Advanced Quality Planning Training

-- Combining Six Sigma and Advanced Product Quality Planning Methodologies

--- AQP Training Materials Rev:1.2 - 2008 Aug.

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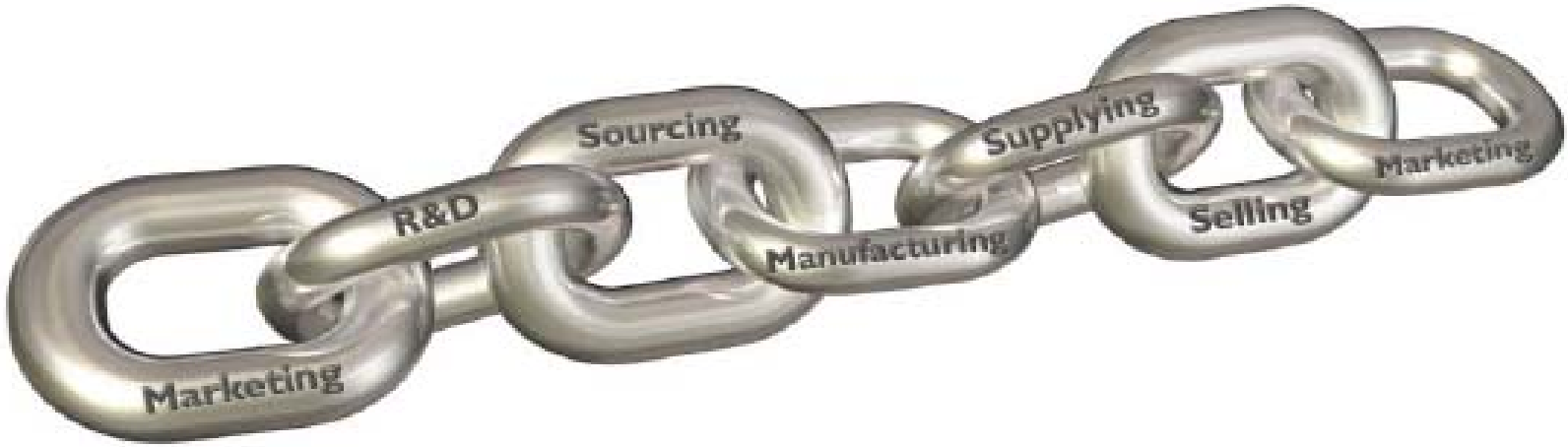
Why need AQP ?

- A reduction in the complexity of product quality planning for the customers and suppliers.
- A means for suppliers to easily communicate product quality planning requirements to subcontractors.
- To direct resources to satisfy the customer.
- To promote early identification of required changes.
- To avoid late changes.
- To provide a quality product on time at the lowest cost.



Cost of Quality

- Cost of Quality (COQ) is a performance indicator that lets you know how much it is costing the company to ensure that the product and services you deliver are of suitable quality. It does not include creation costs, however.

- Cost of Quality includes only those costs that are involved with quality assurance, such as:
  - Prevention costs
  - Appraisal costs
  - Internal failure costs
  - External failure costs

Cost of Poor Quality

s is a measure of how much variation exists in a process

Old Belief

High Quality = High Cost

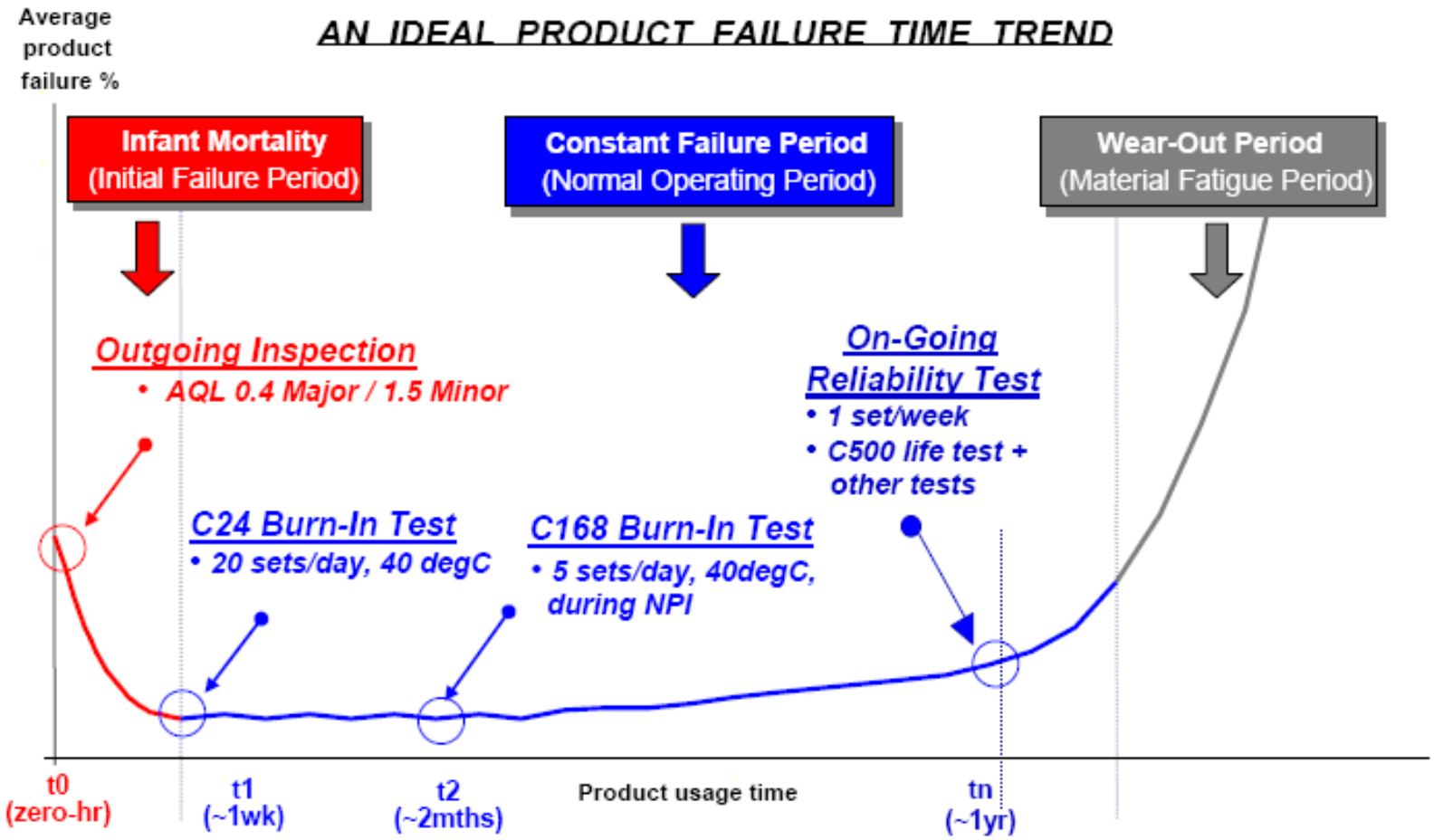
New Belief

High Quality = Low Cost

better processes reduce cost

Make sure product are in-fact ready to go

… Repairable vs Non-Repairable

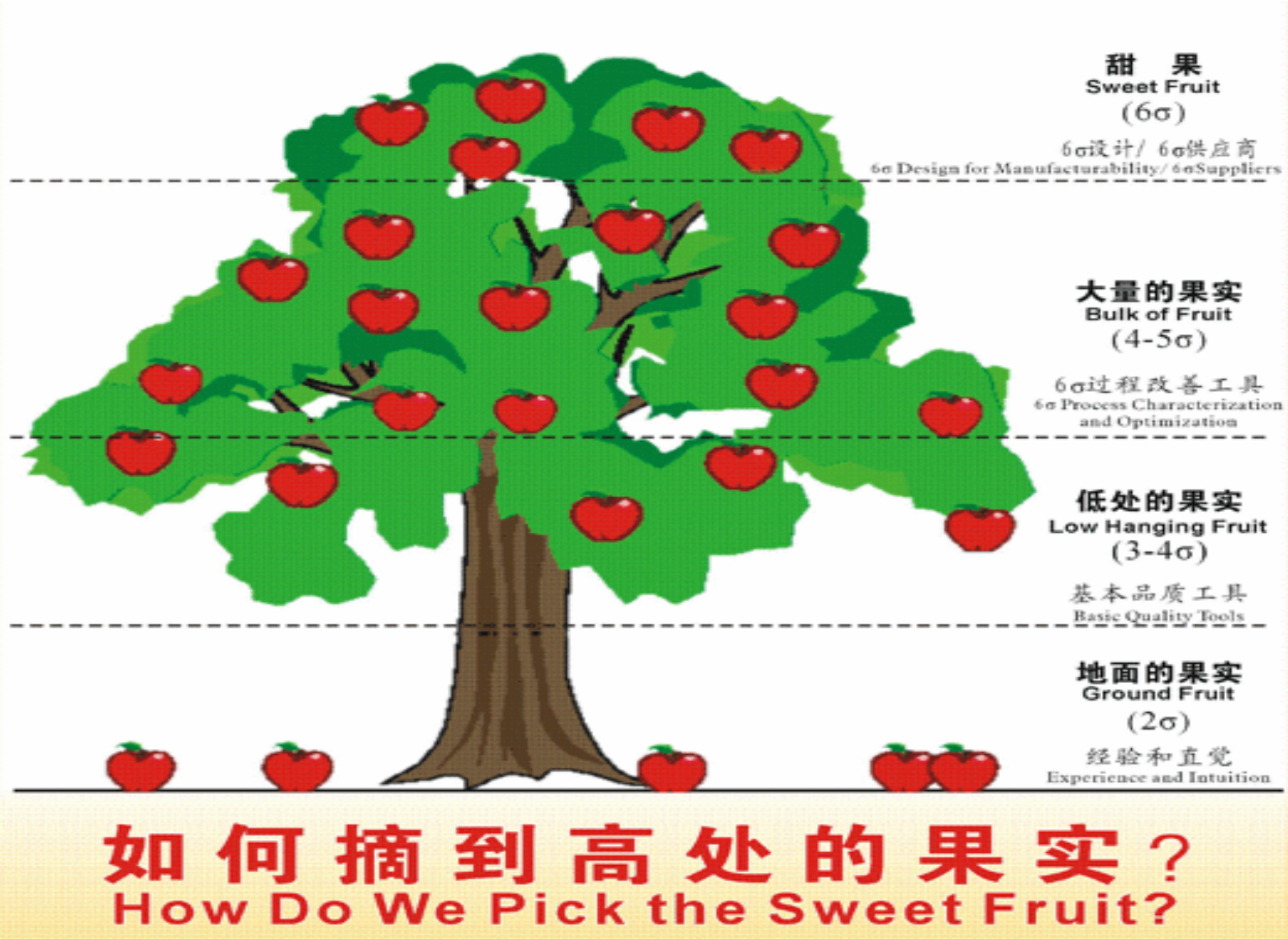


… MTBF is a measure of how reliable a product is. MTBF is usually given in units of hours; the higher the MTBF, the more reliable the product is.

Cost of Poor Quality:

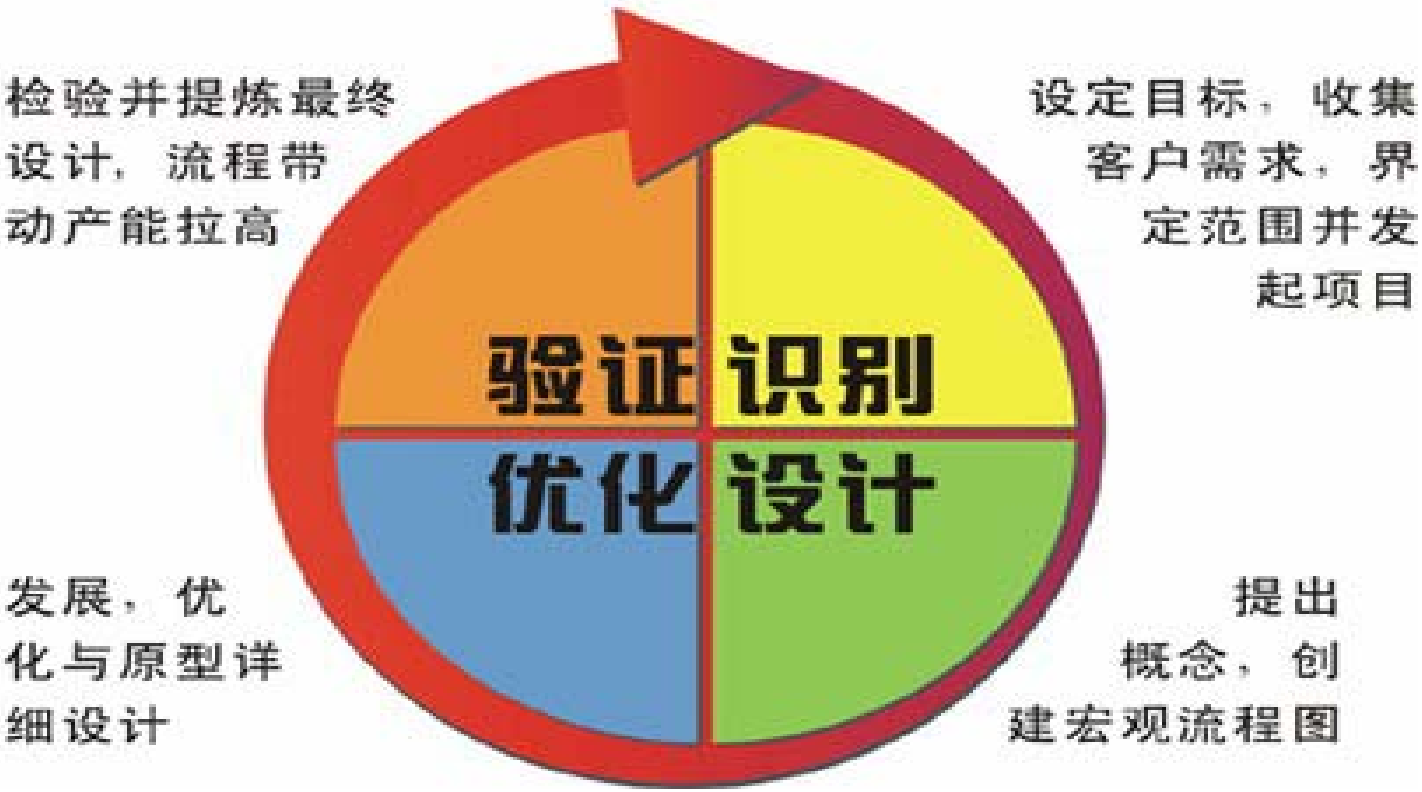
- Cost of Poor Quality
  - Internal failure costs.
  - External failure costs.

- The effects of poor quality can be far-reaching. The cost of poor quality is ultimately measured by lost customer bids, declining market and declining profit.
- It is imperative that customer continue to develop quality systems that:
  - Drive defect prevention.
  - Reduce variation and waste in the supply chain.


甜 果
Sweet Fruit
(6σ)
6σ设计/ 6σ供应商
6σ Design for Manufacturability/ 6σSuppliers
大量的果实
Bulk of Fruit
(4-5σ)
6σ过程改善工具
6σ Process Characterization and Optimization
低处的果实
Low Hanging Fruit
(3-4σ)
基本品质工具
Basic Quality Tools
地面的果实
Ground Fruit
(2σ)
经验和直觉
Experience and Intuition
如何摘到高处的果实？
How Do We Pick the Sweet Fruit?

DFSS flow 1 :

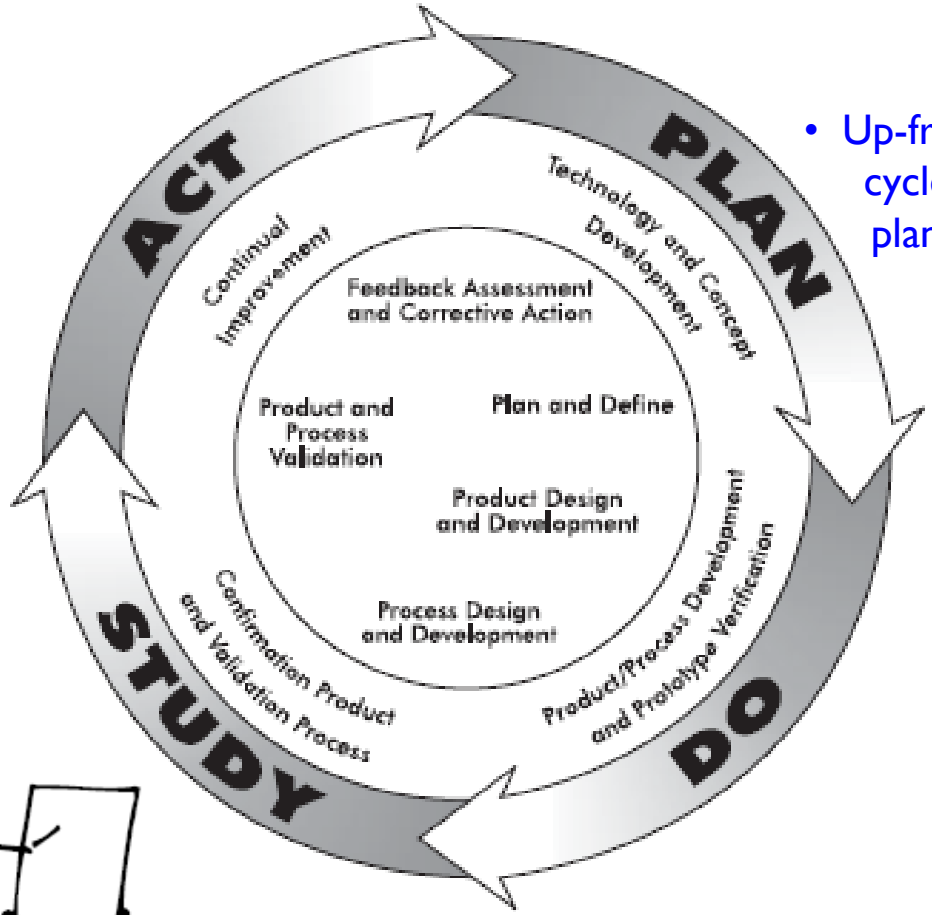
IDOV 发展路线图



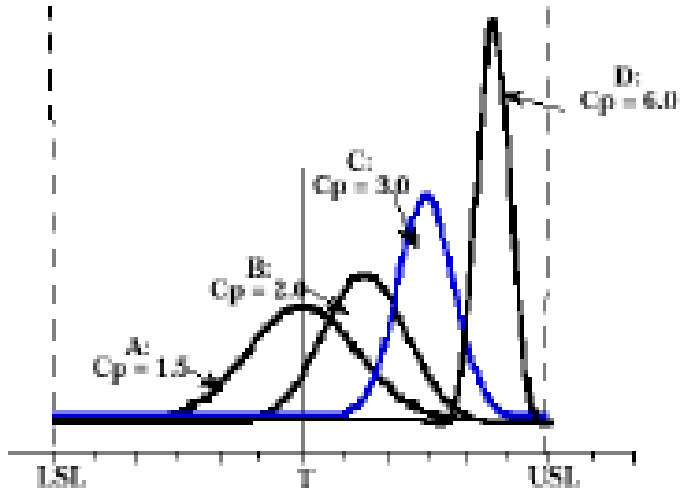
DFSS flow 2 :


IDOV 开发流程
计划及需求
概念设计
详细设计
产能拉高
设定目标、
收集客户需求、
界定范围并
发起项目
提出概念、
创建宏观
流程图
发展、
优化与
原型详细
设计
检验并提炼
最终设计、
产能拉高
识别
设计
优化
验证
客户域
功能域
物理域
流程域

Products quality Planning Cycle:

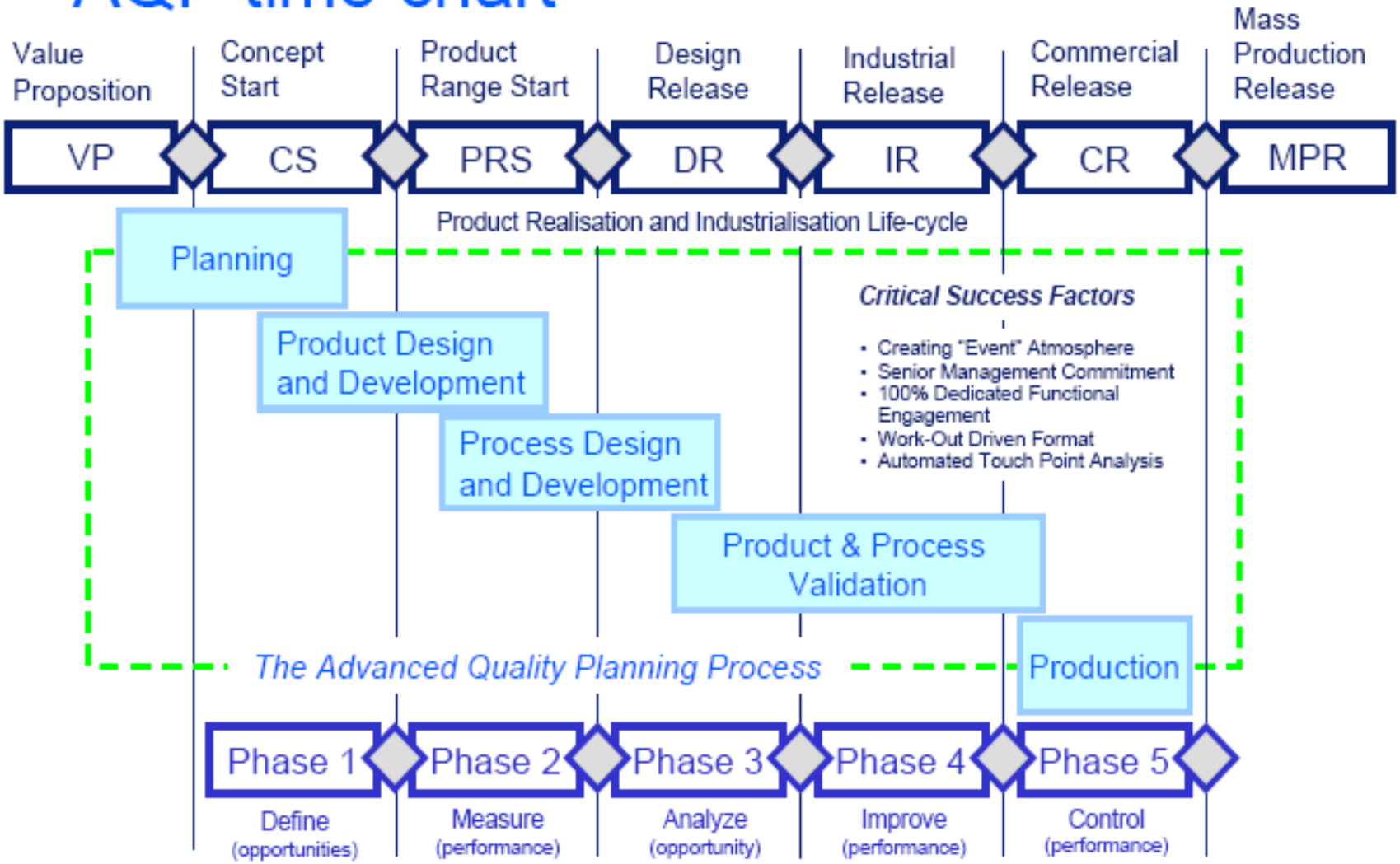


- Up-front planning - The first three quarters of the cycle are devoted to up-front product quality planning through product/process validation.

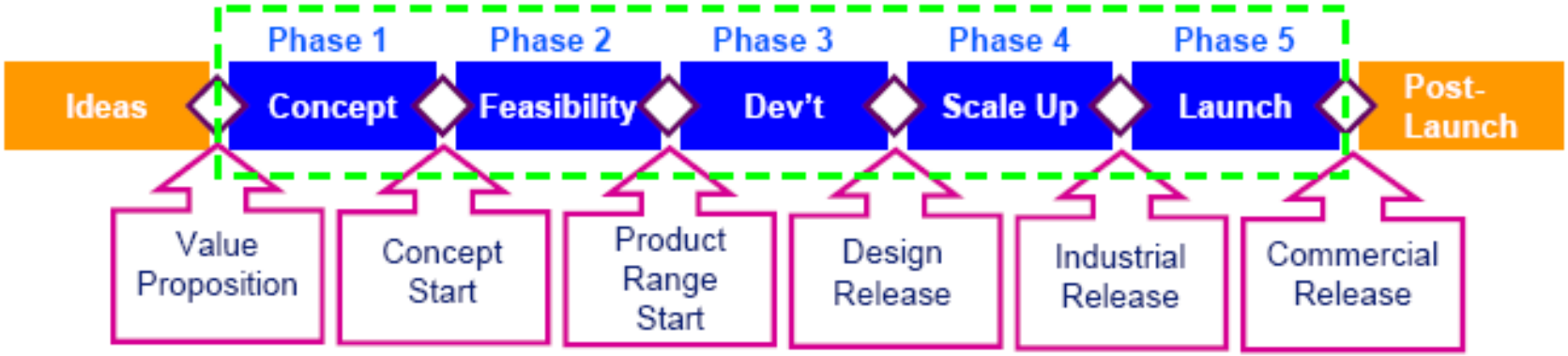


- The act of implementation - The fourth quarter is the stage where the importance of evaluating the output serves two functions: to determine if customers are satisfied, and to support the pursuit of continual improvement.

AQP time chart



NPI scorecard for Phases Review Risk Assessment



Every Gate is used to manage risk based on the accumulation of DATA and the delivery of key RESULTS!

Teams, using tools, deliver results and their assessment of results from tool utilization helps provide information on risk at the gate.

When tools are used well & the results are poor then we either manage the risk or kill the program.

Color Code for Risk Ratings

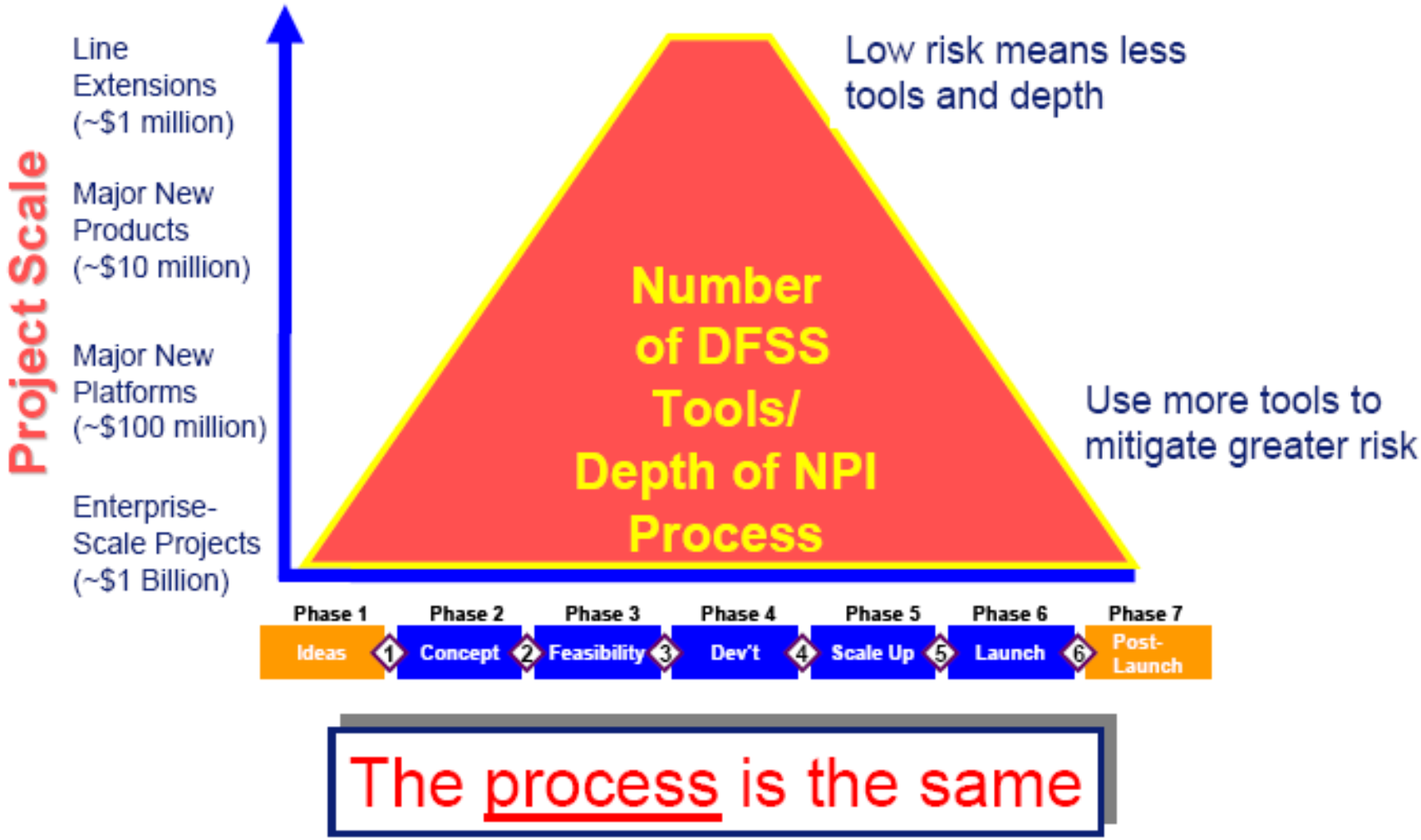
High risk… a significant number of major deliverables are not met & have no corrective actions identified, numerous minor deliverables are unmet: NO gate passage!!!

Moderate risk… one or two major deliverables are unmet but are manageable through identified corrective actions… using the right tools!; A few minor deliverables are unmet: Conditional gate passage.

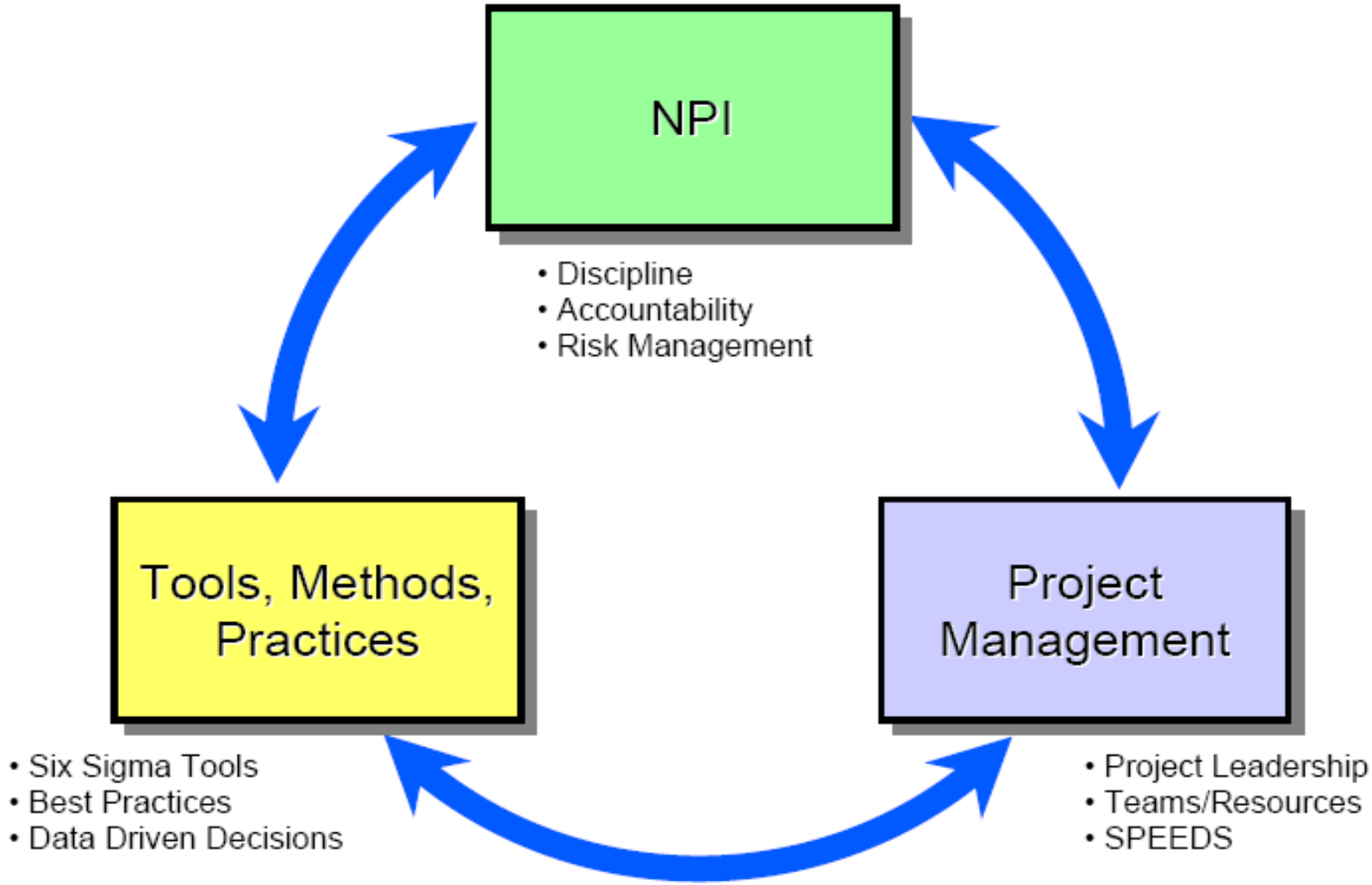
Low risk… all major deliverables are met; A few minor deliverables are unmet: Unconditional gate passage.

8 CE, AQP - Awareness & Breakthrough , 2006, Eddie Lim

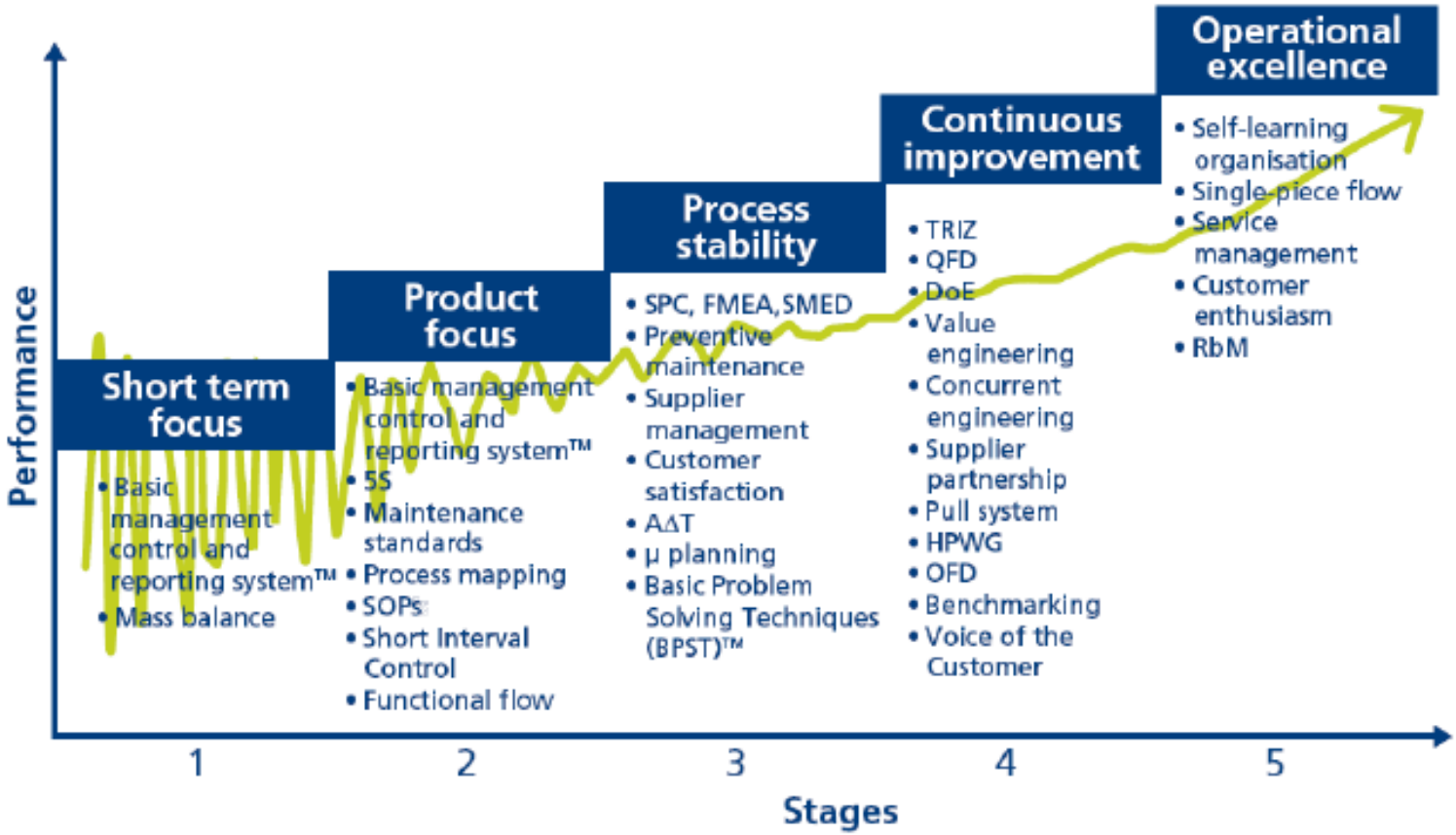
The Deployment …



AQP is the Integration of …



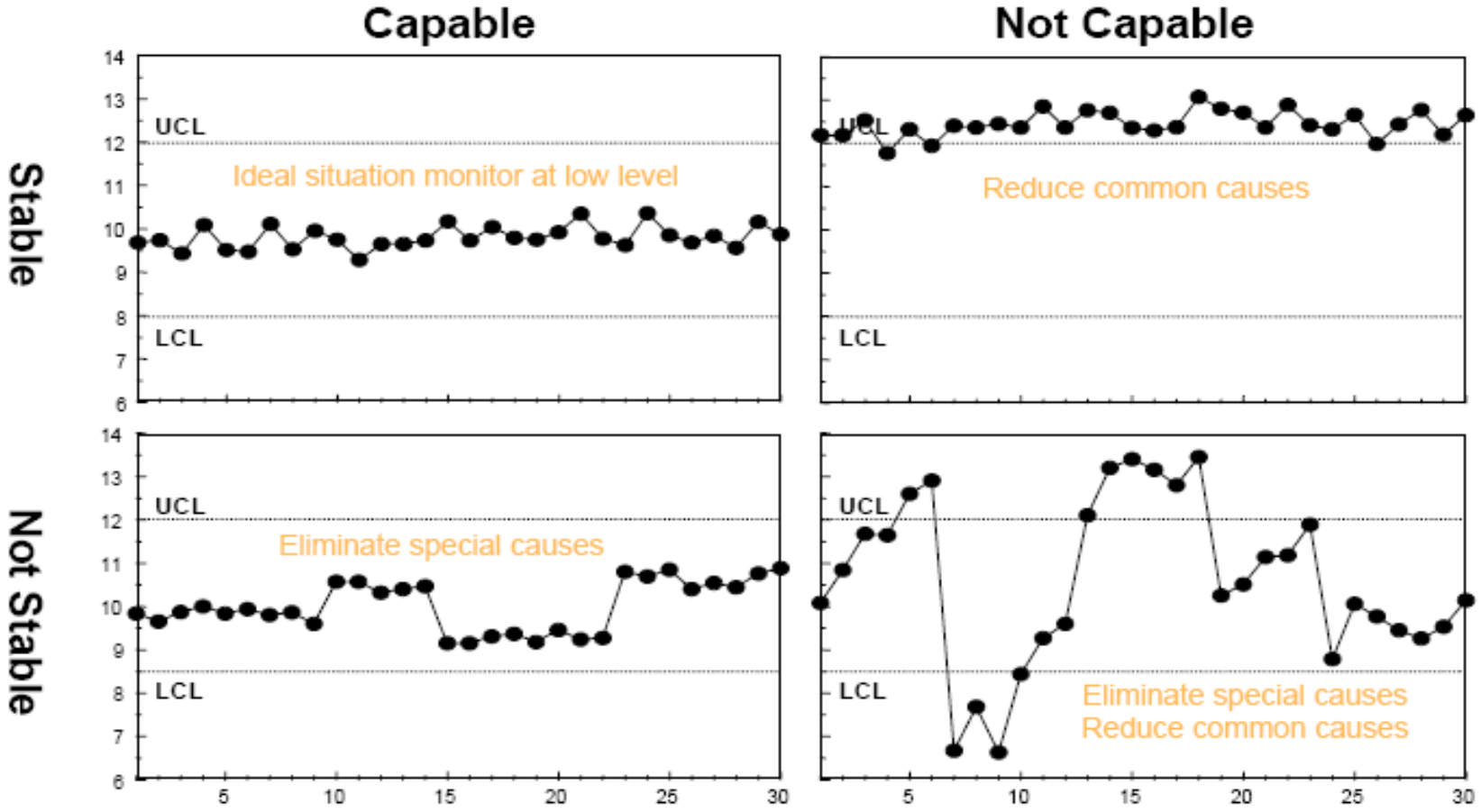
Use 20% of the Six Sigma tools to deliver 80% of the benefit



Most companies focus all their Six Sigma efforts on training in tools and techniques. However, those tools and techniques will not deliver their full potential in a sustained way if processes are inefficient and over-complex,and/or the right management and reporting systems are not in place to promote learning and achieve action on performance shortfalls.

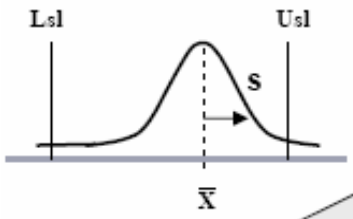
Make sure processes are in-fact ready to go

… Stability vs Capability (the 4 possible states of any process)



… Process stability and capability are two distinct properties

Sigma (Z_{ST}) calculation



Begin

Type of data?

Continuous data

Pass / fail (discrete) data

Is data normal? (P > 0.10)

No

Yes

Can data be transformed to make it normal?

No

Yes

Use total failures and total opportunities to calculate DPMO

$Z_{upper} = (USL - \overline{X}) / S$

$Z_{lower} = (\overline{X} - LSL) / S$

Calculate Z_{upper} and Z_{lower}

Use Box-Cox to find λ. Transform data and specs

Convert DPMO to DPO

$DPO = (DPMO) \times 10^{6}$

Compute DPO

$DPO = DPO_{er} + DPO_{lower}$

Using DPO and Z tables, find Z_{bench}

Long or short term data?

Long term

$Z_{ST} = Z_{bench} + 1.5$

Short term

$Z_{ST} = Z_{bench}$

Standard Normal Z table

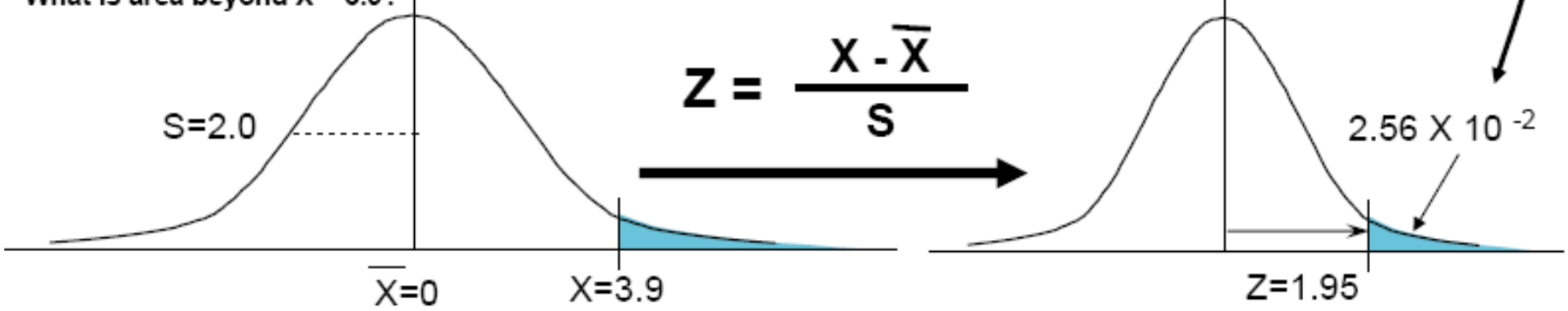
Standard Normal Z table

Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.50	6.68e-002	6.55e-002	6.43e-002	6.30e-002	6.18e-002	6.06e-002	5.94e-002	5.82e-002	5.71e-002	5.59e-002
1.60	5.48e-002	5.37e-002	5.26e-002	5.16e-002	5.05e-002	4.95e-002	4.85e-002	4.75e-002	4.65e-002	4.55e-002
1.70	4.46e-002	4.36e-002	4.27e-002	4.18e-002	4.09e-002	4.01e-002	3.92e-002	3.84e-002	3.75e-002	3.67e-002
1.80	3.59e-002	3.51e-002	3.44e-002	3.36e-002	3.29e-002	3.22e-002	3.14e-002	3.07e-002	3.01e-002	2.94e-002
1.90	2.87e-002	2.81e-002	2.74e-002	2.68e-002	2.62e-002	2.56e-002	2.50e-002	2.44e-002	2.39e-002	2.33e-002
2.00	2.28e-002	2.22e-002	2.17e-002	2.12e-002	2.07e-002	2.02e-002	1.97e-002	1.92e-002	1.88e-002	1.83e-002
2.10	1.79e-002	1.74e-002	1.70e-002	1.66e-002	1.62e-002	1.58e-002	1.54e-002	1.50e-002	1.46e-002	1.43e-002
2.20	1.39e-002	1.36e-002	1.32e-002	1.29e-002	1.25e-002	1.22e-002	1.19e-002	1.16e-002	1.13e-002	1.10e-002
2.30	1.07e-002	1.04e-002	1.02e-002	9.90e-003	9.64e-003	9.39e-003	9.14e-003	8.89e-003	8.66e-003	8.42e-003
2.40	8.20e-003	7.98e-003	7.76e-003	7.55e-003	7.34e-003	7.14e-003	6.95e-003	6.76e-003	6.57e-003	6.39e-003
2.50	6.21e-003	6.04e-003	5.87e-003	5.70e-003	5.54e-003	5.39e-003	5.23e-003	5.08e-003	4.94e-003	4.80e-003
2.60	4.66e-003	4.53e-003	4.40e-003	4.27e-003	4.15e-003	4.02e-003	3.91e-003	3.79e-003	3.68e-003	3.57e-003
2.70	3.47e-003	3.36e-003	3.26e-003	3.17e-003	3.07e-003	2.98e-003	2.89e-003	2.80e-003	2.72e-003	2.64e-003
2.80	2.56e-003	2.48e-003	2.40e-003	2.33e-003	2.26e-003	2.19e-003	2.12e-003	2.05e-003	1.99e-003	1.93e-003
2.90	1.87e-003	1.81e-003	1.75e-003	1.69e-003	1.64e-003	1.59e-003	1.54e-003	1.49e-003	1.44e-003	1.39e-003
3.00	1.35e-003	1.31e-003	1.26e-003	1.22e-003	1.18e-003	1.14e-003	1.11e-003	1.07e-003	1.04e-003	1.00e-003
3.10	9.68e-004	9.35e-004	9.04e-004	8.74e-004	8.45e-004	8.16e-004	7.89e-004	7.62e-004	7.36e-004	7.11e-004
3.20	6.87e-004	6.64e-004	6.41e-004	6.19e-004	5.98e-004	5.77e-004	5.57e-004	5.38e-004	5.19e-004	5.01e-004

DPO

Defects Per Opportunity

What is area beyond X = 3.9?



Selective Use of Specific Six Sigma Tools

- Phase/Gate Processes
- Critical Parameter Management
- SWOT Analysis
- Concept Engineering
- Pugh Concept Selection
- KJ Methodology
- Quality Function Deployment (QFD)
- Project Management Techniques
- Concept Design for Practitioners
- Measurement systems analysis
- Design Capability analysis
- Descriptive statistics
- Graphical techniques
  - Box Plots
  - Histograms
  - Scatterplots
  - Time series plots
  - Run charts
  - Pareto charts
- Hypothesis testing
- Basic Statistical techniques
- Analysis of Variance
- Simple and multiple regression
- Multi-Vari studies
- Inferential statistics
  - ← Central limit theorem
  - ← Confidence intervals
- Design Failure Modes and Effects Analysis (DFMEA)
- Taguchi Robust Design Techniques
- Design of Experiments for empirical modeling
- 1st Principles (Y = f(x) modeling
- Sequential experiments
- Response surface methods
- Non-normal Data Transformations
- Normal distribution eval.
- Sample size determination
- Screening studies
- Statistical Tolerancing
- Tolerance Design
  - Analytical Methods
  - Empirical Methods
- Design for Manufacturability and Assembly
- Platform & Modular Design
- System Architecting
- Practical Design Principles
- Reliability Analysis
- Statistical Process Control

Estimated Tool Usage for this Project

AQP Toolbox (Common with six sigma toolbox)

(Potential Too-To-Use)

Graphical Tools:

- Box plots
- Scatter plots
- Multi-vari graphs
- Normality plot
- Pareto charts
- Capability analysis
- Histograms
- Statistical process control (SPC) charts
- Main effects plots
- Interaction plots

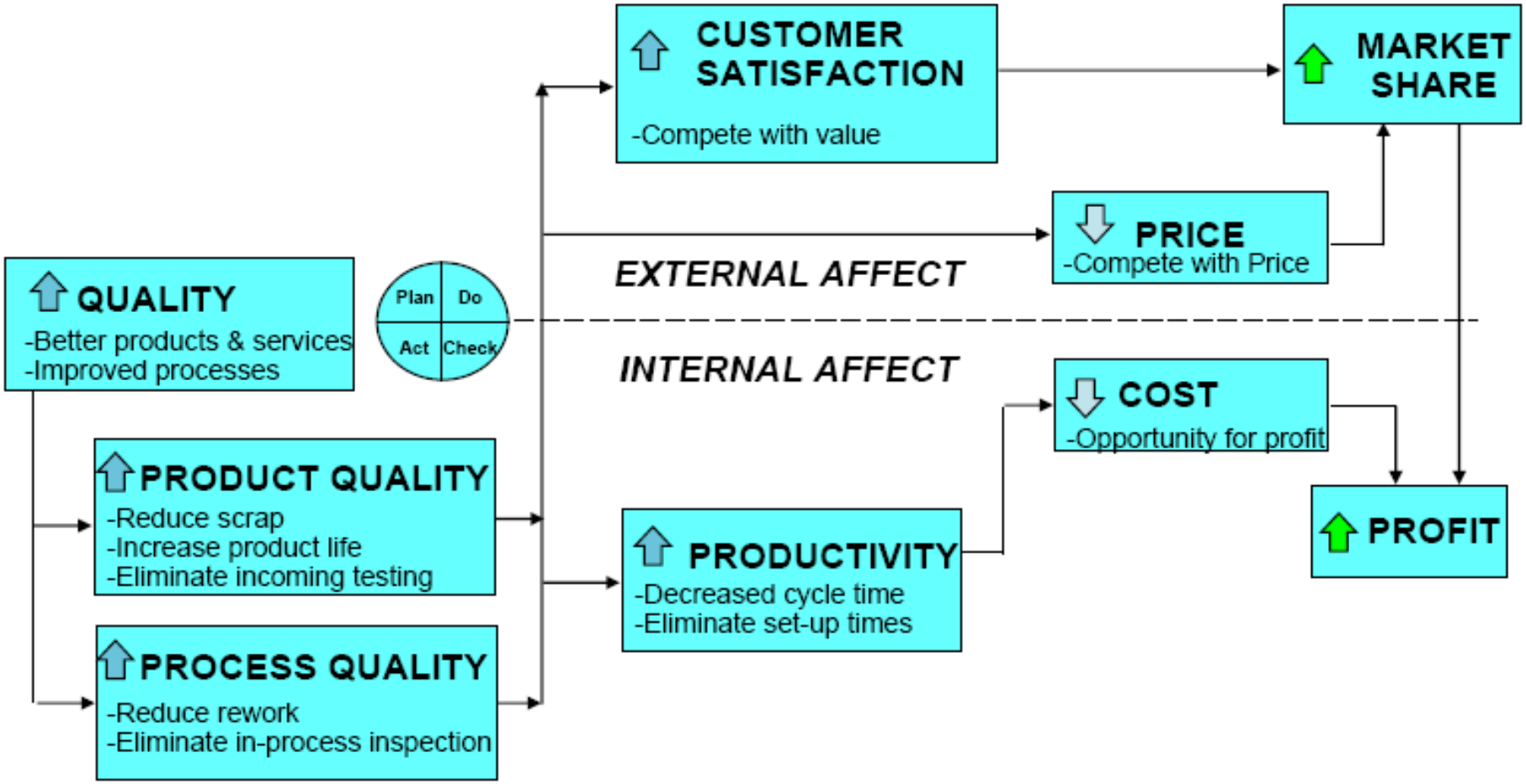
Brainstorming Tools:

- CTQ flowdown
- Design concept matrix
- Cause & effect diagram
- Failure modes & effects analysis (FMEA)
- Process mapping
- Benchmarking

Analytical Tools:

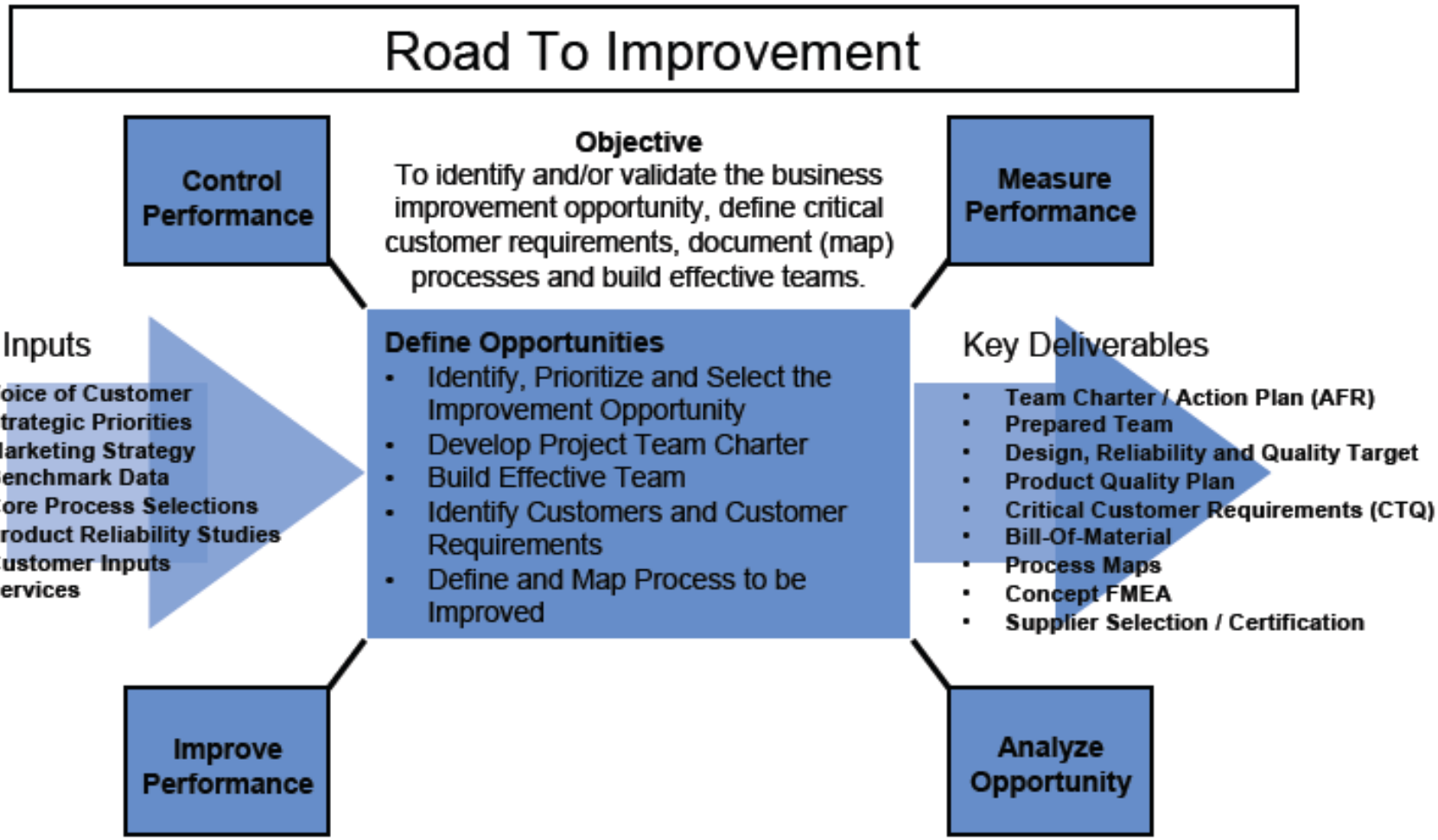
- Z - test
- T-test
- F-test
- p-test
- C^2 - test
- Confidence intervals
- Hypothesis test & risk
- sample size
- Sigma assessment tool
- Analysis of variance (ANOVA)
- Gage repeatability & reproducibility (GR&R)
- Normality test
- Transformation of non-normal distributions
- C^2 test of independence
- Regression analysis
- Logistic regression
- Design of experiments (doe)
- Monte Carlo simulations

Quality's business contribution

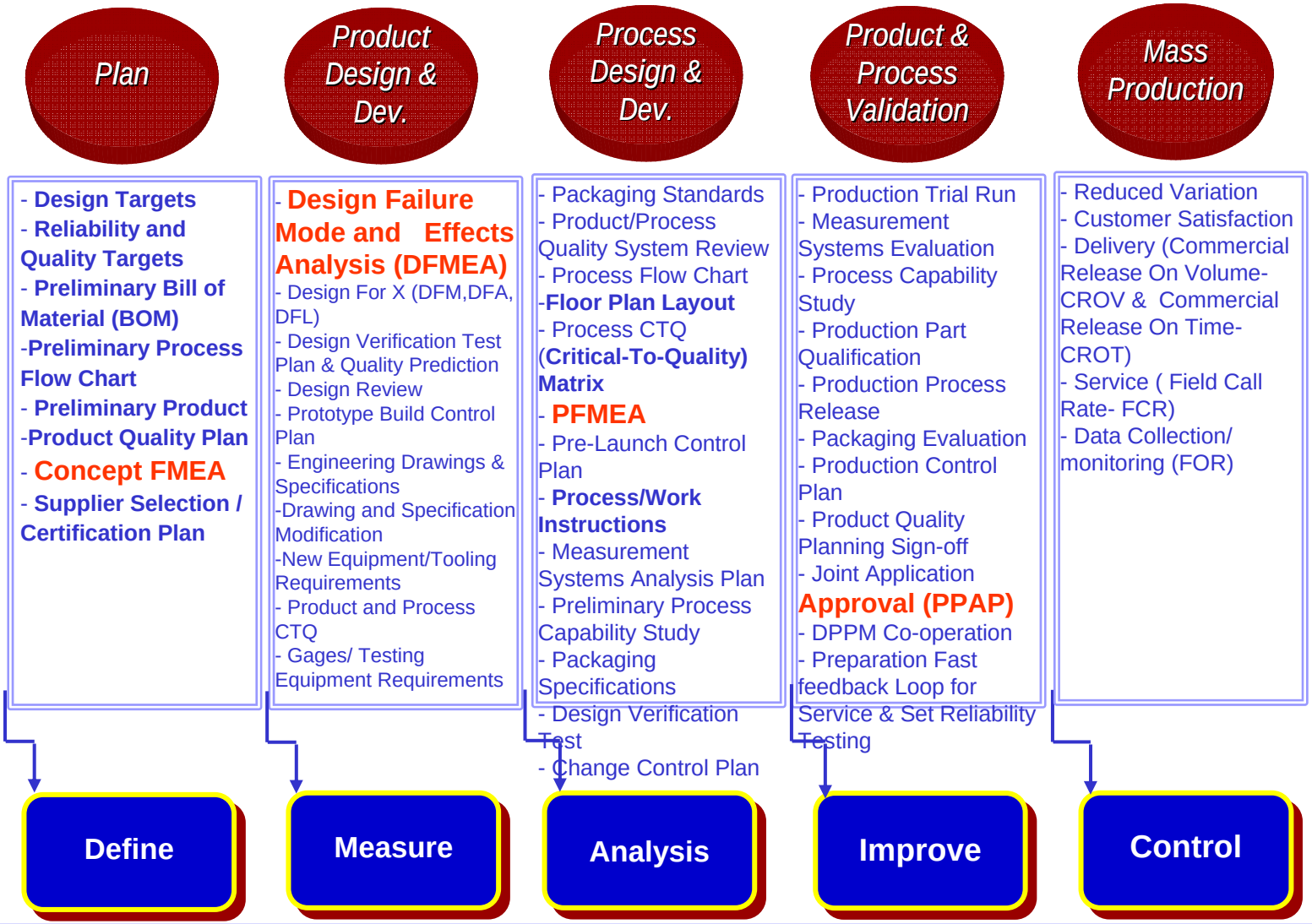


Quality contributes to profitability...

Example … Phase 1 - Planning overview



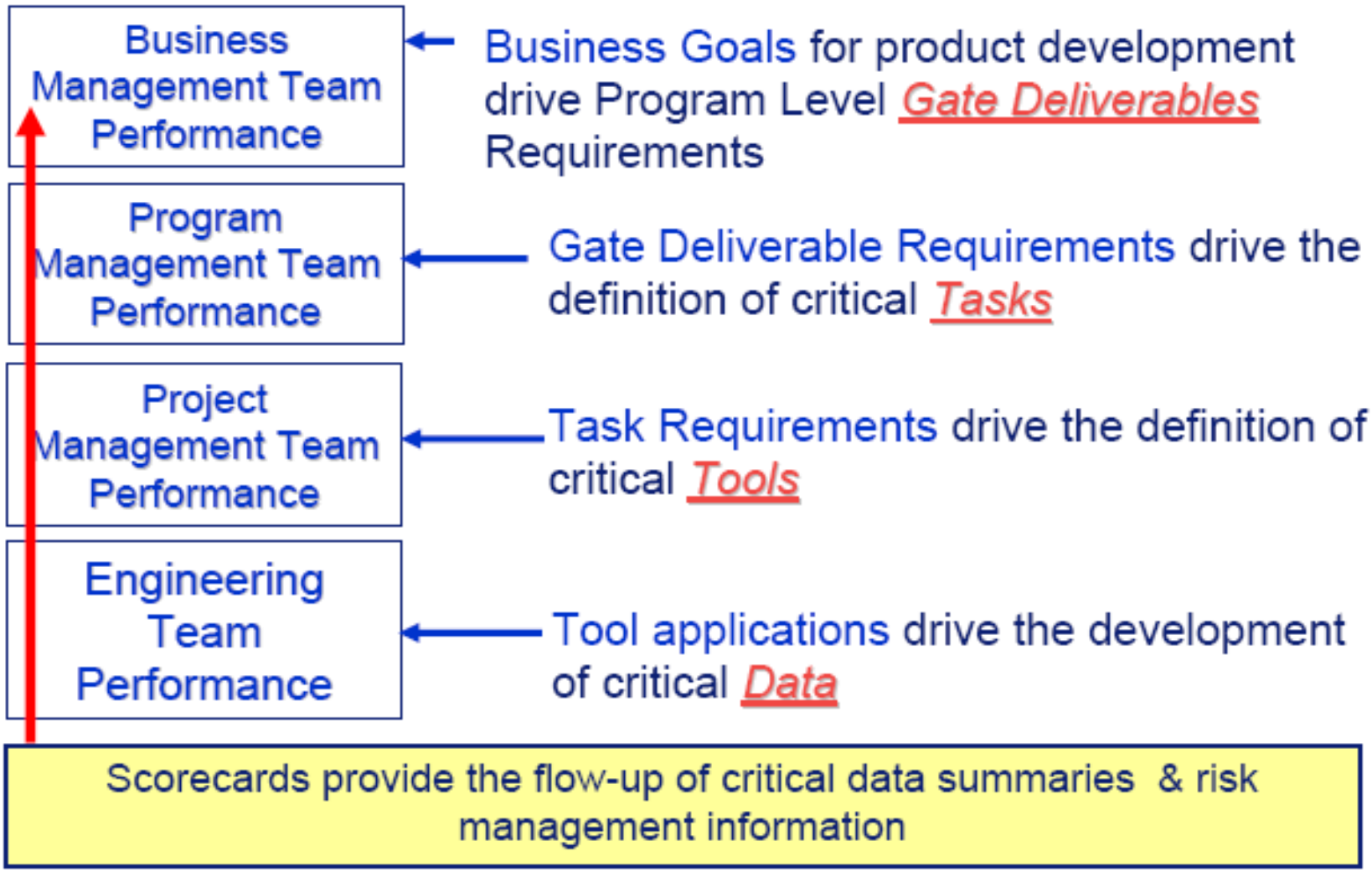
AQP Process:


Plan
Product Design & Dev.
Process Design & Dev.
Product & Process Validation
Mass Production
- Design Targets
- Reliability and Quality Targets
- Preliminary Bill of Material (BOM)
-Preliminary Process Flow Chart
- Preliminary Product
-Product Quality Plan
- Concept FMEA
- Supplier Selection / Certification Plan
- Design Failure Mode and Effects Analysis (DFMEA)
- Design For X (DFM,DFA, DFL)
- Design Verification Test Plan & Quality Prediction
- Design Review
- Prototype Build Control Plan
- Engineering Drawings & Specifications
-Drawing and Specification Modification
-New Equipment/Tooling Requirements
- Product and Process CTQ
- Gages/ Testing Equipment Requirements
- Packaging Standards
- Product/Process Quality System Review
- Process Flow Chart
-Floor Plan Layout
- Process CTQ (Critical-To-Quality) Matrix
- PFMEA
- Pre-Launch Control Plan
- Process/Work Instructions
- Measurement Systems Analysis Plan
- Preliminary Process Capability Study
- Packaging Specifications
- Design Verification Test
- Change Control Plan
- Production Trial Run
- Measurement Systems Evaluation
- Process Capability Study
- Production Part Qualification
- Production Process Release
- Packaging Evaluation
- Production Control Plan
- Product Quality Planning Sign-off
- Joint Application Approval (PPAP)
- DPPM Co-operation
- Preparation Fast feedback Loop for Service & Set Reliability Testing
- Reduced Variation
- Customer Satisfaction
- Delivery (Commercial Release On Volume-CROV & Commercial Release On Time-CROT)
- Service (Field Call Rate- FCR)
- Data Collection/ monitoring (FOR)
Define
Measure
Analysis
Improve
Control

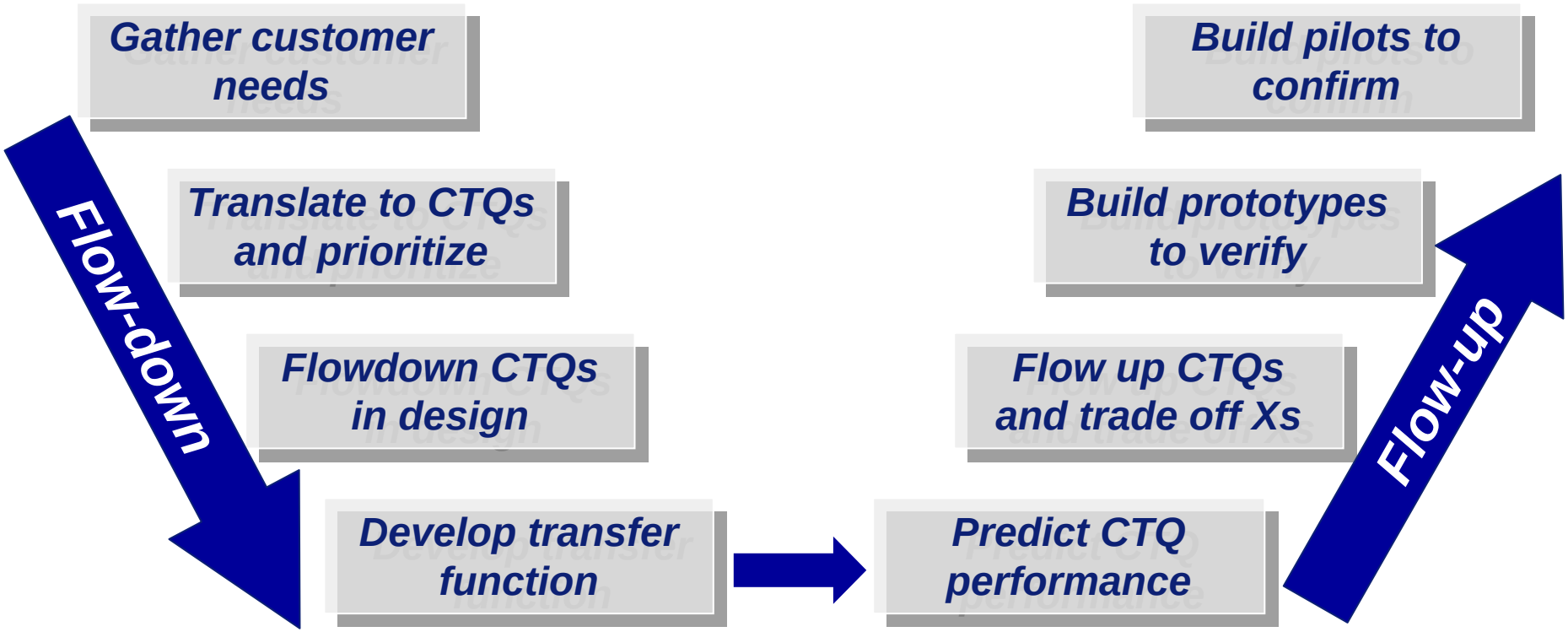
Phase 1 - Plan and Define Program (Inputs)

- Voice of the Customer
  - Market Research
  - Historical Warranty and Quality Information
  - Team Experience
- Business Plan/Marketing Strategy
- Product/Process Benchmark Data
- Product/Process Assumptions
- Product Reliability Studies
- Customer Inputs

Critical-to-Quality

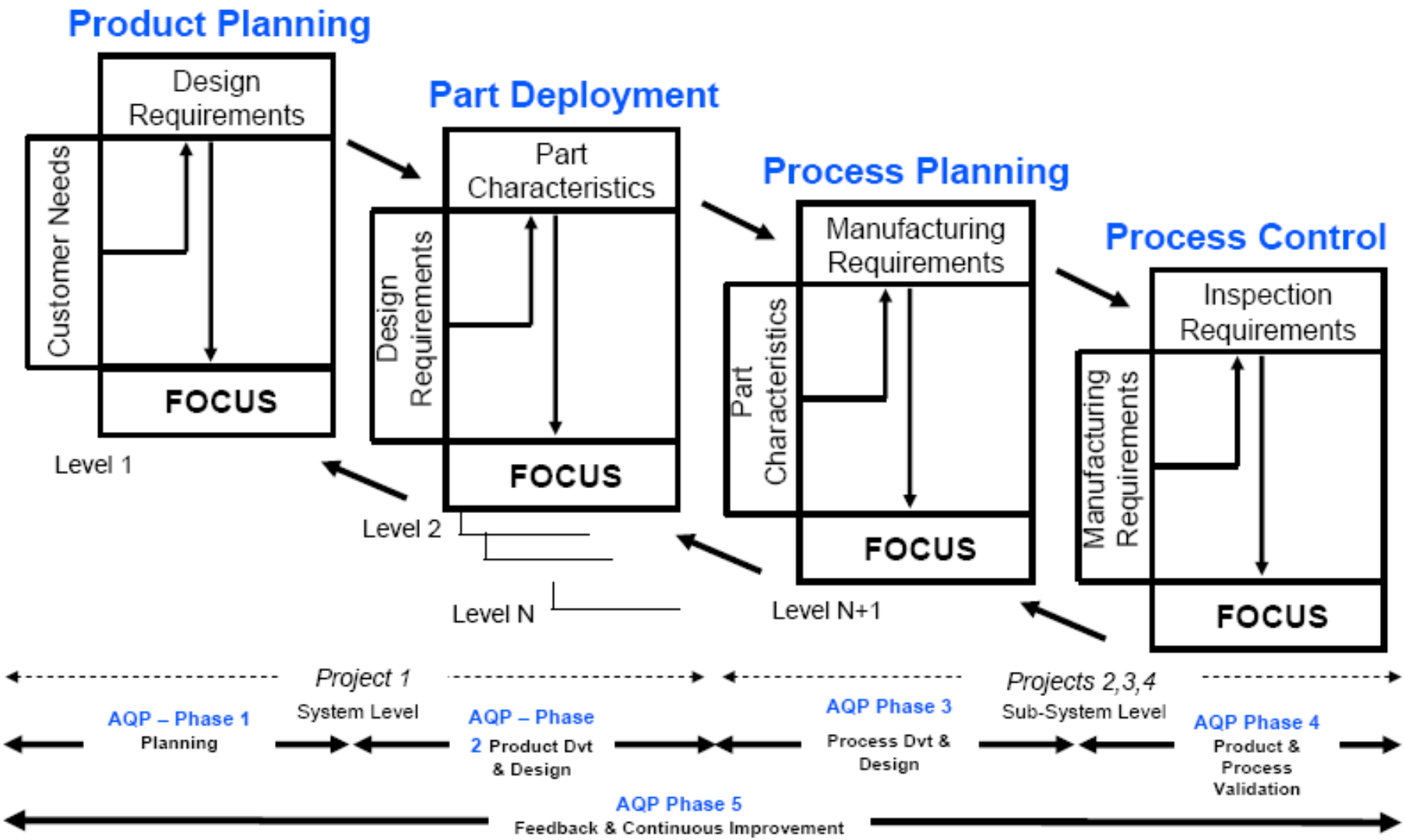


CTQ's Flow-down / Flow-up



1. Use real manufacturing capability data if possible
2. If there are too many Xs to collect capability data all at once, start predictions with mean and tolerance / 6 for standard deviation
3. Collect real process capability information for the most sensitive Xs

Multi-Level CTQ Flowdown



Phase 1 - Plan and Define Program

Outputs: Become inputs for Phase 2.

- Design Targets
- Reliability and Quality Targets
- Preliminary Bill of Material (BOM)
- **Preliminary Process Flow Chart**
- Preliminary Product and Process CTQ (Critical-To-Quality)
- **Product Quality Plan**
- Concept FMEA
- **Supplier Selection / Certification Plan**

Phase 1 : Preparation	Kick-Off	Project Letter		CS		PRS		DR		CR		MPR	
a. Design Targets				♦									
b. Quality and Reliability Targets				♦									
c. Preliminary Material list				♦									
d. Preliminary Process Flowchart				♦									
e. Advanced Quality Planning				♦									
f. Supplier Certification of involved design and production facilities				♦									
g. Supplier Management Commitment				♦									
h. CE Management Support				♦									

	❑ standards (safety, environmental, technical, reliability,...) ❑ *Supplier's awareness of specific CE assembly process requirements. (Pb-free, wave or reflow soldering, hand or automatic mounting?)* ❑ *Evaluation of necessary PCE compatible design tools*
b. *Quality and Reliability Targets*	❑ *PCE Quality Specification submitted and agreed upon by the supplier* ❑ *Mutual Agreement on Quality (Fall-of-Rate) and Reliability (Field Call-Rate) Targets and Roadmaps via specific Quality Agreement. Both parties should sign.* ❑ *Prediction and target of supplier's internal reject rate.*
c. *Preliminary Material list*	❑ *Preliminary Bill of Material and subcontractor list mentioning not yet approved required components or materials* ❑ *Formal verification of absence of banned materials is confirmed* ❑ *Formal verification of content level of other environment relevant substances is confirmed*
d. *Preliminary Process Flowchart*	❑ *Submission of Preliminary Process flowchart including possible up-front supplier chain description with mention of not yet approved subcontractors. (In-house process flow should mention inspection and control points)*
e. *Advanced Quality Planning*	❑ *Supplier agreement on Advanced Quality Planning and in-line with agreed project planning milestones* ❑ *Preparation of checklist according UAT-0515. Checklist completed by CE-team and sent to the supplier.*
f. *Supplier Certification of the involved design and production facilities*	❑ *Supplier shall show evidence of ISO9000/2000 certification.* ❑ *If ISO9000/2000 certification is not available at CS milestone, a dedicated roadmap including timeline will be presented to CE.*
g. *Supplier Management Commitment*	❑ *Supplier's allocated Quality Management resource*
h. *CE Management support*	❑ *Project registration letter signed (see chapter 8)*

Phase 2 - Product Design and Development

Outputs: Become inputs for Phase 3.

- Design Failure Mode and Effects Analysis (DFMEA)
- **Design For X (DFM,DFA,DFL)**
- Design Verification Test (DVT) Plan & Quality Prediction
- Design Review
- Prototype Build Control Plan
- Engineering Drawings & Specifications (Including Math Data)
- Drawing and Specification Modification
- New Equipment/Tooling Requirements
- Product and Process CTQ (Critical-To-Quality)
- Gages/ Testing Equipment Requirements

Phase 3 - Process Design and Development

Outputs: Become inputs for Phase 4.

- Packaging Standards
- Product/Process Quality System Review
- Process Flow Chart
- **Floor Plan Layout**
- Process CTQ (Critical-To-Quality) Matrix
- PFMEA
- Pre-Launch Control Plan
- **Process/Work Instructions**
- Measurement Systems Analysis Plan
- Preliminary Process Capability Study
- Packaging Specifications
- Design Verification Test
- Change Control Plan

Phase 4 - Product and Process Validation

Outputs: Become inputs for Phase 5.

- Production Trial Run
- Measurement Systems Evaluation
- Process Capability Study
- **Production Part Qualification**
- **Production Process Release - Supplier Product / Process Audit Checklist**
- Packaging Evaluation
- Production Control Plan
- Product Quality Planning Sign-off
- Joint Application Approval (PPAP)
- DPPM Co-operation
- Preparation Fast feedback Loop for Service & Set Reliability Testing

Phase 5 - Feedback, Assessment and Corrective Action

Outputs:

- Reduced Variation
- Customer Satisfaction
- Delivery (Commercial Release On Volume- CROV & Commercial Release On Time- CROT)
- Service (Field Call Rate- FCR)
- Data Collection/ monitoring (FOR)
- Post Mortem

Roles and Responsibilities of CFT

ORGANIZE THE TEAM

The supplier's first step in Product Quality Planning is to assign responsibility to a cross functional team. Effective product quality planning requires the involvement of more than just the quality department. The initial team should include representatives from engineering, manufacturing, material control, purchasing, quality, sales, field service, subcontractors, and customers, as appropriate.

TEAM-TO-TEAM

The Product Quality Planning Team must establish lines of communication with other customer and supplier teams. This may include regular meetings with other teams. The extent of team-to-team contact is dependent upon the number of issues requiring resolution.

… the AQP Leader and the AQP Champion ensure that the team is properly staffed and trained

Structure of CFT

Executives / Sponsor

Project Champion

Master Champion/Master Black Belt

AQP Champions /Managers

AQP Leader (Joint Quality Manager + Suppliers)

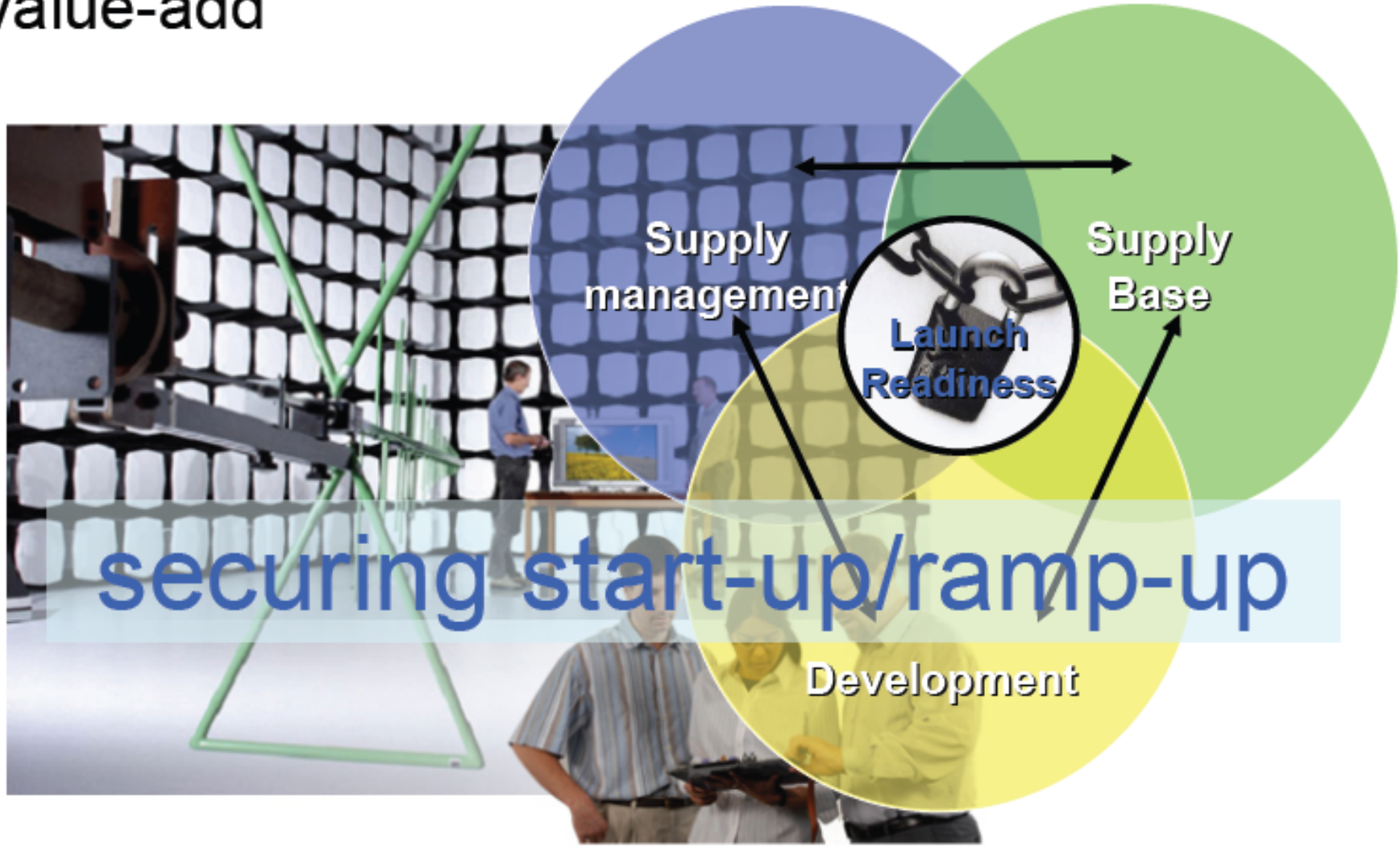
AQP Team Members

Subject Matter Experts

Green Belts

Line Managers & Staff

Where are the areas of activity … what is the value-add



Many Thanks

for Your Attention !!!

Tool Kits

House of Quality

Microsoft Excel Worksheet

Product FMEA

Microsoft Excel Worksheet

Process FMEA

Microsoft Excel Worksheet