DATA SCIENCE IN MANUFACTURING

WEEK 5

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LECTURE: WEEK 5

Current Manufacturing Software / PLM / ERP /MES

BY THE END OF THIS LECTURE YOU SHOULD:

Have an understanding of the PLM process and its industrial uses

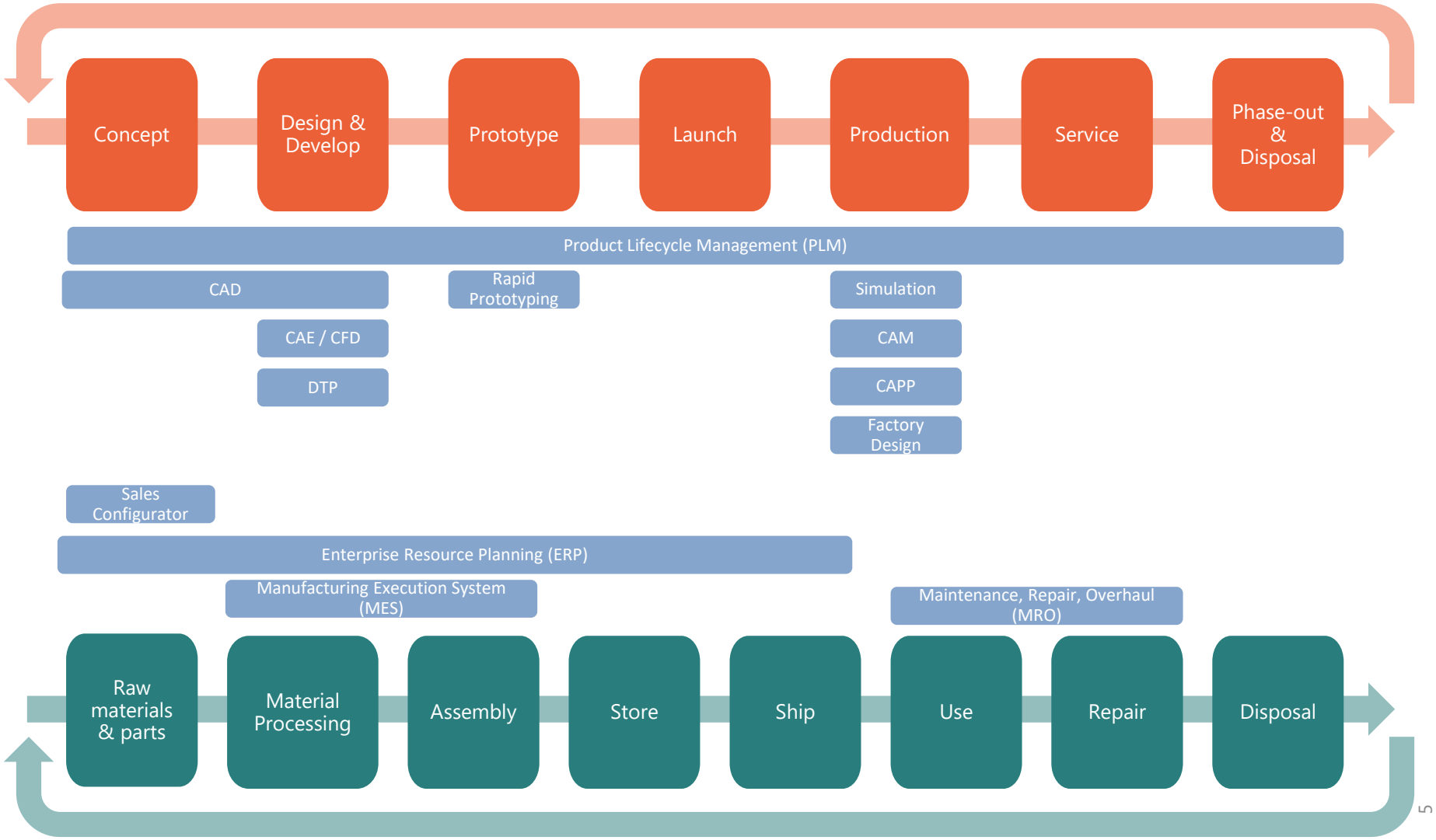
Be introduced to Enterprise Resource Planning and understand its industrial uses and relationship to PLM

Have an understanding of MES systems

Use of relational databases in PLM, ERP and MES

PLM/ERP/MES

Product-type lifecycle



Product lifecycle / Material Flow

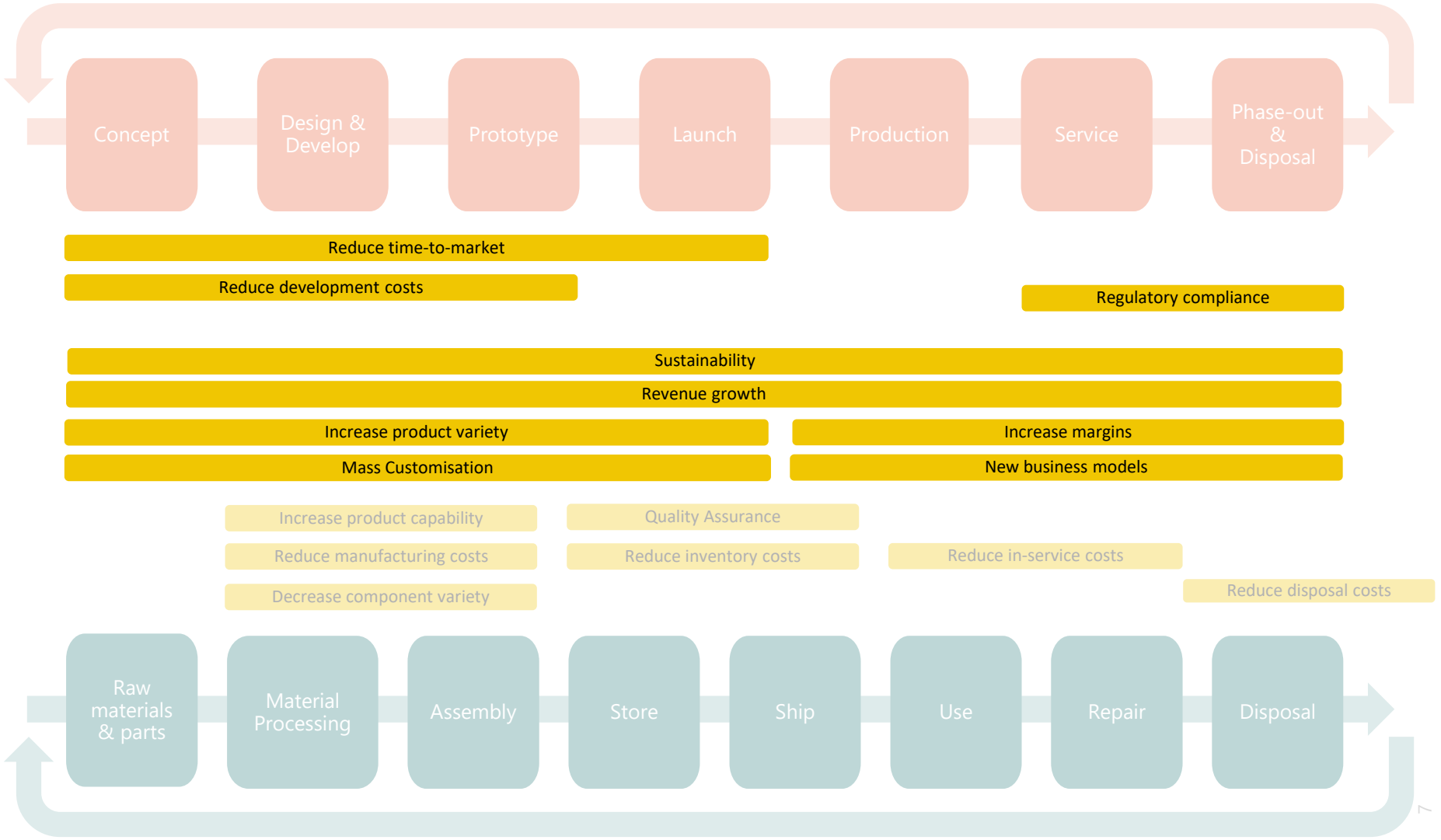
Suppliers

Customers

PLM OVERVIEW

- What is PLM?
- Why do companies use PLM?
- In which industrial sectors is PLM used?
- When did PLM emerge?
- What problems does PLM address?
- What are the strategic and operational benefits of PLM?

Product-type lifecycle



Product lifecycle / Material Flow

Suppliers

Customers

PLM OVERVIEW

Why do companies use/do PLM?

Future profitability relies on competitiveness.

Competitiveness relies on innovation.

Innovation can be delivered through product development.

But product development can take a long time and be costly.

PLM looks to manage the product development process (and subsequent steps in product lifecycle) to allow increased innovation, shorter product development cycles, quicker time-to-market and lower costs.

What is PLM?

From Wikipedia:

In industry, product lifecycle management (PLM) is the process of managing the entire lifecycle of a product from inception, through engineering design and manufacture, to service and disposal of manufactured products. PLM integrates people, data, processes and business systems and provides a product information backbone for companies and their extended enterprise.

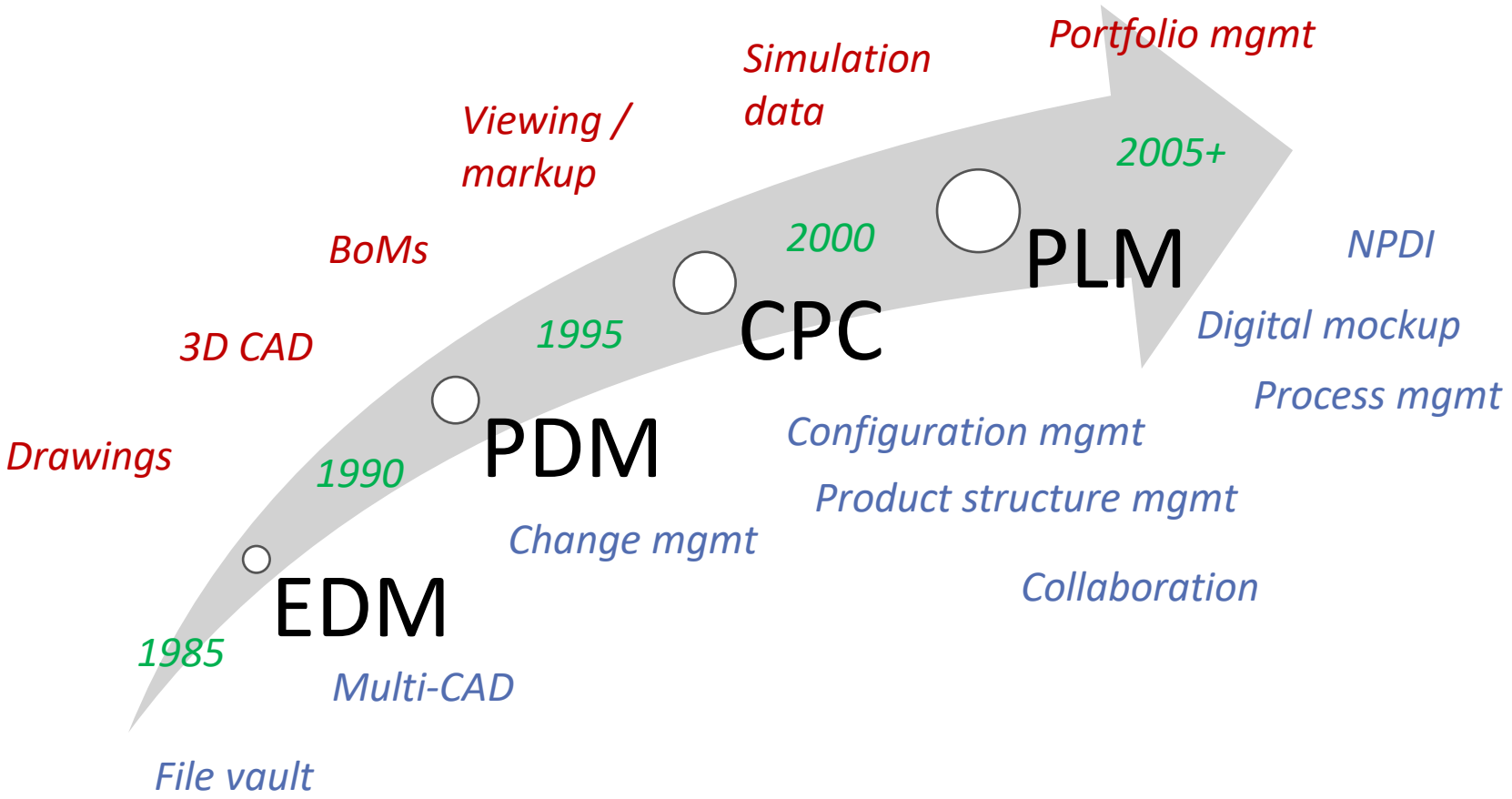
PLM OVERVIEW

In which industrial sectors is PLM used?

Aerospace & Defence, Automotive, Consumer Goods, Energy, Food & Beverage, Healthcare, High Tech Electronics, Industrial, Medical Devices, Pharmaceutical, …

PLM OVERVIEW

When did PLM emerge?



PLM OVERVIEW

What are the strategic and operational benefits of PLM?

Operational Benefits:

- **Internal**

  Improvements to internal process efficiency

- **Supplier-facing**

  Supplier cost reductions

- **Customer-facing**

  Reduce cost of serving customers, better service etc.

PLM OVERVIEW

- What are the strategic and operational benefits of PLM?

Operational Benefits

Internal

Research done by AMR/Gartner:

ECO = Engineering Change Order

TTM = Time to market

NPD = New product development

- ECO cycle time reduced by 50%; ECO admin expense reduced by 60% (Personal Computers)
- Cut box assembly from 3 hours to 2 hours 15 minutes; ECO cycle time improved 40% (Storage)
- TTM improved 40% (Farm Equipment)
- Company spends 12%-14% of sales on product development. Improvement in NPD cycle time 20%; quality improvement of 40%. Key is increasing overall NPD capacity of the organization (Medical Devices)
- 110 hours manual, 80 hours in AutoCAD 2d, 50 hours in Catia 1990, 1-2 hours today—90+% improvement (Engineered Systems)
- Reduced design errors and rework by 25% (Transport Temperature Control)
- TTM reduced by 5%; design errors and development costs reduced by 5% (Semiconductors)
- Reduced TTM from 48 months to 18 months between 1997 and 2002; engineering productivity increased 10% per year 1997-2002; 35% reduction in Global Product Development budget (Automotive)
- 7%-14% improvement in engineering non-value added time, reduction in ECO cycle time by 10% (Defense Programs)
- 90% faster FDA document generation cycle time (Medical Devices)
- Design cycle time reduced 25% (Weapons Systems)
- Overall engineering administrative activity 80% improvement (ECO, search, vault, etc) (Storage)
- ECO cycle time reduced from 33 days to 5 days (Electronics)

PLM OVERVIEW

- What are the strategic and operational benefits of PLM?

  Operational Benefits

  - Supplier-facing

Research done by AMR/Gartner:

- Reuse improved from less than 2% to 59%. Total savings: $500M over 3 years on direct materials (Computers)
- Internal supply chain organization found 2% savings on direct materials purchase; $640M in materials acquisition savings potential across all groups (Industrial Products)
- 10%-20% reduction in costs for packaging; reduction of 5%-10% on direct materials spend (Consumer Goods)
- Target savings $3.9M in 2002; $8.5M in 2003 (Seatbelts for Auto)
- By allowing suppliers access to its CAD files they have reduced the lead time in developing tooling by 80% (Semiconductor Equipment)
- Material cost reductions approximately 2%-3% (Electronic Manufacturing Services)
- 2% reduction in direct materials costs (Defense Programs)
- 50% increase in component reuse, resulting in 5%-15% decrease in prices for standard parts (Aircraft)

PLM OVERVIEW

- What are the strategic and operational benefits of PLM?

  Operational Benefits

  - Customer-facing

RFQ = Request for Quote

Research done by AMR/Gartner:

- Order to manufacture cycle time reduced from 4 weeks to one day; errors essentially eliminated (Wireless Transmissions)
- "Significant" savings on allowances for warranty and returns (Farm Equipment)
- Order errors reduced by 50% (Elevators)
- RFQ response time reduction from 2 weeks to 24 hours (Electronic Manufacturing Services)
- 30% reduction in cycle time for complex customer order taking, pulling in live CAD models, cost models, thermal models all linked (Custom Electrical Switch Gear)
- Reduced order lead time by 50% (from 8-12 weeks to 4 weeks) using what if scenarios on screen and direct feedback from distributor customers (Custom Aftermarket Wheels)
- Order volume increase 40%; order errors decrease 75% (Semiconductor)
- Eliminated almost 100% of customer order errors; cut down purchasing order cycle time by 30 minutes per transaction; 100% elimination of sending out of date product records to customers (Electromechanical Machinery)
- Reduced order errors by 60%-90% and reduced design spec time by 35%-90% (Furniture)
- 50%-70% reduction in project (order to quote) cycle time Specialty Chemicals (non-asset) (Project Management)
- 50% customer RFQ to prototype cycle time reduction (Bearings and Motion Control)
- Customer RFQ cycle time reduced by 75% (Electronic Manufacturing Services

PLM OVERVIEW

What are the strategic and operational benefits of PLM?

Strategic Benefits

Can PLM be used to enable a change in overall strategy of business?

SCOPE OF PLM

What is Product Data?

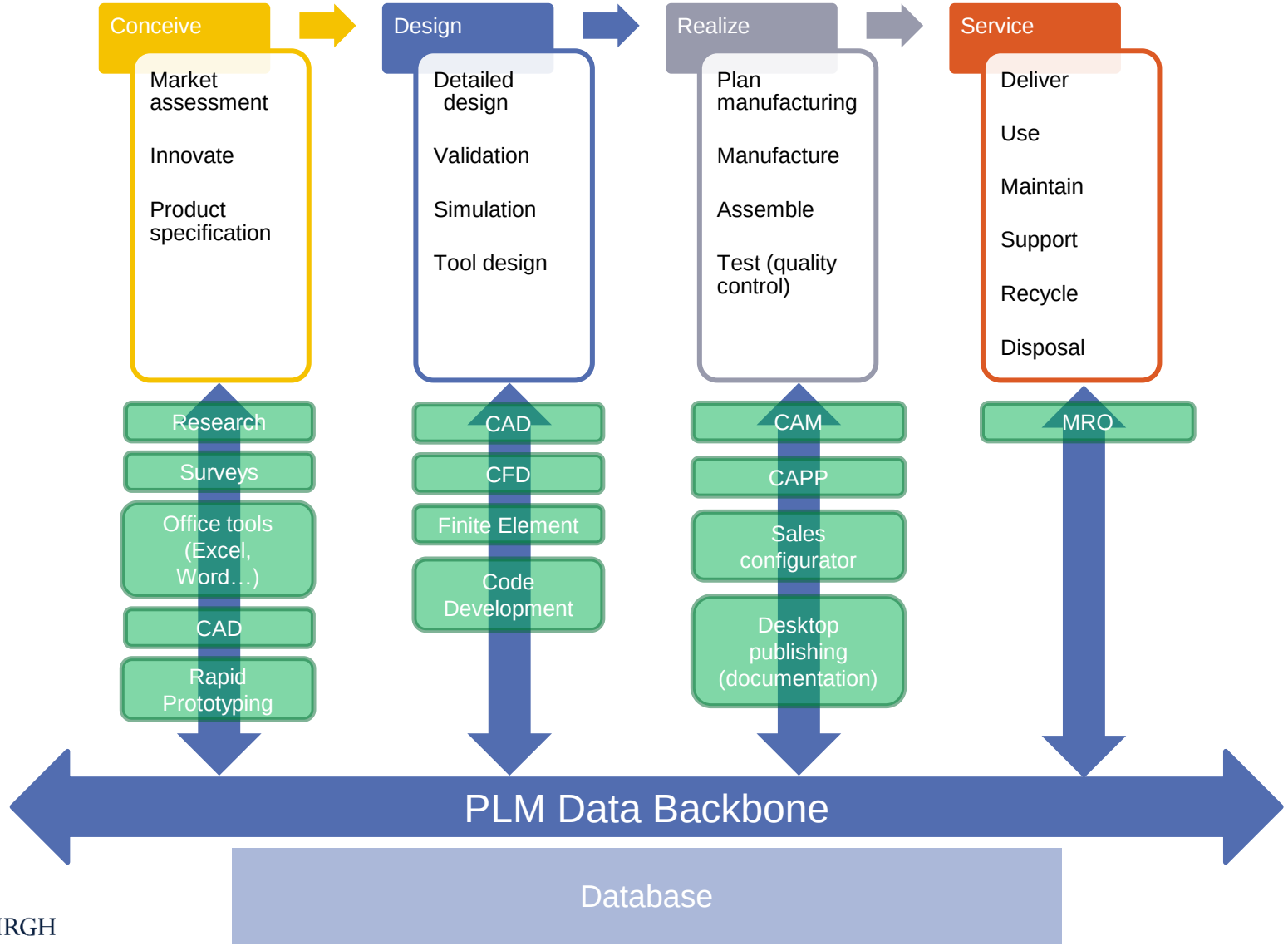
- How is it managed in PLM?

What are business processes?

- How does PLM support business processes?

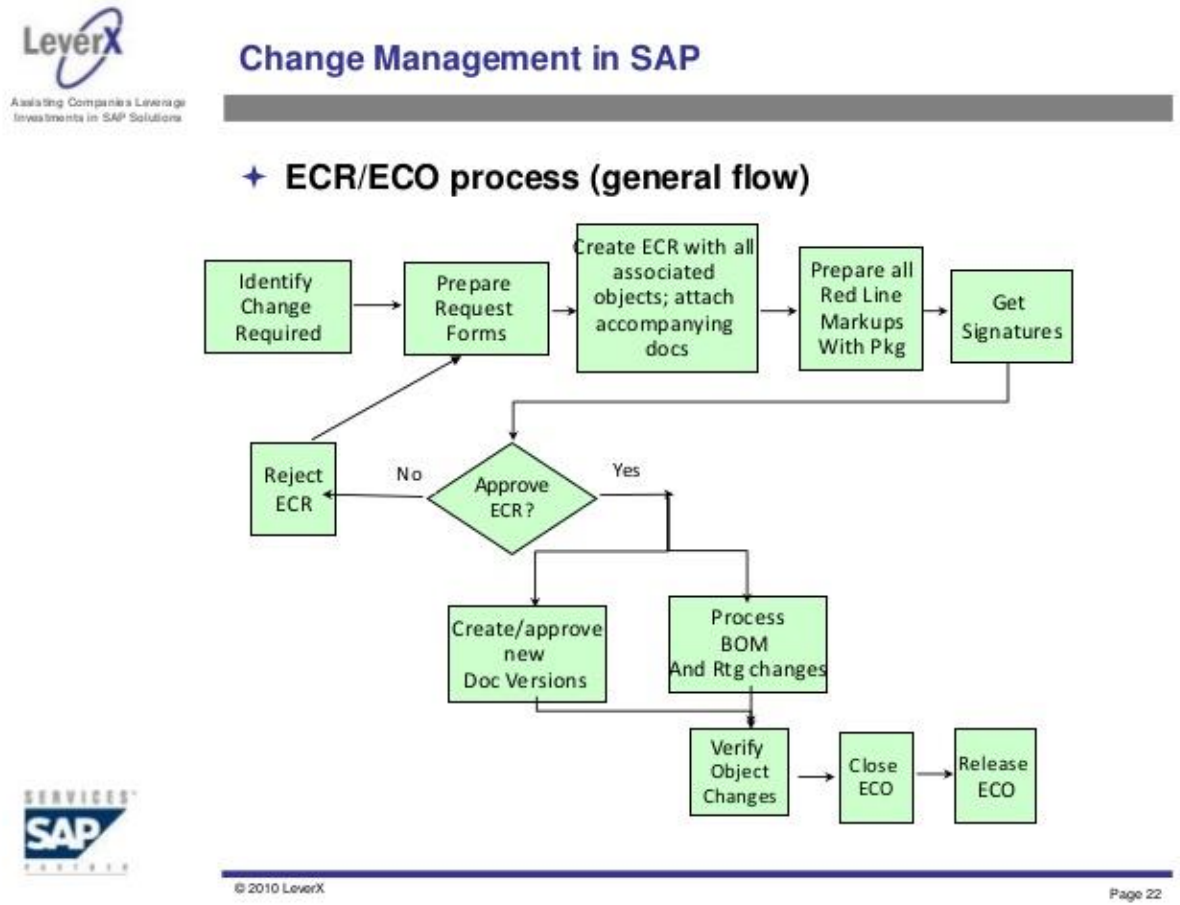
SCOPE OF PLM

What is Product Data?



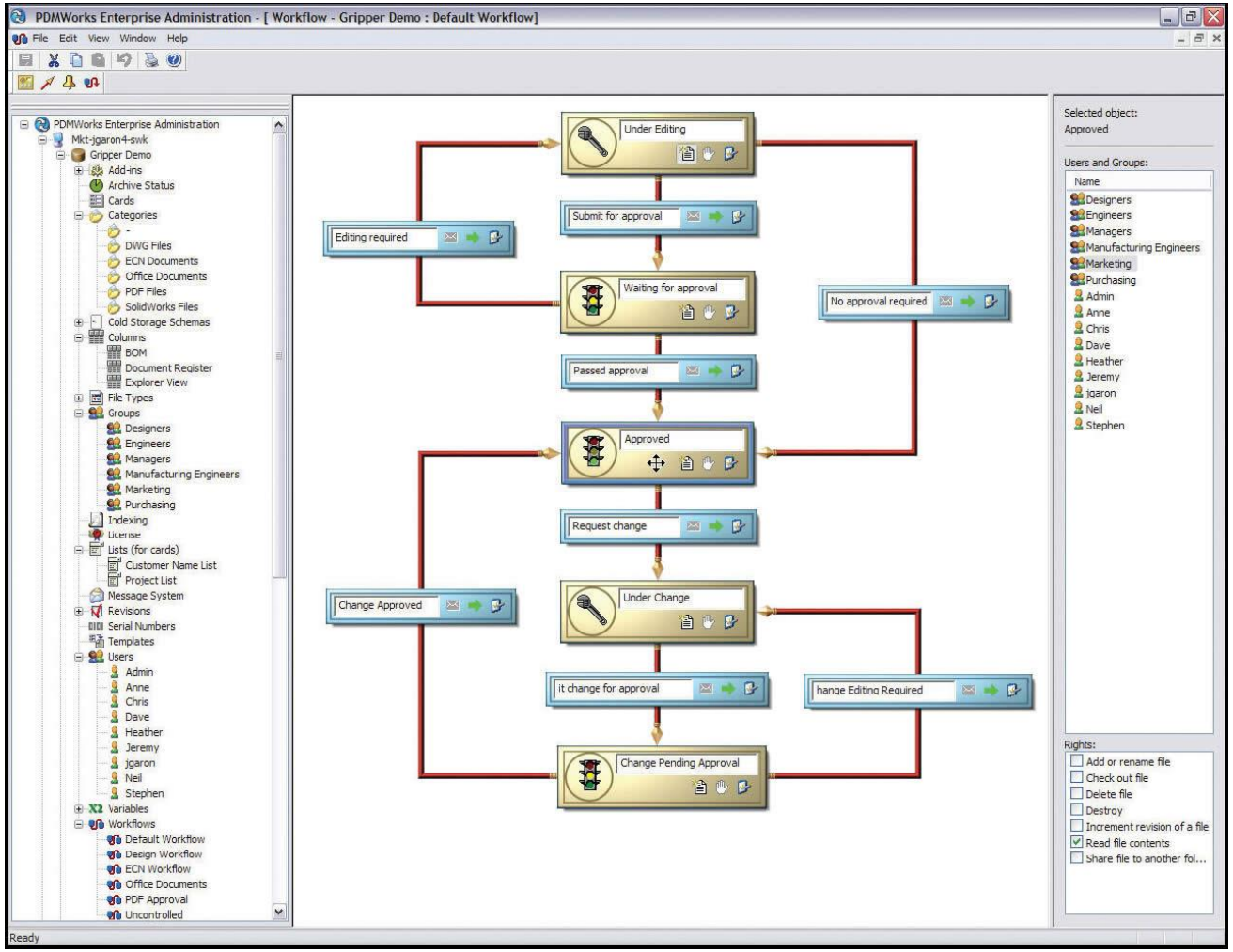
SCOPE OF PLM

What are business processes?

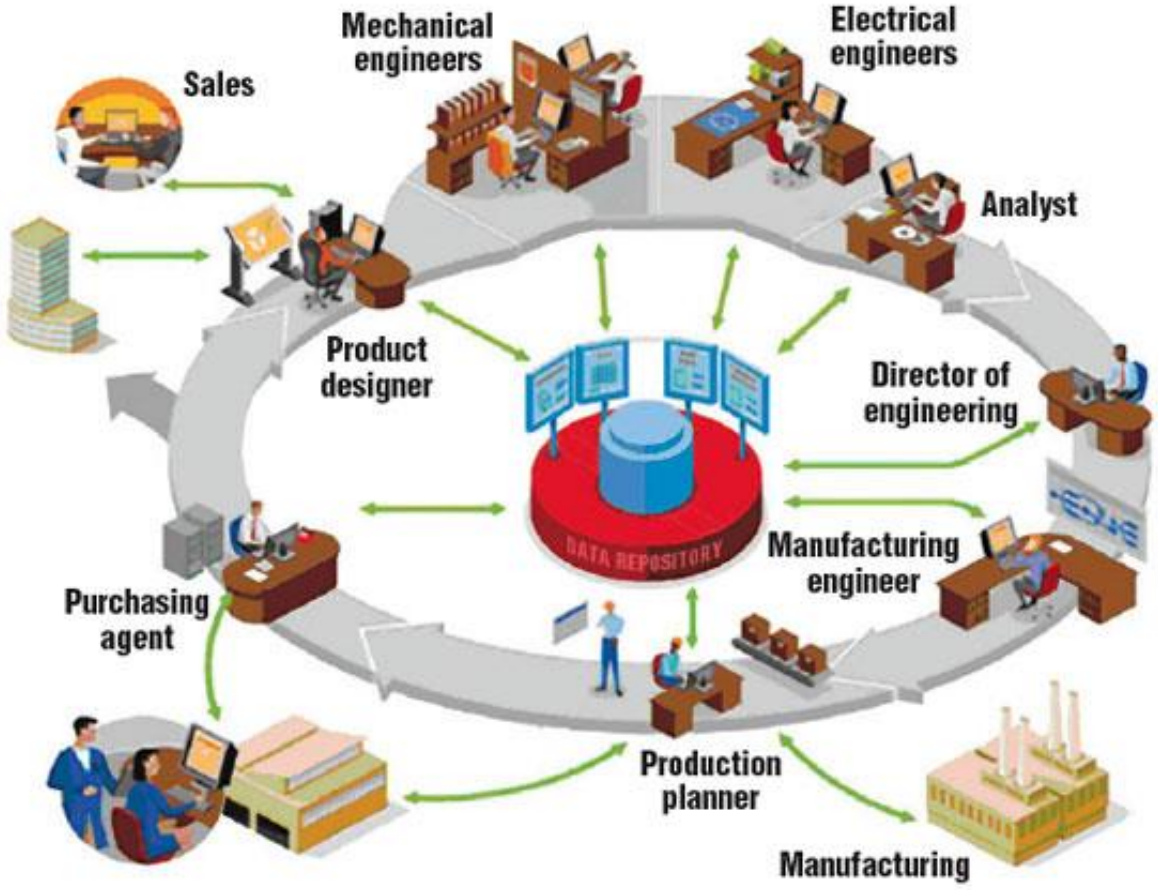


SCOPE OF PLM

What are business processes?



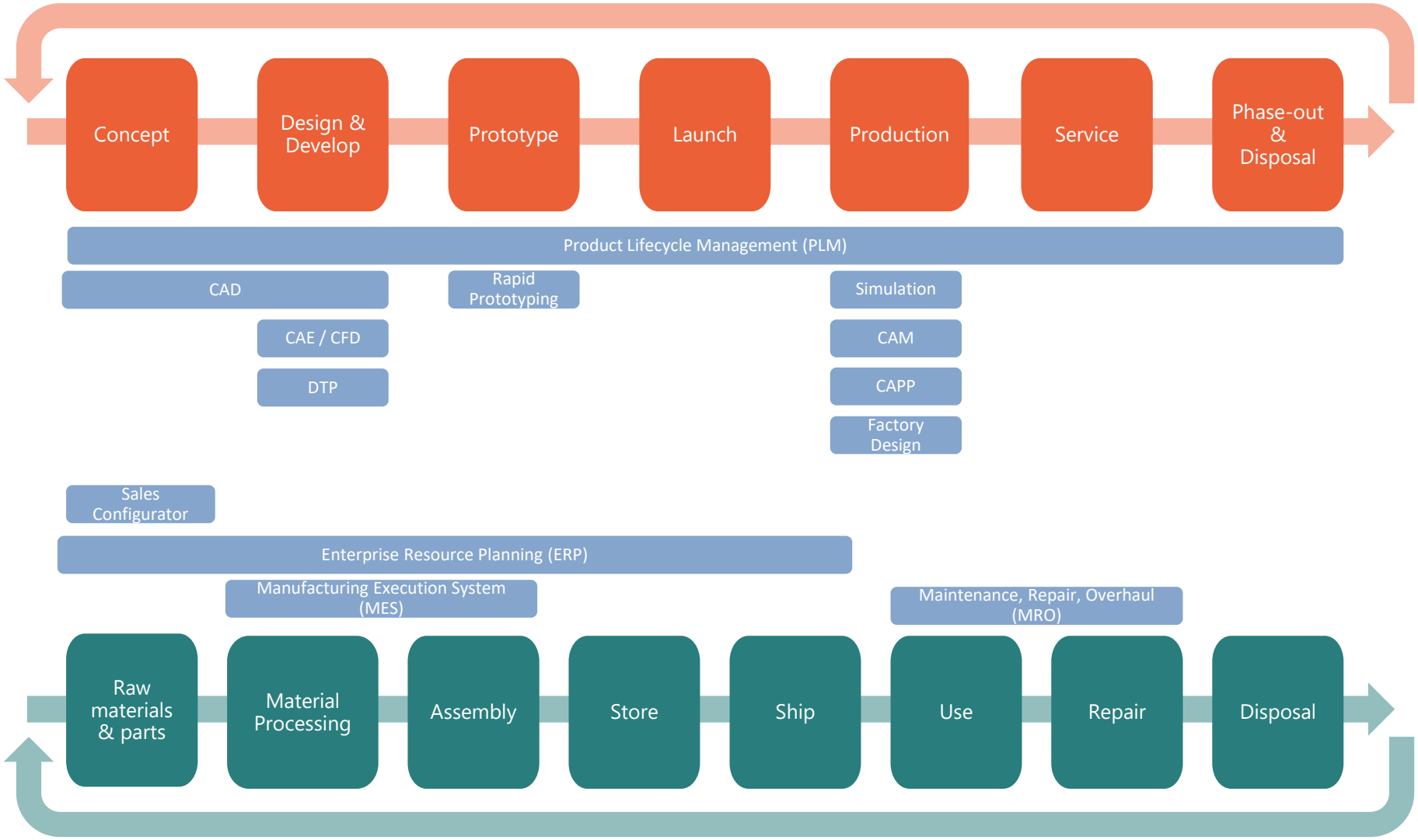
PLM APPLICATIONS & TECHNOLOGIES



ERP

- What is Enterprise Resource Planning
- What is its relationship with engineering, design and PLM
- Understand the industrial uses of ERP

Product-type lifecycle

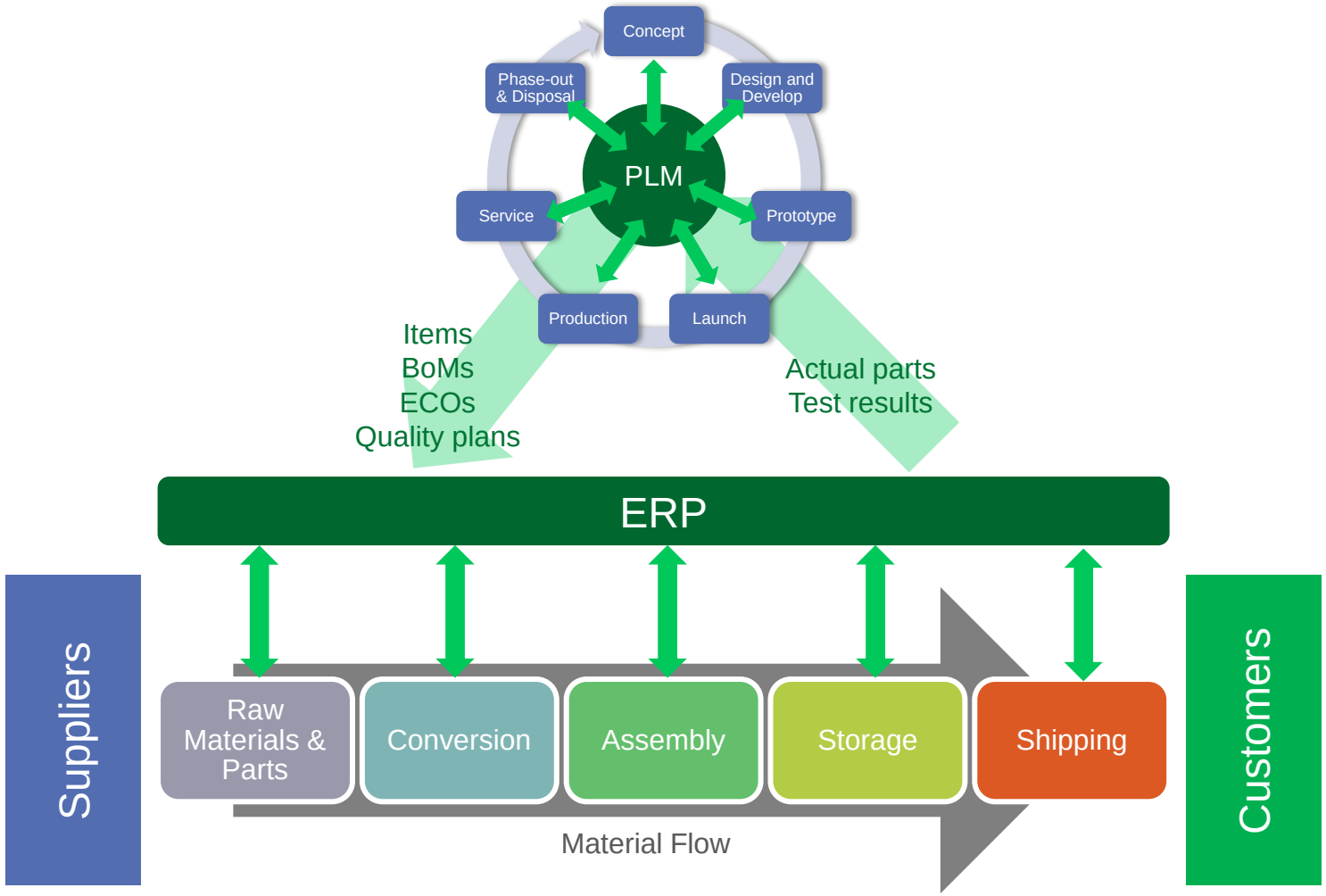


Product lifecycle / Material Flow

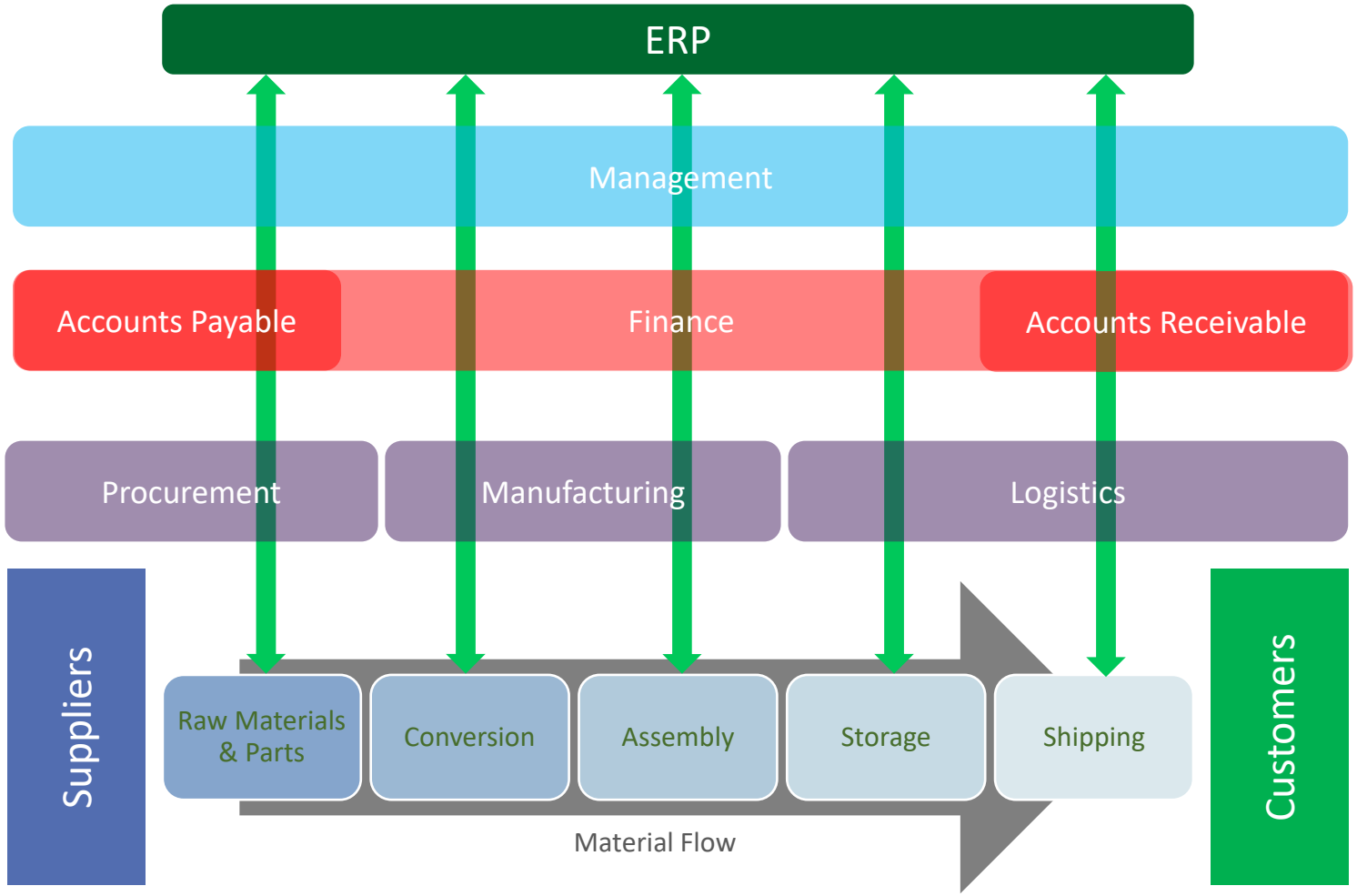
Suppliers

Customers

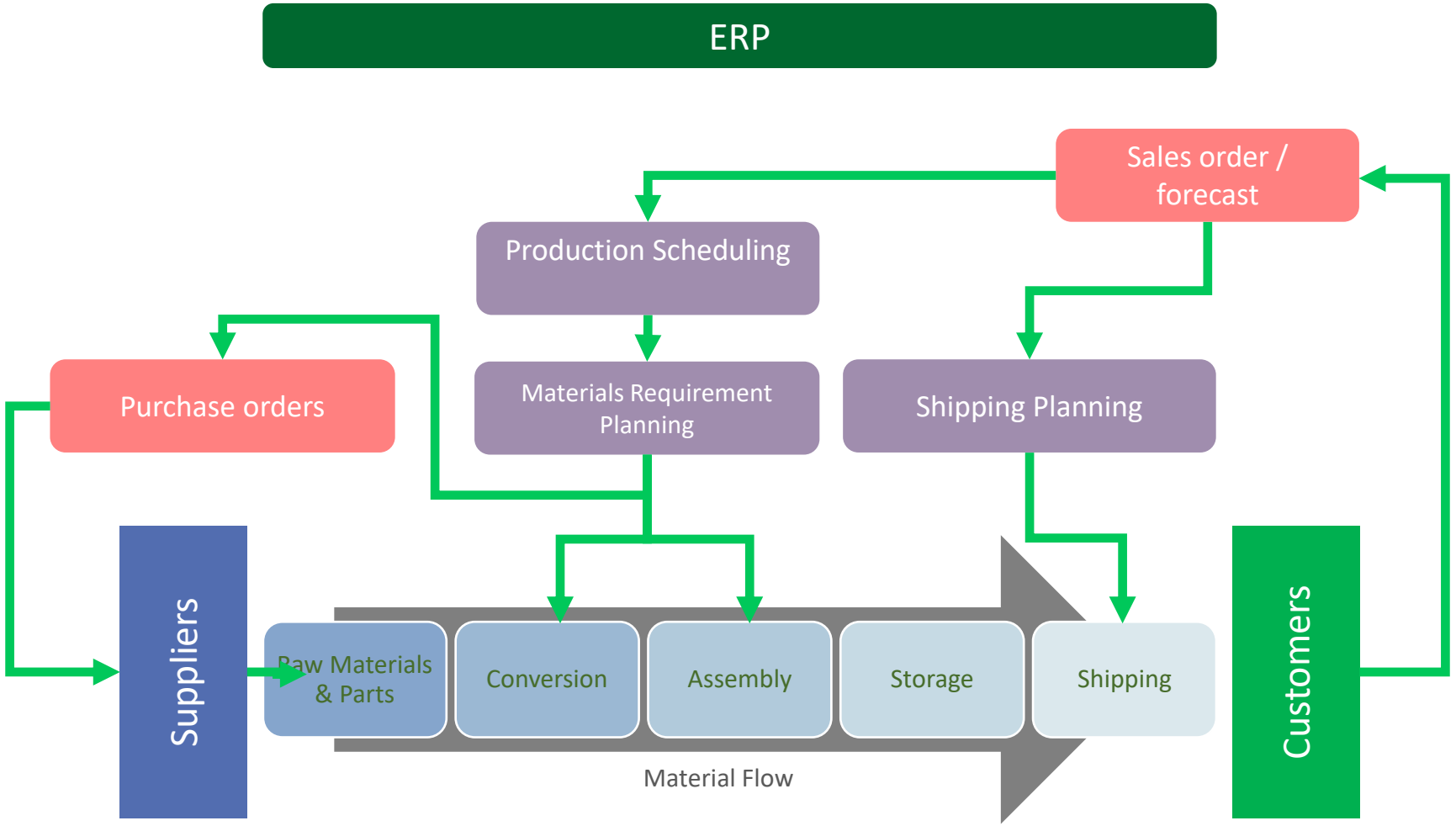
ENTERPRISE RESOURCE PLANNING



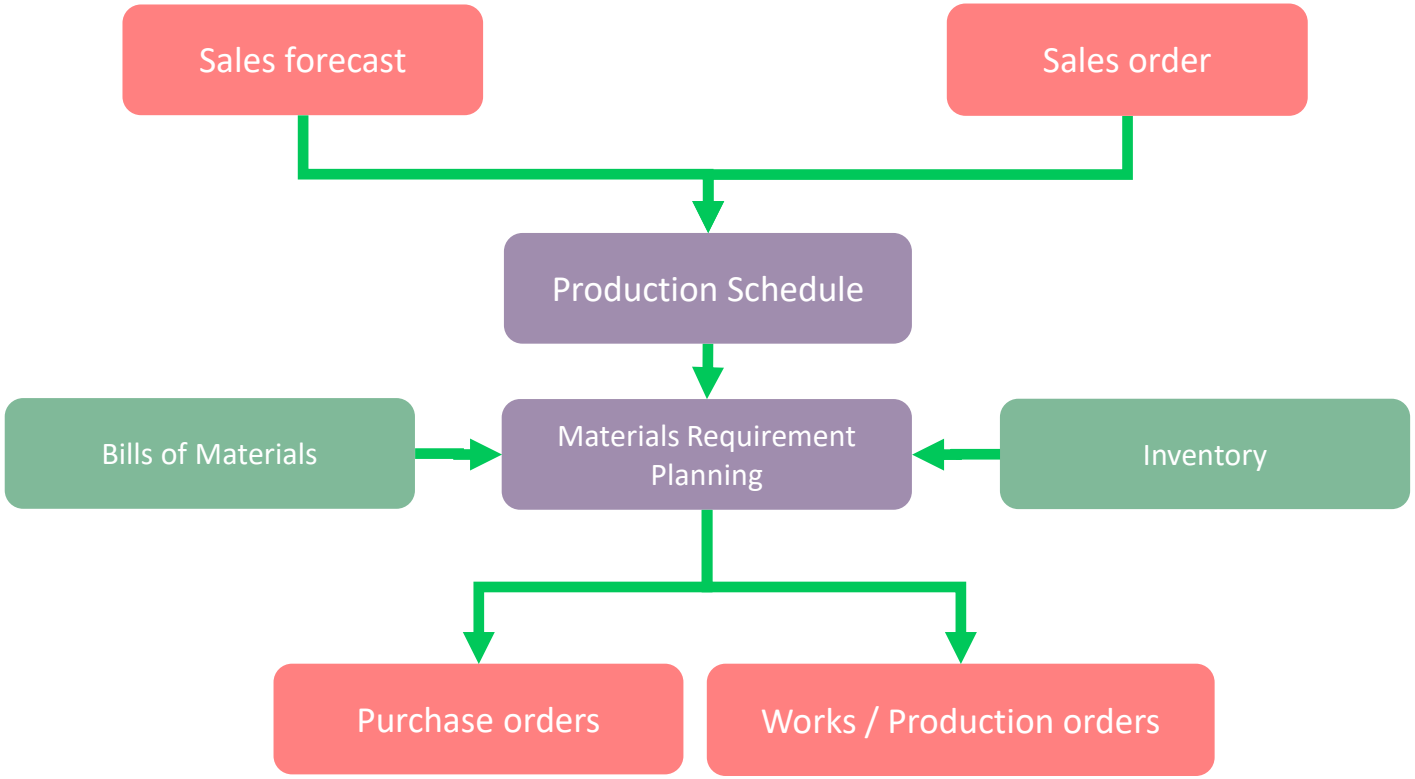
ERP


ERP
Management
Accounts Payable
Finance
Accounts Receivable
Procurement
Manufacturing
Logistics
Suppliers
Raw Materials & Parts
Conversion
Assembly
Storage
Shipping
Customers
Material Flow

ERP – A TRANSACTION



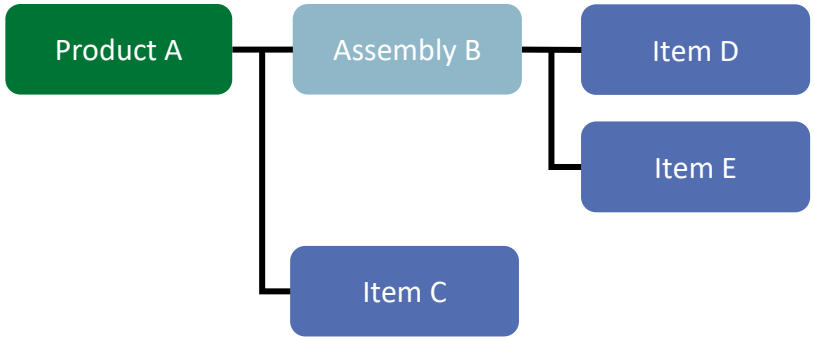
MATERIALS REQUIREMENT PLANNING



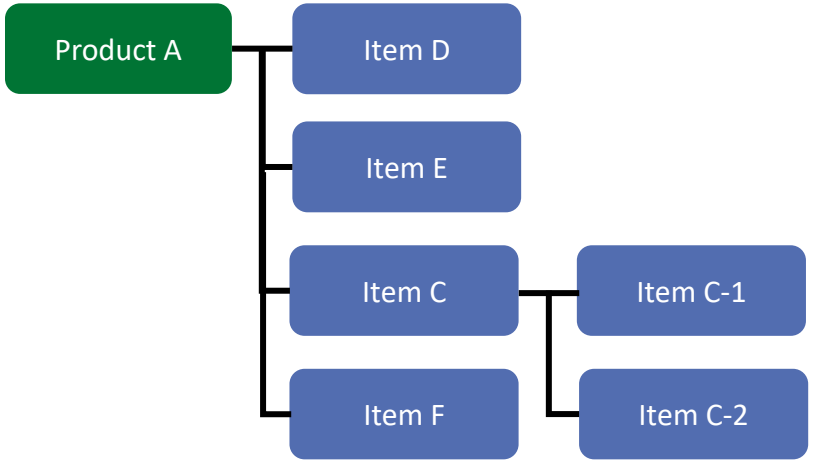
Material Flow

EBOM VS MBOM

Engineering BoM



Manufacturing BoM

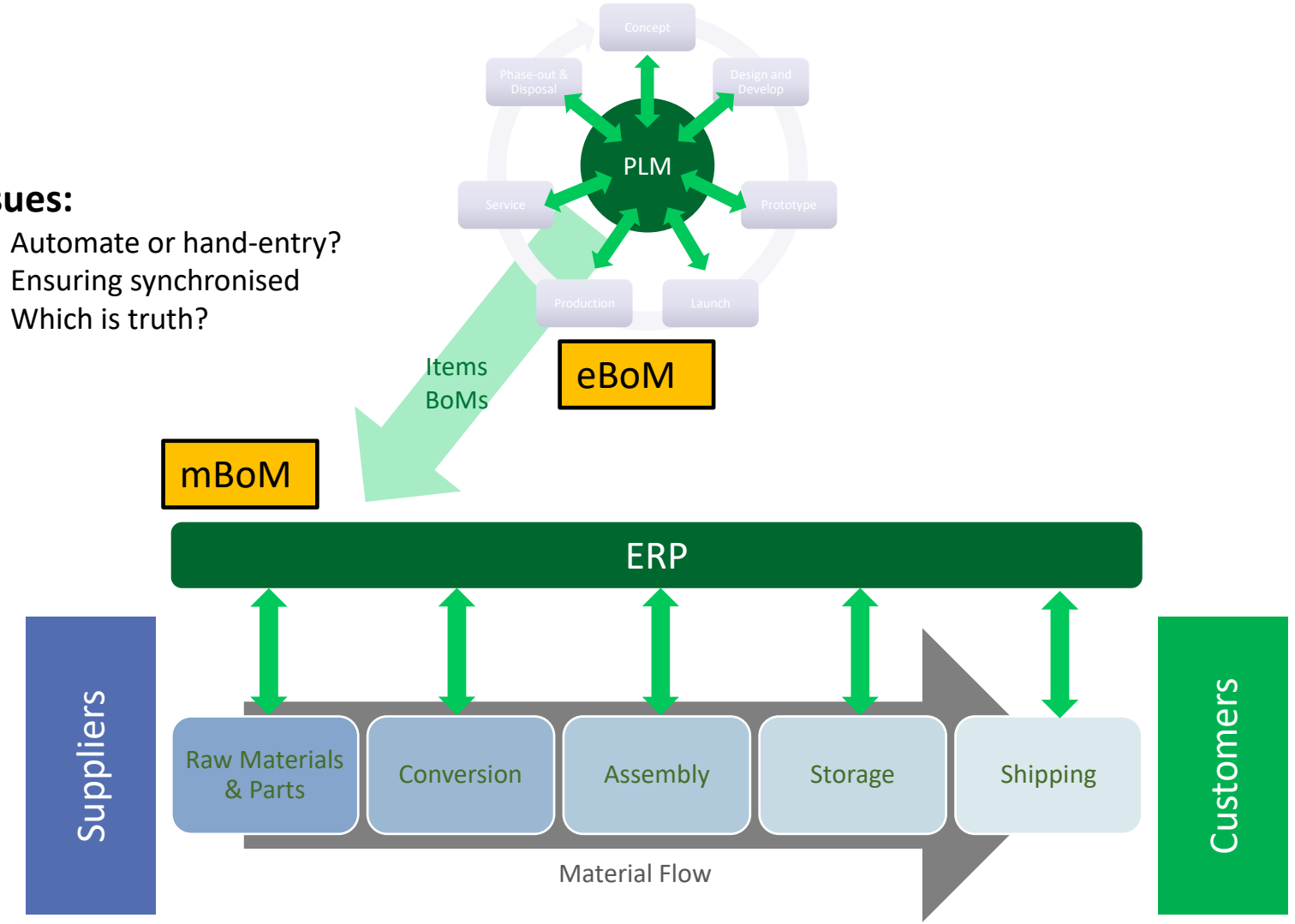


- Flatten structure?
- Item made from multiple intermediate parts?
  (think of plug pin…)
- Additional items (glue, paint, oil etc.)

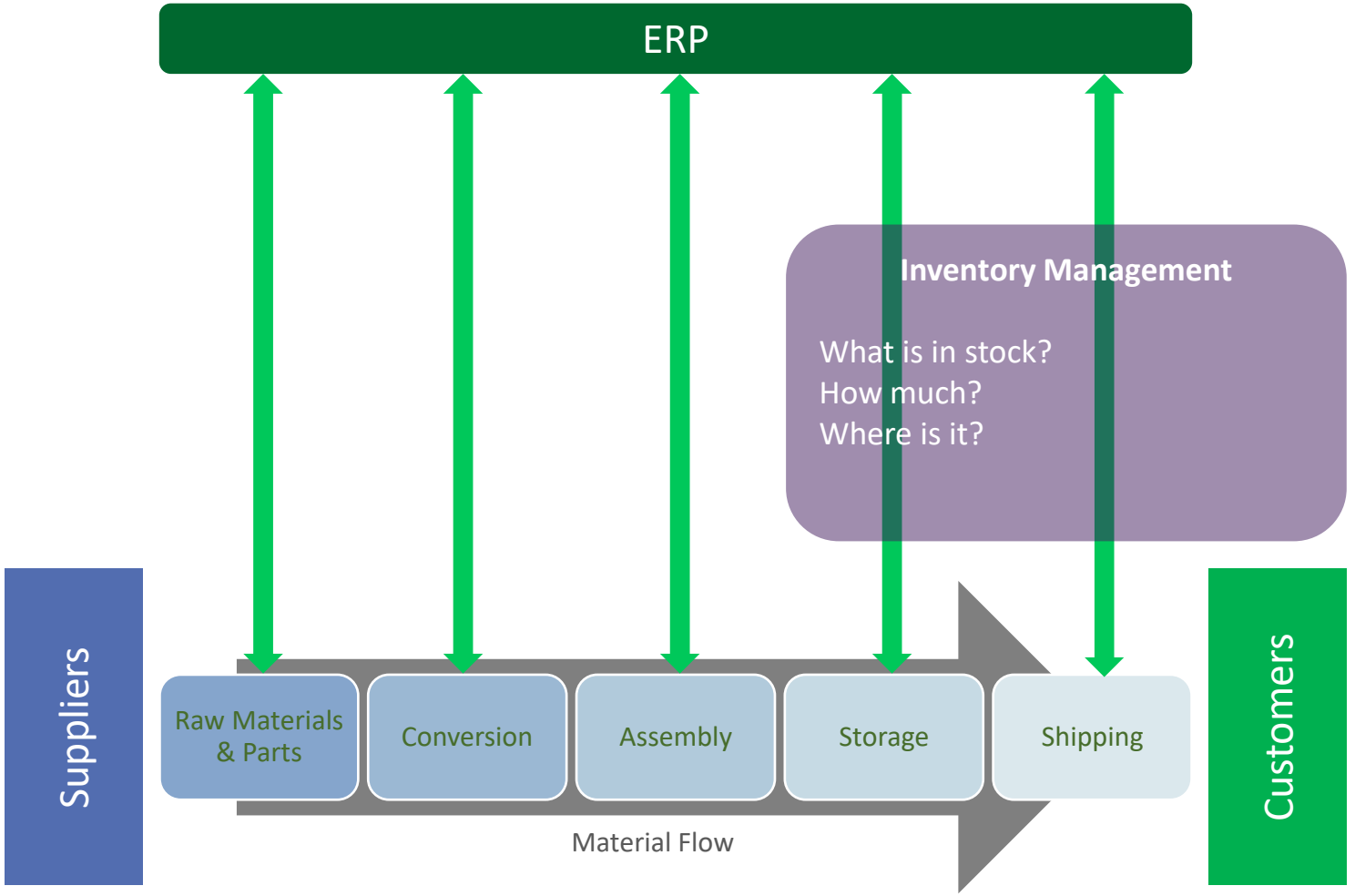
PLM & ERP: BOMS

Issues:

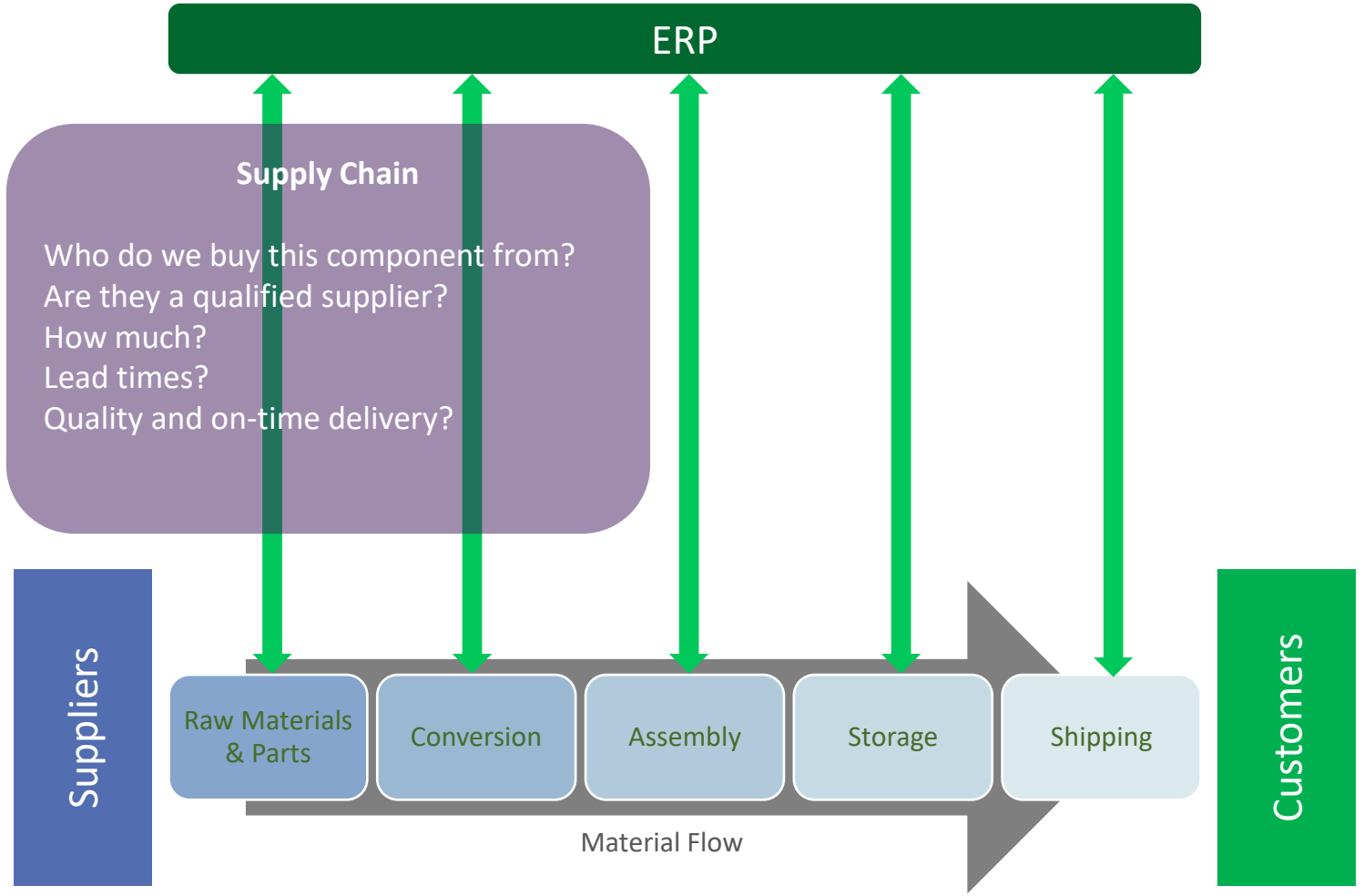
- Automate or hand-entry?
- Ensuring synchronised
- Which is truth?



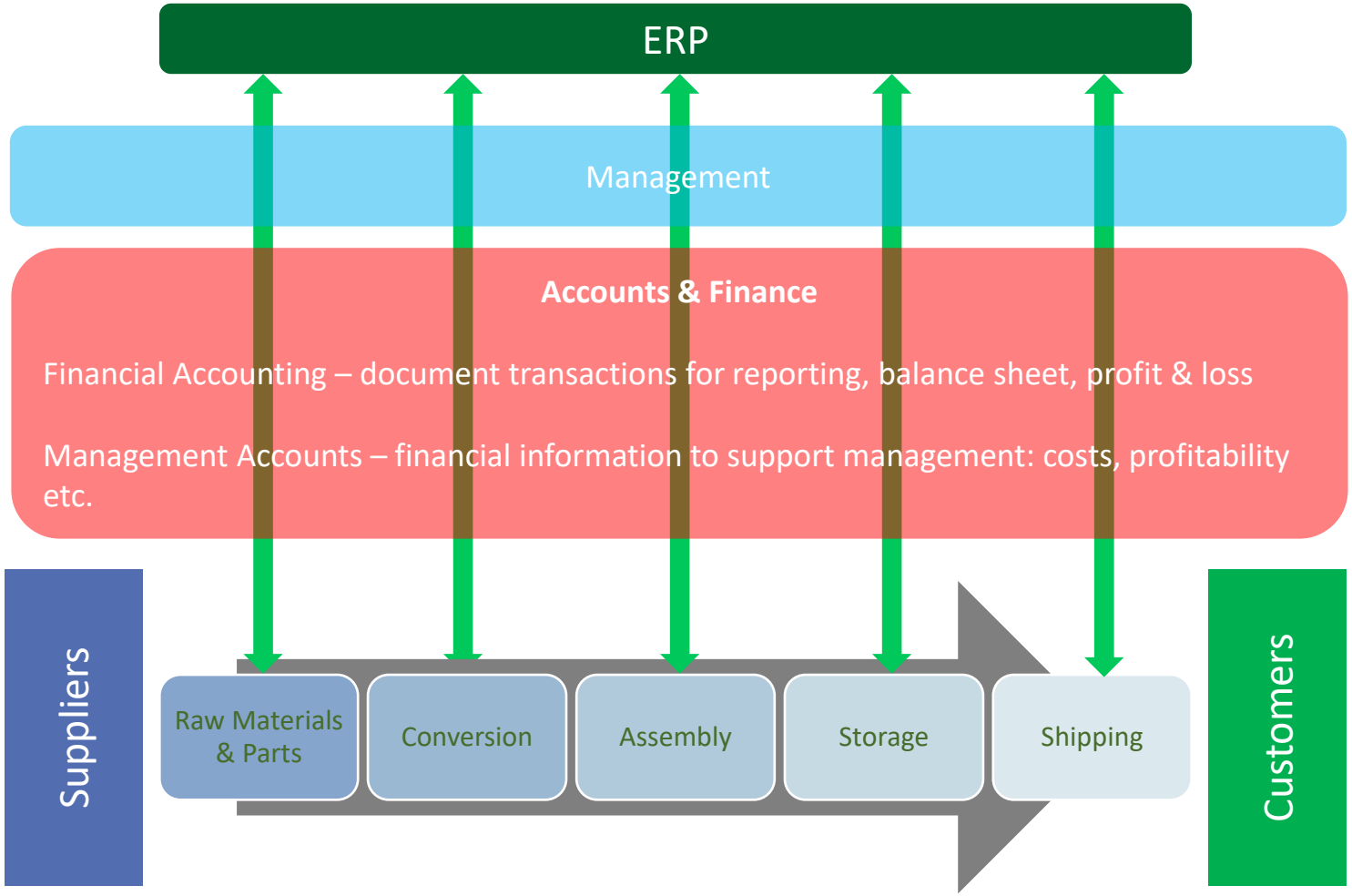
ERP - INVENTORY



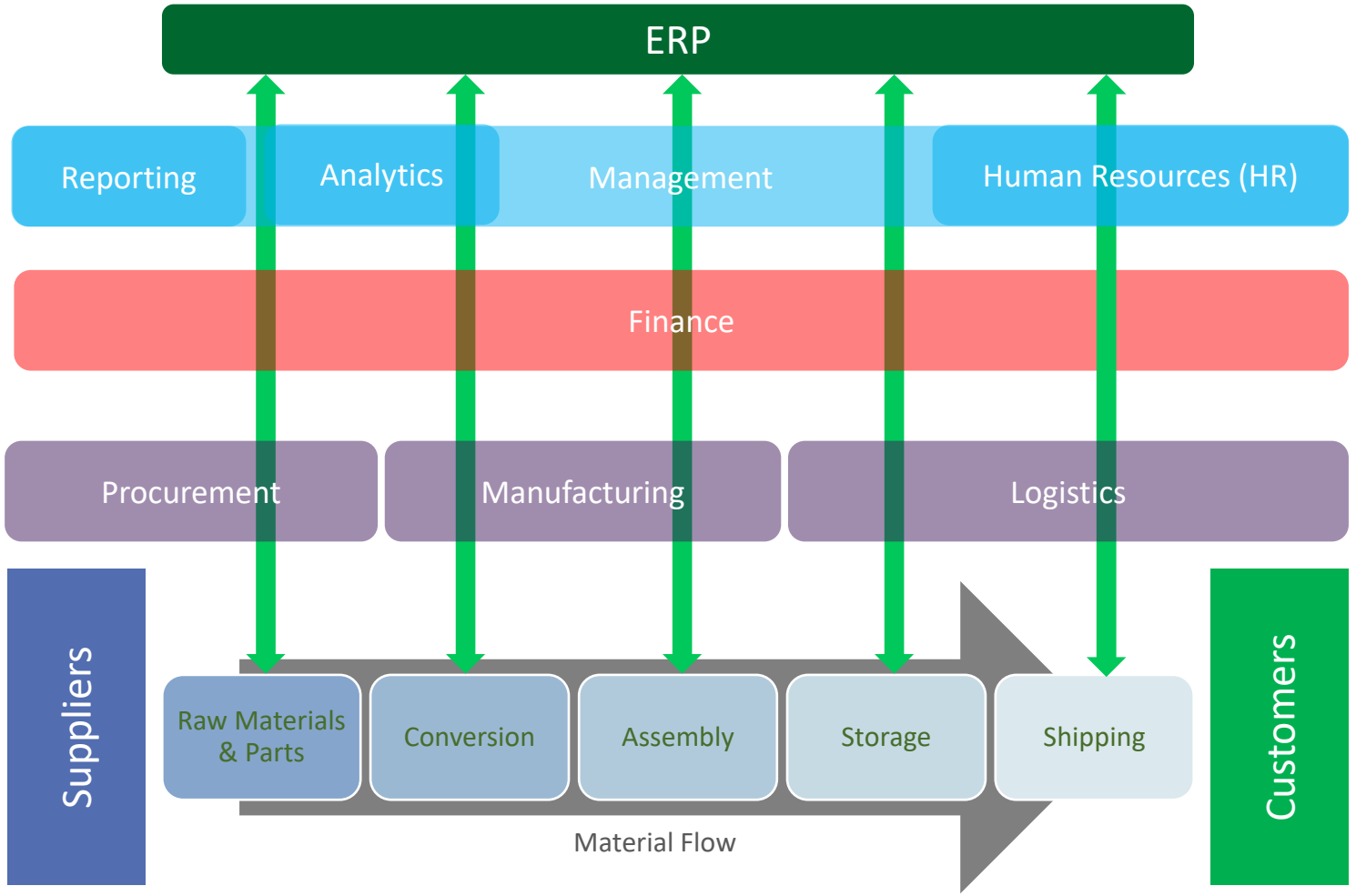
ERP – SUPPLY CHAIN



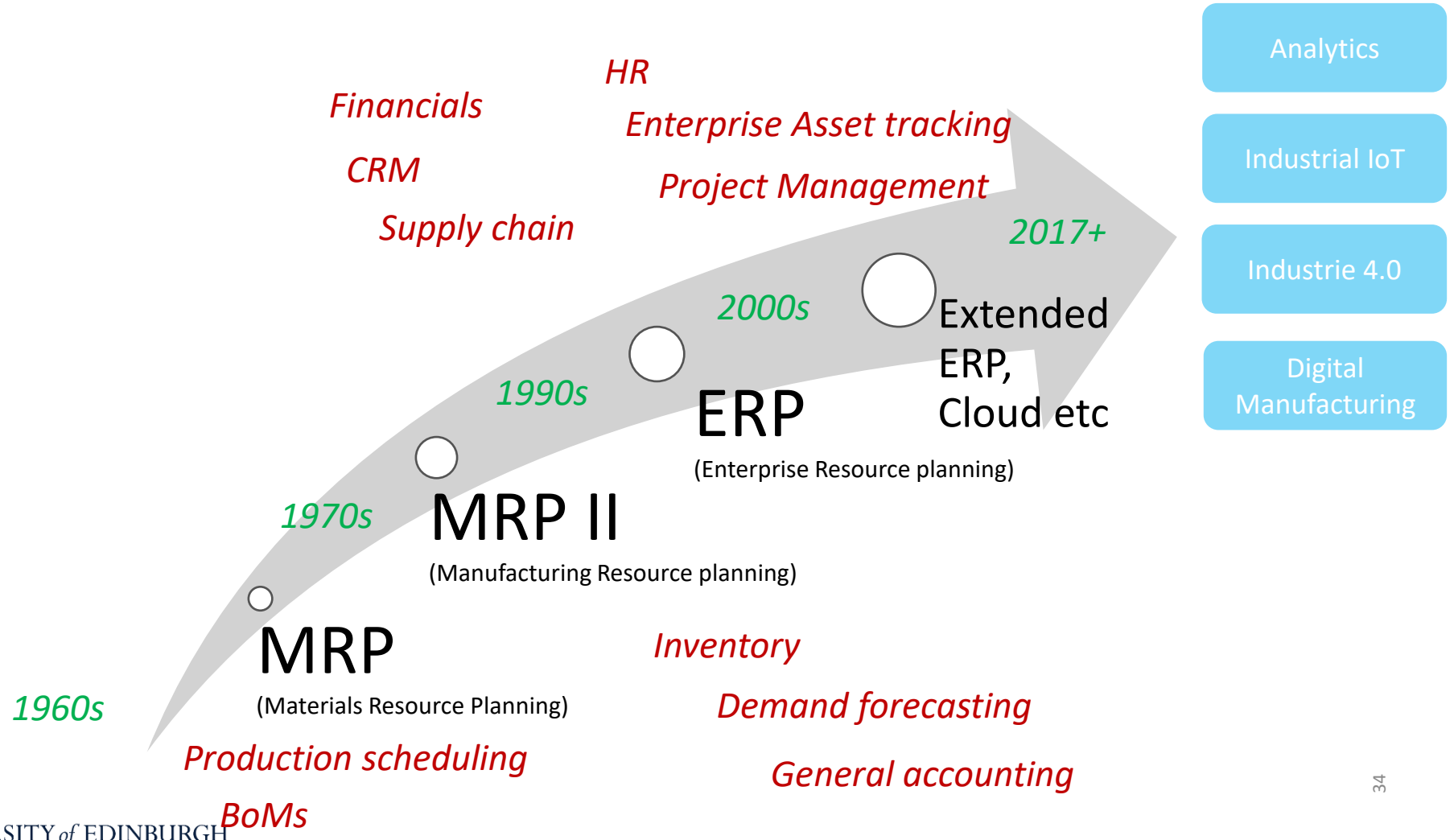
ERP - ACCOUNTING



ERP – MANAGEMENT SUPPORT



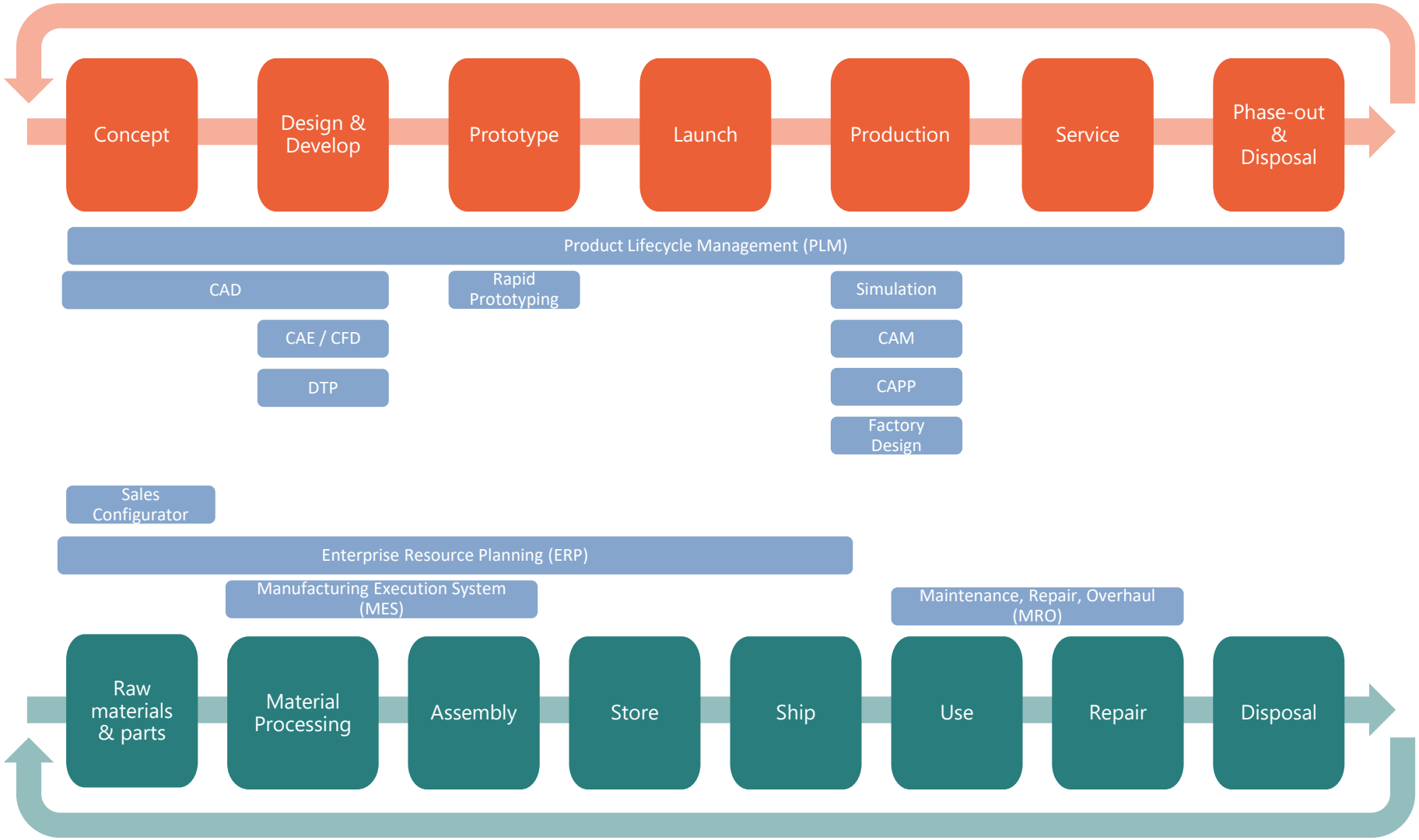
ERP HISTORY


Analytics
Industrial IoT
Industrie 4.0
Digital Manufacturing
HR
Financials
Enterprise Asset tracking
CRM
Project Management
Supply chain
2017+
2000s
Extended ERP, Cloud etc
1990s
ERP
(Enterprise Resource planning)
1970s
MRP II
(Manufacturing Resource planning)
MRP
(Materials Resource Planning)
Inventory
1960s
Demand forecasting
Production scheduling
General accounting
BoMs

MES

- What is MES?
- What are the benefits of MES?
- How does MES work?
- MES of the future

Product-type lifecycle



Product lifecycle / Material Flow

Suppliers

Customers

MES

What is MES?

MES stands for manufacturing execution systems.

Most manufacturing companies use a planning process (MRPII/ERP or equivalent) to determine what products are to be manufactured.

There must then be a translation of this plan to deal with physical machines and resources.

MES takes input from the planning system and translate that into instructions to the plant floor to execute the plan [1].

MES

What are the benefits of MES?

Benefits as reported by system users [1]:

- Reduces manufacturing cycle time.
- Reduces or eliminates data entry time.
- Reduces work-in-process inventory.
- Reduces lead times.
- Reduces paperwork between shifts.
- Improves product quality.
- Eliminates lost paperwork/blueprints.
- Empowers plant operations people.
- Improves customer service.
- Responds to unanticipated events.

MES

- How does MES work?

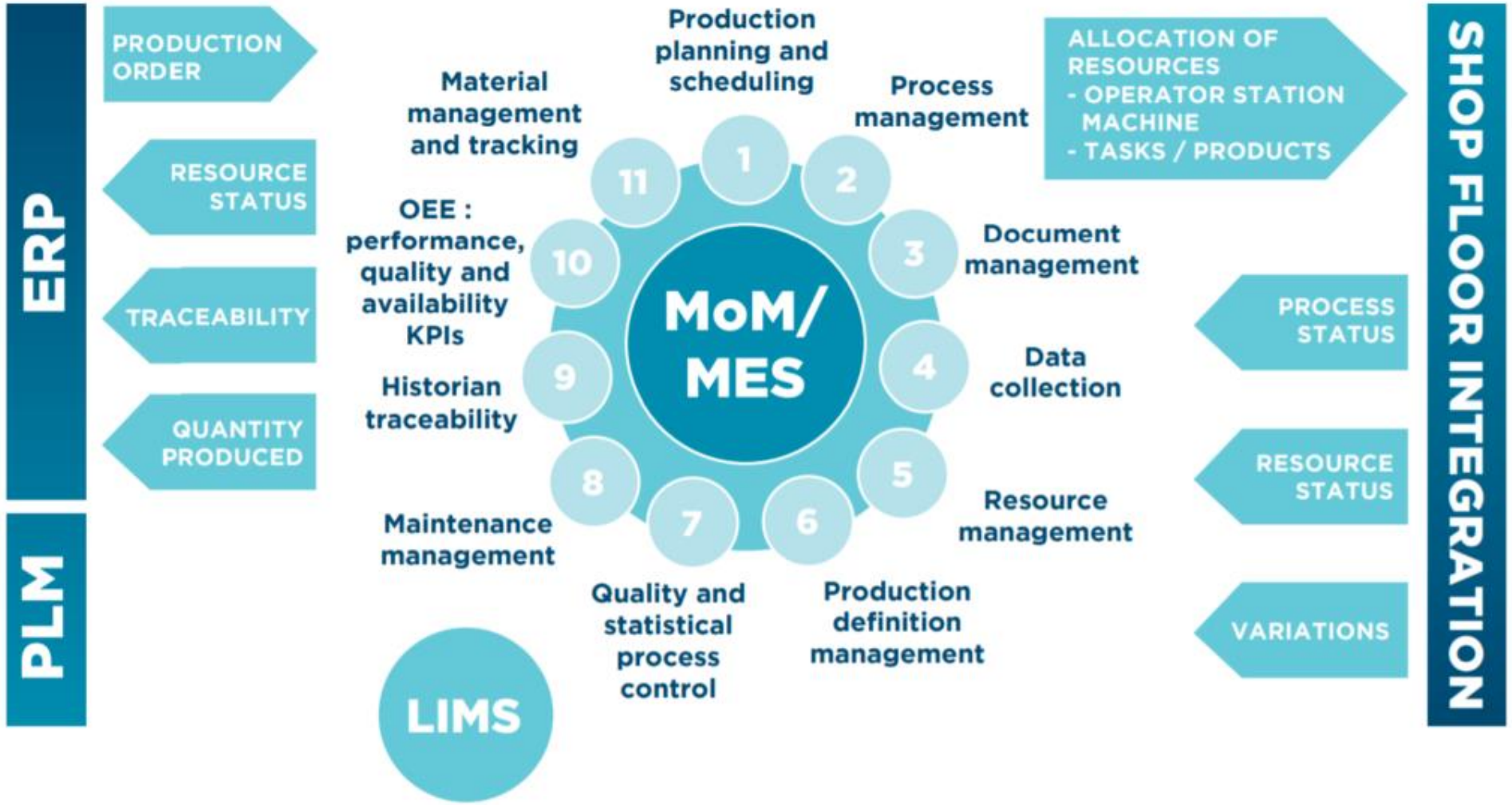
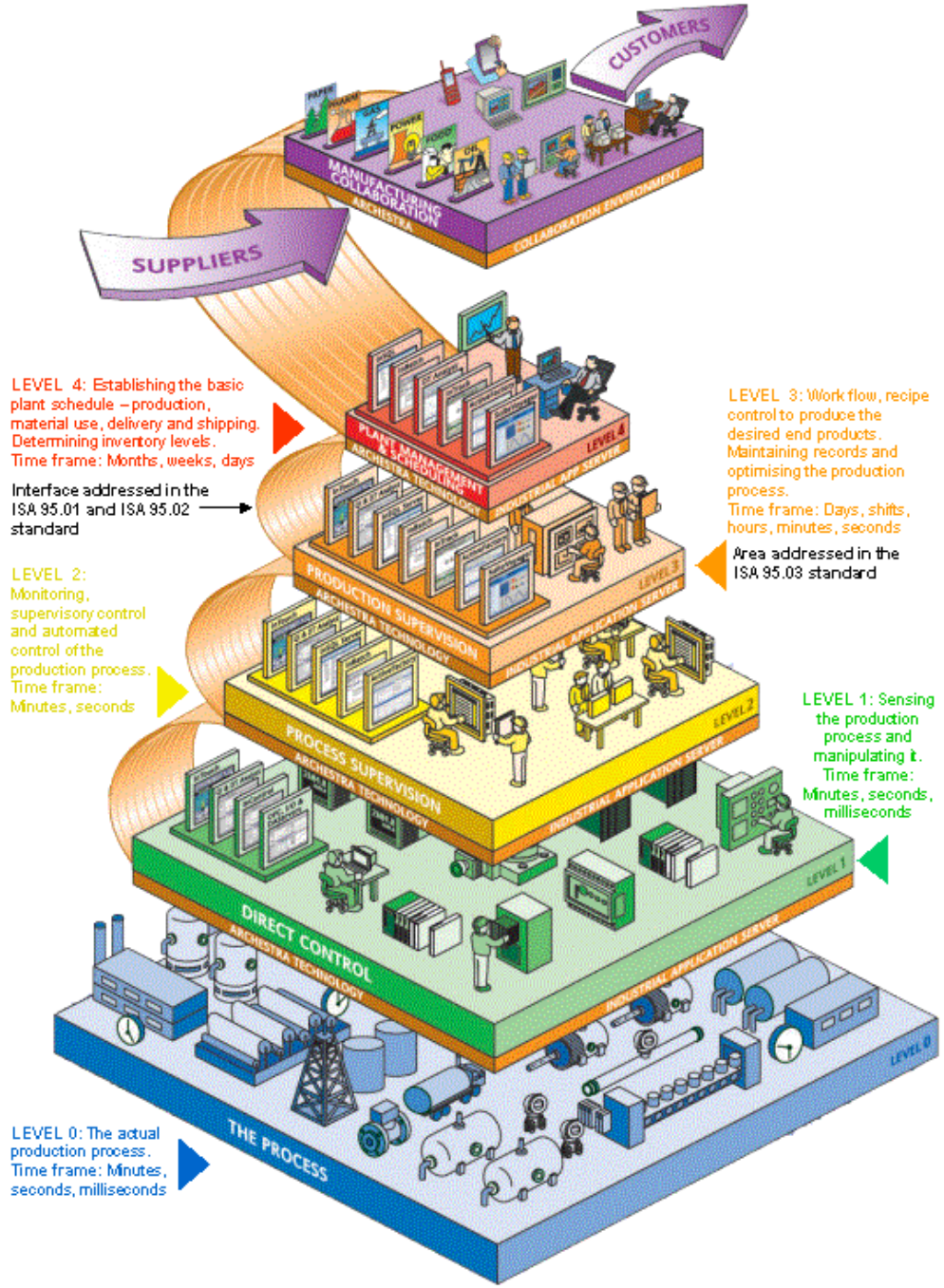


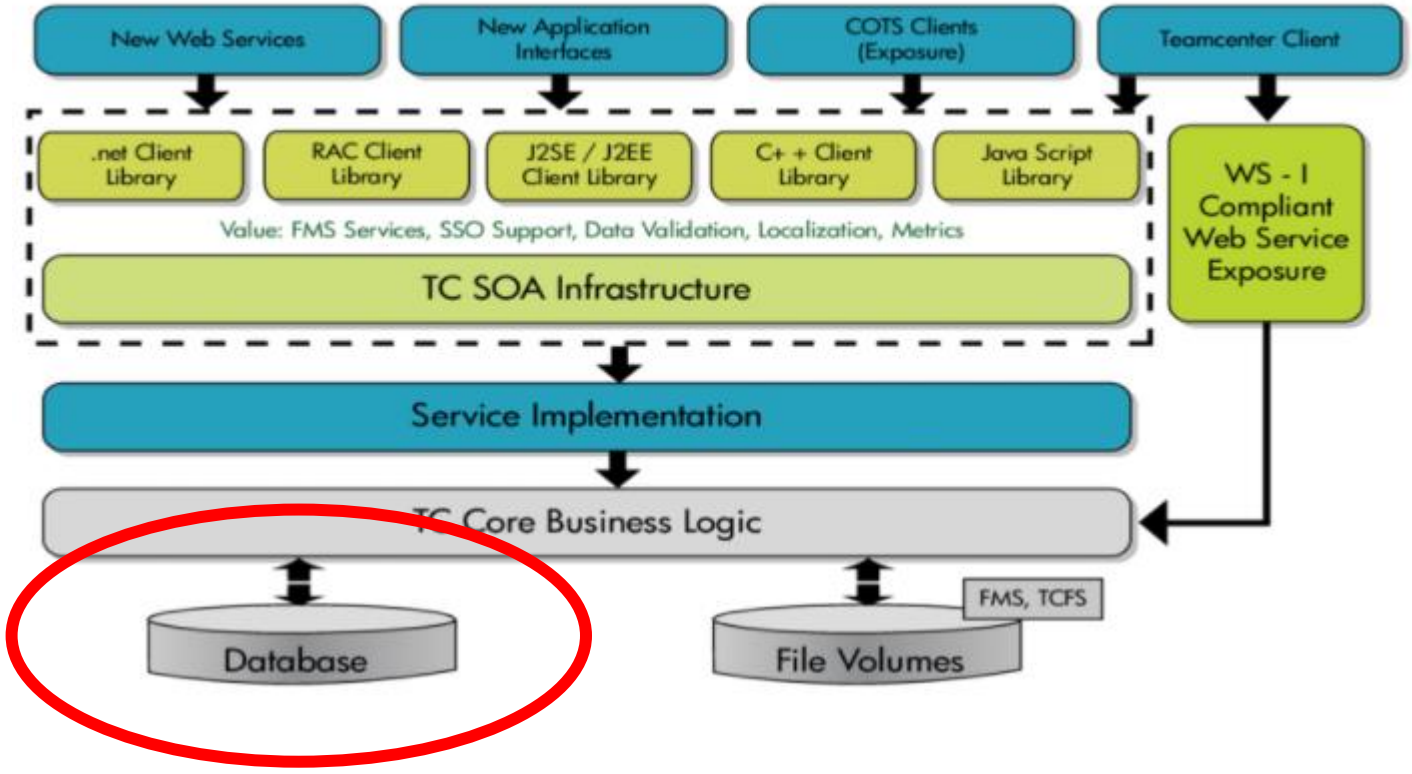
Image by Mark Barry

ISA95



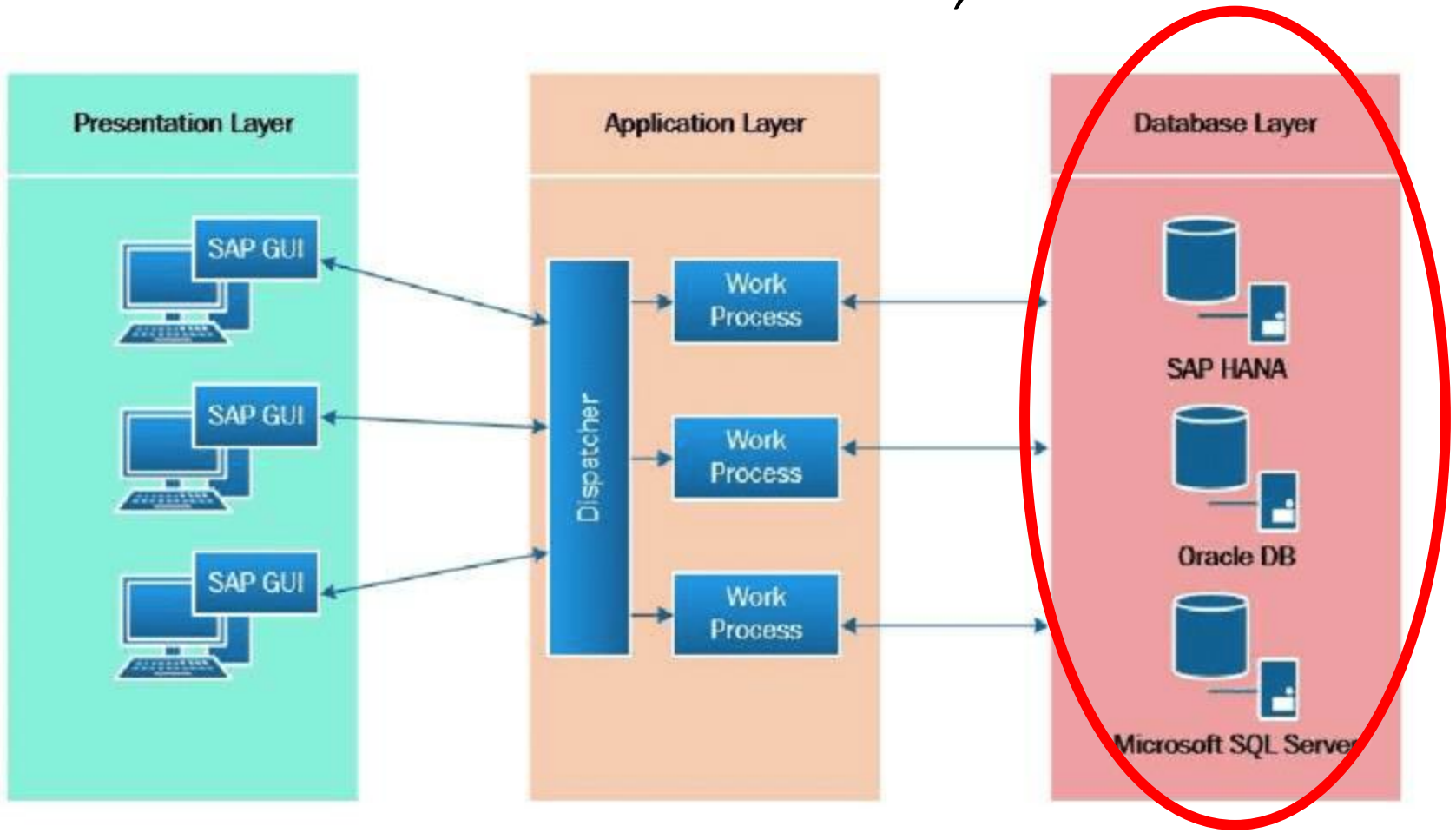
Wonderware Archestra

DATABASES UNDERPIN PLM, ERP AND MES



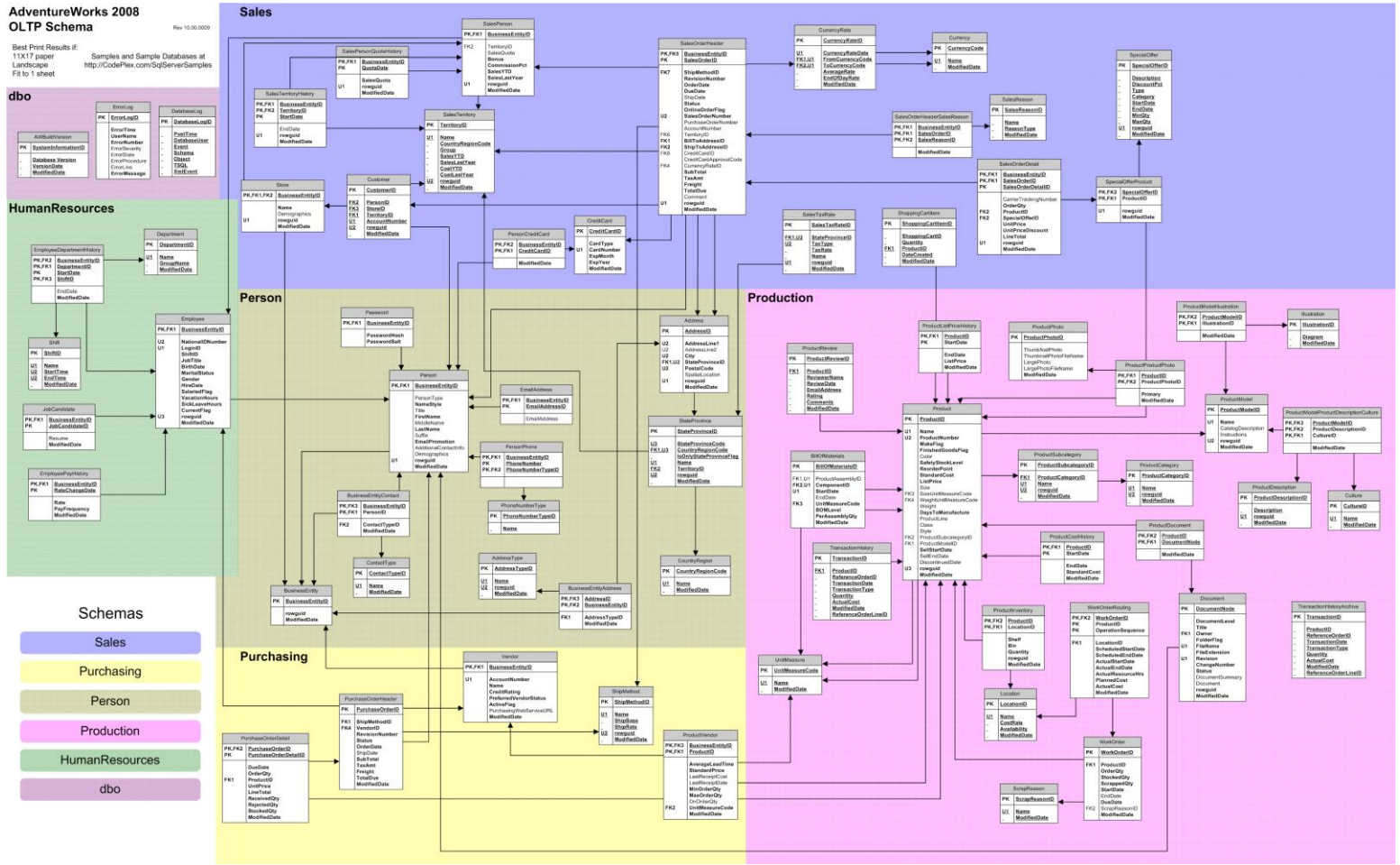
TeamCenter Unified Architecture

DATABASES UNDERPIN PLM, ERP AND MES



SAP Unified Architecture

DATABASES UNDERPIN PLM, ERP AND MES



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2. Almada-Lobo, F., 2016. The Industry 4.0 revolution and the future of Manufacturing Execution Systems (MES). *Journal of Innovation Management*, 3(4), pp.16-21.
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4. Mantravadi, S. and Møller, C., 2019. An Overview of Next-generation Manufacturing Execution Systems: How important is MES for Industry 4.0?. *Procedia Manufacturing*, 30, pp.588-595.
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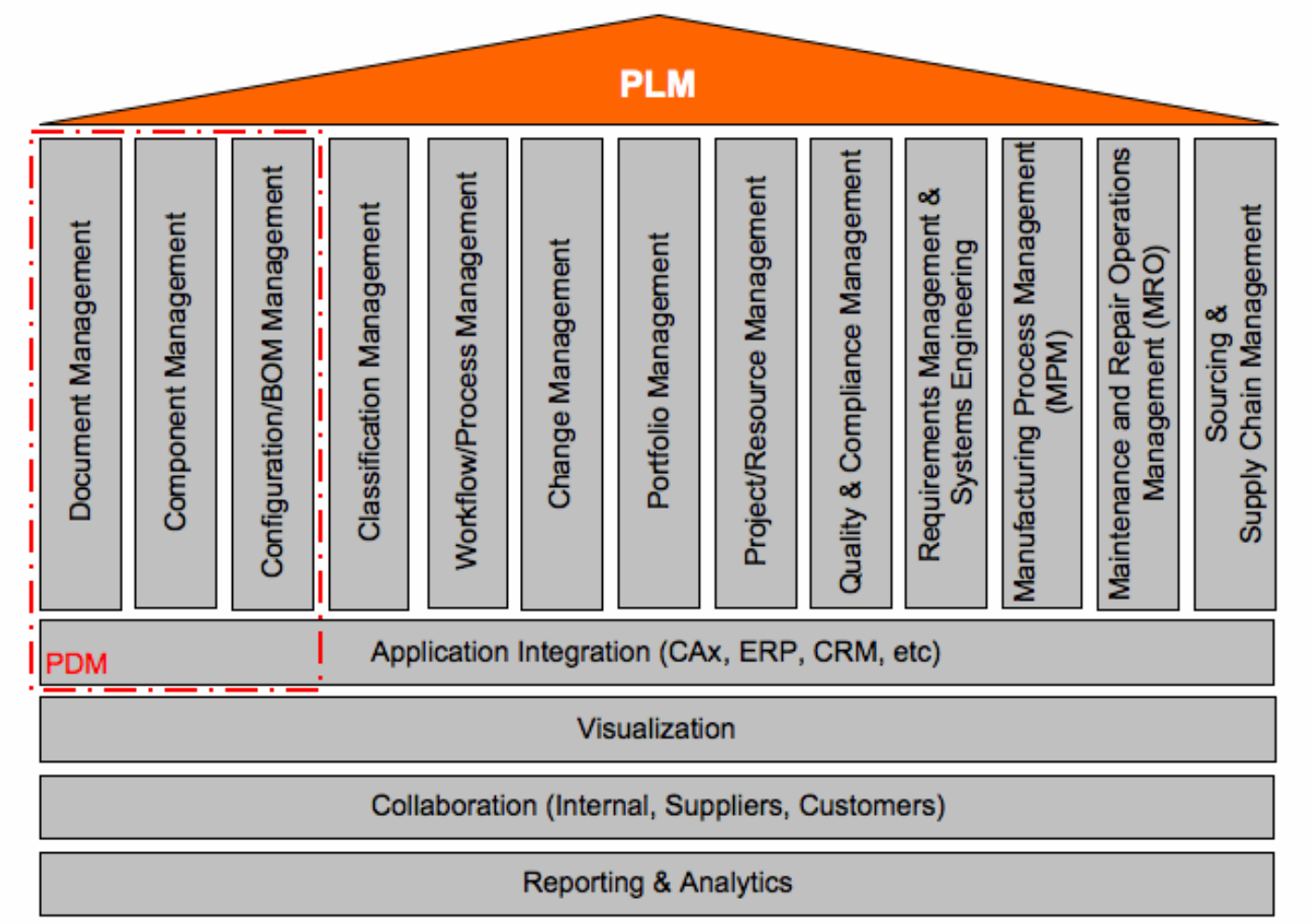
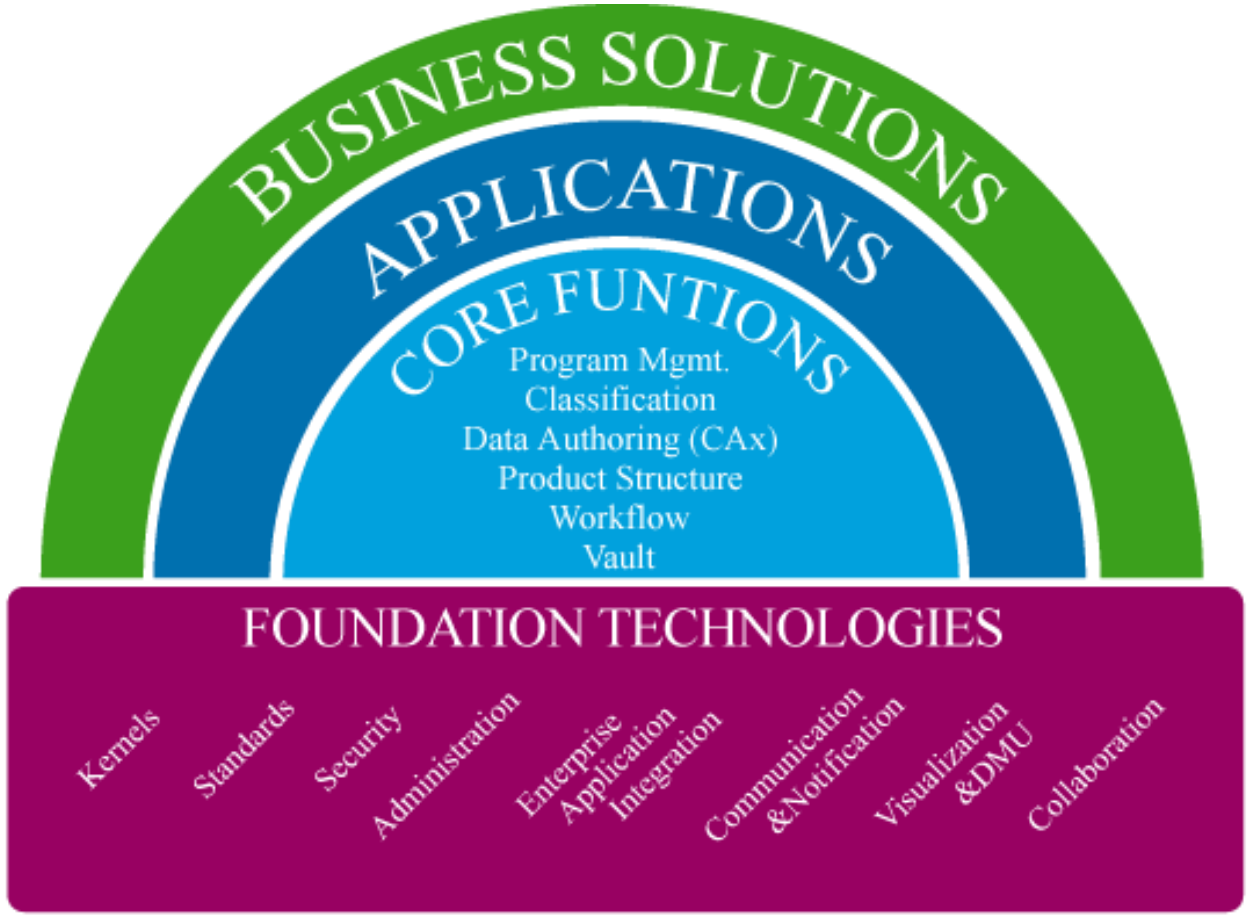
PLM APPLICATIONS & TECHNOLOGIES



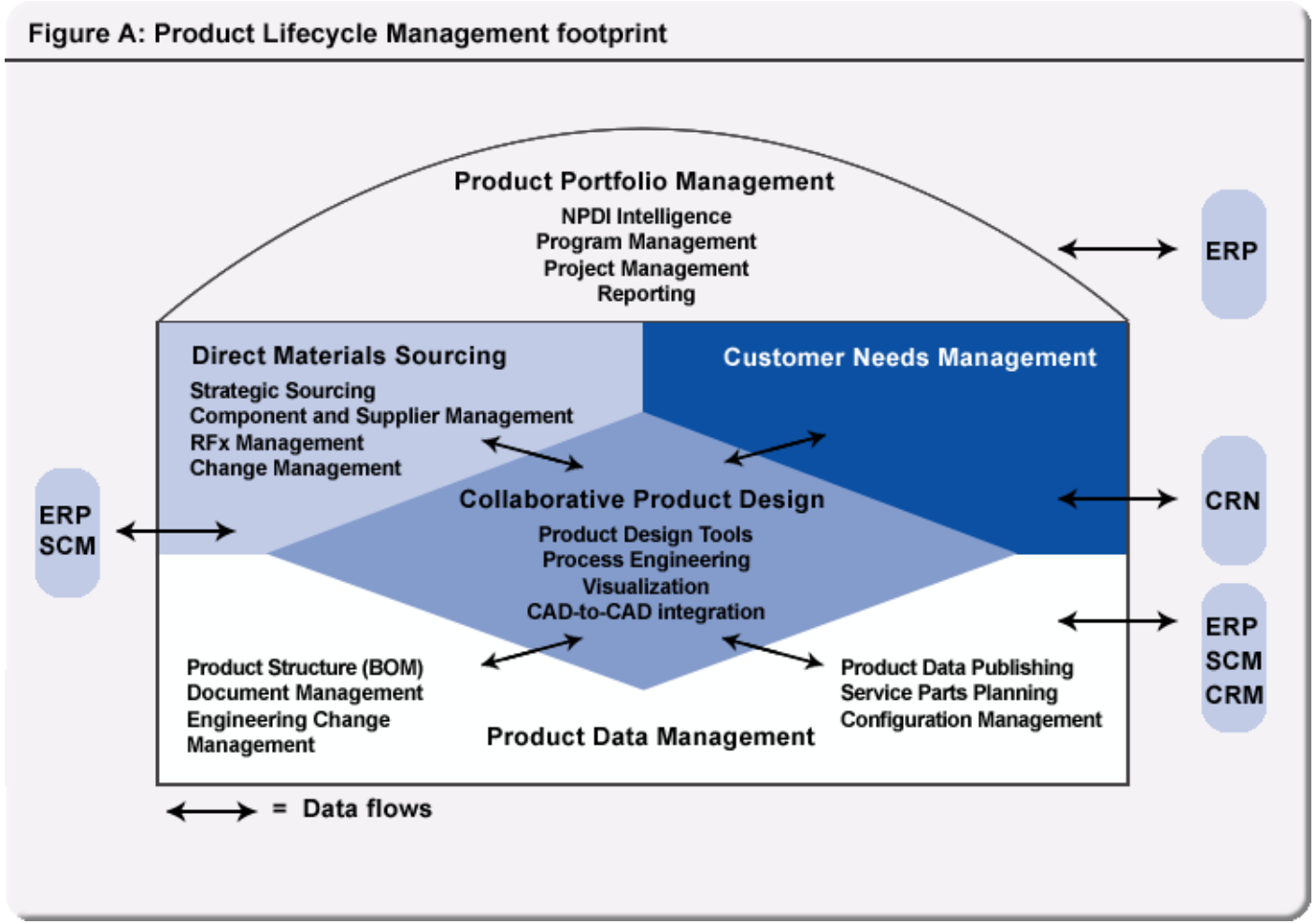
PLM Technology Guide

PLM APPLICATIONS & TECHNOLOGIES



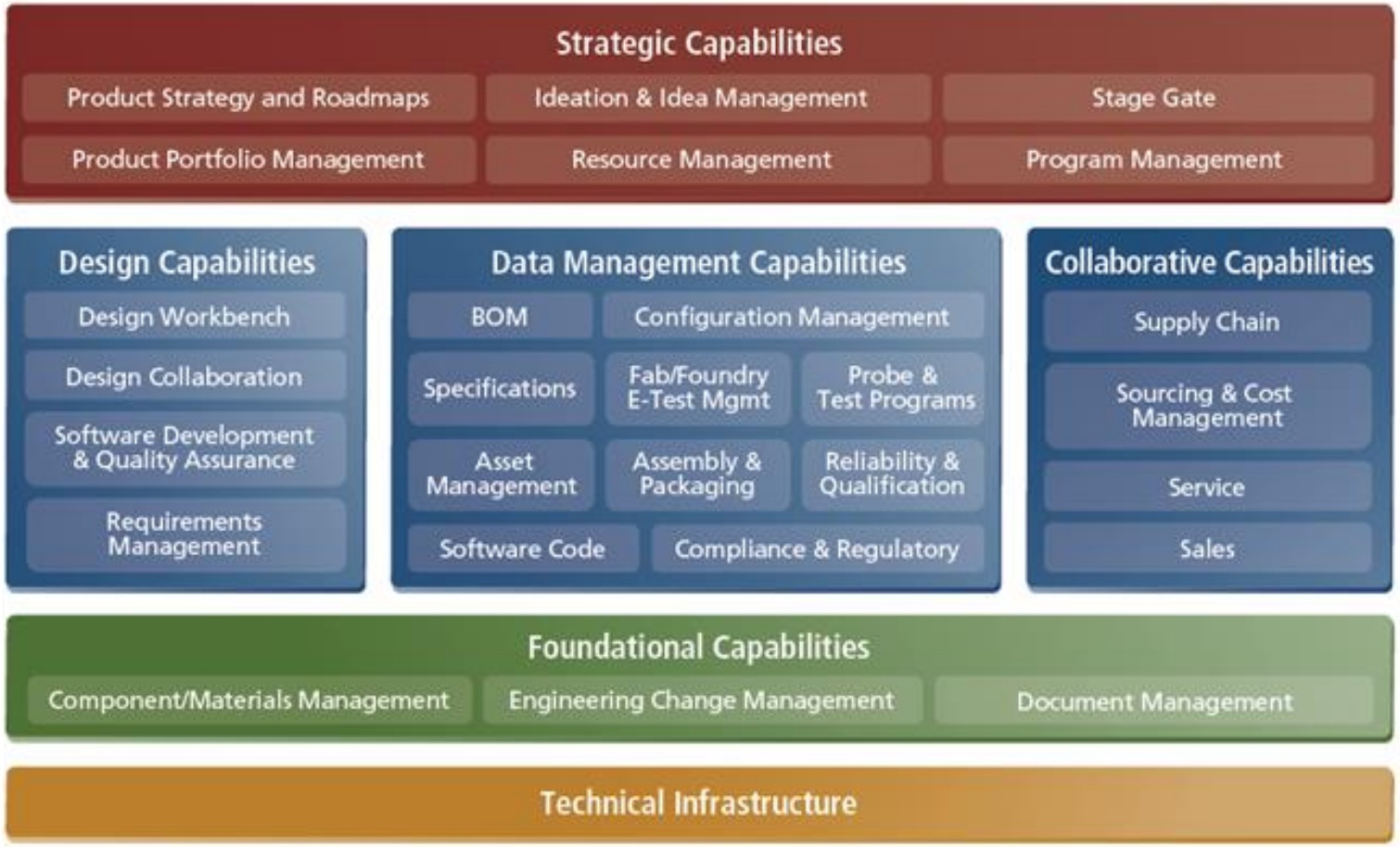
CIMdata

PLM APPLICATIONS & TECHNOLOGIES



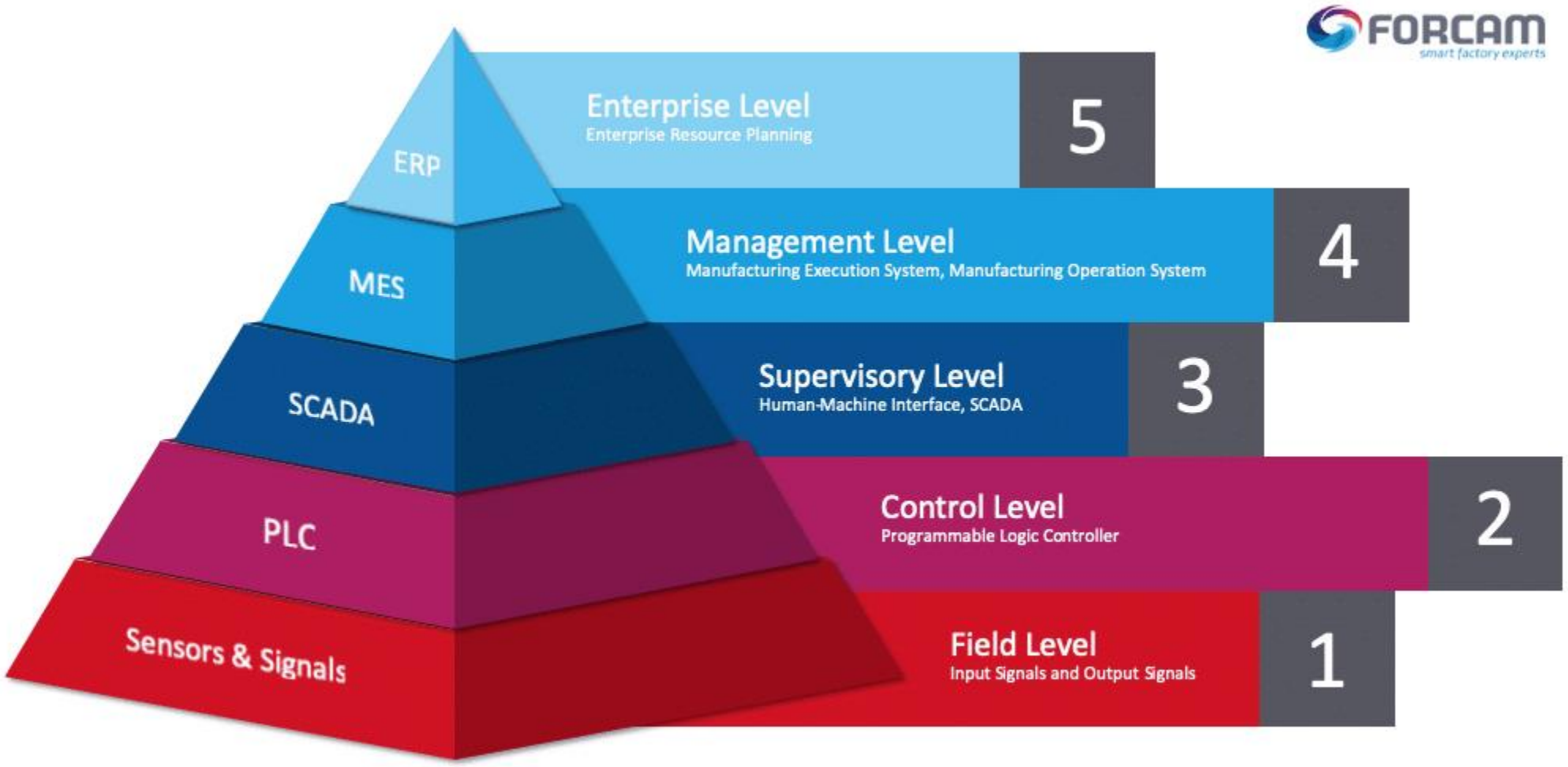
AMR/Gartner

PLM APPLICATIONS & TECHNOLOGIES



Kalypso

MES


FORCAM
smart factory experts
ERP
MES
SCADA
PLC
Sensors & Signals
Enterprise Level
Enterprise Resource Planning
5
Management Level
Manufacturing Execution System, Manufacturing Operation System
4
Supervisory Level
Human-Machine Interface, SCADA
3
Control Level
Programmable Logic Controller
2
Field Level
Input Signals and Output Signals
1