CPIM
CERTIFIED IN PLANNING
AND INVENTORY MANAGEMENT

MODULE 9:
QUALITY, BUSINESS INVESTMENTS, AND CONTINUOUS IMPROVEMENT

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Module 9 Overview

Quality, Technology, and Continuous Improvement

- Section A: Quality
- Section B: Capital Equipment and Facilities
- Section C: Technology
- Section D: Continuous Improvement

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SECTION A:
QUALITY

Section A Overview

Section A Learning Objectives

- Quality and total quality management
- Juran's trilogy of quality planning, control, and improvement as quality framework
- Management's role in implementing quality initiatives
- Costs of poor quality and of appraisal and prevention
- Quality tools: basic seven and seven new tools

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Total Quality Management (TQM) and Quality

- TQM focuses on long-term success through customer satisfaction.
- Quality
  - Transcendent: an ideal
  - Product-based: low grade can be high quality
  - User-based: expectations, features, aesthetics, conformance to specifications, services
    - Reliability
    - Durability
    - Maintainability
  - Manufacturing-based: conformance to requirements and quality of conformance (past failures)
  - Value-based: value for money (competition, perceptions)

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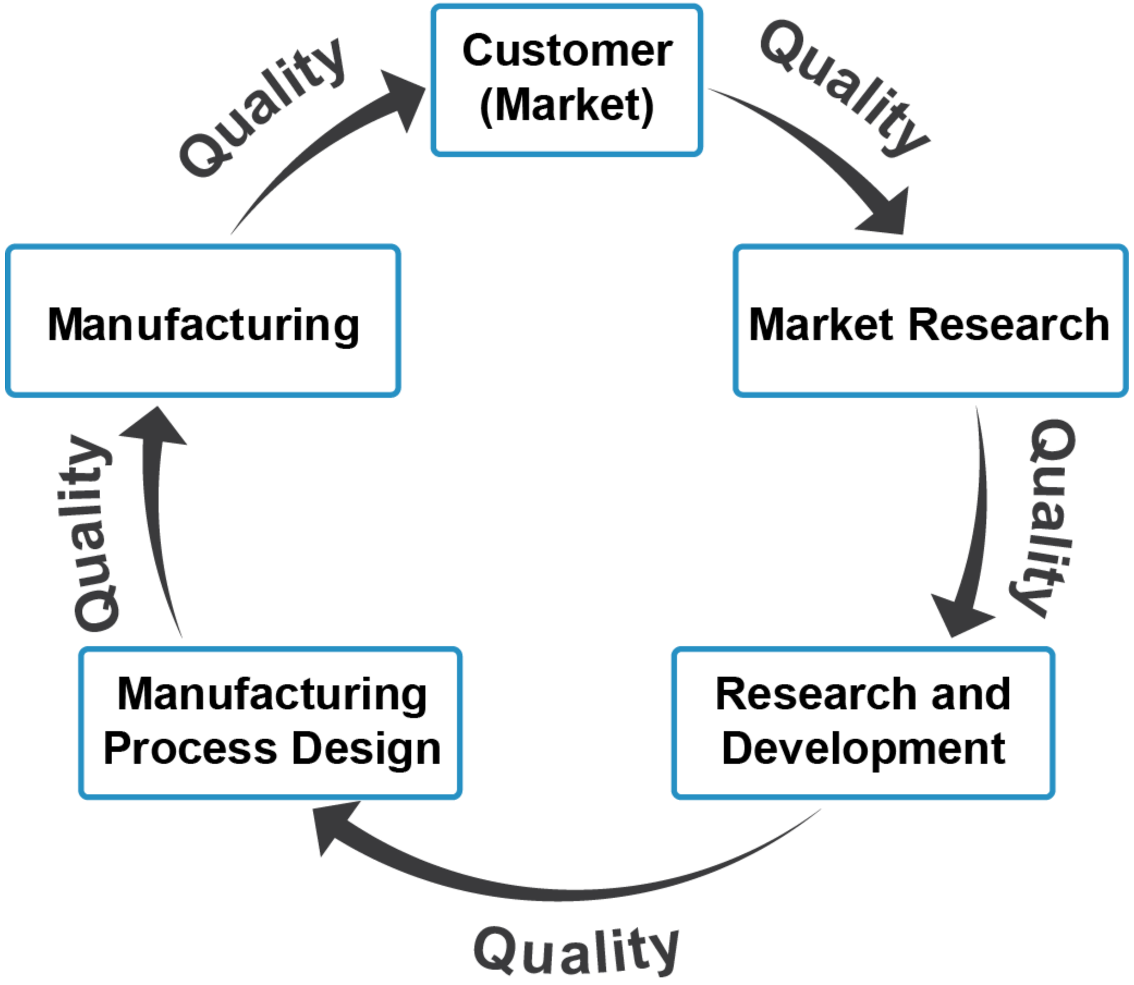
Product Development Cycle with Quality at Each Step



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Objectives of TQM

- Long-term success through customer satisfaction.
- Meet customers' required product and service specifications.
- Minimize variation to degree possible because processes have central tendency with variations.
  - "Made to specifications" means only within upper and lower limits of what organization has determined to be acceptable.
  - Several components near opposite limits could cause problems with final assembly.

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Quality Planning and Assurance/Control

Core Concepts of TQM

- **Management champions**
  - Absolute commitment and funding.
  - Mission, vision, culture.
- **Performance measurement**
  - Evidence-based system.
  - Lost customers hard to measure.
- **Involvement/empowerment**
  - Cross-training, problem solving, root cause analysis.
- **Focus on customer**
  - Quality
  - Flexibility (agility)
  - Dependability (resilience)
  - Service
  - Speed (lead time)
  - Stability (low variability in specifications or measures)
  - Cost

  Find combination customer finds acceptable; continuous improvement can improve all at once.
- **Quality as source of competitive advantage**
  - Quality is not added value; it is essential requirement.

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Quality Planning and Assurance/Control

Juran's Trilogy

- Successful implementation of quality initiatives requires application of Juran's trilogy.
- Many organizations use trilogy as framework upon which to build quality initiatives.

Quality planning

- Define your customers.
- Determine their needs.
- Define requirements for and develop your product/process/service/system requirements.

Quality control

- Determine what needs to be measured.
- Set performance goal.
- Measure actual performance.
- Take action on gap.

Quality improvement

- Repair
- Refinement
- Renovation
- Reinvention

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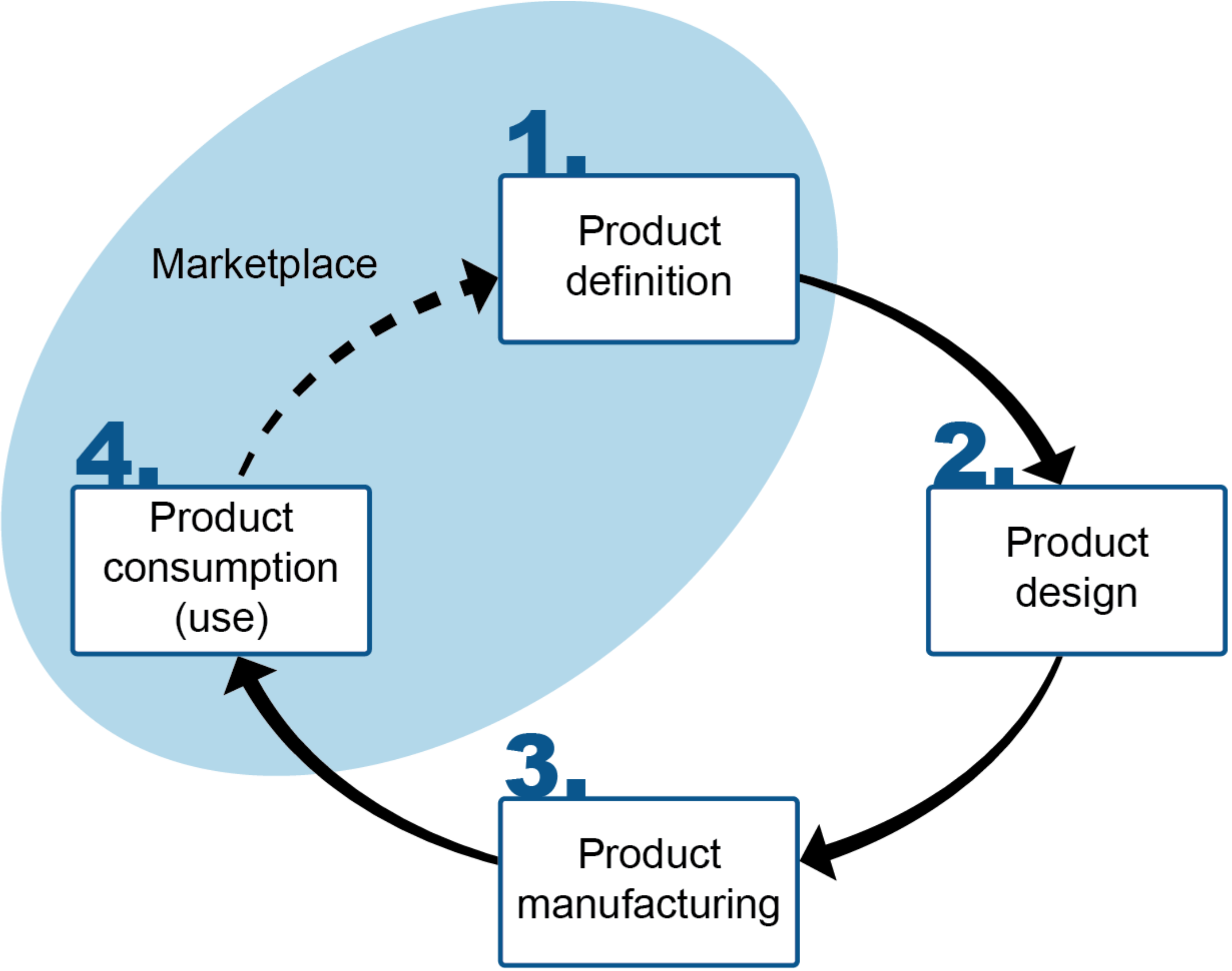
Quality Planning Cycle



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Quality Assurance/Control

- Quality assurance: Looks at process itself.
- Quality control: Ensures that process is applied correctly.
- These are not universally accepted distinctions.
- Purposes of quality assurance/control:
  - Meet standards consistently.
  - Maintain gains from improvement projects.
  - Promote analysis of process variation and identify improvements.
  - Clarify quality improvement team member responsibilities and achieve a state of self-control.
  - Validate that process outputs conform to quality requirements.

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Commitment to Quality Activity

- XYZ makes an electronic product. They find a defect in a batch that affects 10% of production. XYZ has two options: rework the defective components (requires 3 days) or rerun an entire batch (requires 5 days).
- Management of XYZ must consider presenting these two options to the component's primary customer, who uses it as the critical component in a line of products. The line sells at a premium over competitors' prices due to product quality and high market demand.

1. What would you expect the customer's likely concerns might be regarding reworking as opposed to running an entirely new batch?
2. What are the relative advantages for XYZ of reworking or running a new batch?

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Managing for Quality

Quality Planning	Quality Control	Quality Improvement
Executed by senior leadership	Executed by middle management	Executed by team leaders/employees
Example of quality planning for new product introductions: ▪ Determine goals. ▪ Identify customers. ▪ Determine customer needs. ▪ Build features that meet customers' needs. ▪ Develop processes that enable production. ▪ Determine process controls. ▪ Transition plans to operational team.	Example of monitoring and controlling of process controls: ▪ Select control subjects. ▪ Measure actual performance. ▪ Compare actual performance against targets and goals. ▪ Act on difference(s).	Example of project portfolio improvement process: ▪ Present and prove need with business case. ▪ Build project infrastructure. ▪ Specify and prioritize improvement projects. ▪ Initiate projects and select project teams. ▪ Ensure that teams have resources, training, and motivation. ▪ Implement controls that will maintain gains.

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Management's Leadership Role

- Create a quality vision.
- Build a quality culture.
- Champion various types of change.
- Model leadership.
- Recruit the right people.
- Promote empowerment.
- Serve as change agents.
- Enlist middle management.

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Middle Management

- Provide employees with good feedback that includes
  - Being able to review feedback while in motion—at a glance
  - Dealing with only the important defects
  - Dealing with only defects they can control
  - Providing prompt information regarding symptoms and causes
  - Providing enough information to guide corrective action.
- See the actual work
  - Management by walking around (MBWA)

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Cost of Poor Quality

Not investing in quality is more expensive in long term. (Short-term, costs go up due to quality investment.)

Costs of Failure (~80% of quality costs if little prevention)	Costs of Controlling Quality
External failure costs ▪ After product reaches customer ▪ Warranty, returns ▪ Most expensive (lost customers) **Internal failure costs** ▪ Before release ▪ Rework, scrap ▪ Long lead times or backorders	**Appraisal costs (lean: waste)** ▪ Conformance to specifications ▪ Process conformance ▪ Finished good inspections ▪ Calibration **Prevention costs** ▪ Reduce failure and appraisal costs ▪ Preventive maintenance ▪ Education, training, supplier certification

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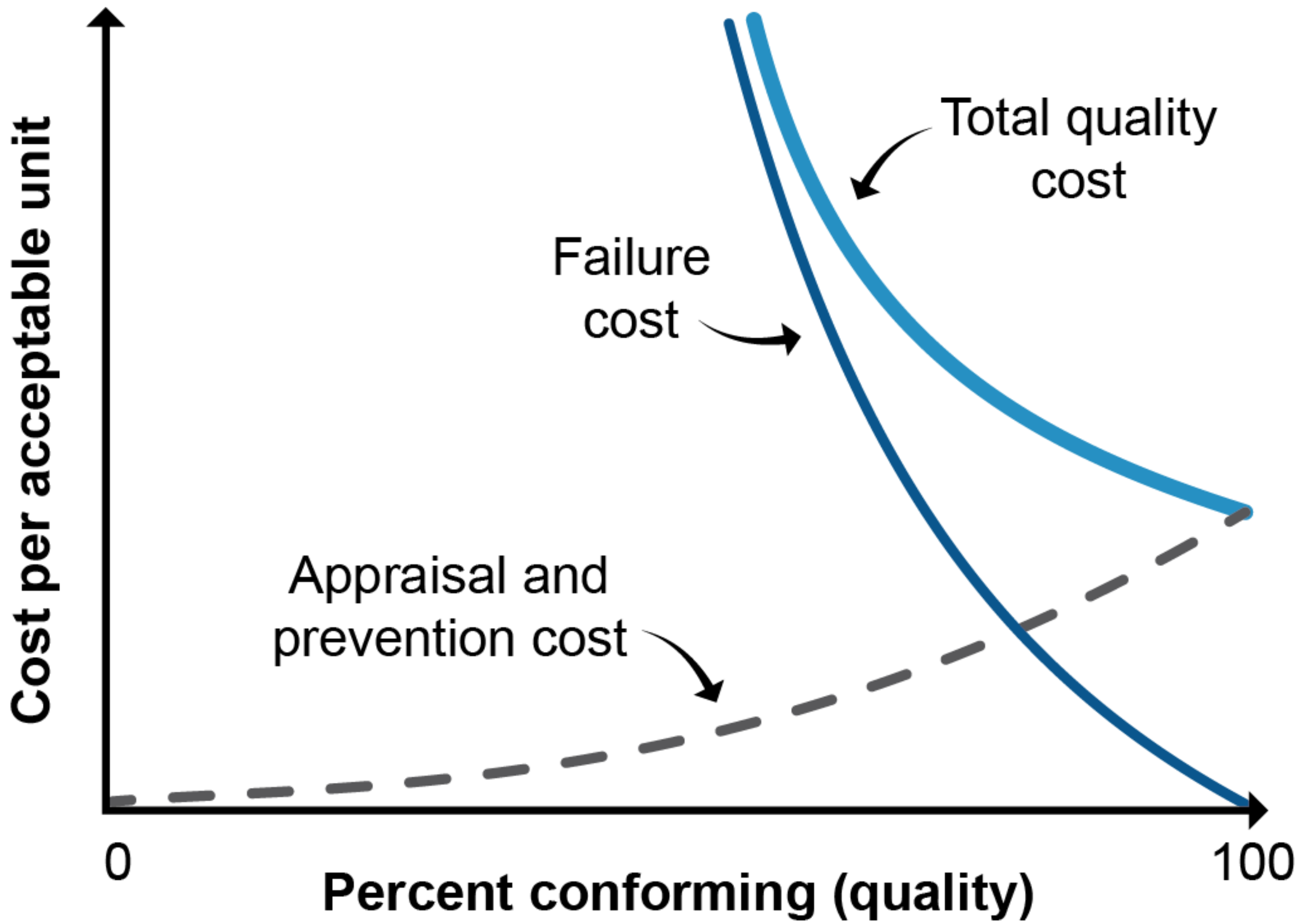
Optimizing Conformance and Quality Costs



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Basic Seven Tools of Quality (B7)

- Check sheet
- Pareto chart
- Cause-and-effect diagram
- Flowchart
- Histogram
- Scatter diagram
- Control chart

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Check Sheet

Records number of times particular event occurs; is interpreted using other tools.

Product

<table>
<tr><th></th><th>A-SD Silver</th><th>A-SD Bronze</th><th>A-DD Silver</th><th>A-DD Bronze</th><th></th></tr>
<tr><td>Wrong lot</td><td>||</td><td>|||</td><td>|</td><td>|||</td><td>9</td></tr>
<tr><td>Dented</td><td>||</td><td>||</td><td>卌</td><td>||</td><td>11</td></tr>
<tr><td>Broken</td><td>|||</td><td>卌</td><td>|||</td><td>|</td><td>12</td></tr>
<tr><td></td><td>7</td><td>10</td><td>9</td><td>6</td><td></td></tr>
</table>

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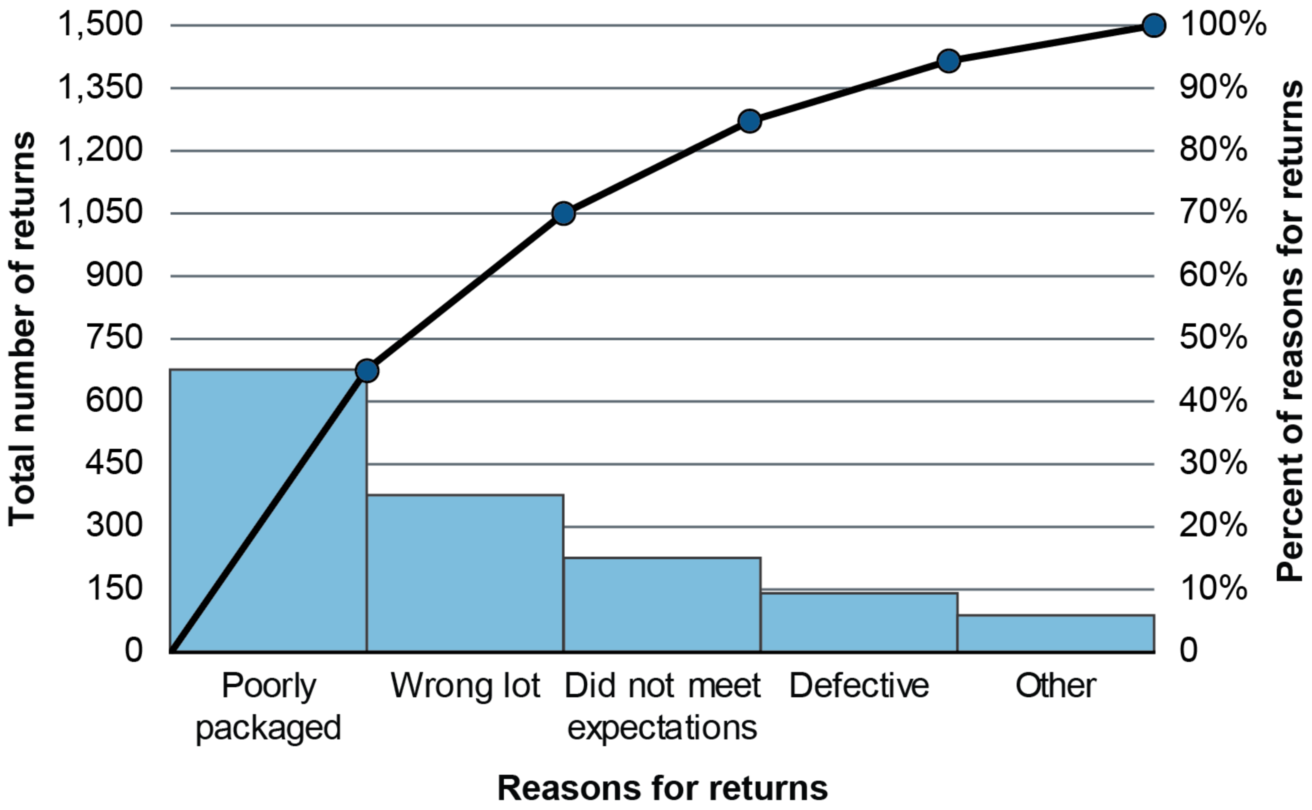
Pareto Charting and Analysis

80-20 cut

- Significant few
  - Here, first two are 70%.
- Trivial many
  - "Other" may be many.



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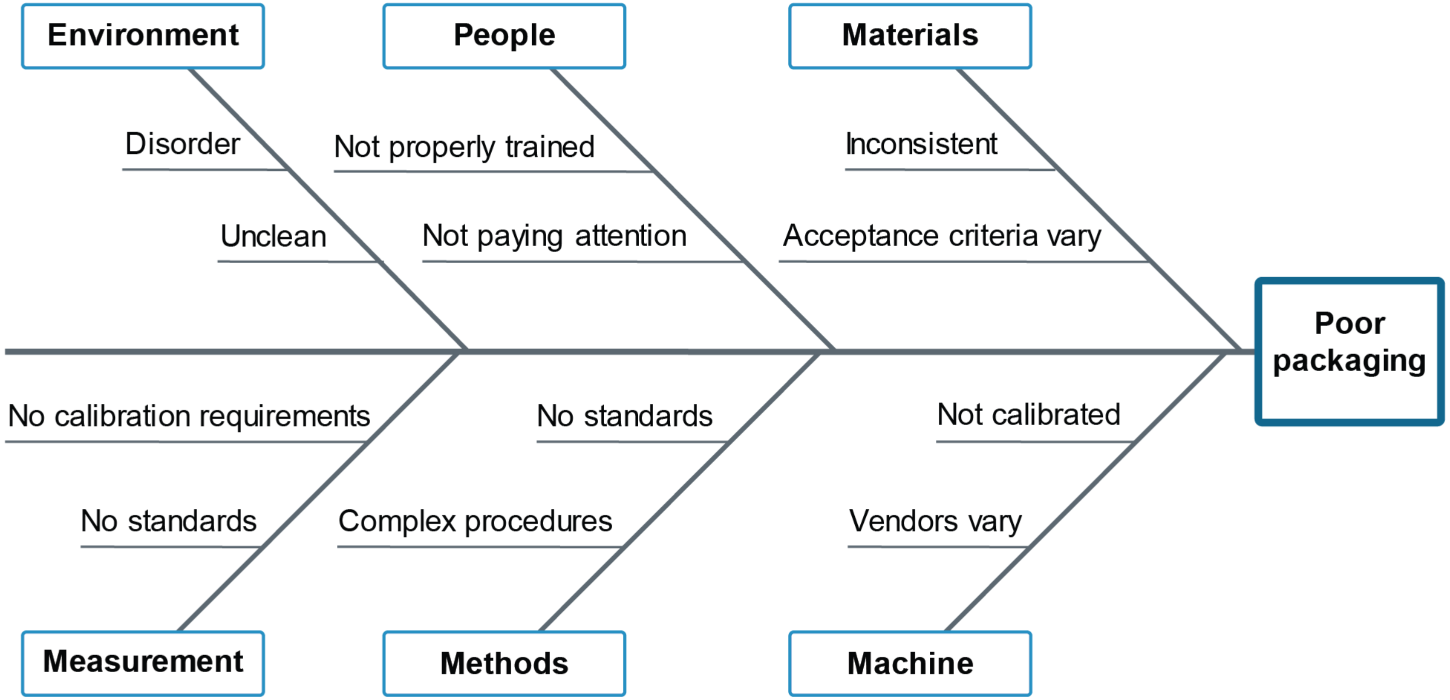
Cause-and-Effect Diagram

- Starts with effect and then identifies all possible causes.
- For all possible causes, ask “why” five times to get to ultimate cause of problem.



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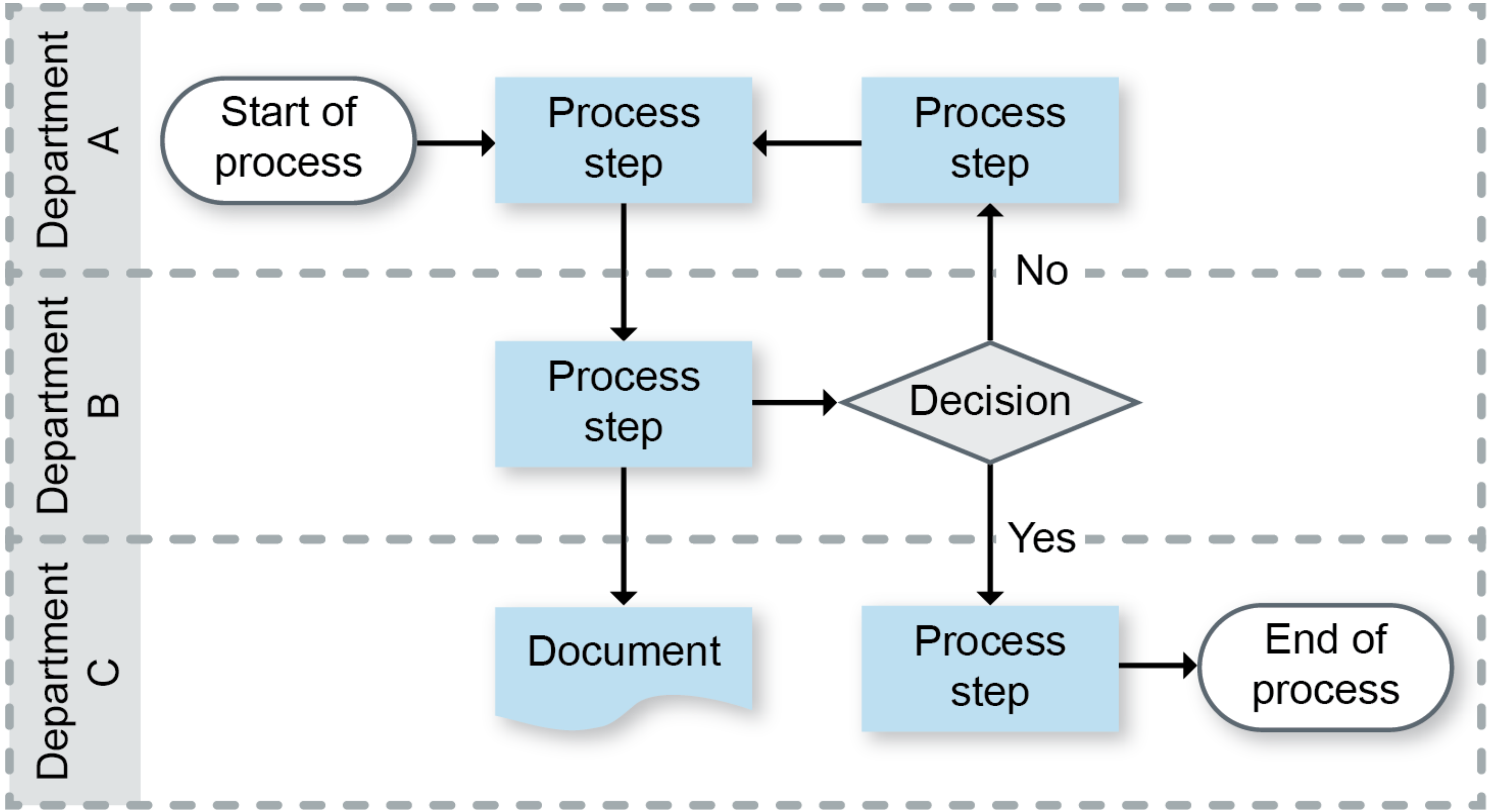
Flowchart

Studying flowcharts may reveal improvements.



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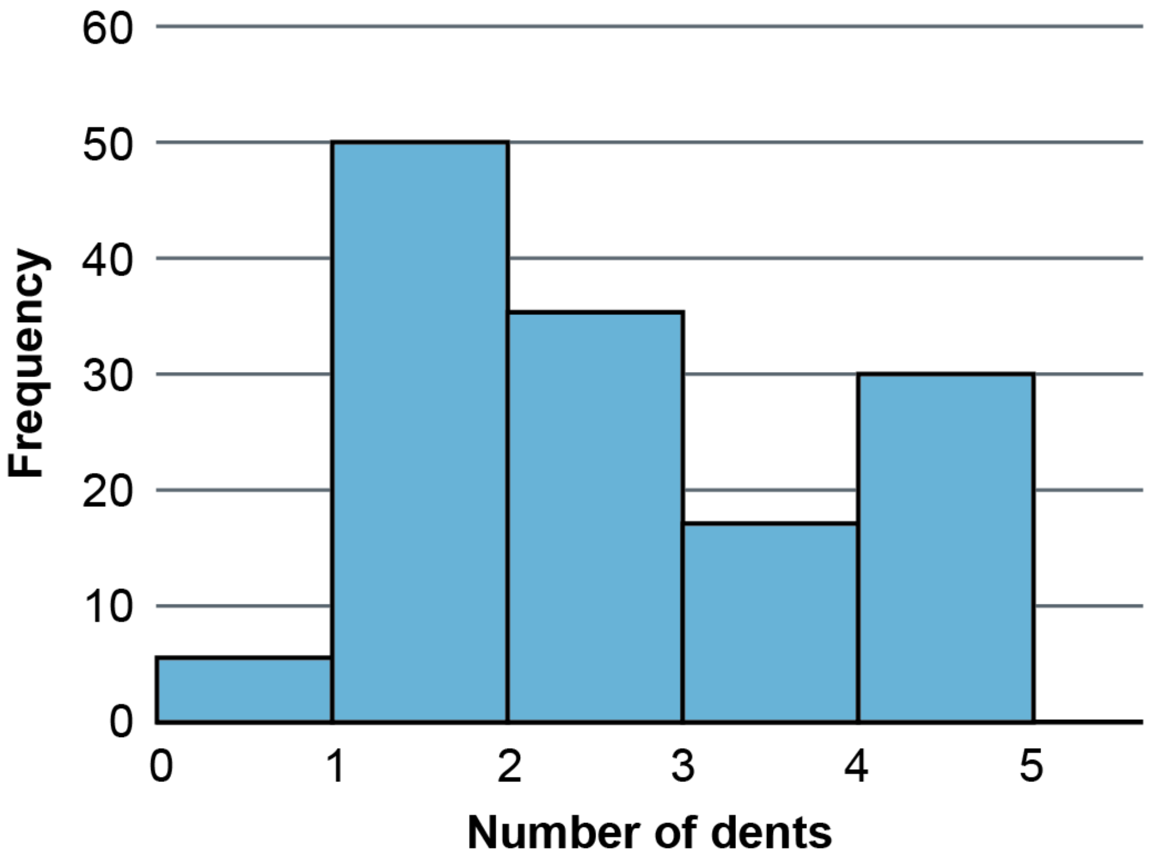
Histogram

- Vertical bar chart
- Frequency distribution
- Groups or classes
- Number of items per class
- Visualize actual data (not ranked)



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Product Quality Exercise: Specification is 140 mg ± 40 mg

Fill weight (milligrams)				
150	140	170	160	130
140	140	160	150	150
160	150	150	160	140

	100	110	120	130	140	150	160	170	180
5						X			
4					X	X	X		
3					X	X	X		
2					X	X	X		
1				X	X	X	X	X	

Milligrams

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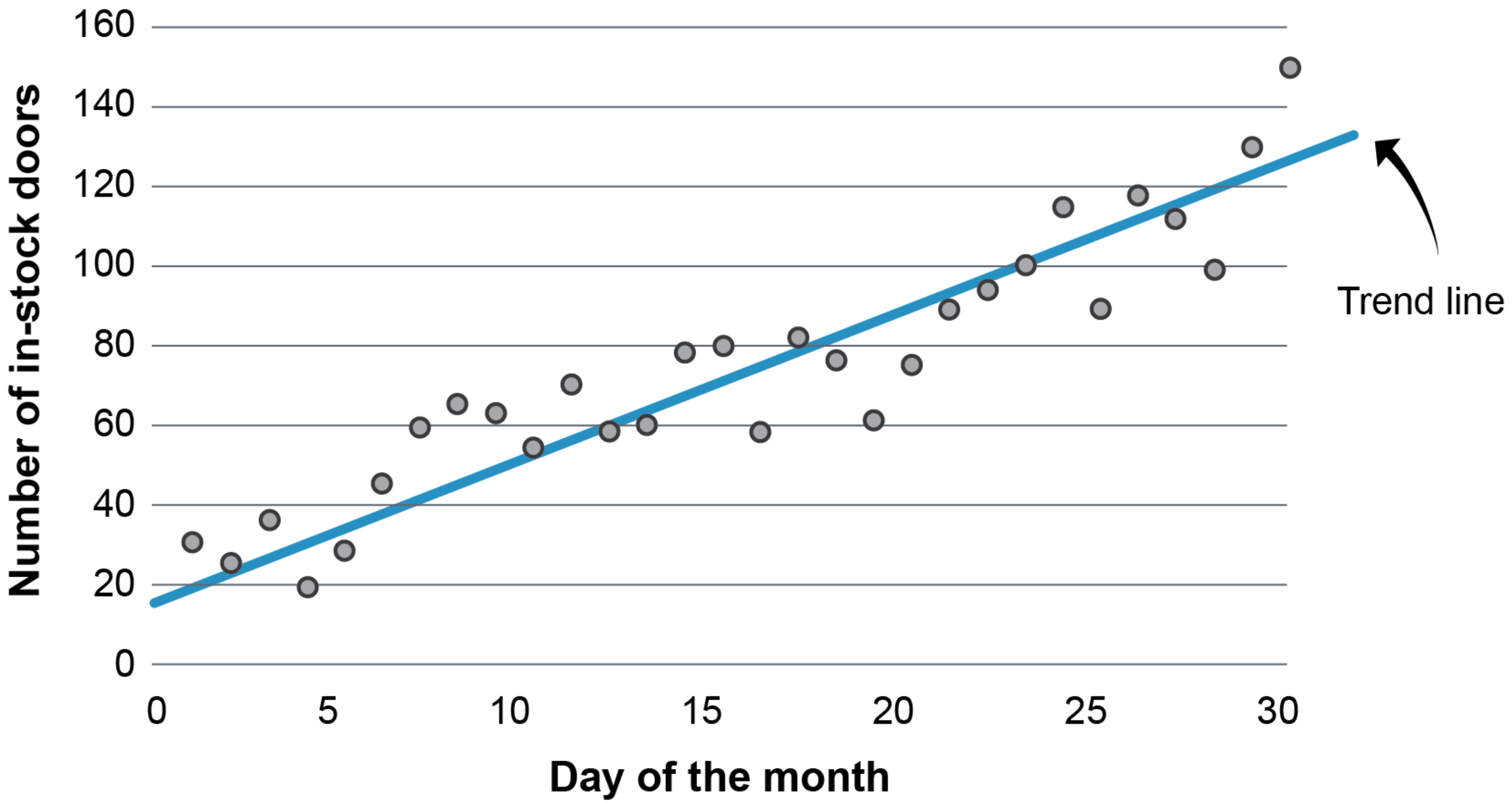
Scatter Chart

Plots data against variables that form the chart's *x* and *y* axes



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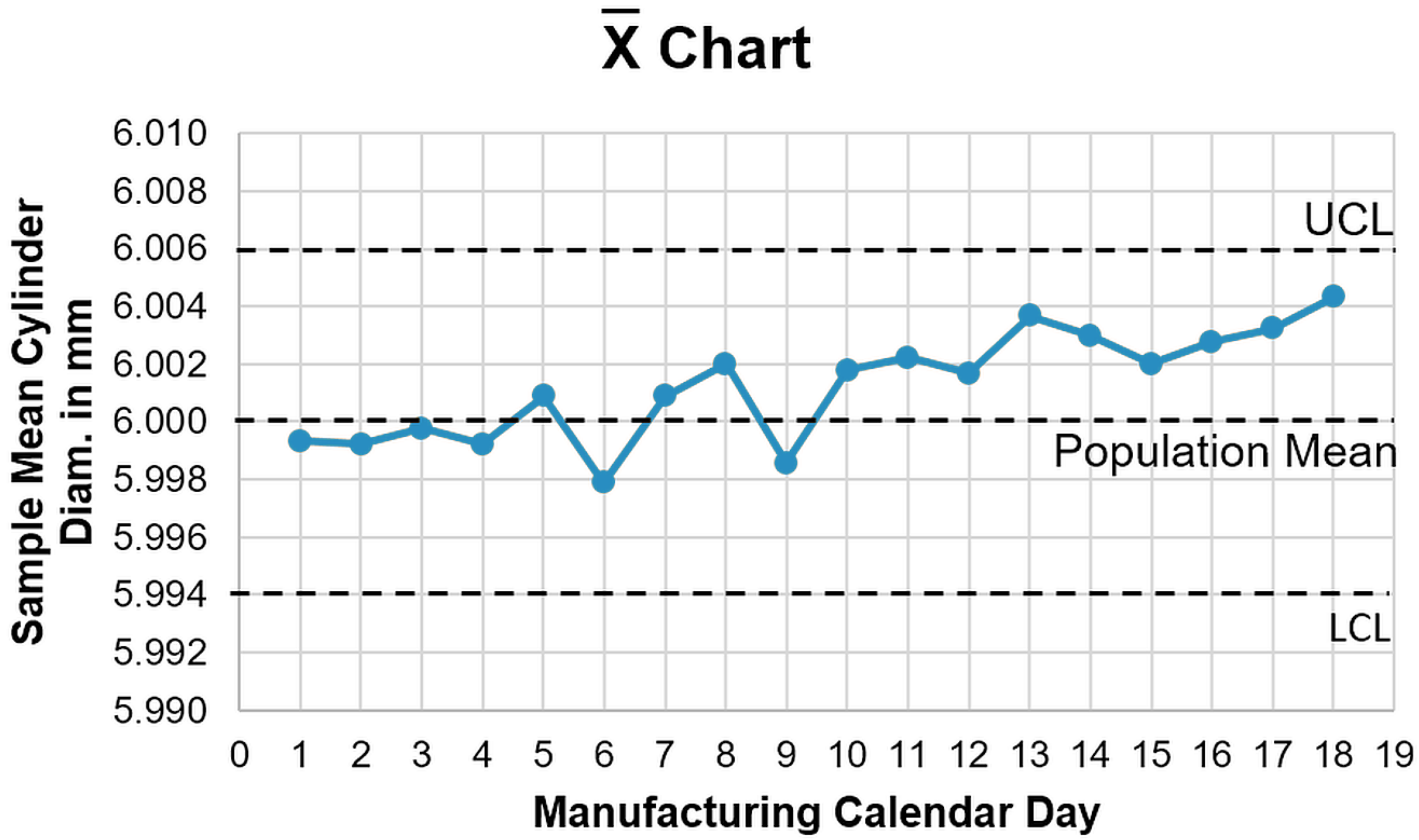
Control Chart



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Seven New Tools of Quality (N7)

- Affinity diagram
- Relationship diagram
- Matrix diagram
- Tree diagram
- Prioritization Matrix (Matrix data analysis chart)
- Process decision program chart
- Activity network diagram

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Affinity Diagram

Useful for organizing many brainstormed ideas

Issue: Product recall causes		
Inspection	Customer feedback	Product materials
Frequency	Costs	Return processes

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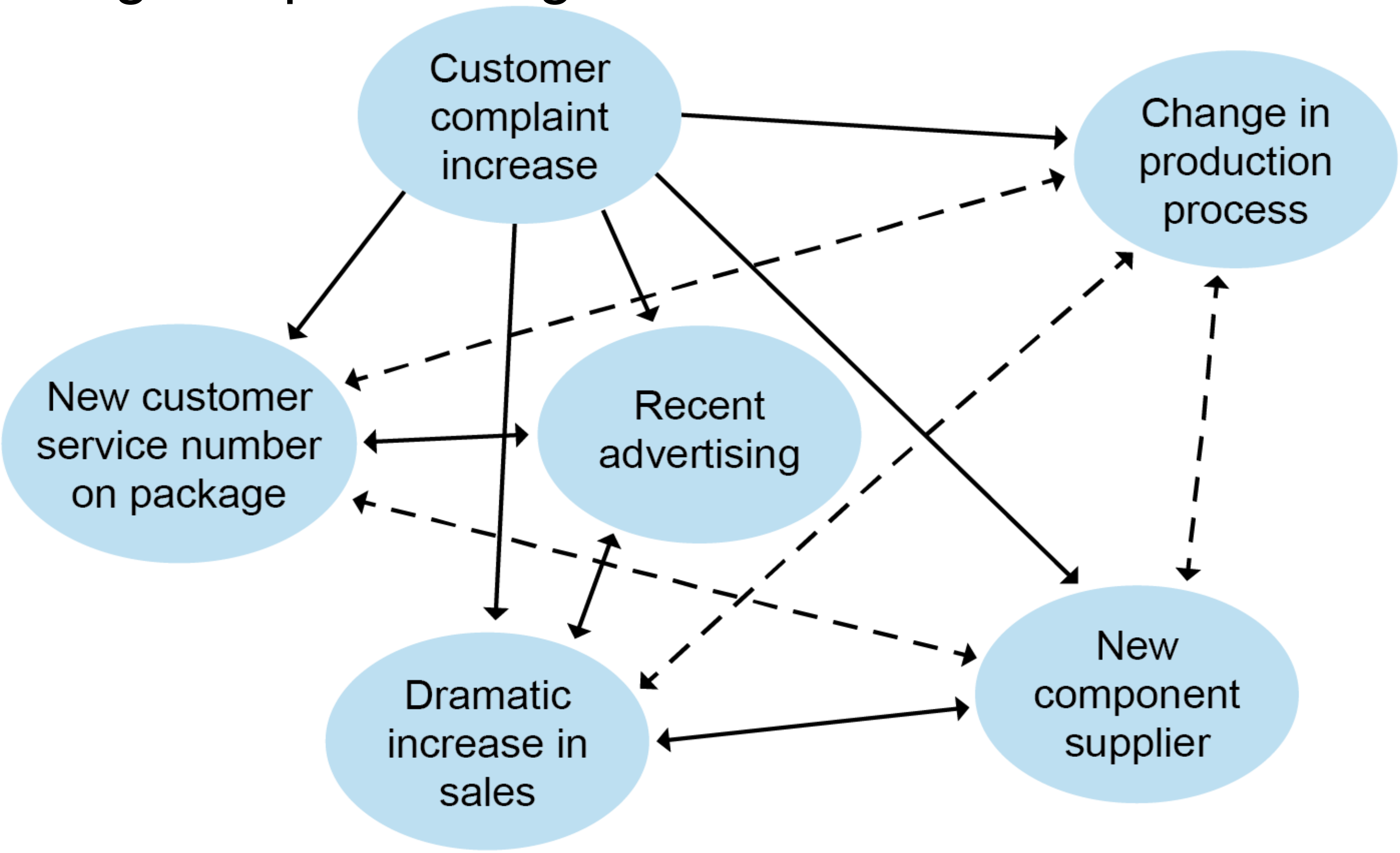
Relationship Diagram

Useful for evaluating complex linkages



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Matrix Diagram

Shows relationships between groups of information

Specification	Customer A	Customer B	Customer C
Width	≤0.789 cm	≤0.790 cm	≤0.785 cm
Length	≤1.11 cm	≤1.20 cm	≤1.01 cm
Thickness	≤0.55 cm	≤0.575 cm	≤0.545 cm
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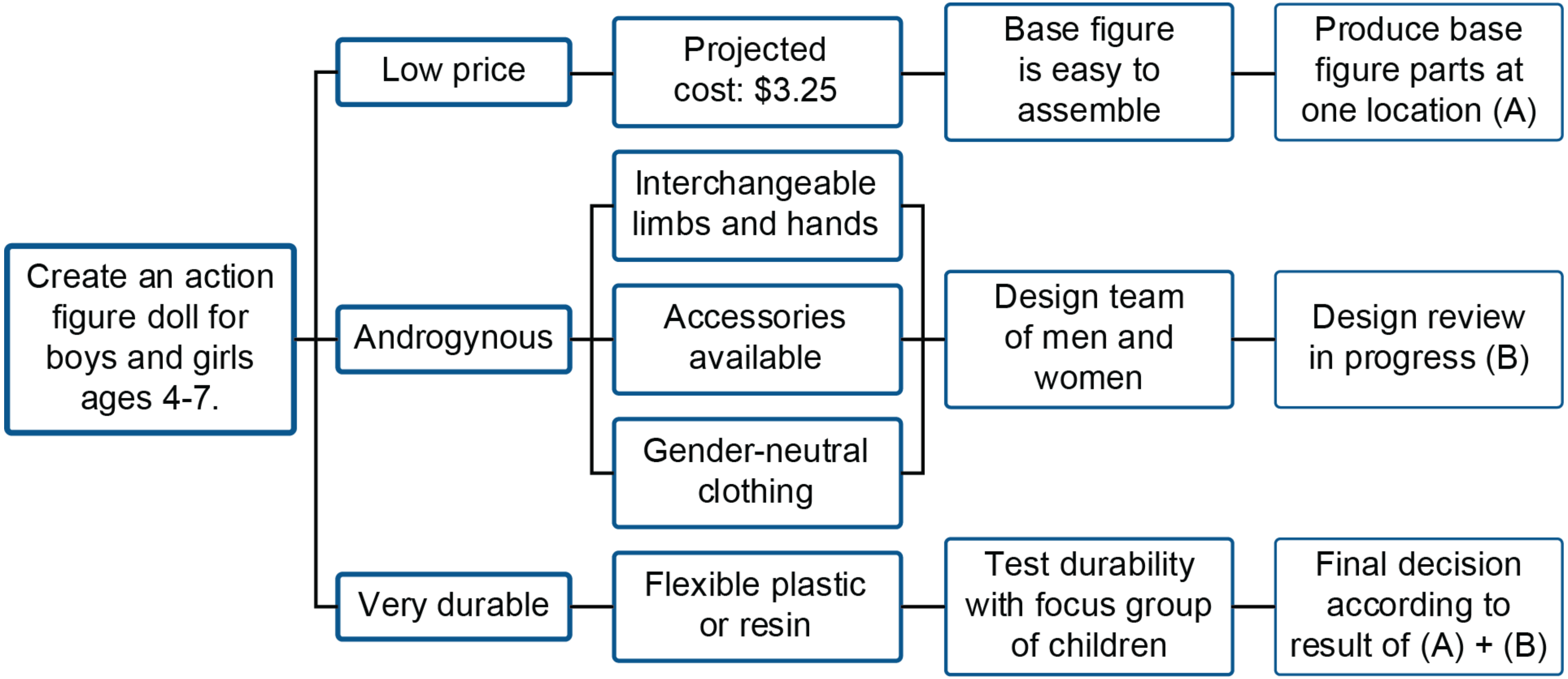
Tree Diagram

Start with a goal; specify aspects in increasing detail



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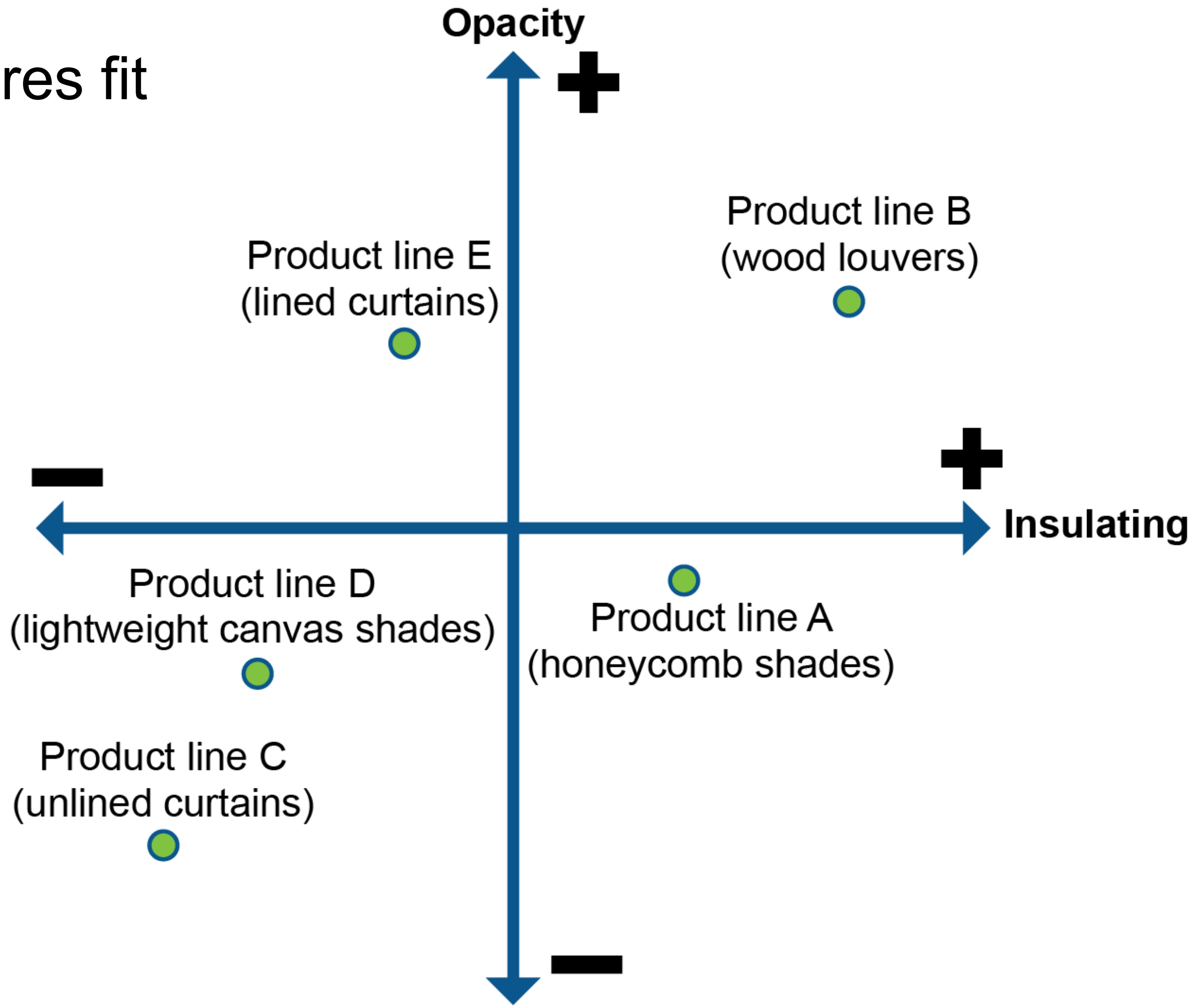
Prioritization Matrix (Matrix Data Analysis Chart)

Compares how products/features fit along two ranges



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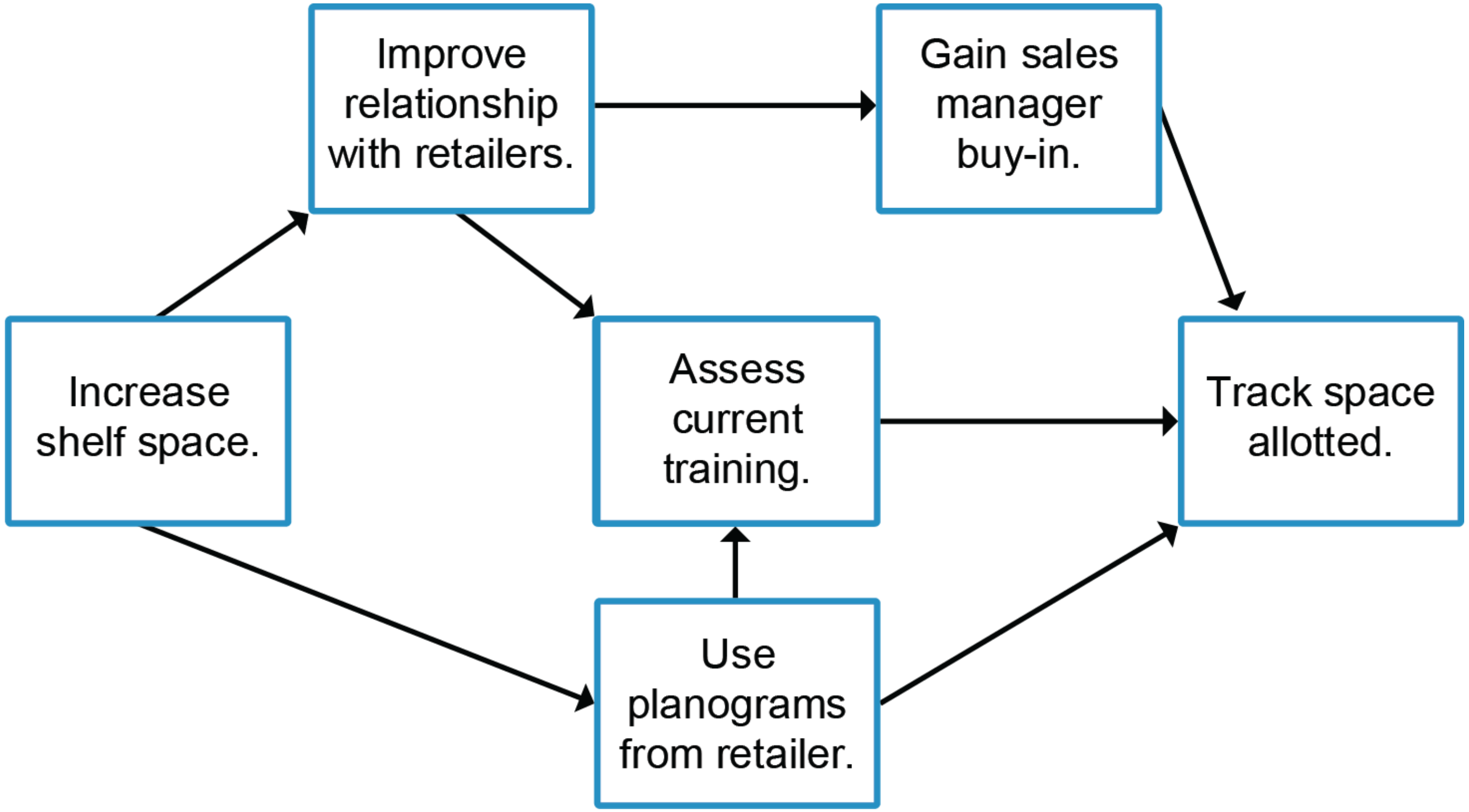
Quality Tools

Process Decision Program Chart

Visually shows proactive steps to be sure to include



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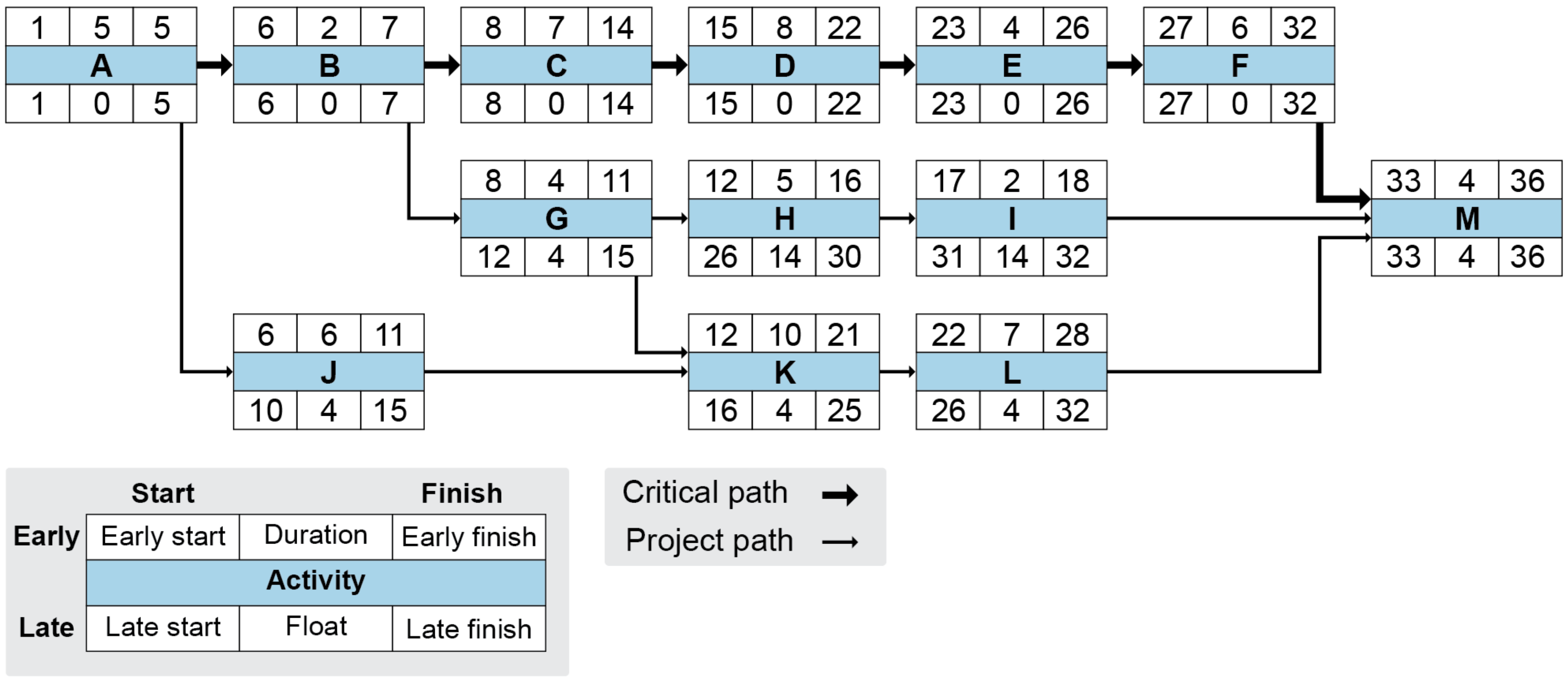
Activity Network Diagram

Project dependencies and simultaneous activities



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SECTION B:
CAPITAL EQUIPMENT AND FACILITIES

Section B Overview

Section B Learning Objectives

- Business planning
- Capital budgeting, payback period, net present value, internal rate of return, and profitability index
- Total productive maintenance
- Health, safety, and environment compliance
- Environmental footprint tradeoffs

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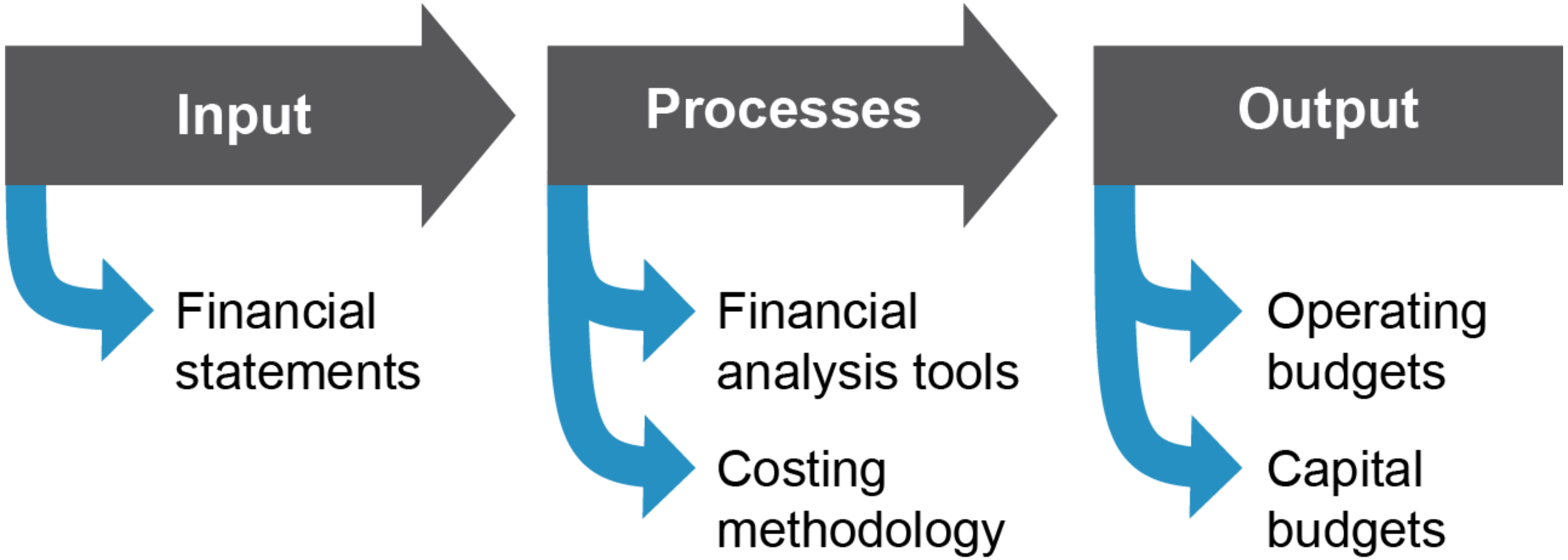
Business Planning

Statement of long-term strategy and revenue, cost, and profit objectives

Accompanied by budgets, a projected balance sheet, and a cash flow statement. Grouped by product family and translated into tactical functional plans through … S&OP.



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Capital Budgeting

Planning and financing of outlays for new equipment, new product lines, and plant modernization

- Opportunity cost
  - Return on capital that could have resulted if capital had been invested in another way
- Sunk cost
  - A cost already paid and not relevant to future decisions

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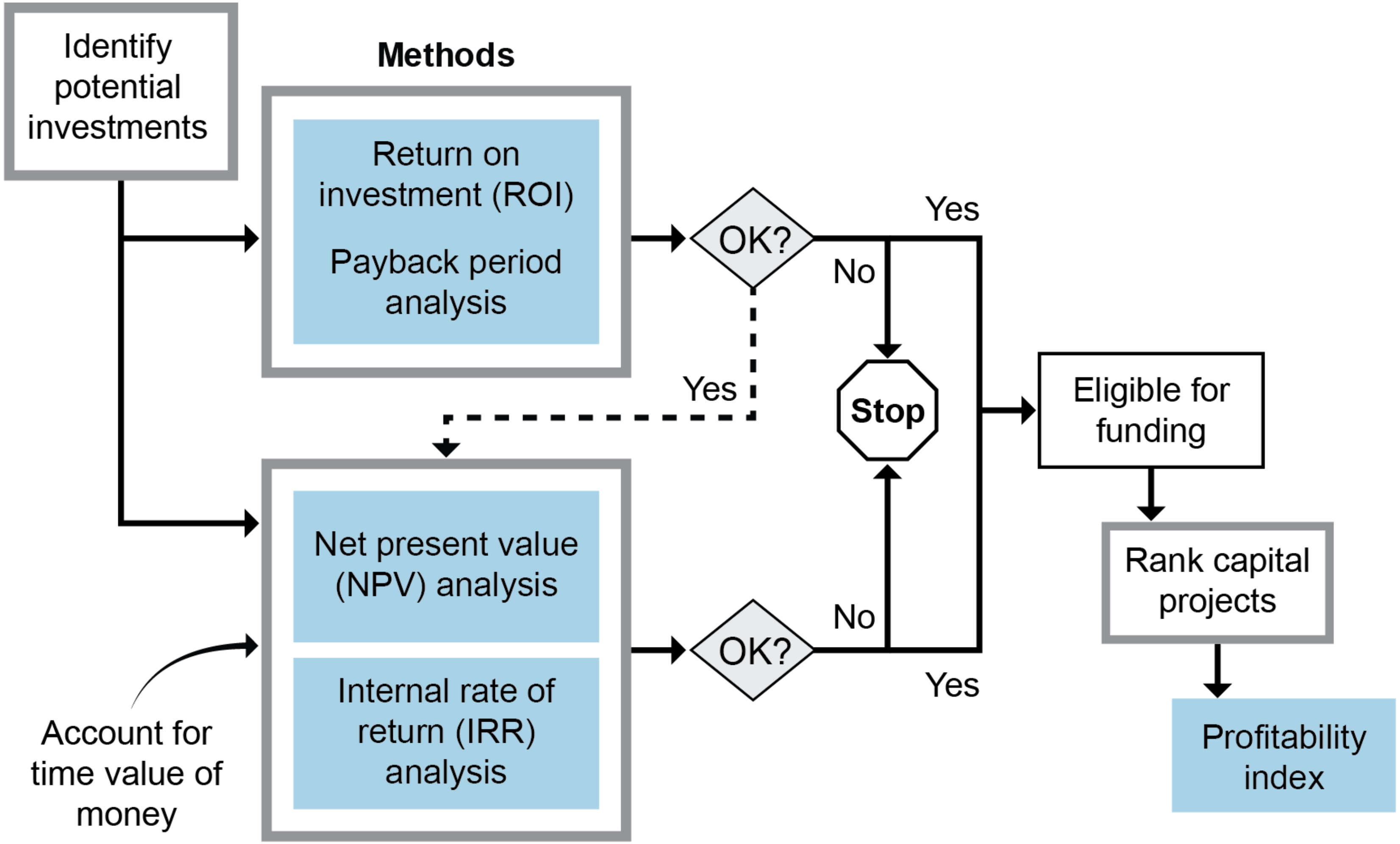
Business Planning and Capital Budgeting

Capital Budgeting Tools



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Net Present Value

General Process and Formula

- Anticipated net cash flows over project lifetime = future value (FV).
- Initial outflow is in period 0.
- Future is periods 1 to end.
- Future periods are reduced to present value (PV) using formula below or “annuity” calculation.
- Initial investment less PV is NPV.
- Formula for single sums (2 period example):

$$\text{Net Present Value} = \frac{\text{Cash Flow Period 1}}{(1 + \text{Discount Rate})} + \frac{\text{Cash Flow Period 2}}{(1 + \text{Discount Rate})^2} - \text{Initial Investment}$$

Annuity Example

Initial investment	$20,000
Estimated life	20 years
Annual cash inflows	$5,000
Cost of capital (minimum return)	12%
Present value ($5,000 x 7.47)	$37,350
Initial investment	($20,000)
Net present value	$17,350

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Reducing Facility Impact on HSE

Total productive maintenance (TPM)

- Preventive maintenance: scheduled downtime
- Flexibility, less material handling, and continuous flows
- Benefits
  - Equipment life/investment protection
  - Worker safety
  - Resilience

Health, safety, environment (HSE)

- Regulatory compliance
- Efficient use of energy, water, and other resources
- Protecting employee health and improving employee productivity
  - PPE
  - Lockout/tagout
- Reducing noise, waste, pollution, and harm to the environment

Safety data sheet (SDS)

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SECTION C: TECHNOLOGY

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Section C Learning Objectives

- Developing technology specifications to meet goals
- Current versus ideal state and gaps
- Factors affecting technology choices
- Technology implementation and maintenance
- Tradeoffs
- Managing technology risks
- Enterprise resources planning (ERP) systems
- Advanced planning and scheduling (APS) systems
- Emerging technologies

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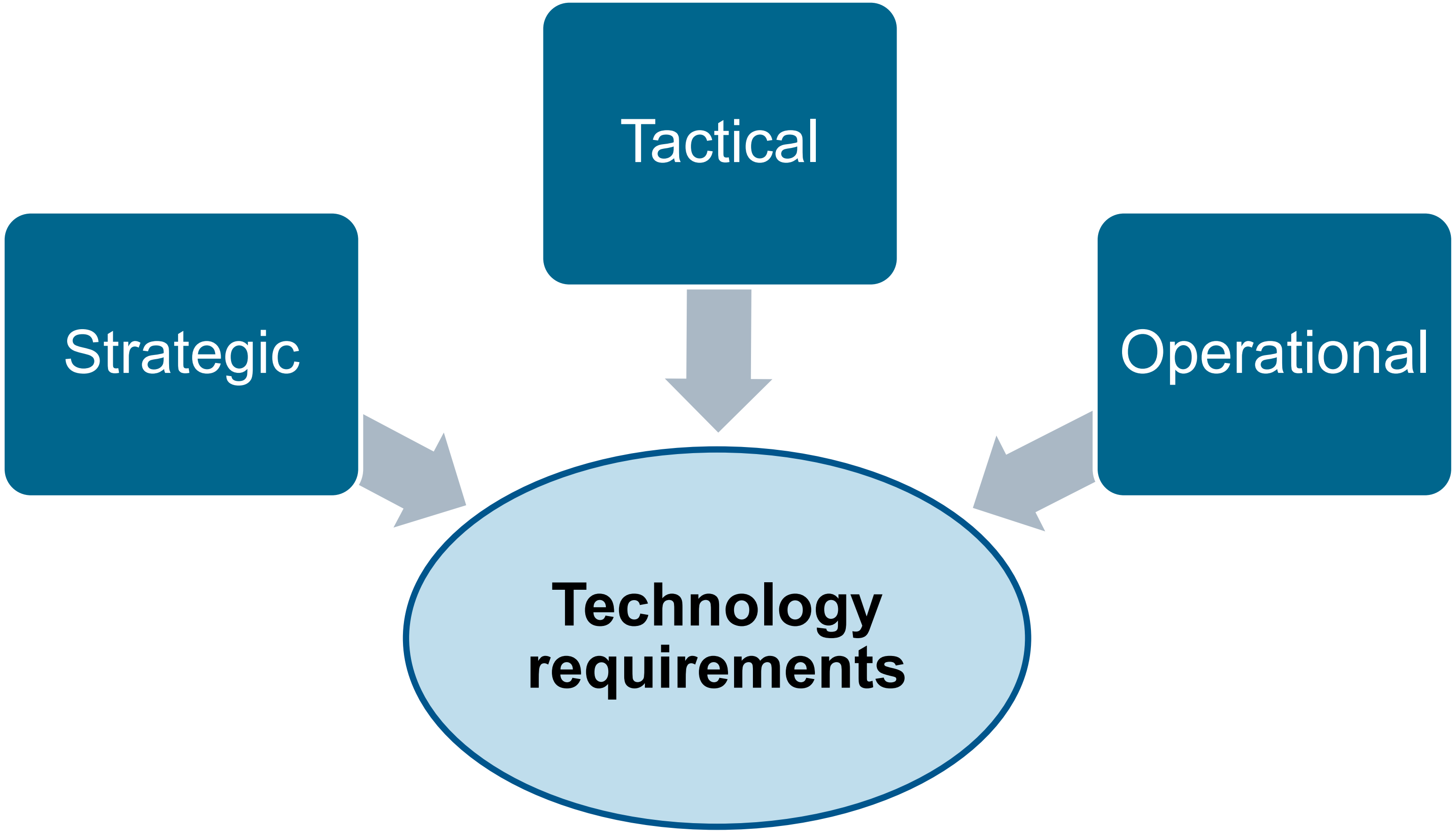
Technology and Equipment Requirements



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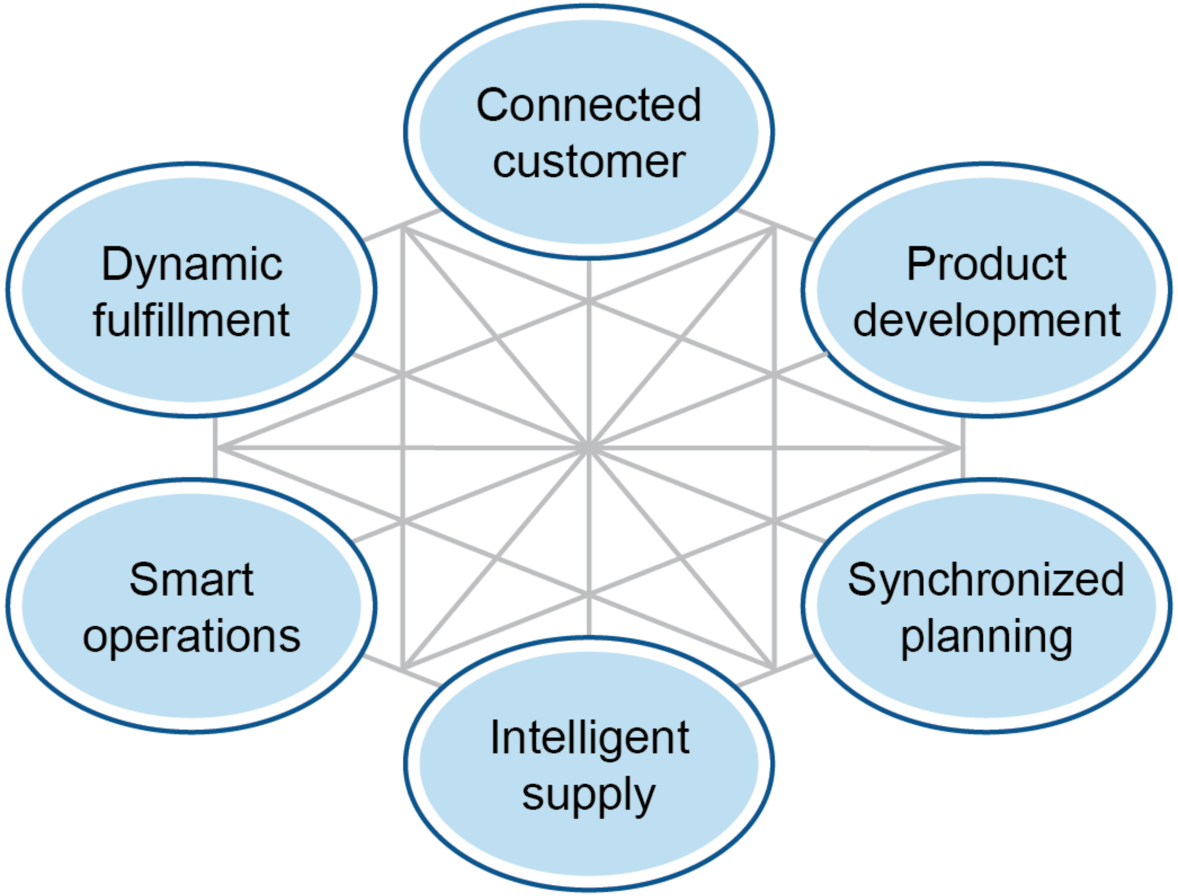
DCM for Supply Networks



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Technology Gap Analysis

Moving from the current state…

…to the desired future state

Using analytic tools
(e.g., benchmarking, flowcharts)

Can reveal

- Limitations or untapped uses of existing technology
- Processes that need to change
- Gaps in available human resources and supply chain partner capabilities.

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Technology Selection Criteria

Competitive advantage

- Is the technology scarce?
- Is it difficult to move, copy, or substitute?

Feasibility

- Is the technology cost-effective when all costs are considered?
- What is the predicted learning curve?

Risk

- Can changes negate or lessen the advantages the technology conveys?
- Are the effects of the technology sustainable?

Validation against requirements

- Does the technology advance the ability to meet performance objectives?

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Implementing Technology

Technology benefits	Overcoming common obstacles
▪ Increasing decision-making speed and quality ▪ Increasing responsiveness to change in markets ▪ Reducing risks ▪ Increasing top and bottom lines	▪ Show business case and ROI. ▪ Support technology investment with investments in workforce development. ▪ Manage risks and provide for business continuity. ▪ Secure vendor/supplier support.

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Preparing for Implementation

Technology cutover plan	Maintaining technologies
▪ Select plan for implementation: – Go live – Cutover while maintaining old system – Rolling cutover (e.g., by site)	▪ Assign responsibility. ▪ Establish maintenance policies and procedures. ▪ Assess impacts on and of maintenance. ▪ Develop necessary skills. ▪ Determine schedules and parts inventory.

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Master Data and Data Governance

Master data

Core data needed to perform business activities

Master data management

Data storage methods to ensure sharing between functions

Data governance

Accessibility, usability, reliability, and security policies

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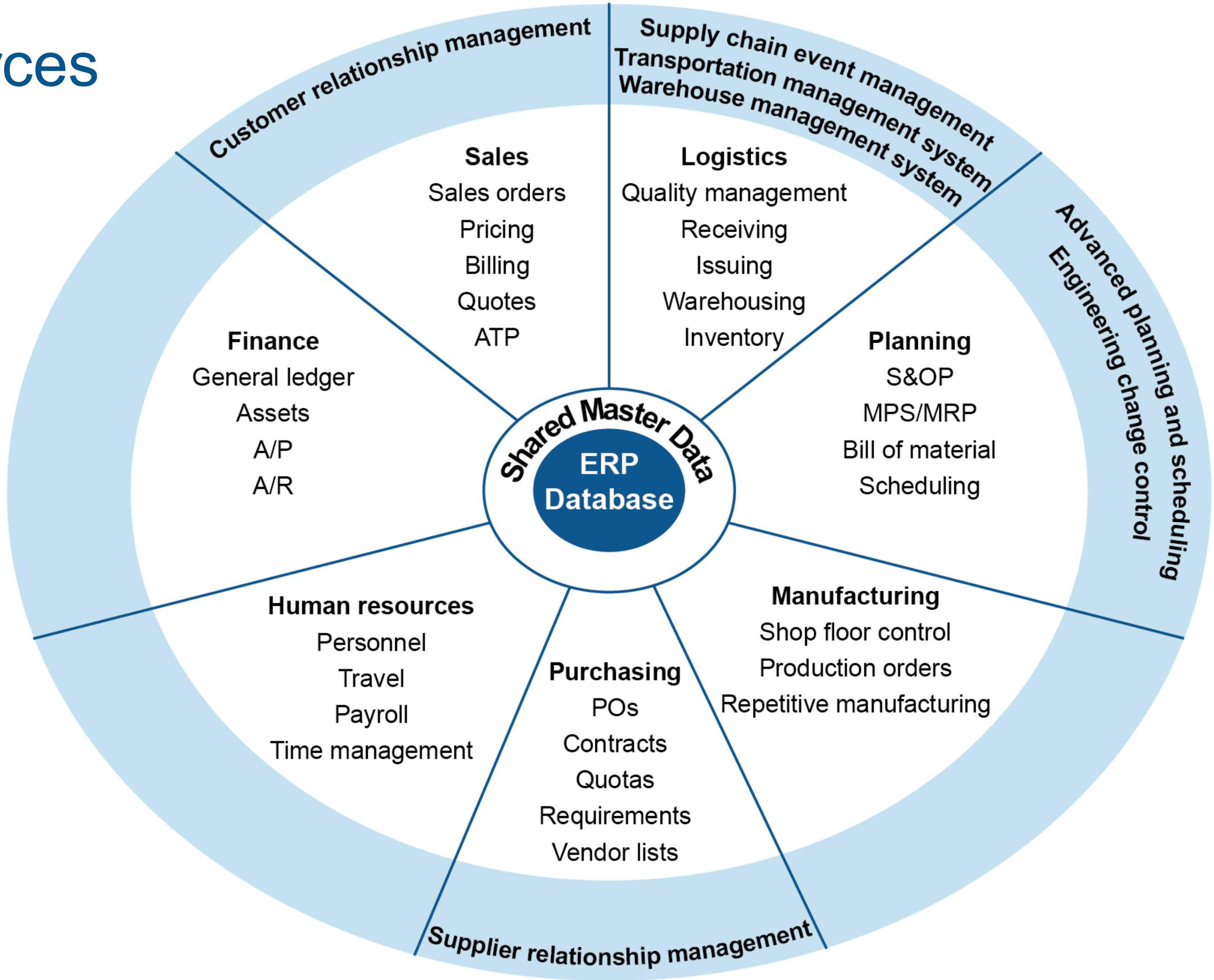
Enterprise Resources Planning (ERP)



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Evolution from MRP to ERP

	MRP	MRP closed loop	MRP II	ERP
MRP processor	●	●	●	●
Closed-loop feedback		●	●	●
Best-practice processes			●	●
Common database			●	●
Sales and operations planning			●	●
Total cross-functional software and process integration				●

MRP II = Manufacturing resources planning

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APS Systems

- "…analysis and planning of logistics and manufacturing during short, intermediate, and long-term time periods." (*ASCM Supply Chain Dictionary*)
- Simultaneously plans and schedules production based on available materials, labor, and plant capacity.

Capacity Planning	
RCCP	**APS**
Uses load data	Uses both transactional and operational data
Plans work center capacity	Plans multiple sites
Does not address logistics capacity	Integrates production and logistics capacity analysis

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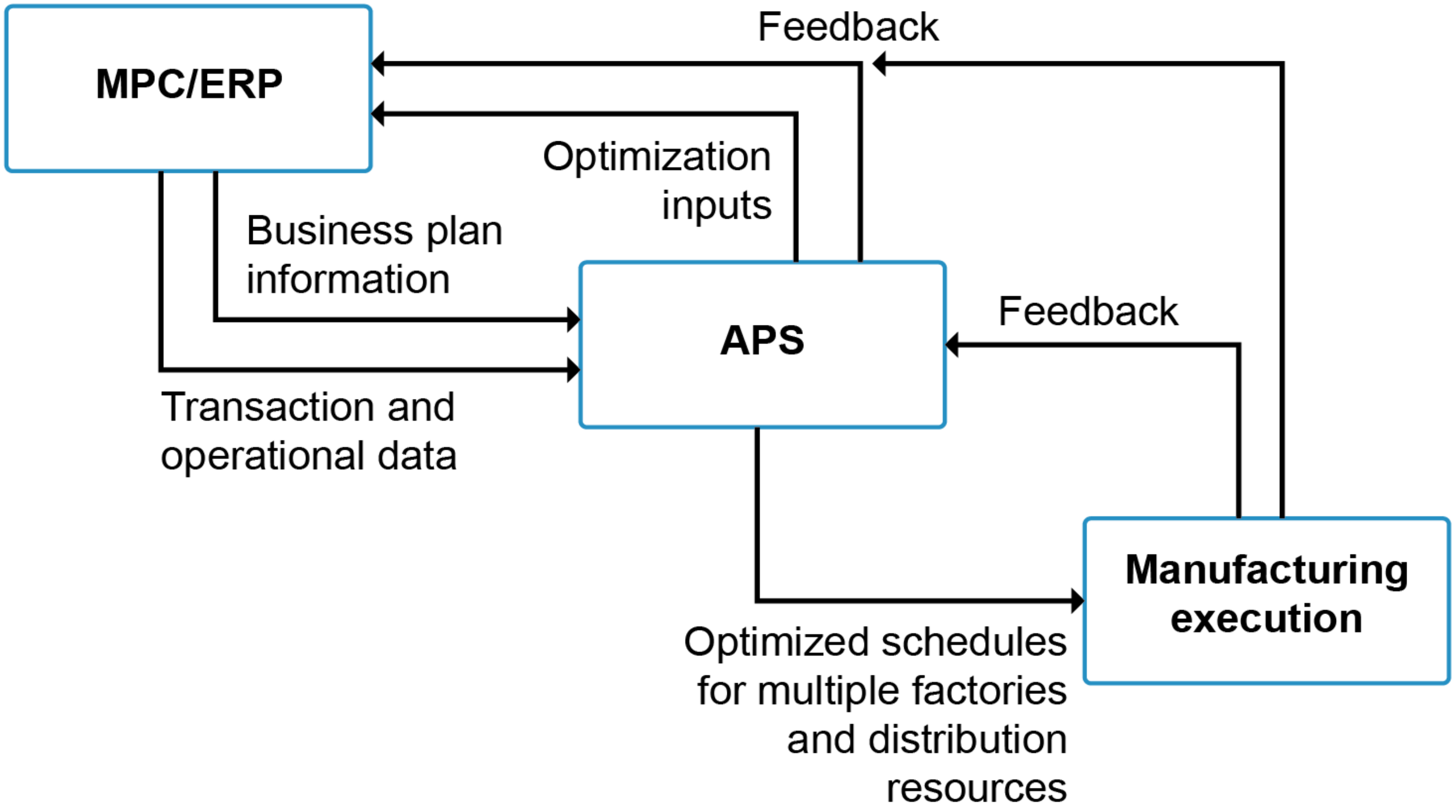
APS Process Flow



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Other Established Technologies

Electronic data interchange	Decision support systems

Electronic data interchange

Paperless exchange of
- Purchase orders
- Shipment authorizations
- Advanced shipping notices
- Invoices

Decision support systems

- AI-enabled system to aid managers in selecting course of action through logical analysis of relevant factors
- Process
  - Draw data from multiple sources.
  - Filter data to manageable level.
  - Load data into a model.
  - Suggest actions.

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Emerging Technologies Exercise

- Cloud computing
- Machine learning, artificial intelligence, data analytics
- Blockchain
- Internet of Things (IoT)
- Sensors and telematics
- 3D printing
- Wearable technology and augmented reality (AR)
- Robotic process automation (RPA)
- Autonomous and automated solutions

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SECTION D:
CONTINUOUS IMPROVEMENT

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Section D Learning Objectives

- Cross-functional teams
- Continuous improvement strategies
- Lean philosophy and continuous improvement
- Lean tools
- Employee participation in continuous improvement
- Root causes and problem solving: six sigma, DMAIC, PDCA, brainstorming
- Benchmarking
- Work area design
- Statistical process control
- Process capability analysis

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Continuous Improvement Strategies

Continuous Process Improvement

- Small step as opposed to big step
- Never-ending
- Make product or process
  - More effective (Do the right things.)
  - More efficient (Do the things right.)
- End results
  - Better quality: customer satisfaction, market share
  - Productivity and eliminating waste: more done with existing, less investment
- Necessary for competitive survival

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Continuous Improvement Strategies

Continuous Process Improvement for Products or Processes

Continuous improvement of products	Continuous improvement of processes
▪ Update market qualifiers and winners. – Features to add/remove ▪ Product improvements have many stakeholders. – Ensure efficient manufacture	▪ Also a team effort. ▪ Can focus on small part of process: – One work center – One area under your control ▪ Find the right improvement methodologies to apply.

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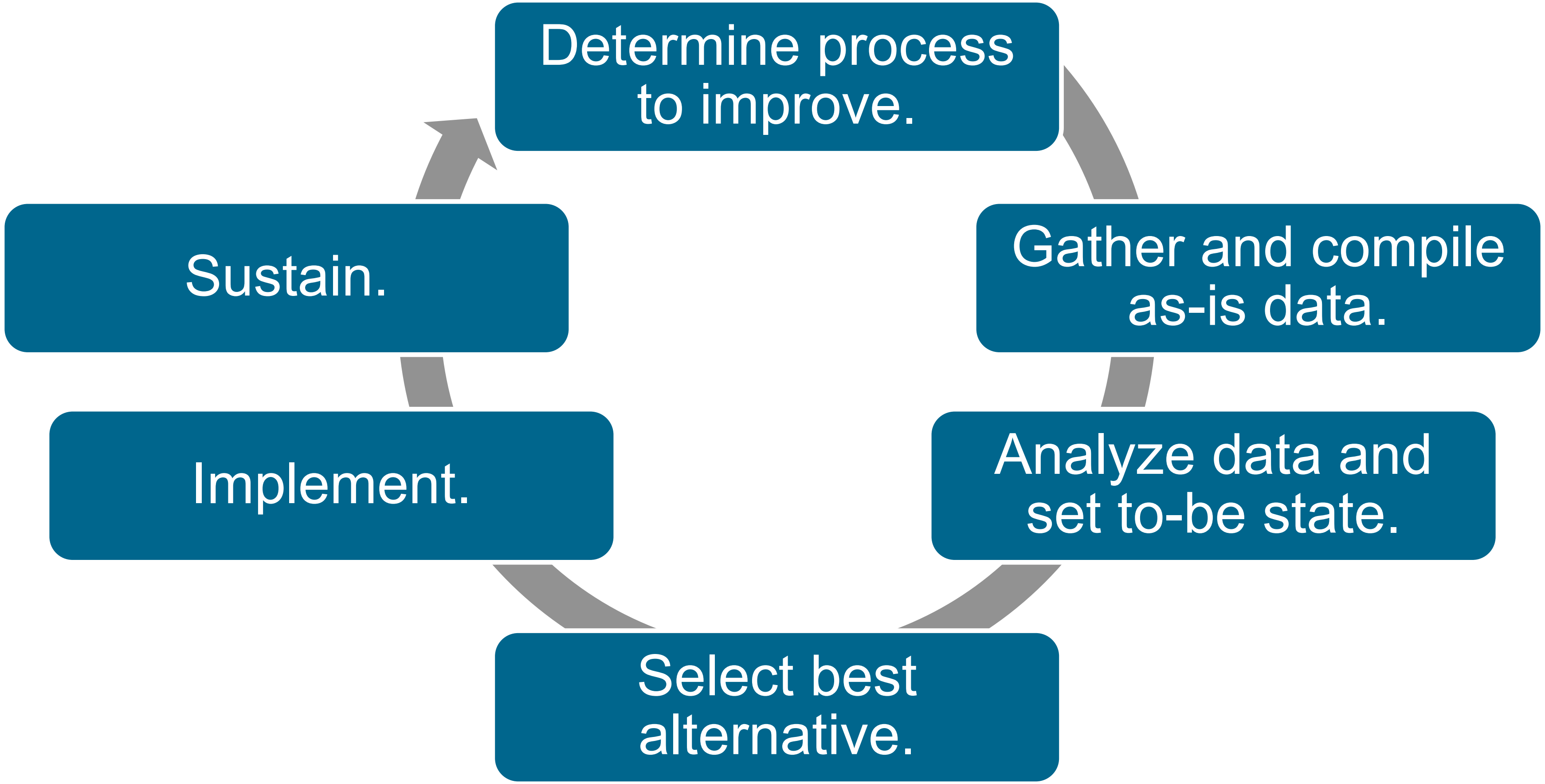
Continuous Process Improvement



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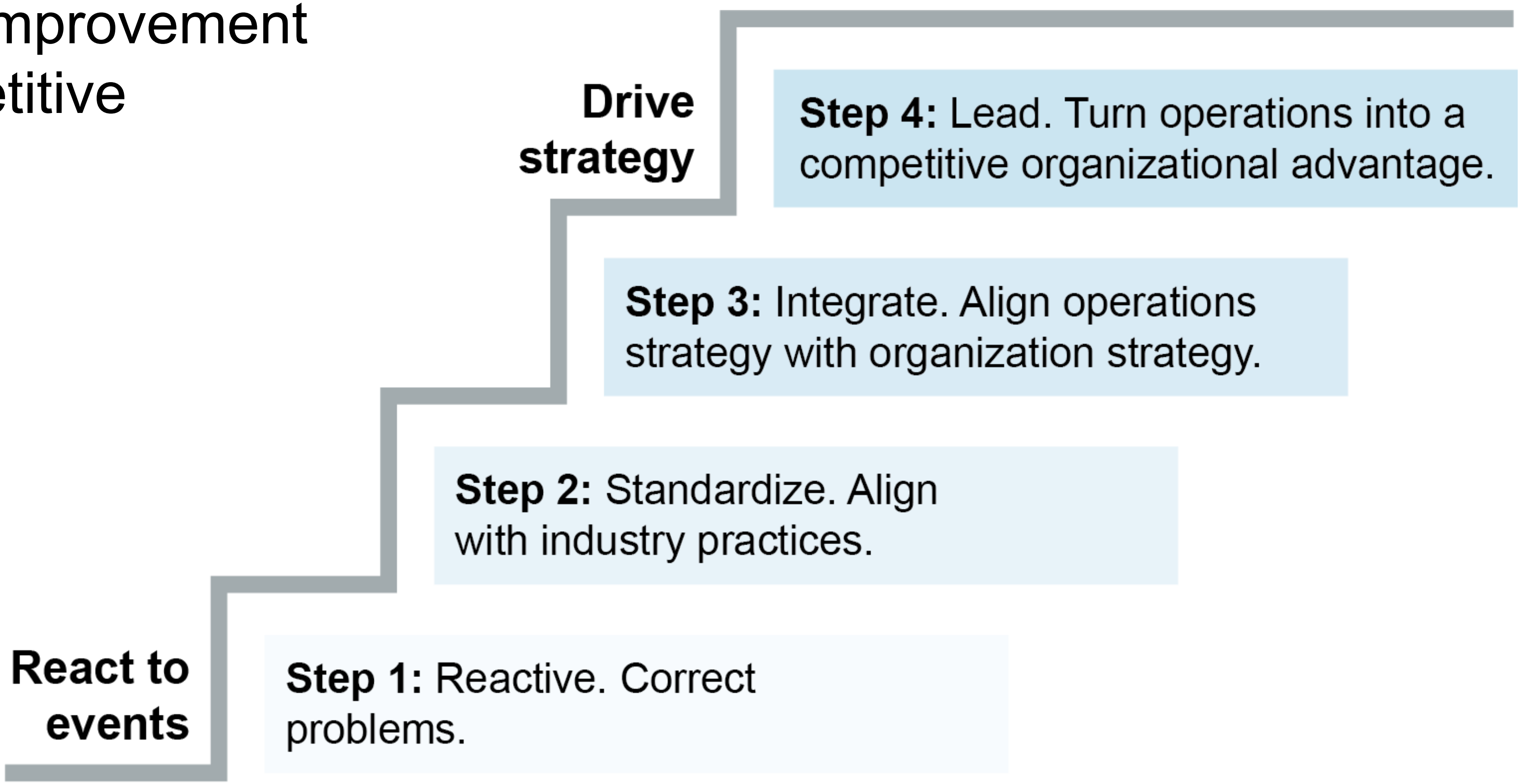
Operations’ Evolving Contribution to Competitive Advantage

Continuous improvement drives competitive advantage.



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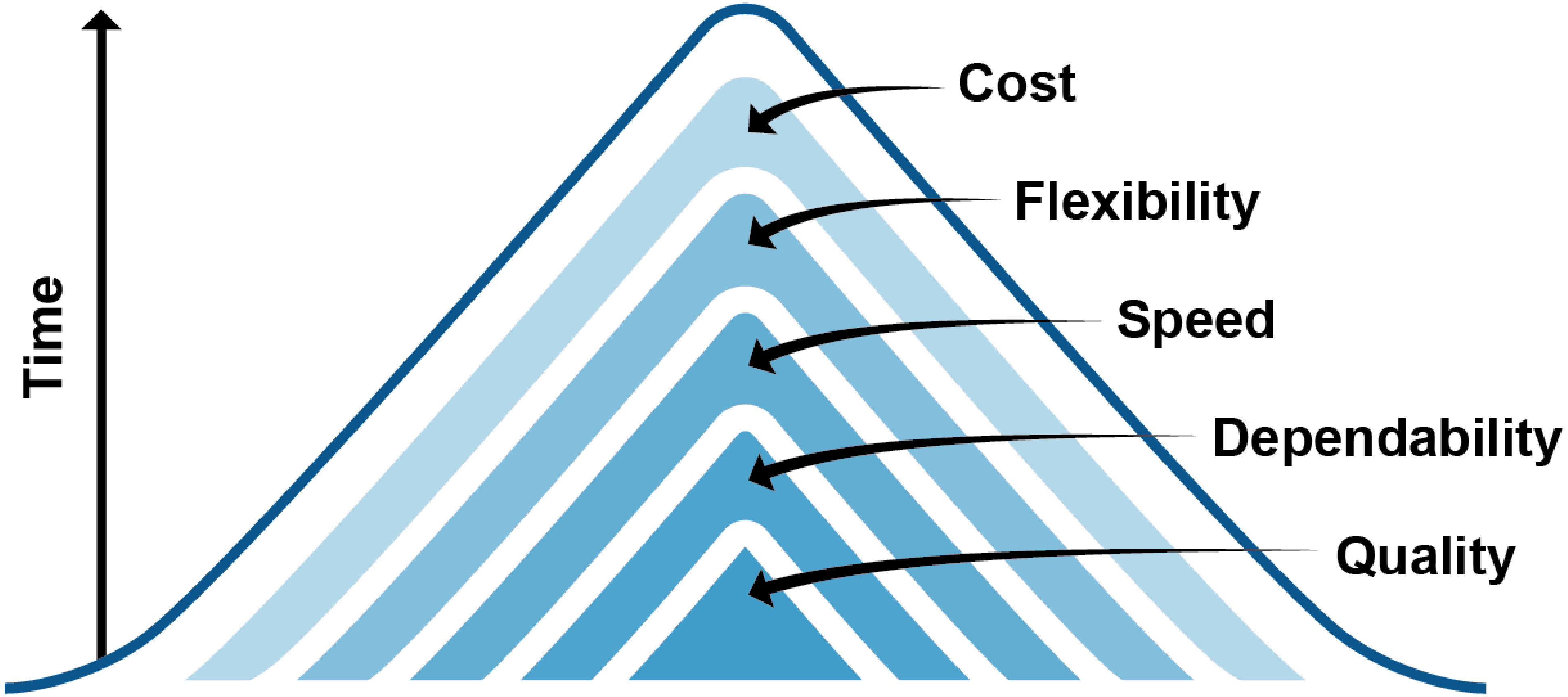
Continuous Improvement Strategies

Sand Cone Model



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Continuous Improvement Commonalities

Ensuring employee involvement, empowerment

- Employee involvement
  - All parts of organization are involved and contribute to constructive change.
- Employee empowerment
  - Managers delegate certain duties to subordinates.
  - Generally smaller teams are used to ensure that changes are accomplished quickly and efficiently.

Focusing on customer

- Customer is ultimate definer of quality.
- What customer is willing to pay for.
- Internal and external customers.

Sustaining continuous improvement

- Ongoing cycle, "continuous."
- Sustainable.

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Knowledge Management

Integrated approach to capture, share, develop, and use organizational knowledge

Tacit knowledge → Explicit knowledge =

- Productivity
- Customer service
- Collaboration
- Reduced risk

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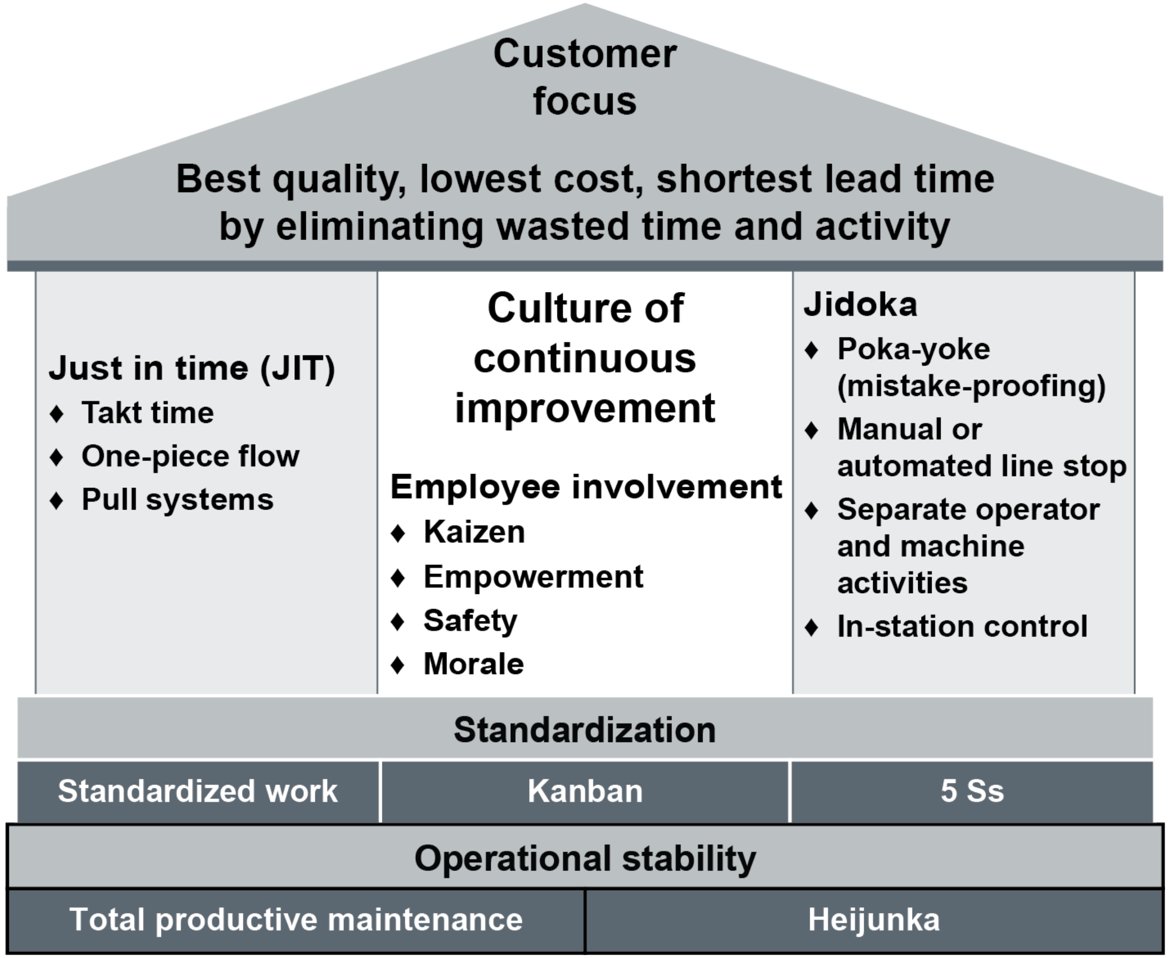
House of Lean (House of Toyota)



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Roof: Eliminate Waste

Waste	Description	Examples
Processing	Unnecessary or inefficient steps	Scrap, wrong tools
Movement (transportation)	Excess movement	Storage before need, long moves
Methods (motion)	Wasted time or effort	Excess walking, looking for tools
Product defects	Product or service not to specifications	Repair, rework, replacement, inspection
Waiting time	Queuing delays	WIP build-up, waiting for materials
Overproduction	Production over demand	Equipment busy despite no demand
Excess inventory	Inventory above demand	Excess safety stock
Unused people skills	Waste of capabilities	Not asking shop floor

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Center: Culture of Involvement and Continuous Improvement

- Respect employees.
- Real responsibility for quality.
- Listen to workers on shop floor.

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Foundation: Standardization and Operational Stability

- Level the schedule to process volume/mix using capacity.
- Standardize processes, parts.
- Two tools:
  - Total productive maintenance, or TPM (operator-oriented preventive maintenance)
  - 5Ss (sort, simplify, scrub, standardize, sustain)

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Pillar One: Just in Time Manufacturing

- Quality: zero defects
- Takt time: Daily demand rate = daily production rate
  - Heijunka: Supply chain on takt time
- One-piece flow (Optimal batch is one unit.)
  - Process flexibility to change volume/mix
  - Operator flexibility (cross-training)
  - Quick setups (short lead times)
- Pull systems (continuous flow production)
  - Cellular reduces WIP and simplifies scheduling
  - Demand pull

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Pillar Two: Jidoka

- Correct first instance: find root cause
  - Mistake-proof process or design
- Automated or manual line stop after defect detected

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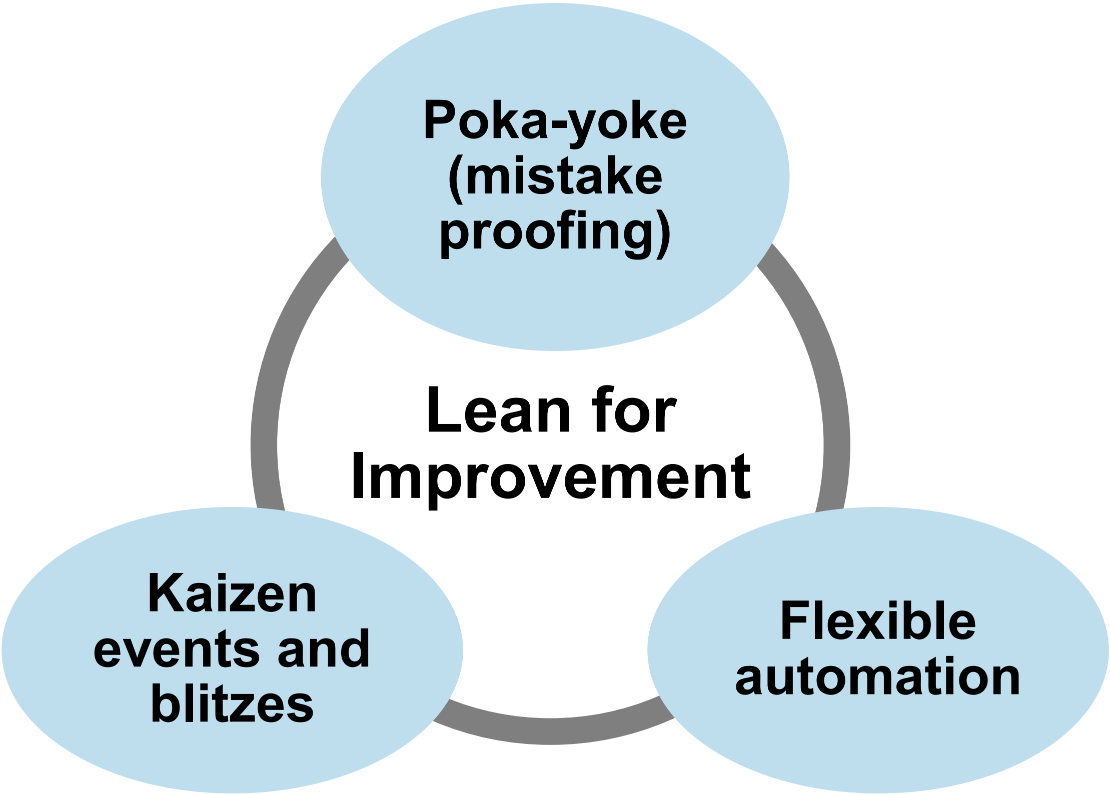
Lean Tools and Techniques



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Lean Principles for Process Improvement

Reduce WIP and lead time by

- Producing only what is needed to meet customer demand
- Capping finished goods at demand needs
- Improving flexibility of processes and decreasing changeover times.

Lean production tools

- Value stream mapping
- Pull systems
- Setup reduction
- Total productive maintenance

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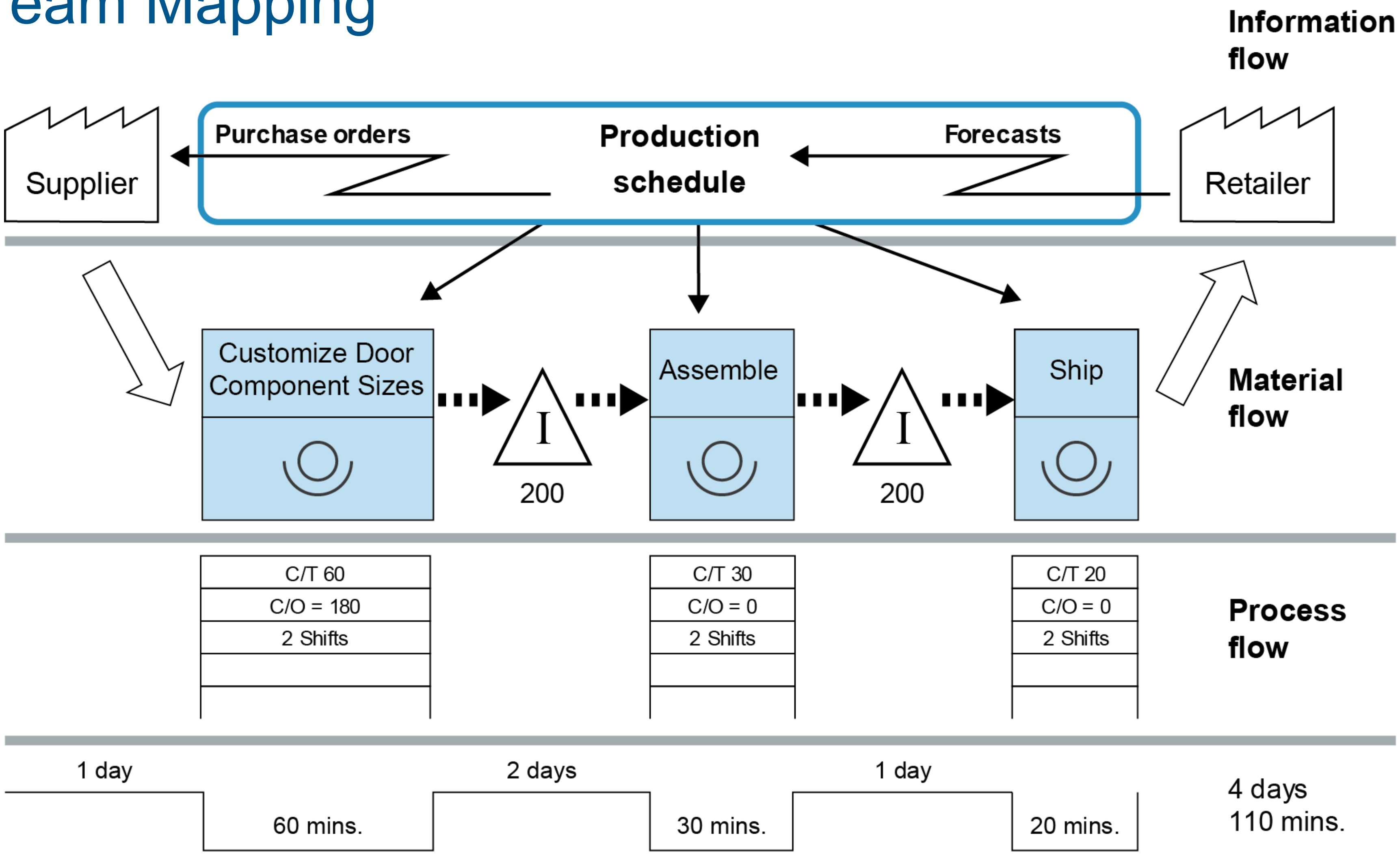
Value Stream Mapping



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Pull System

- Supply is matched to demand.
  - Factory produces only what its customers use.
  - Each workstation produces only enough to supply what the next workstation in the process requires.
- Parts inventory may be managed with supermarket approach.
- Synchronous systems control velocity of process flow; results in reduction of lead time.

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Reducing Setup/Changeover Time

1. Classify internal/external tasks.
2. Convert internal tasks to external.
3. Streamline internal setup.
4. Eliminate adjustments.
5. Minimize preparation time.

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Total Productive Maintenance (TPM)

- Proactive strategy aimed at both threats and opportunities
- Multiple benefits
  - Reduces downtime and improves dependability
  - Improves quality
  - Improves costs
  - Triggers continuous technology and process improvements
  - Extends life of equipment and protects organization's capital investments
  - Improves worker safety
  - Makes system more resilient to unexpected interruptions

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Overall Equipment Effectiveness (OEE) Metric

OEE Category	Six Big Losses	Examples
Loss of availability	Breakdowns	Unplanned maintenance, tooling failure, motor failure, overheated bearing
	Setup and adjustment	Setup/changeover, operator shortage, major adjustment, material shortage, warm-up time
Loss of performance	Idling and minor stops	Minor adjustment, component jam, blocked sensor, cleaning/checking, delivery blocked
	Reduced speed	Equipment wear, wrong setting, alignment problem
Loss of quality	Quality losses	Rework, scrap
	Start-up	Rework, scrap

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Lean in Service Environments

- Use as a framework.
- Prerequisite: service organization has clear operational objectives.
- Time required to deliver service is a primary cost driver.
- Wait time reduction.
- Tactics to implement
  - Common vision
  - Kaizen event or blitz
  - Lean in action

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Employee Involvement and Empowerment

Critical success factors

- Management shapes policy direction.
- Management provides feedback.
- Workers have skills, varying attitudes, and capabilities.
- Quality goal setting is collaborative.
- Management is supportive.
- The culture of the organization is important.

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Worker Self-Control

Workers have

- Knowledge of what to accomplish
- Knowledge of performance against goals
- Means of regulating performance

…In an environment in which

- Worker tasks are adequately planned
- Work is standardized
- Process variation is under control
- Workers have access to tools to maintain self-control.

Workers can be held responsible for quality.

Quality problems are worker-controllable.

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Bonus Rewards Program Exercise

- Manufacturer Y bases its annual employee bonus program mainly on meeting production and profit goals. Quality goals are long-term goals to maintain industry competitiveness.

  Assess the strengths and weaknesses of the current bonus program.

- Manufacturer Y is considering a quality-focused employee bonus program, consistent with worker self-control of production and quality, to drive down failure, prevention, and appraisal costs, improve yields, and increase market share.

  What criteria can be used to design a new bonus program?

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Job Enlargement and Enrichment

Characteristic	Action
Skill variety	Combine sequential tasks. Worker performs more tasks and uses more skills in producing a product (enrichment through horizontal job enlargement).
Autonomy	Workers help decide how to do a job because they are closest to the process. They are decision makers and producers (enrichment through vertical job enlargement).
Task identity	Work is assigned to small teams to assemble a product from start to finish. Workers thus see and identify strongly with the finished product.
Task significance	Workers have authority to communicate directly with customers on production issues.

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Employee Empowerment

Training

Cross-functional training	Focused, timely training

- Benefits
  - Cost savings
  - Replacement workers
  - Employee motivation

Challenges to reaping benefits from training

- Timeliness
- Wrong things/participants
- Wrong method of delivery
- Over-complication

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Performance Appraisals and Rewards

Recognition/reward system

- Sense of ownership
- Long-term focus on continuous improvement
- Less service operating cost
- Teamwork
- Minimizes dissatisfaction
- Enhances interest in financial performance of organization

Appraisals

Direct labor performance measurement categories:

- Ideas
- Teamwork
- Flexibility
- Quantity
- Quality

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Relationship Improvement Tools

Supply Chain Quality Improvement

Management endorsement

- Publicly endorsing and actively supporting joint planning
- Synchronizing operations with suppliers and customers

Cross-functional quality improvement teams

- Coordinating SCM strategies and operations
- Finding and attacking chronic problems
- Implementing cost-reduction efforts
- Creating value, eliminating waste

Pareto analysis

- Vital few over trivial many
- Cross-functional customer and supplier teams set priorities, resource requirements, and schedules

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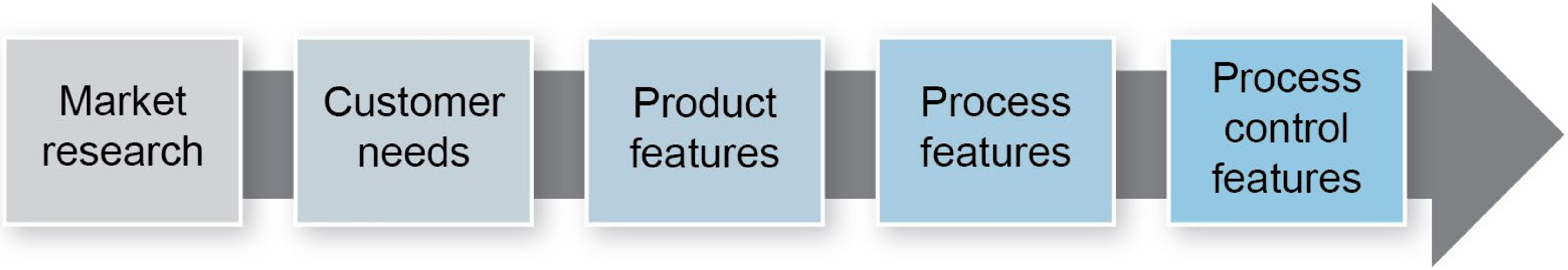
Relationship Improvement Tools

Quality Function Deployment



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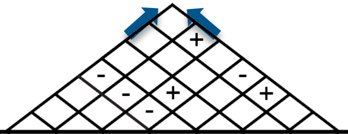
VOC and House of Quality

- Value analysis.
- Voice of the customer (VOC), e.g., "easy graffiti removal":
  - Direct input from customers regarding needs and experiences
  - Difference between what is value-added versus waste
  - New product features determined by working backward
- Manage tradeoffs.
- Identify and meet all major customer requirements.

Key:
+ Supporting requirement
- Conflicting requirement



In-Stock, All-Glass Vandal-Proof Double Door Customer Needs	Priority (1–5)	Vandal proofing	Glass thickness	Break-in resistance	Smooth operation	Door durability	Crashbar durability	Insulation value	Competitor Evaluation U = Us X = Competitor X Y = Competitor Y Low				High
Easy graffiti removal	5					-			Y		X		U
Break-in resistance, door	5	+				+				Y	X		U
Break-in resistance, lock	5				+		+		Y		U		X
Smooth, durable operation	4		-	+		-	+	-	U	X	Y		
Long-term attractiveness	3	-			+		+	+			U	Y	X
Low maintenance parts	2			+	+					U		X	Y
Insulation value	1	+	+			+					U	Y	X
Target Engineering Values		Polycarbonate thickness 1 mm	Tempered glass thickness 4 mm	Floor-to-top lock rods 6mm diam.	Closer hydraulic cylinder 6mm diam.	Stainless steel thickness 3mm	Crashbar springs 8 gauge	Weather seal thickness 2 mm					
Responsibility		C	C	W	F	B	B	R					

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Partnership-Based Quality Planning

Quality planning techniques	Supplier control steps

Quality planning techniques

- Teams
- Multiple channels
- Value engineering
- Total cost of ownership
- Other quality-related planning activities
- Co-location

Supplier control steps

1. Assemble cross-functional team.
2. Select critical performance metrics and minimum standards of performance.
3. Assess supplier performance: quality system, business management, product fitness for use.
4. Reduce supplier base: can meet minimum standards.

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Continuous Improvement Design Activities

Collaboration Technologies	Supplier Feedback
Effective collaboration with supply chain partners requires that your organization share valuable information in real time. ERP systems provide a **holistic view of the impact of tradeoffs** between conflicting needs in various parts of the organization and the supply chain.	Concept of quality at the source includes receiving quality components from suppliers. **SIPOC** **S** (supplier) **I** (input) **P** (process) **O** (output) **C** (customer)

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Six Sigma

- Six sigma and Lean Six Sigma
- Objectives
  - High customer satisfaction
  - Low product return rates
  - Systematic reduction in variation in all processes to no more than 3.4 defects per million opportunities
  - Upper and lower specification limits that create doorway twice as wide as vast majority of process spread (six sigma control limits)

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Structured Problem-Solving Tools

Six Sigma Methodology

- Combined approach for process improvement and problem solving partly based on lean.
- Initiate at top levels of management and translate into goals and guidelines at middle levels.
- Major concepts:
  - Begin with customer's needs in mind.
  - Variation is cause of defects.
  - Output of any process is function of its inputs.

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Structured Problem-Solving Tools

Six Sigma and DMAIC

- Emphasis on measuring results and making fact-based decisions
- DMAIC process
  - **D**efine
  - **M**easure
  - **A**nalyze
  - **I**mprove
  - **C**ontrol

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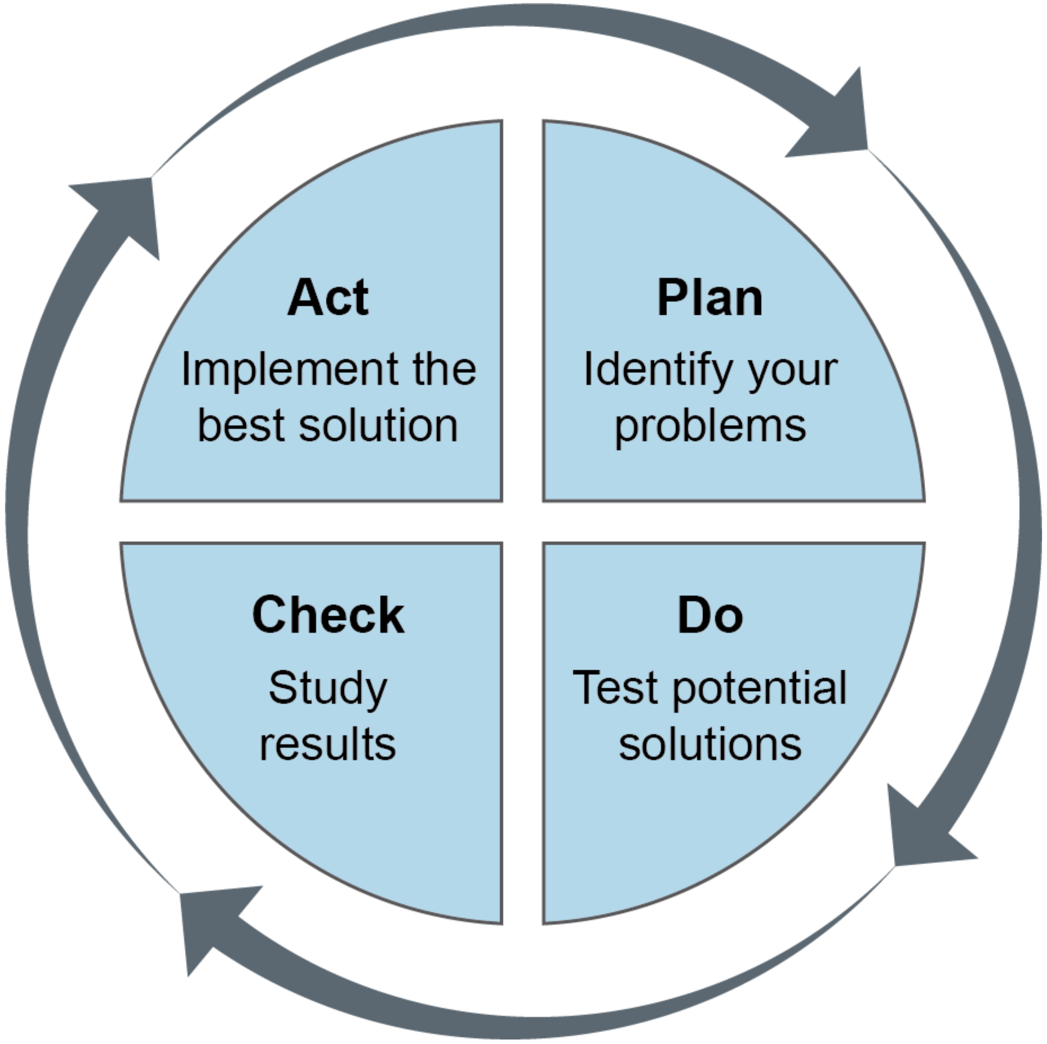
Plan-Do-Check-Act (PDCA) Cycle



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Additional Tools

Brainstorming	Nominal group technique	Root cause analysis
▪ Generate ideas. ▪ All team members have an opportunity to participate.	▪ Similar to brainstorming. ▪ Ideas shared one by one. ▪ Ideas are prioritized by group.	▪ Used in control charting and cause-and-effect diagramming. ▪ Determines core problem.

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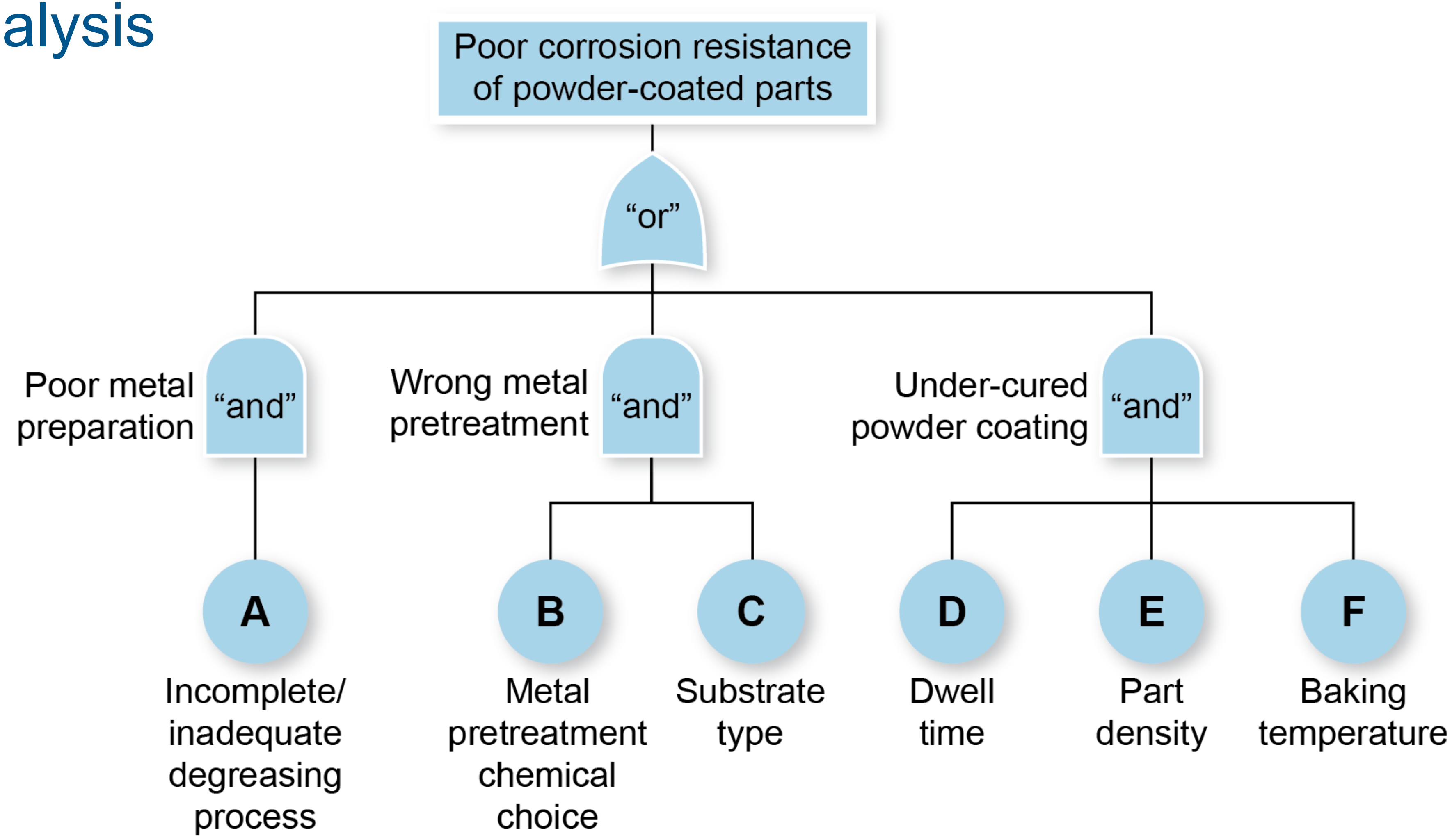
Structured Problem-Solving Tools

Fault Tree Analysis



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Design of Experiments (DOE)

DOE	▪ Impact of input variables on output variables
Minimize impact of noise factors through…	▪ Blocking ▪ Randomization ▪ Repetition.
Taguchi methodology	▪ Focus on the robustness of the product. ▪ Design the product to be insensitive. ▪ Minimize variation around a target value.

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Benchmarking

Benchmark measures
Measures used to establish goals for improvements; often derived from best-in-class achievements.

- Used at different levels, from strategy to operations processes.
- Targets may use internal or external performance measures.

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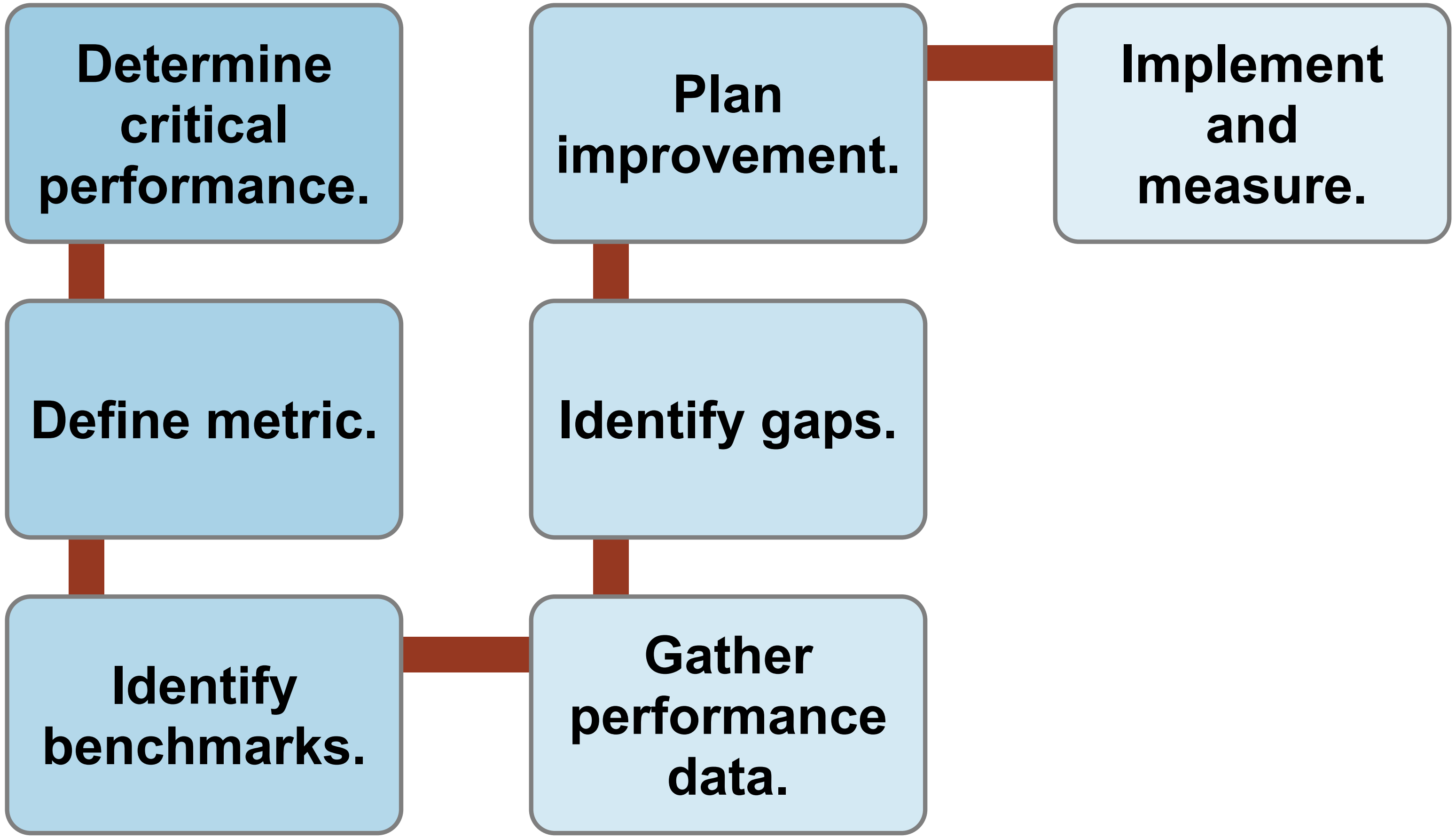
Additional Process Improvement Tools

Benchmarking Process



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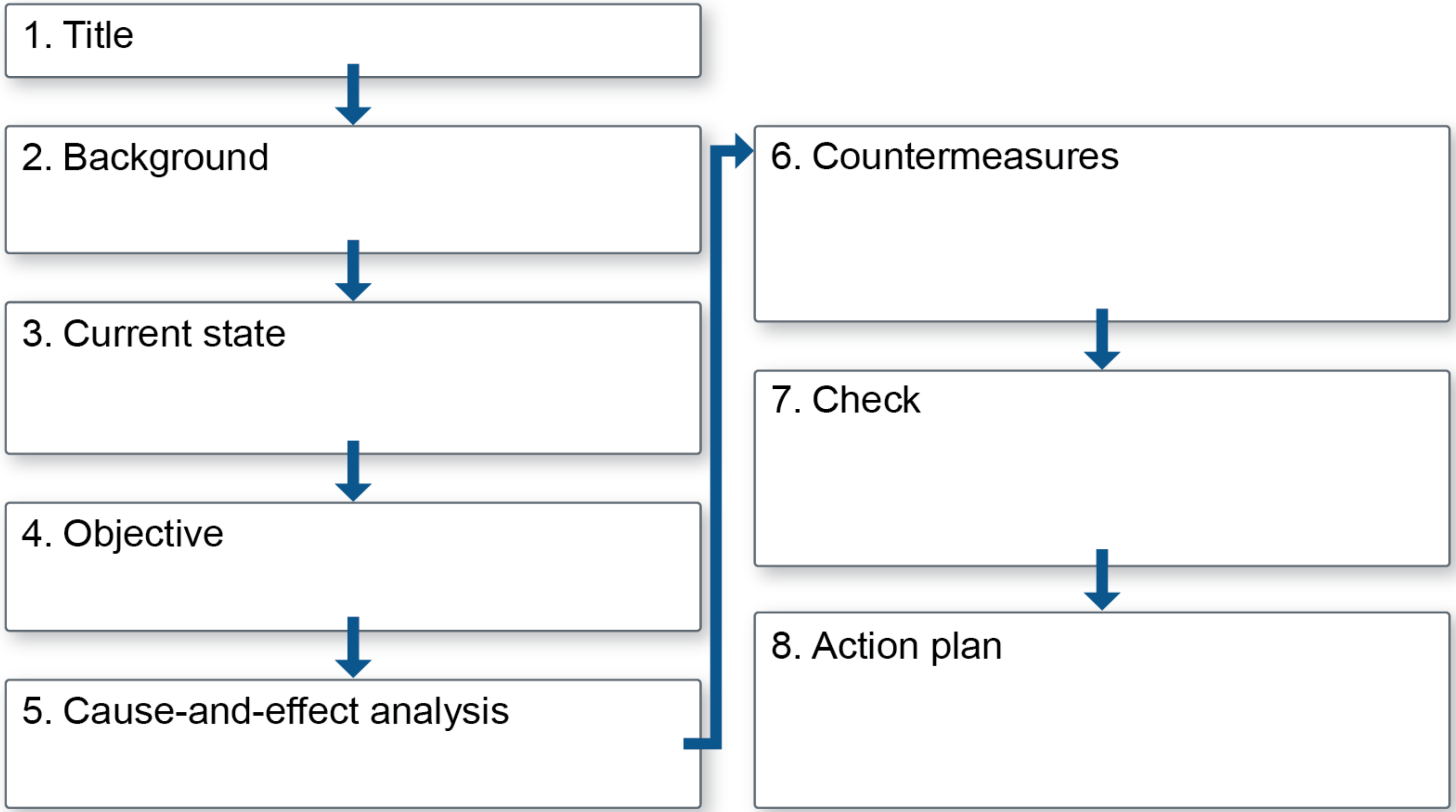
A3 Problem Solving



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Problem Solving A3 Report Discussion

1. Is the following title for a report acceptable? Why or why not?
   "Improve picking accuracy in the warehouse with monthly training sessions."
2. An experienced warehouse staff member writes the A3 report. The person asks the team to list three main causes of picking errors and then has a meeting to rank the causes in order of importance so that the team can identify countermeasures. Do you agree with this step? Why or why not?
3. The meeting ends with a strong consensus that monthly training is not the most important countermeasure. Workers conclude that the error rate is higher on shifts in which the number of items picked per worker is highest. Management pressure to meet order fill rate targets is the most probable cause. They recommend adding more workers to the night shift where pick volume is as high as the day shift but with 25% fewer pickers. Management approves this recommendation, and the countermeasure is rolled out to all warehouses. Do you agree with this action from a PDCA cycle standpoint?

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Work Area Design

Work Area Design Activities

Goal: Reduce the number of mistakes.

1. Develop standardized work.
2. Define the work area.

Examples:

- Production capacity chart
- Standardized work combination table
- Standardized work analysis chart
- Job element sheets

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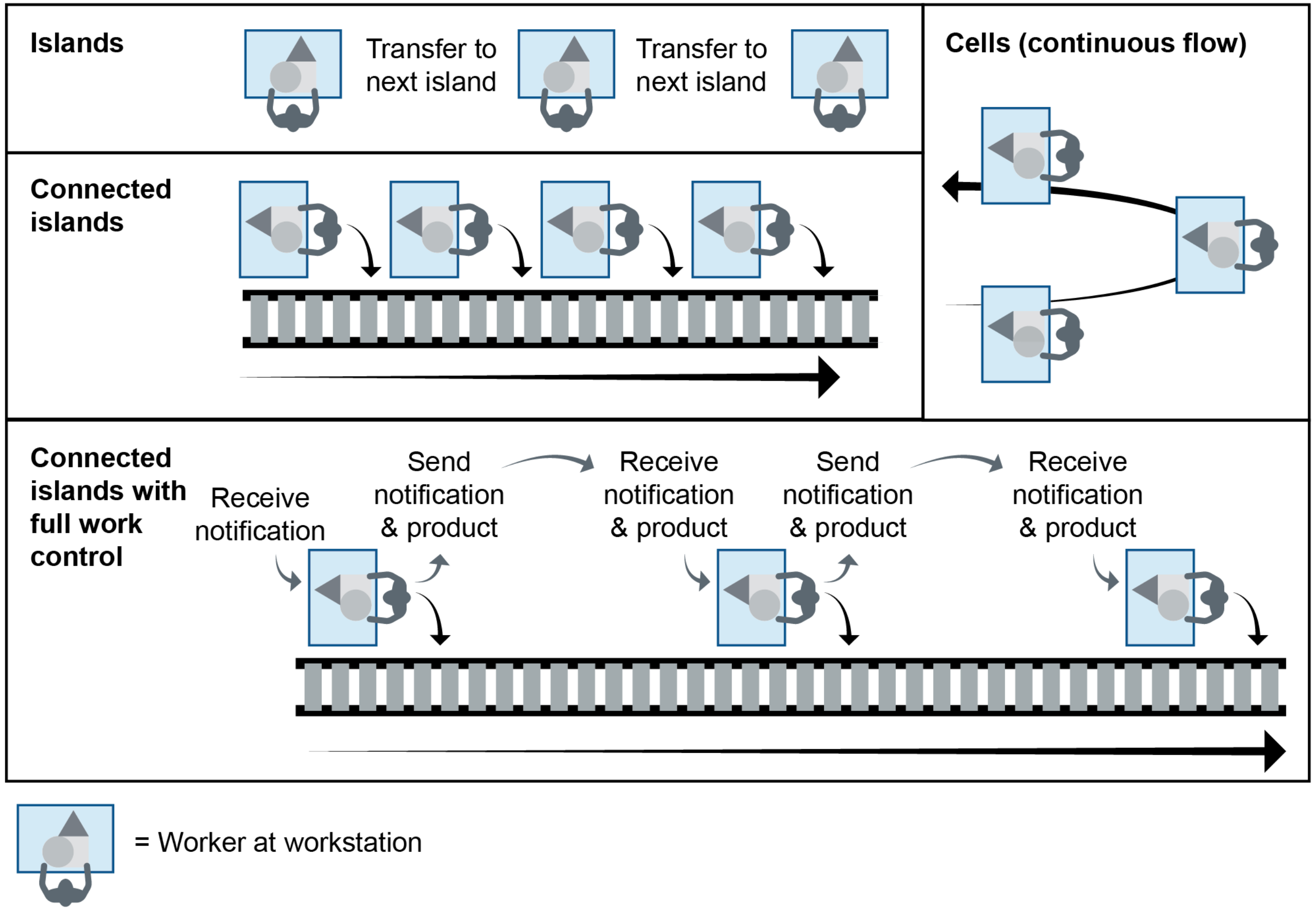
Standardized Work

Tools and equipment layout

Three principles:

- Economy of motion in obtaining, using, and returning tools
- Visibility of tools to facilitate finding and selection
- Ergonomics of using, lifting, and moving tools and materials

Workplace layout



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Additional Work Area Design Activities

Changeovers	Simulation and Modeling	Automation
Time when equipment is unavailable due to tooling, material, part, program, or other changes to production that must be performed while equipment is stopped	Use of software to make computer models of manufacturing systems to analyze and test system design	Competitive advantage in today's manufacturing world; allows companies to mass-produce products at outstanding speed and with repeatability and quality

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Visual Techniques

Visual management techniques

=

- Visual workplace
- Visual management triangle
- Clean workplace
- Visual system
- Visual communication
- Visual workplace reporting

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Conformance and Variation

- Conformance: has met specification, contract, or regulatory requirements
- Variation: special or common cause, tampering, or structural variation
- Common cause (random causes): inherent variation
  - Predictable
  - Categorize to help design process to minimize impact
  - The ideal: Only these are present
- Assignable cause (special cause): can be isolated
  - Root cause exists and can be responded to
  - Does not happen by chance, e.g., worn part
  - Unpredictable changes
  - Not stable over time

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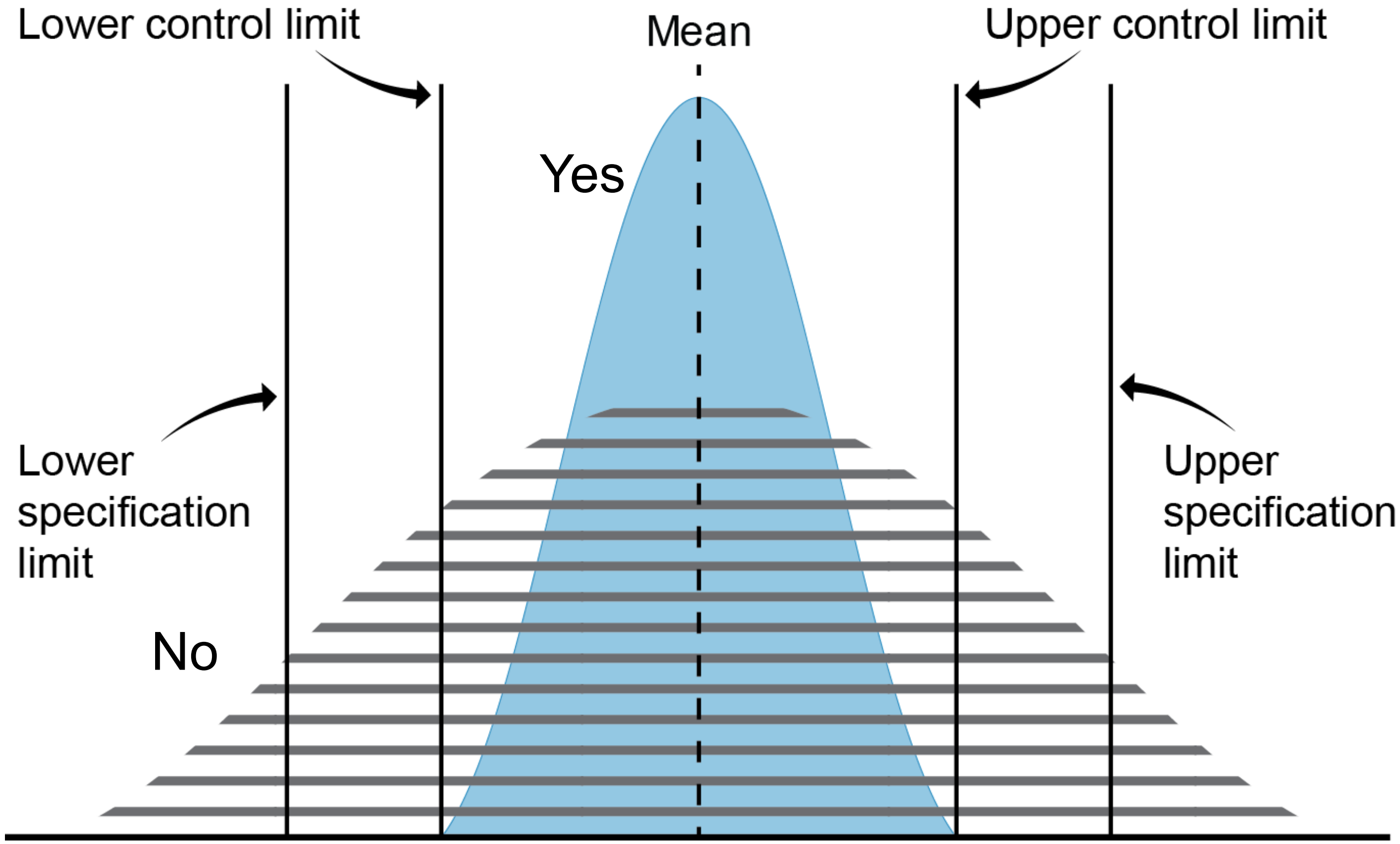
Statistical Process Control (SPC)

Is the process capable?



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Specification Limits Versus Control Limits

- Lower and upper specification limits (LSL and USL)
  - Set by customer and/or engineering
  - Independent of process used (results, not how got there)
  - Voice of the customer
- Lower and upper control limits (LCL and UCL)
  - Set by statistical observations of standard deviations
  - Process specifications (capable of producing results within specifications?)
  - Voice of the process

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Normal Distributions and Standard Deviation (SD)

- Normal distribution (bell curve)
  - Smooths out (normalizes) samples to generalize pattern
  - Shows range and standard deviation.
- A result will fall within
  - 1 SD (1σ) of the average 68.3% of time
  - 2 SD (2σ) of the average 95.4% of time
  - 3 SD (3σ) of the average 99.7% of time.
- If 1 SD is a large number of units (or other thing measured), then wide variation.

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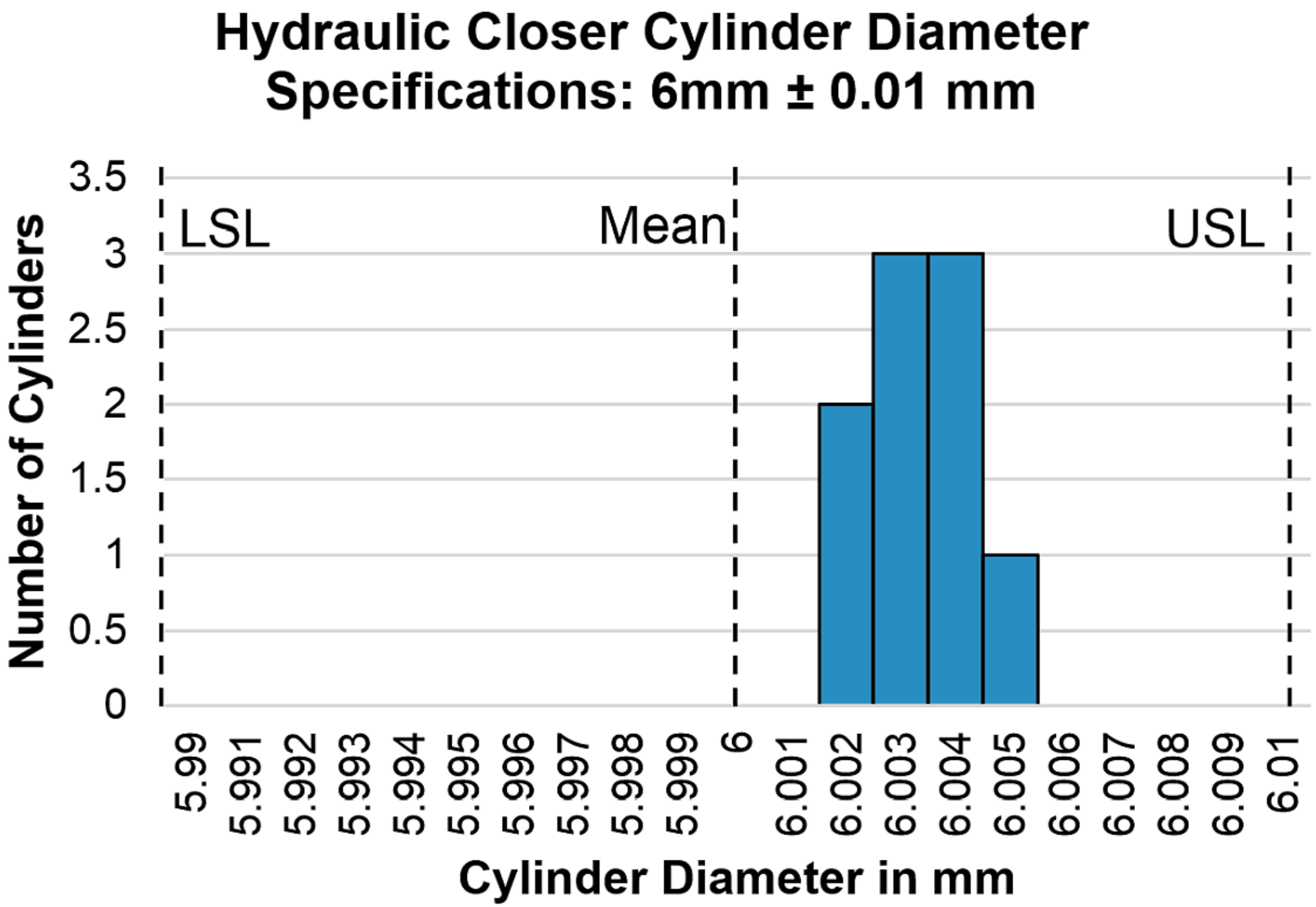
Statistical Process Control with Shift in Mean

Control limits are 5.994 to 6.006, so in control, but shift in mean should be investigated.



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SPC Versus Inspection

- Product inspection is form of waste
  - Inspection of finished goods detects only defects
  - Hard to find root cause

- Statistical process control
  - Monitors process against statistical control limits
  - Detects when processes are getting out of control
  - Corrective action (preventive)

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Control Charts

Types of control charts

- **X-bar-chart**
  - Population mean.
  - Average of samples for given day. (3 to 9 are common.)
- **R-chart**
  - Range of sample results (highest − lowest).
- **P-chart**
  - Percentage variation from mean with UCL and/or LCL.
  - Sample size can vary between samples, still comparable.

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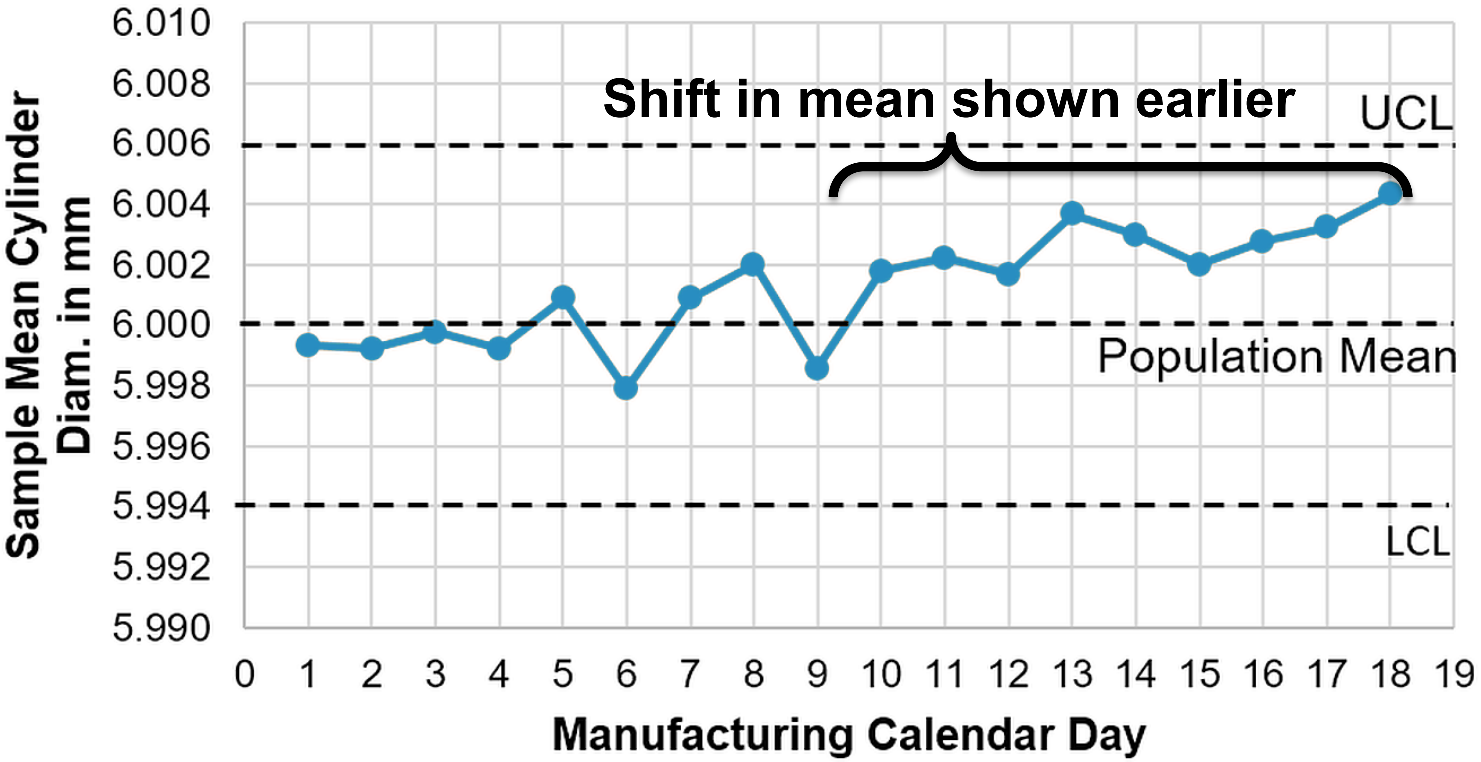
Control Charts: $\bar{X}$- (X-bar-) Chart

Like bell curve turned on side to show results over time. X-bar is sample mean.



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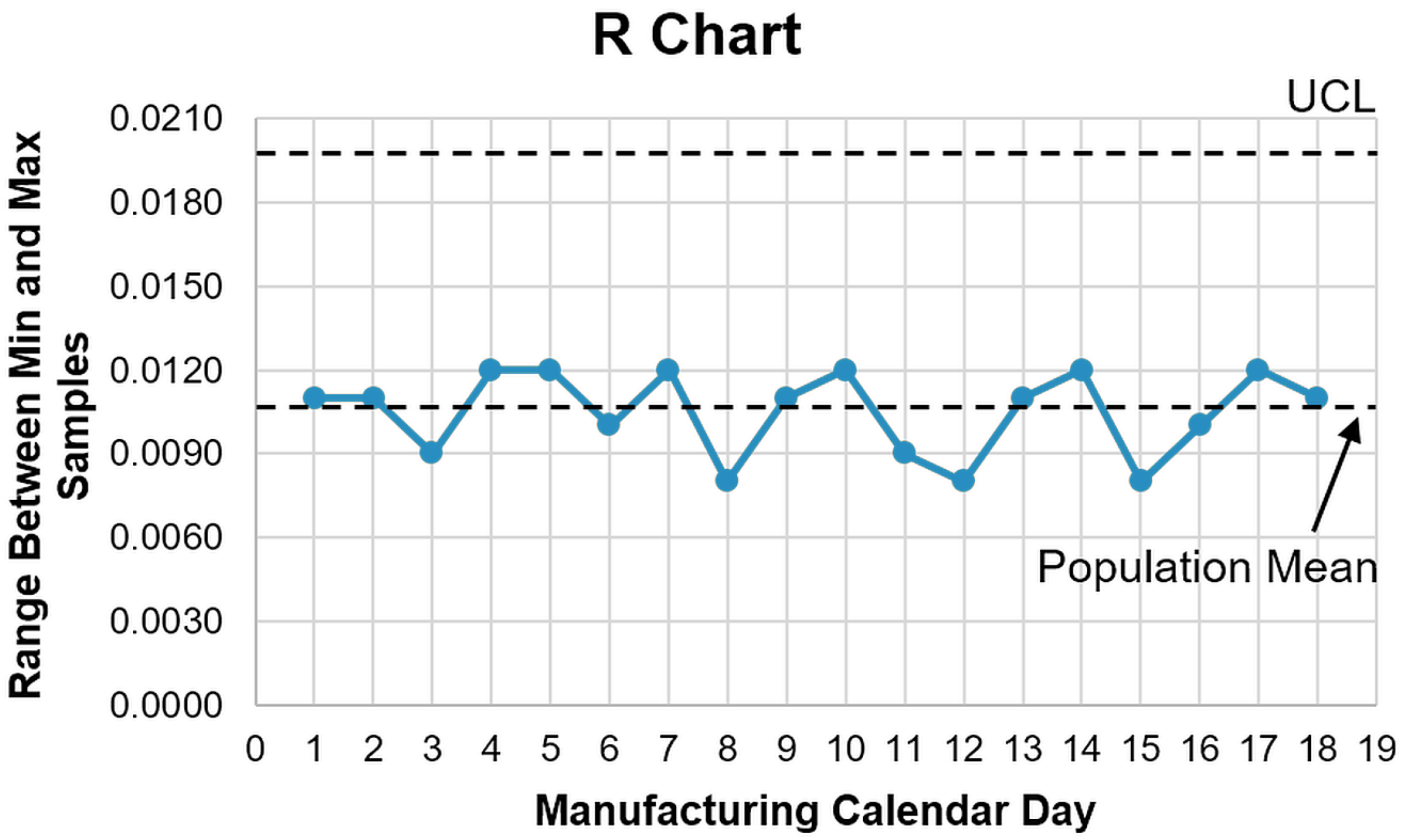
Control Charts: R-Chart

Chart of sample range (highest minus lowest)



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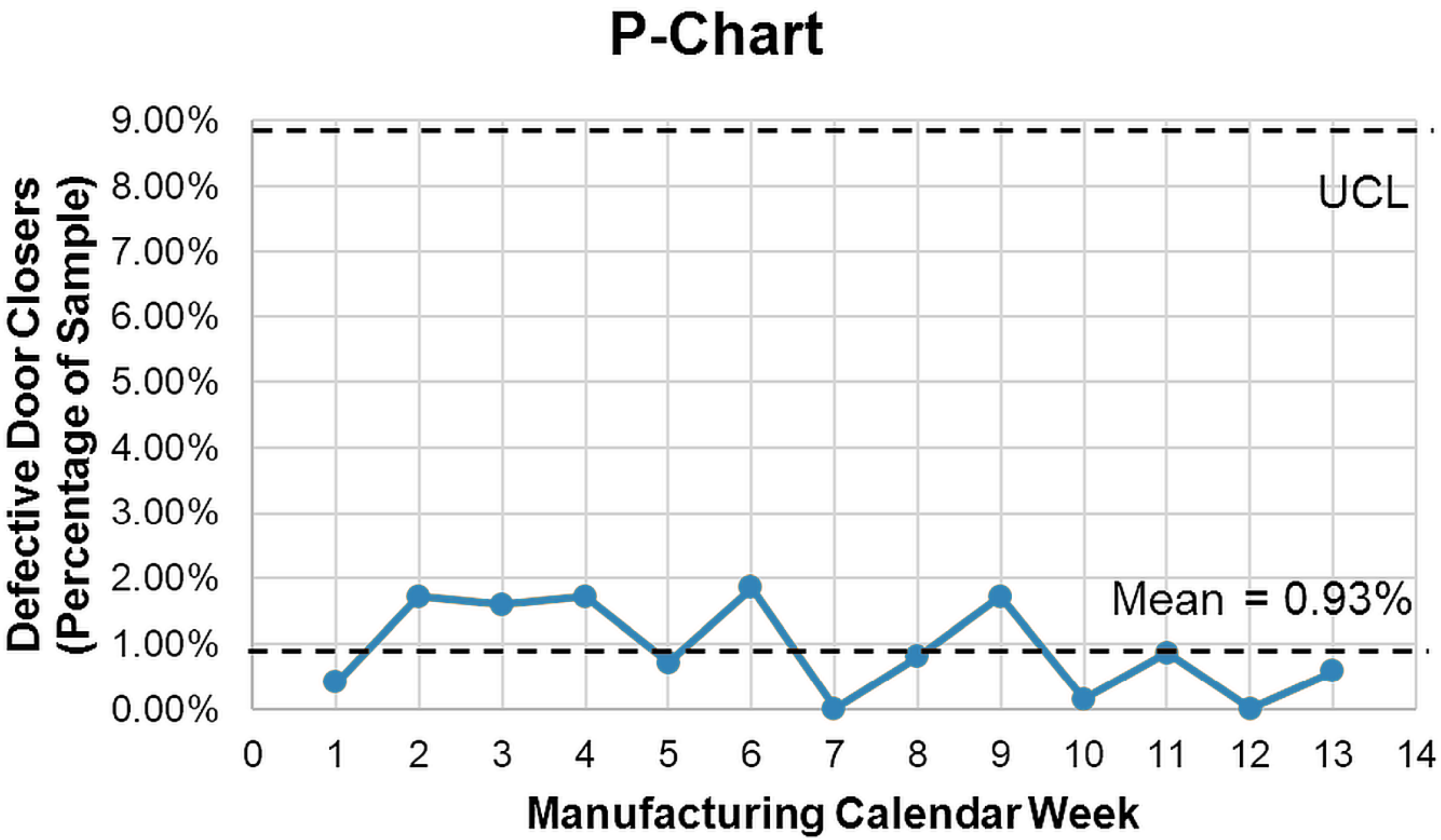
Control Charts: P-Chart



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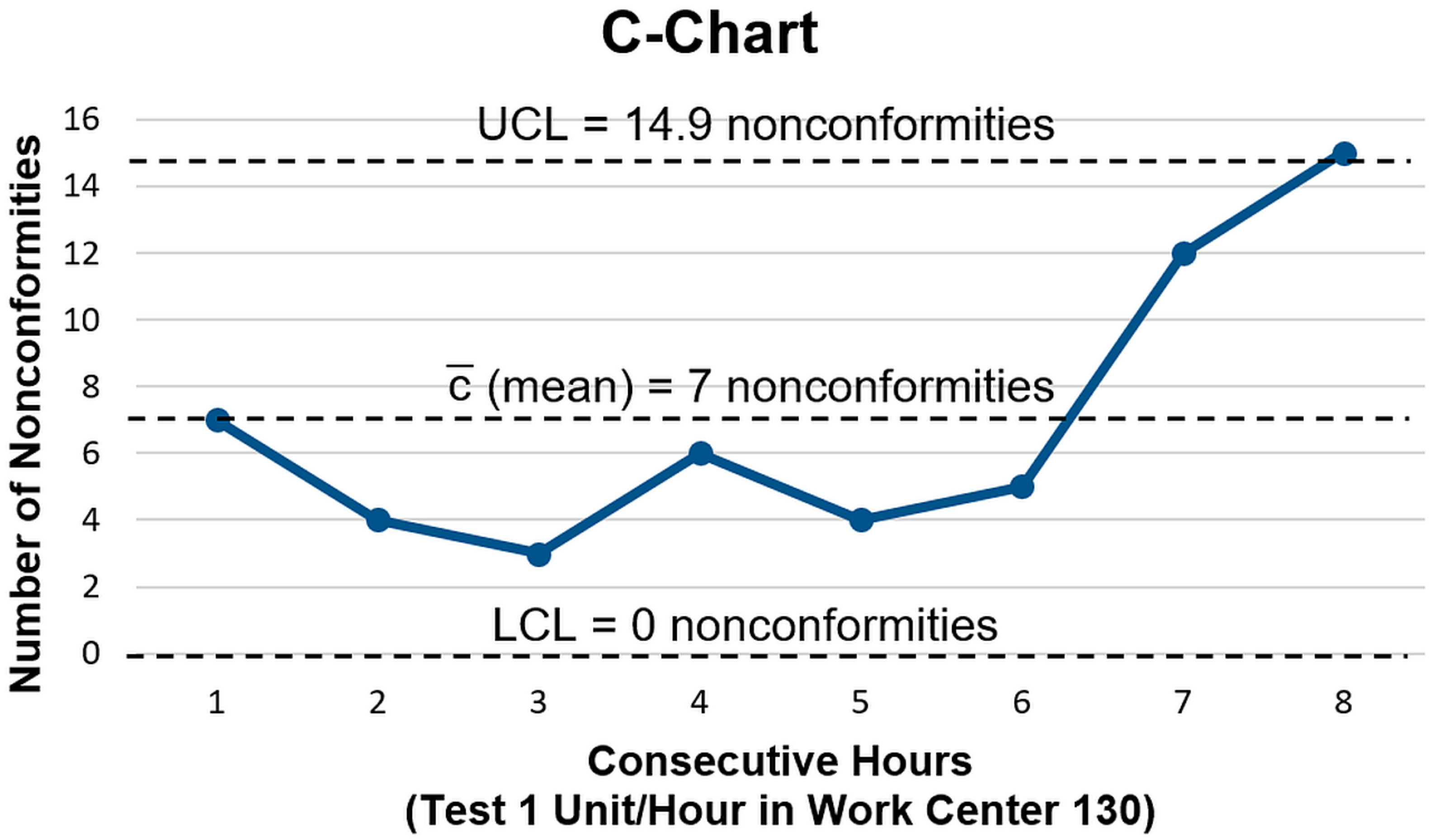
C-Charts



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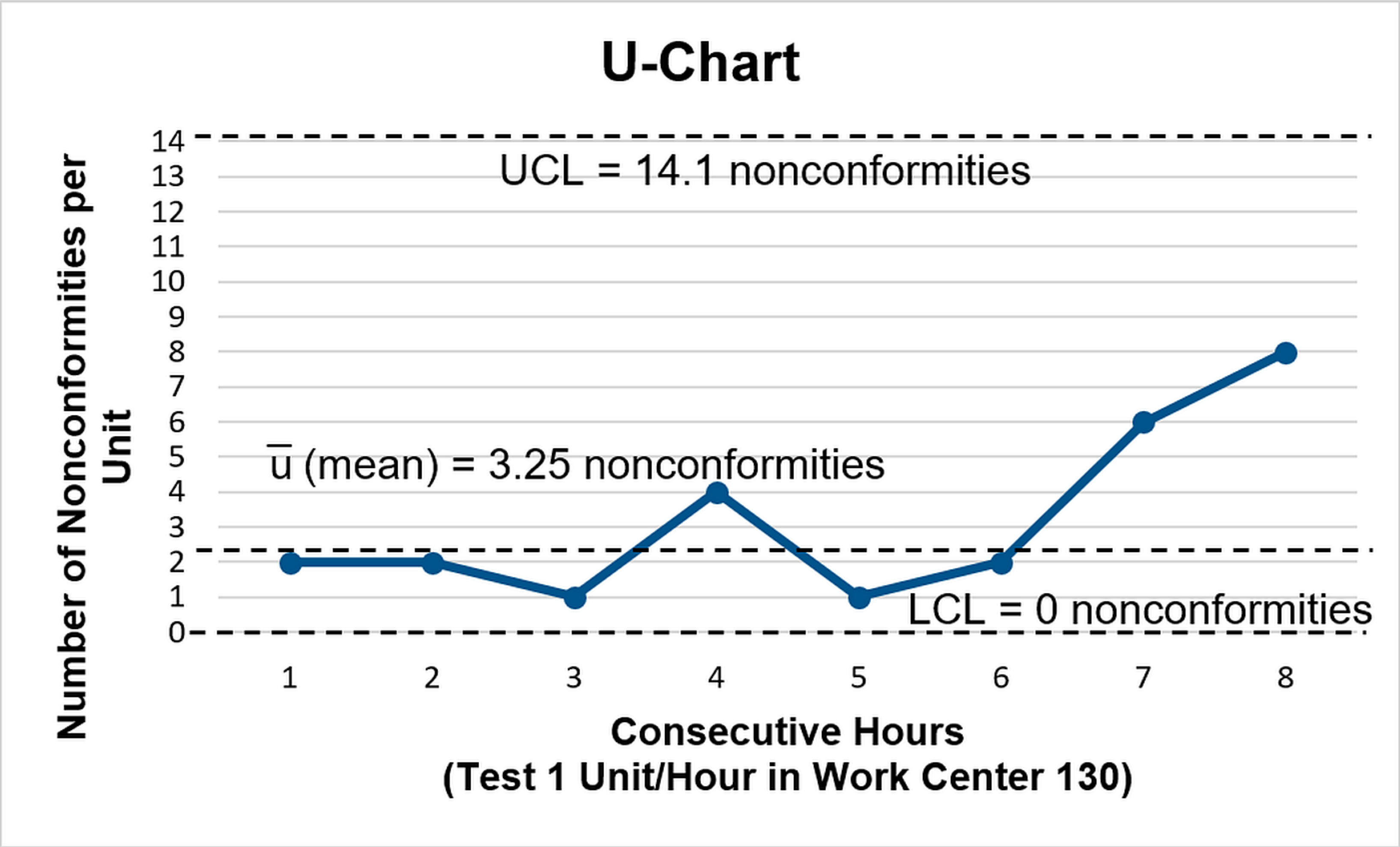
U-Charts



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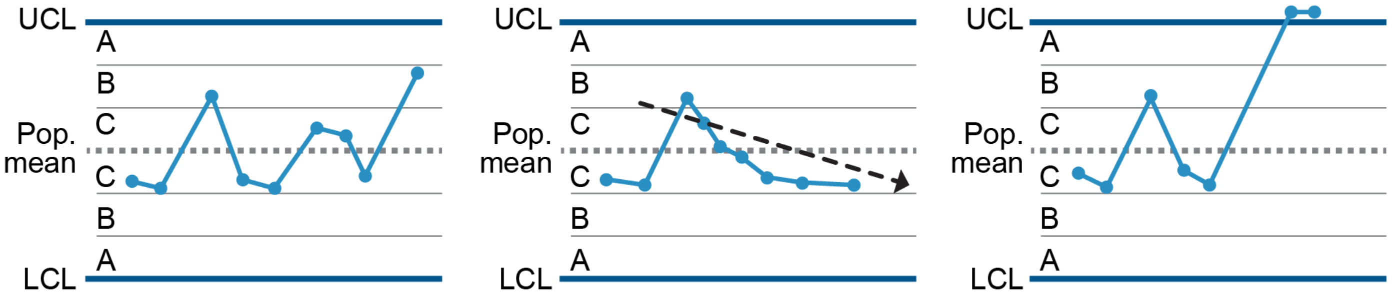
Control Charts: Application



In statistical control. Only common causes of variation are evident.

Six decreasing points in a row indicate that special causes of variation are evident.

Points above the UCL indicate that special causes of variation are evident.

Nelson's tests for special causes (four examples)

1 point beyond zone A (e.g., Chart 3)

9 or more points in a row above (or below) mean

6 points in row steadily increasing or decreasing (e.g., Chart 2)

4 out of 5 points in a row in zone B or beyond

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Statistical Quality Control

Attribute sampling

1. Take a sample of a specified quality characteristic for each unit. Each unit is classified as acceptable or defective.
2. Summarize these into a simple statistic, such as sample average.
3. Compare the observed values to the allowable standard values defined in the quality plan.
4. Make a decision to accept or reject the lot.

Variable sampling

1. Take a sample and a measurement of a specified quality characteristic for each unit.
2. Summarize these into a simple statistic, such as a sample average.
3. Compare the observed values to the allowable standards defined in the quality plan.
4. Make a decision to accept or reject the lot.

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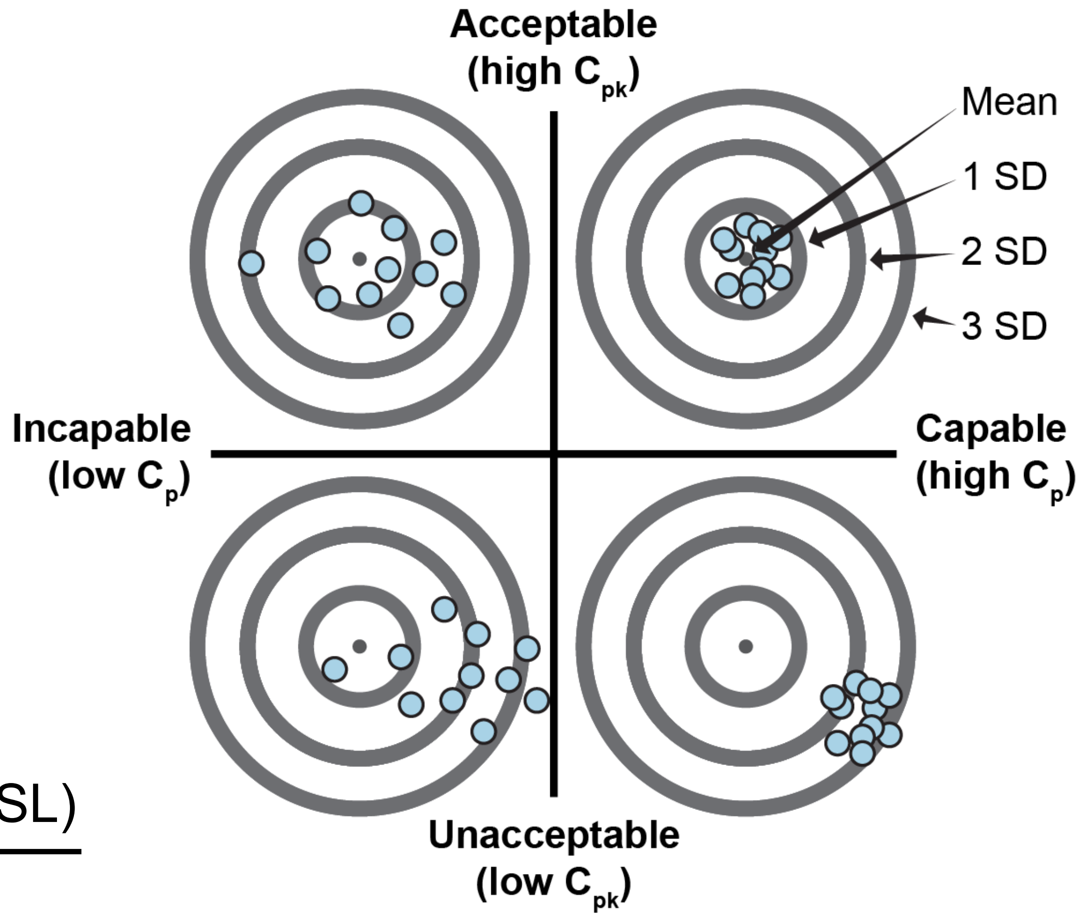
Process Capability Analysis

- **Capability**

$$C_p = \frac{USL - LSL}{6 \times SD}$$

- **Acceptability**

$$C_{pk} = \text{Lesser of } \frac{(USL - Mean)}{3 \times SD} \text{ or } \frac{(Mean - LSL)}{3 \times SD}$$



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Uses for Process Capability Analysis

- Predicting extent of variability that processes will exhibit, to set realistic specification limits
- Choosing most appropriate process for tolerances to be met
- Providing quantified basis for schedule of periodic process control checks and readjustments
- Assigning machines to best-suited classes of work
- Testing theories for causes of defects during quality improvement programs
- Serving as basis for specifying quality performance requirements for purchased machines
- Planning interrelationship of sequential processes

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