**🔹 Unified Digital Product Definition (DPD) Model**

This model follows a structured **five-layer approach**, ensuring smooth transition from product design to manufacturing and quality control.

**📌 1. 3D Model-Based Definition (MBD) Layer**

**Purpose:** Replace 2D drawings with detailed **3D CAD models** to serve as the primary source of product information

🔗 **Integration:** The generated **3D model** is stored in the **PLM layer** for team collaboration.

✅ **Tool:** **FreeCAD** or **Fusion 360 or Blender (Free Version)**

**📌 2. Product Lifecycle Management (PLM) Layer**

**Purpose:** Centralized **data management** to maintain product versions, documentation, and team collaboration.

🔗 **Integration:** The **PLM system** sends product data to the **Manufacturing Execution System (MES)** for production planning.

✅ **Tool:** **OpenPLM**

**📌 3. Manufacturing Execution System (MES) Layer**

**Purpose:** Connect **design and production** to ensure accurate and efficient manufacturing.

🔗 **Integration:** MES sends real-time data to the **Quality Control Layer** to monitor defects and compliance.

✅ **Tool:** **OpenMES**

**📌 4. Quality Control & Compliance Layer**

**Purpose:** Ensure manufactured products meet **industry standards** and reduce defects.

🔗 **Integration:** Sends **quality insights** back to the **PLM system** for design improvements.

✅ **Tool:** **qTest (Free Version)**

**📌 5. Digital Twin & Simulation Layer**

**Purpose:** Simulate **real-world product behavior** before physical manufacturing.

🔗 **Integration:** Feedback from simulations is sent to the **PLM system** for design optimizations

✅ **Tool:** **OpenModelica** or **SimScale (Free Community Plan)**

**🌟 How the Entire System Works Together (Unified Workflow)**

**Step 1: Design (3D MBD Layer)**  
✔ Engineers create **3D models** in **FreeCAD/Fusion 360**.  
✔ Store them in **PLM** for approval & collaboration.

**Step 2: PLM Management**  
✔ PLM (OpenPLM/Odoo) **manages product revisions**.  
✔ Once approved, **PLM sends models** to MES for production.

**Step 3: Manufacturing Execution (MES Layer)**  
✔ MES (OpenMES/ERPNext) **converts 3D models into production workflows**.  
✔ Tracks **real-time machine & labor data**.

**Step 4: Quality Control & Compliance**  
✔ Quality tools (qTest, Zeiss PiWeb) **inspect products based on 3D model specifications**.  
✔ Non-compliance issues **trigger corrections in PLM**.

**Step 5: Digital Twin Simulation**  
✔ OpenModelica/SimScale runs **real-world simulations** before manufacturing.  
✔ If simulations detect **weaknesses**, feedback is sent **to PLM** for improvements.