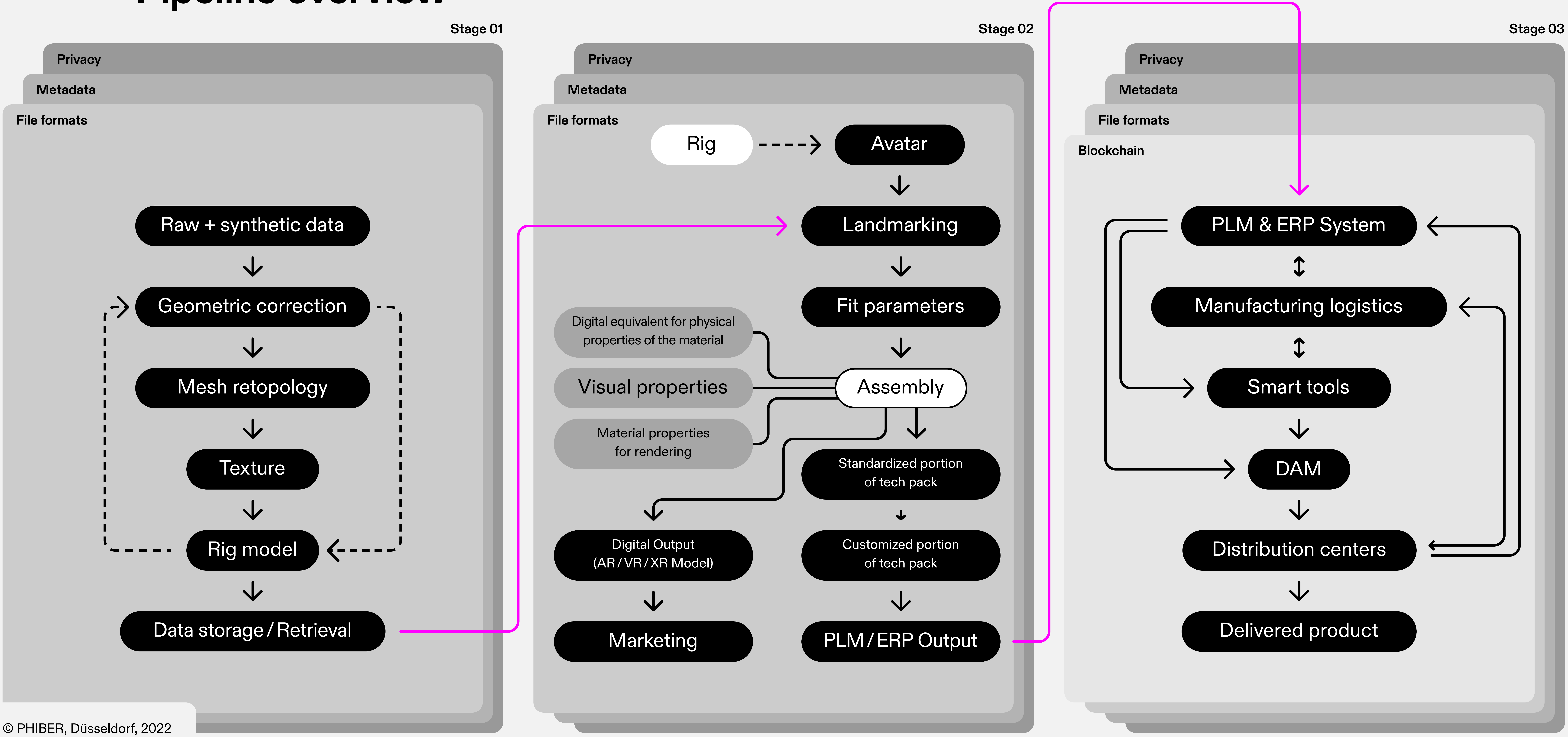
- How to design an appropriate chain structure for data management in PLM
- The sources and types of data collected in different stages vary significantly
- How to reach real-time data transmission and access in the scenario of high demand
- How to design suitable smart contracts for collaborative scenarios in PLM
- How to meet a balance between transparency and privacy among multiple stakeholders

Requirements

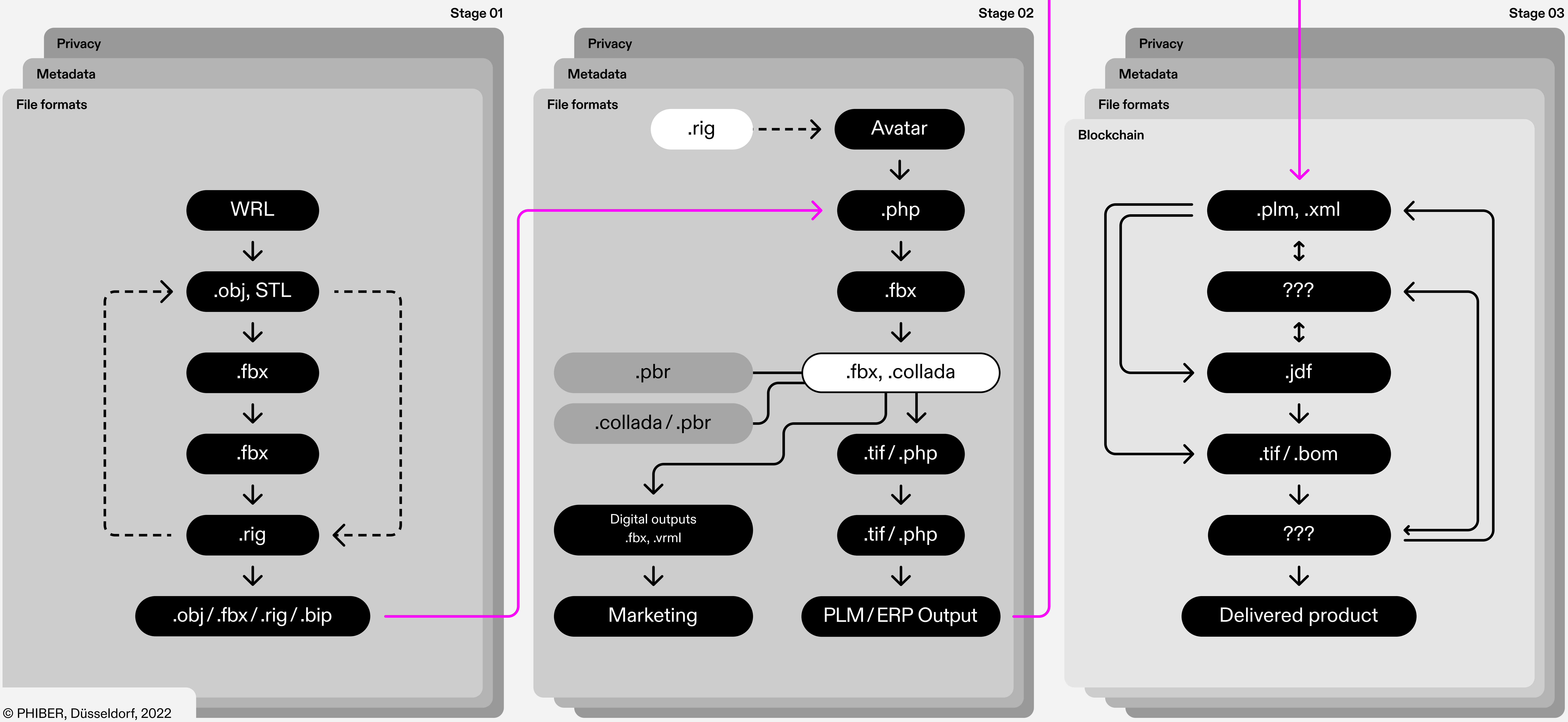
- Multi-source heterogeneous data supplied by blockchain nodes must be appropriately integrated to enable rapid searches
- Maintain the local manufacturing on-demand with the need of human capital investment and skills
- Security (when data should be open and transparent and when it should be maintained and guarded)
- Make sure no data leakage, especially when product is copyrighted or recycled and customer datais at risk
- Maintain bidirectional data flow

Planning for future

Pipeline overview



File format framework overview



Exercise

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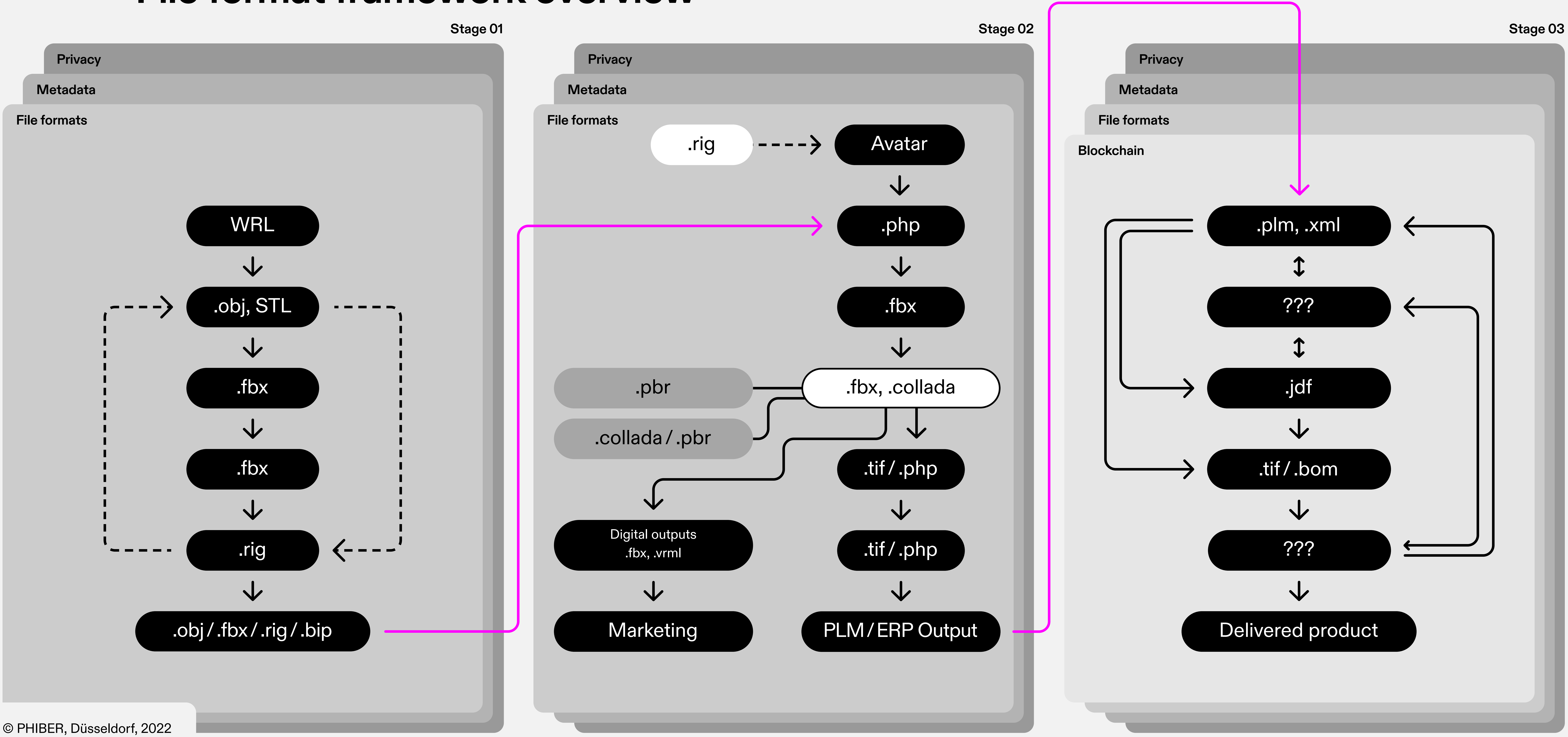
File format framework overview



Thank you!

Feel free to share your thoughts or contact us.

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