Prosperity Heights Software

Experiencing Product Line Adoption

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Tutorial Scope

Domain-specific Engineering™ (DsE)

   The nature of a product line process

Reuse-driven Process Improvement™ (PI$_r$)

   Instituting product line business objectives

   Assessing product line needs and capabilities

   Adopting and improving a product line approach

Terminology

- **Market: A set of customers having similar needs**

- **Product: A set of artifacts that represent a problem and its solution**

- **Product line: A set of similar products (to be) created by an organization for a market**

- **Product family: A unified representation of a set of similar products**

- **Domain: The knowledge and expertise needed to create a set of similar products**

Questions to Consider

Why do organizations adopt a product line approach?

How does a product line process differ from a conventional process?

How does process improvement differ for a product line?

PL Business Motivations

Improve productivity and product quality by focusing efforts on a set of similar products

Gain competitive advantage by being more responsive to diversity and change in customer and market needs

Topic Outline

- **Domain-specific Engineering for a product line business**

- **PI_r**

  - **The adoption/improvement process**

  - **Assessment models**

  - **Product line strategy**

- **Future directions**

Domain-specific Engineering (DsE)

A framework and discipline for the

engineering and manufacture

of similar products

What Makes DsE Different?

**Standardizing on the most effective solutions
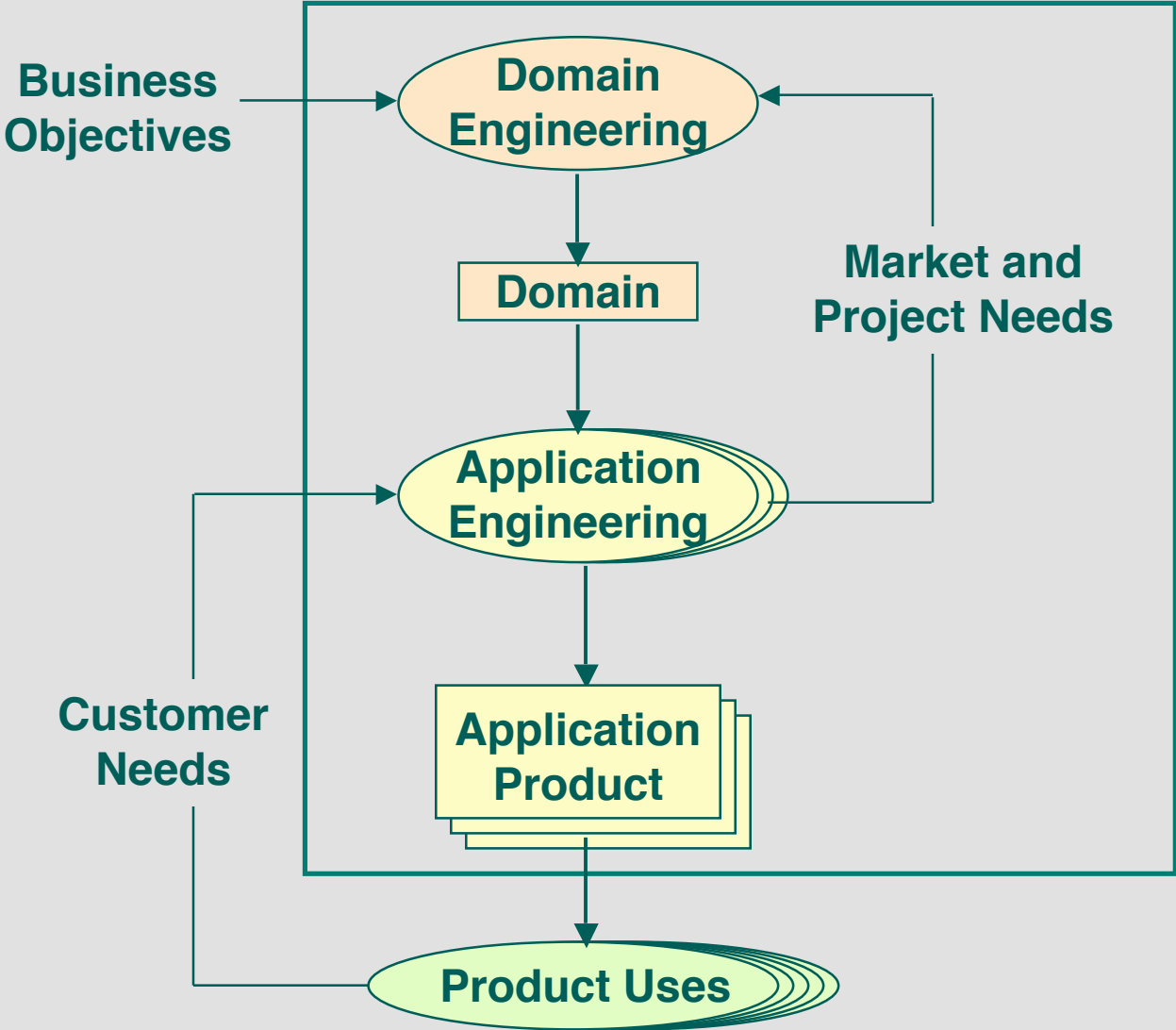to a class of similar problems**

- **Focusing exclusively on a market (customers who have similar needs)**

- **Achieving a consensus on how and why customers' needs differ and change**

- **Developing a product family and process for rapidly building customized products**

The Point Being to Build Products

- **Create a domain-specific infrastructure to enhance your ability to build products (*Domain Engineering*)**

- **Build products using a domain-specific infrastructure (*Application Engineering*)**

2 interdependent objectives => a 2-step iterative process

The DsE Process

Business Objectives → **Domain Engineering**

Domain Engineering → **Domain**

Market and Project Needs

Domain → **Application Engineering**

Customer Needs

Application Engineering → **Application Product**

Application Product → **Product Uses**

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Domain Engineering

Domain Management

Organize, plan, and direct domain efforts to achieve business objectives

Domain Definition

Characterize buildable products in terms of commonalities and variabilities (decisions)

Product Family Engineering

Develop assets and mechanisms for deriving individual products

Process Engineering

Define an AE process and create a supporting infrastructure

Project Support

Ensure that the domain meets business, organizational, and market needs

Potential Benefits of DsE

- Domain knowledge and expertise become an organizational asset

- Customer needs are expressed in a standardized form and terminology

- Quality improvements in the product family improve the quality of all products

- Process standardization fosters more predictable schedules and cost estimates

- Process streamlining, based on a product family, reduces time and effort to deliver similar products

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Objectives of PI$_r$

- Establish a focus on a viable product line market

- Define an effective product line strategy (based on DsE)

- Guide adoption and improvement of software practices (engineering and manufacturing) appropriate to the product line

PI$_r$ Objectives, Abbreviated

DsE

Manufacturing Discipline

Engineering Discipline

Product Line Market Focus

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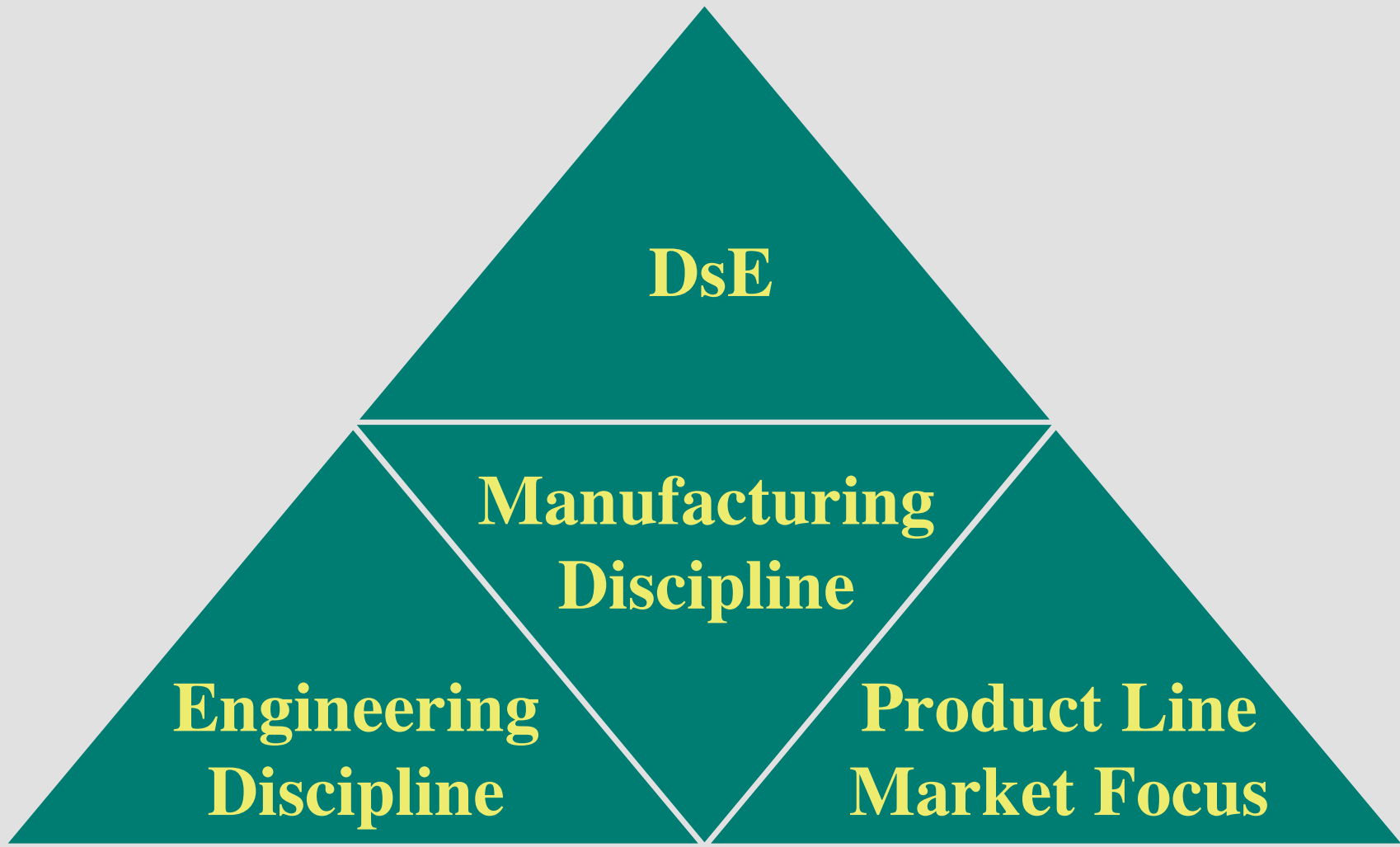
Process Improvement Terms

For a given process P:

Capability
The range of results that are achievable with P
(when P is stable)

Performance
The actual results achieved in following P

Maturity
The predictability with which performance of P attains
the capability of P

Cornerstones of PI$_r$

- **An effective model for improving process maturity**
  {such as SEI Capability Maturity Model® Integration (CMMI)}

- **Reuse as an enabler of improved process capability:**
  - **Higher productivity (more products faster)**
  - **Consistent or improving quality (better products)**
  - **Responsiveness to diverse or changing needs**

- **A limited organizational scope: A product line business area** *(whose focus on similar problems enables reuse of solutions)*

- **An ability to correlate investment-level to capability-level**

Precursors to PI$_r$

- **Software Engineering Institute**
  - *Capability Maturity Model® for Software* **(1993)**

- **Software Productivity Consortium**
  - *Reuse Adoption Guidebook* **(1993)**

- **Prosperity Heights Software (for Thomson-CSF)**
  - **"A Unified Approach to the CMM and RCM for RSP Adopters" (1997)**
  - **"Domain Assessment for RSP Adopters" (1997)**

PI$_r$ Refinements

- **Integrate process improvement and reuse adoption efforts**

- **Distinguish capability improvement from maturity improvement**

- **Define criteria for evaluating viability of a product line orientation before commitment**

- **Defer product line technical choices and effort to DsE**

- **Focus on instituting single product lines, not organization-wide or general-purpose reuse**

- **Emphasize self-assessment and leadership-based action with minimal bureaucracy**

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PI$_r$ Prerequisites

A possible PL business focus

  A product concept

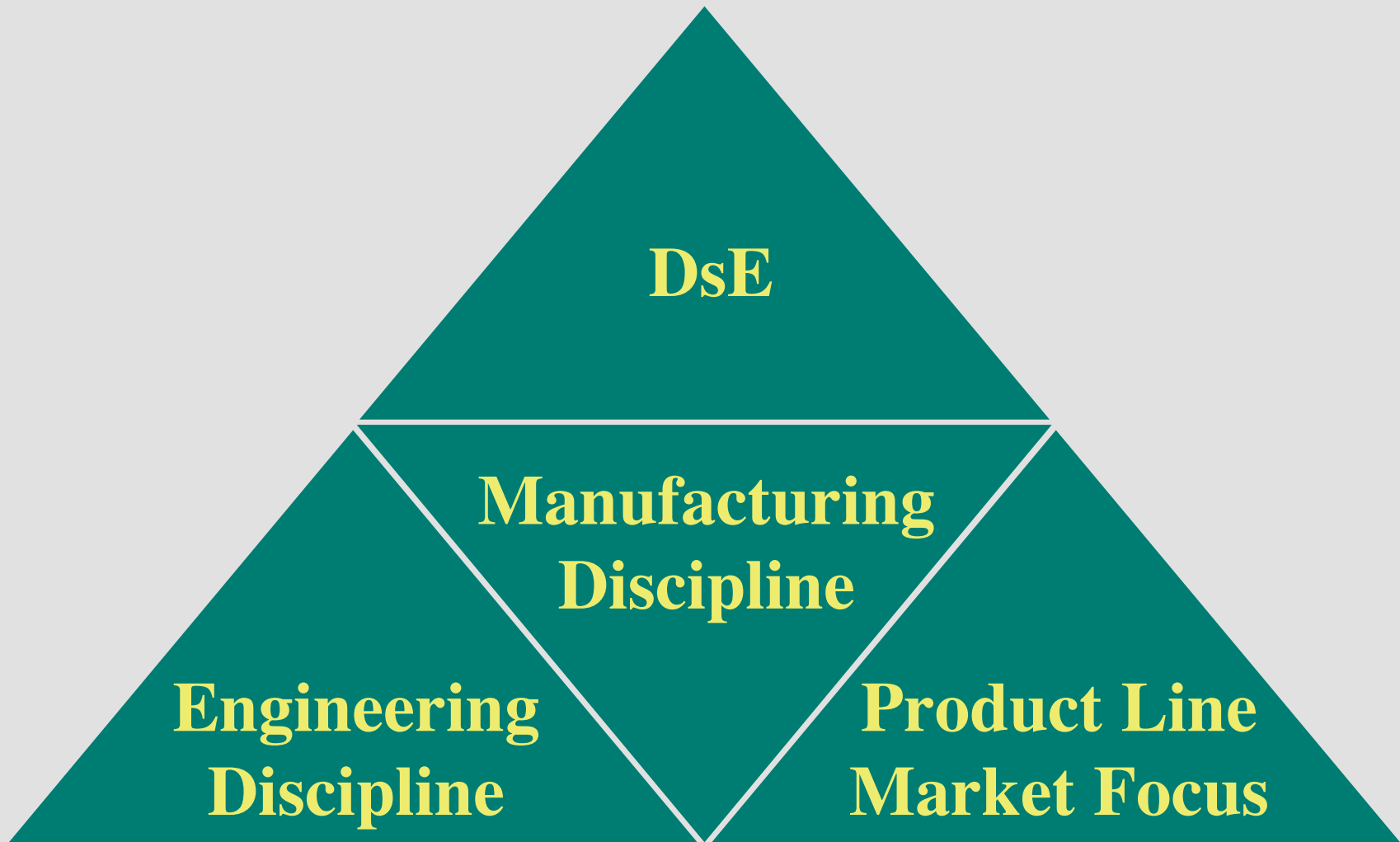 Potential customers

Awareness of PL benefits based on:
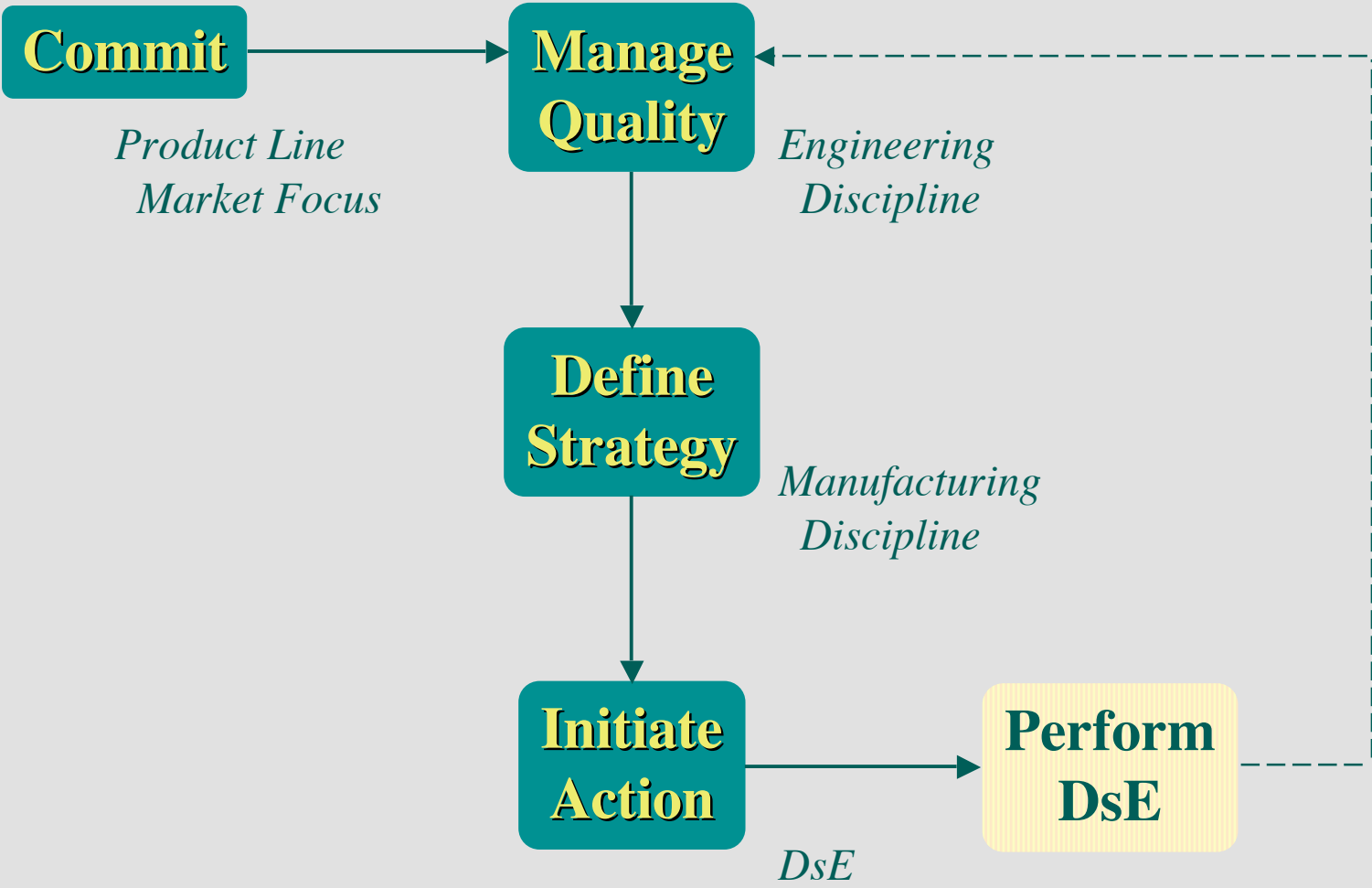
  Tutorials or publications

  Industry anecdotes

  PL or reuse pilot efforts
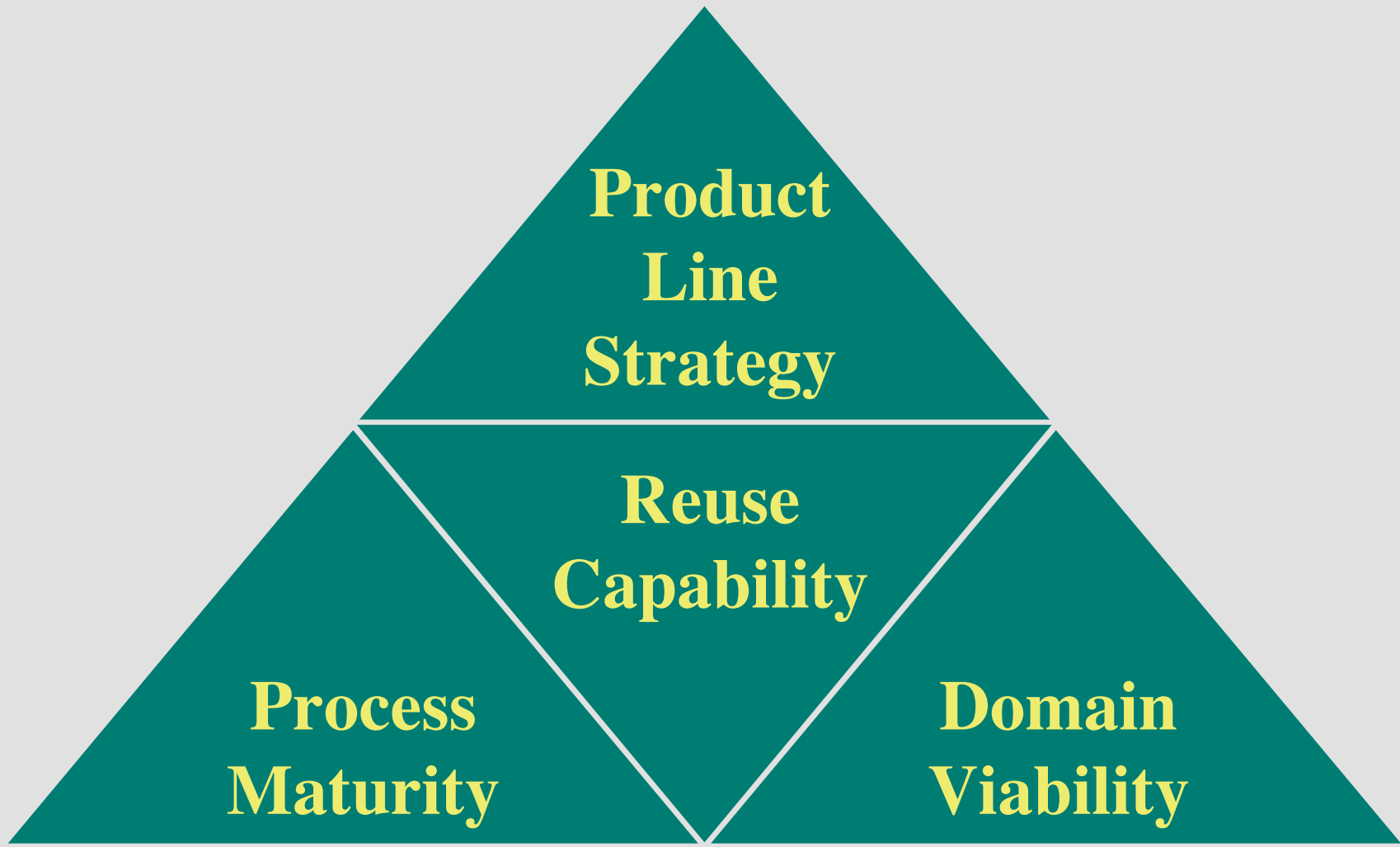
Openness to process improvement efforts

PI$_r$ Objectives

DsE

Manufacturing Discipline

Engineering Discipline

Product Line Market Focus

PI$_r$ Process

Commit → **Manage Quality**

Product Line Market Focus

Engineering Discipline

Manage Quality → **Define Strategy**

Manufacturing Discipline

Define Strategy → **Initiate Action** → **Perform DsE**

DsE

PI$_r$ Tools

Product Line Strategy

Reuse Capability

Process Maturity

Domain Viability

PI_r Process

Commit

Manage Quality

Domain Viability

Process Maturity

Define Strategy

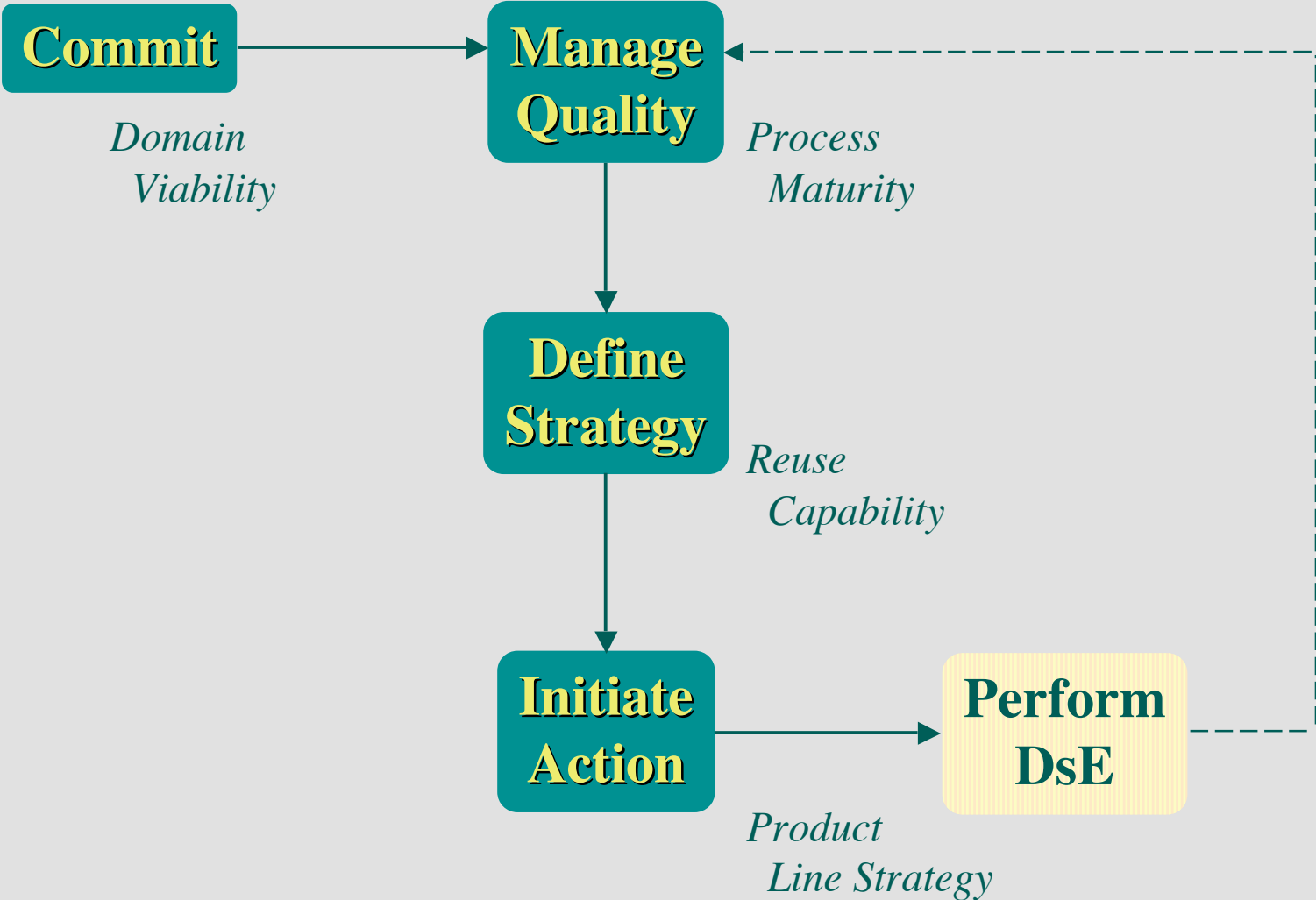*Reuse Capability*

Initiate Action

Perform DsE

Product Line Strategy

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Commit

- **Characterize the product line opportunity**
  - **Products**
  - **Customers**
  - **Business challenges**
- **Define business objectives**
- **Evaluate domain viability**
  - **Subjective factors**
  - **Financial projections**
- **Allocate resources to institute a domain**
- **Monitor progress and revise commitment as circumstances change**

Manage Quality

- **Assess process maturity**
  - **Conventional criteria**
  - **Reuse criteria**
- **Identify needed improvements**
- **Initiate improvement actions**
  - **Define action plans**
  - **Implement actions**
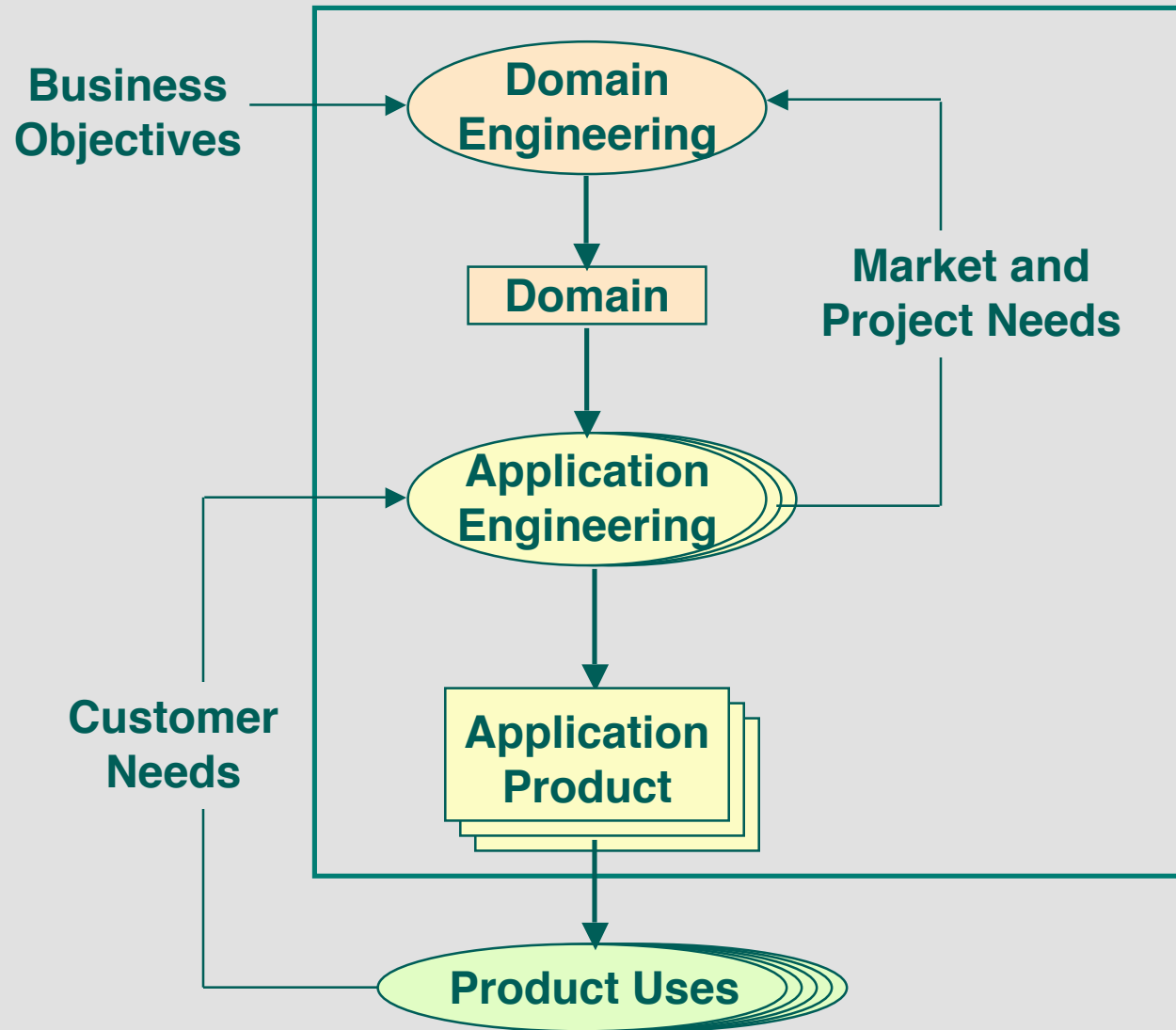 - **Evaluate effects**

Define Strategy

- **Target an appropriate level of reuse capability**
    - **Business objectives**
    - **Risks**
    - **Financial projections**
- **Develop a product line strategy for the business**

Initiate Action

- **Obtain funding and organizational support**

- **Augment staffing**

- **Provide documentation and training**

- **Implement infrastructure**

- **Resolve organizational/cultural and legal/contractual issues**

Perform DsE

Business
Objectives → **Domain Engineering**

Domain

Market and Project Needs

Application Engineering

Customer Needs

Application Product

Product Uses

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PI$_r$ Tool for Committing to a PL Effort

Product Line Strategy

Reuse Capability

Process Maturity

Domain Viability

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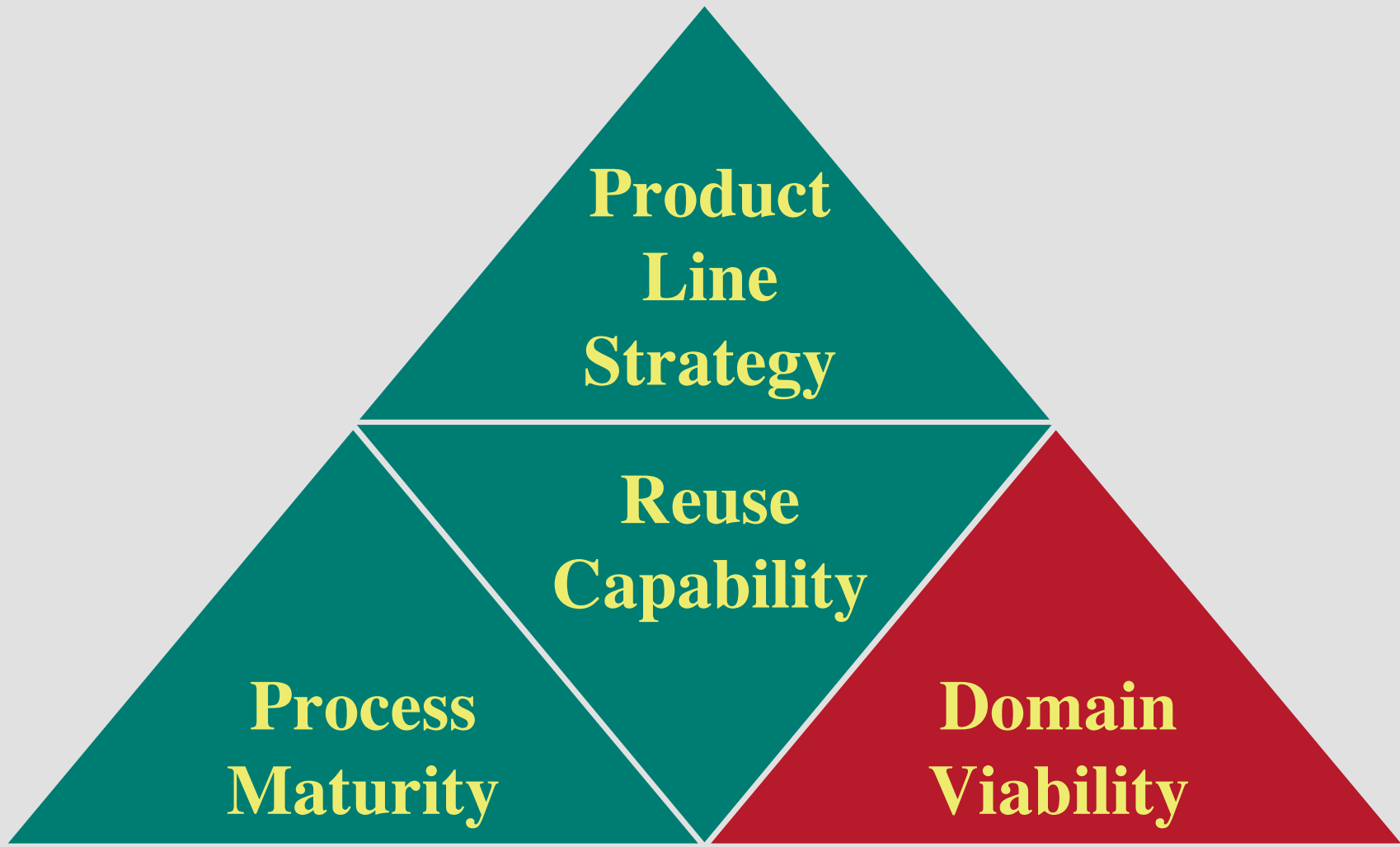
Domain Viability

- **Prerequisite: Preliminary domain scoping**
  - **Products (past, current, future)**
  - **Targeted customers**
  - **Sources of diversity and change**
- **Purpose: Refine business objectives to achieve viability**
- **Approach:**
  - **Evaluate viability <u>prerequisites</u>**
  - **Weigh significance of <u>positive indicators</u>**
  - **Assess risks suggested by <u>negative indicators</u>**
  - **Compare financial projections for current point-solution versus 2-4 product line business strategies**

Domain Viability
Evaluation Criteria

Market opportunity
Are there customers for a line of similar products?

Technical expertise
Does the organization have the expertise to build envisioned products?

Business commitment
Is there a credible case for investing in this business?

Domain Viability
Market Opportunity Examples

- **Prerequisites**

  "There are customers who need products of this type."

- **Positive indicators**

  "Customers will add or replace such products in the future because of changing needs."

- **Negative indicators**

  "Customers have previously adapted their business practices in order to use a generalized product and would disregard or not benefit from customized products."

Domain Viability
Technical Expertise Examples

- **Prerequisites**

   "Assignable technical staff are familiar with the nature of customer needs to be addressed."

- **Positive indicators**

   "Assignable staff understand why products differ as a result of different customer needs."

- **Negative indicators**

   "Direct needs of current/future projects in producing individual products will limit availability of key staff needed for an effective product line effort."

Domain Viability
Business Commitment Examples

- ## Prerequisites

  "Sources for domain investment exist, given a sound business case."

- ## Positive indicators

  "The organization is already a vendor of this type of product."

- ## Negative indicators

  "Proposed domain scoping would create an unacceptable conflict with the product or market alignments of other associated business organizations."

Compare Financial Projections

Baseline

- C_P: current direct cost to build a single product
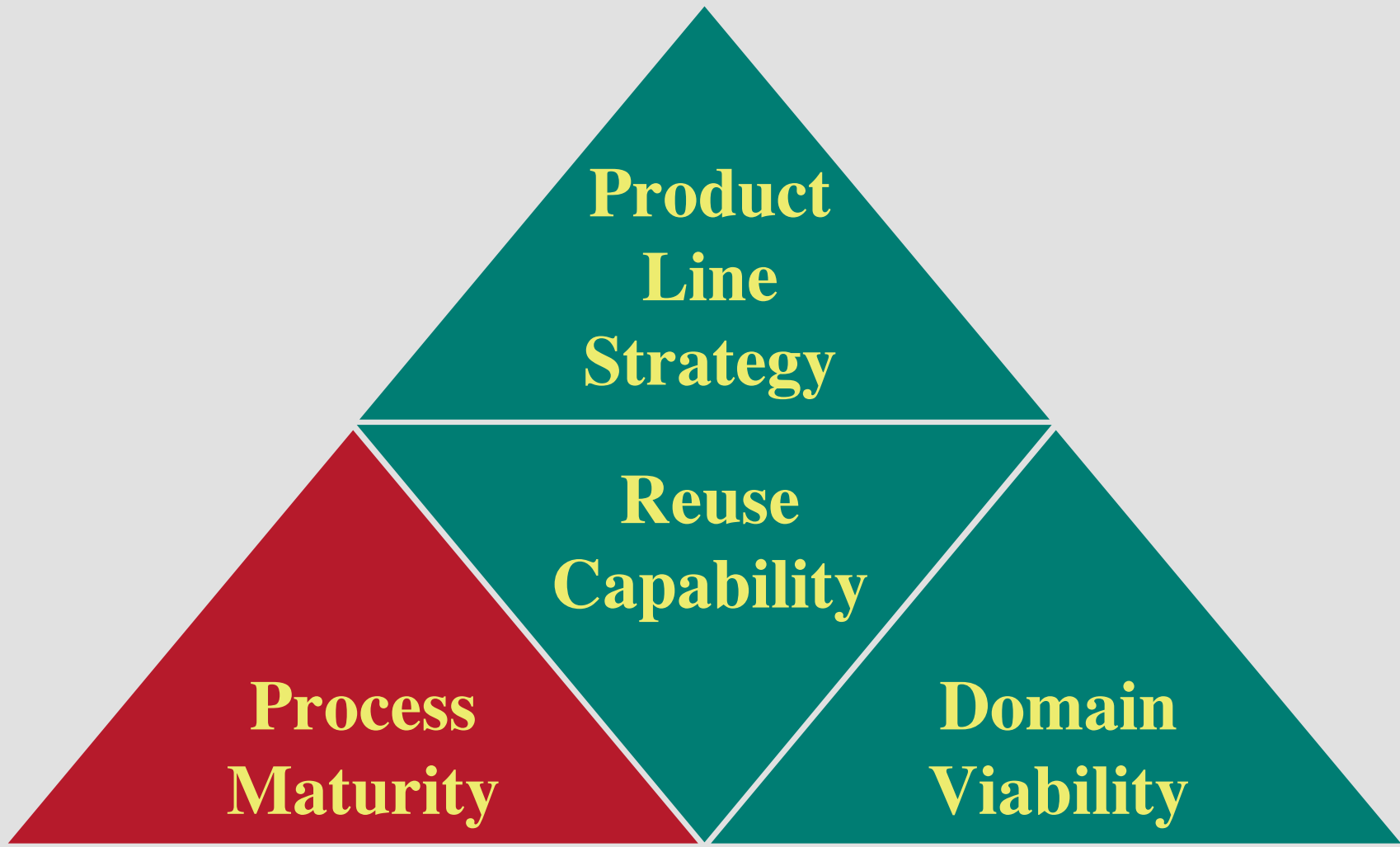- N: projected number of future products

Rough order-of-magnitude cost factors

- Organization transition cost = C_P * 0.5
- C_{DE}: Total DE cost = C_P * 2.0 {?[1.0–>3.0]}
- C_{AE}: Product direct cost = C_P * 0.1 {?[0.5–>0.01]}
- Product adjusted cost = C_{AE} + C_{DE} / N

Projected future cost

- without DsE = C_P * N
- with DsE = C_P * (2.5 + N * 0.1)

PI$_r$ Tool for Managing Quality

Process Maturity

- **Prerequisite:**
  - **Targeted domain scope**
  - **Process improvement method**
- **Purpose: Improve engineering practices for effectiveness and efficiency**
- **Approach:**
  - **Start with an effective process maturity concept**
  - **Extend maturity factors to have a reuse facet**
  - **Add reuse-directed maturity factors**
- **Evaluation technique: Consensus self-assessment**

Process Maturity
Improvement Objectives

Customer/supplier relationships
Manage external interactions effectively

Engineering methods
Perform technical activities properly

Project management
Work within budget and schedule constraints

Product quality and integrity
Achieve quality goals for products

Organizational infrastructure
Establish effective support for common needs

Process predictability
Reduce variation in results experienced across projects

Process Maturity
CMM KPAs Grouped by Objective

- **Customer/supplier relationships** (Requirements Management, Software Subcontract Management)

- **Engineering methods** (Software Product Engineering, Intergroup Coordination)

- **Project management** (Software Project Tracking and Oversight, Software Project Planning, Integrated Software Management, Quantitative Process Management)

- **Product quality and integrity** (Software Quality Assurance, Software Configuration Management, Peer Reviews, Software Quality Management, Defect Prevention)

- **Organizational infrastructure** (Organization Process Focus, Training Program, Technology Change Management)

- **Process predictability** (Organization Process Definition, Process Change Management)

Process Maturity
Example CMM KPA Extensions

CMM KPA Goal

- **SCM-3: Changes to identified software work products are controlled.**

- **OPD-1: A standard software process for the organization is developed and maintained.**

- **OPD-2: Information related to the use of the organization's standard software process by the software projects is collected, reviewed, and made available.**

- **PCM-1: Continuous process improvement is planned.**

Reuse facet

- **Reusable assets are under configuration control.**

- **Standard reuse processes are defined and integrated with the organization's standard software process.**

- **Reuse experiences from past and current projects are collected and made available.**

- **Plans are established to systematically address weaknesses identified in reuse technology training.**

Process Maturity
Objectives Added for Reuse

Product line strategy and management
*Are strategy and management actions consistent with
an effective product line approach?*

Raw materials and assets
Do available raw materials and assets address product line needs?

Process and technology infrastructure
Do infrastructure activities support a product line effort?

Process Maturity
Added Reuse Factors

- **Product line strategy and management**
  - **Organizational Commitment**
  - **Commonality and Variability Definition**
  - **Costing and Pricing**

- **Process and technology infrastructure**
  - **Process Definition and Integration**
  - **Legal and Contractual Constraints**
  - **Tool support**
  - **Technology Innovation**

- **Raw materials and assets**
  - **Needs Identification**
  - **Asset Value Determination**
  - **Asset Quality and Verification**
  - **Asset Awareness, Accessibility, and Evaluation**
  - **Asset Reusability and Application Integrability**

Example Reuse Goals

Organizational commitment: **Management commits funding, staffing, and other resources to define, implement, and improve the organization's approach to reuse**

Commonality and variability definition: **Commonalities and variabilities in customers' needs are identified and guide providing assets that meet differing needs**

Costing and pricing: **Pricing and funding strategies take into account anticipated costs and benefits of following a product line approach**

Asset awareness, accessibility, and evaluation: **Developers have access to assets that have been specifically provided for use in their products**

Asset quality and verification: **Reusable assets are developed and verified against explicit specifications**

Tool support: **Tools are developed or acquired and tailored to support reuse capabilities of the organization's standard processes**
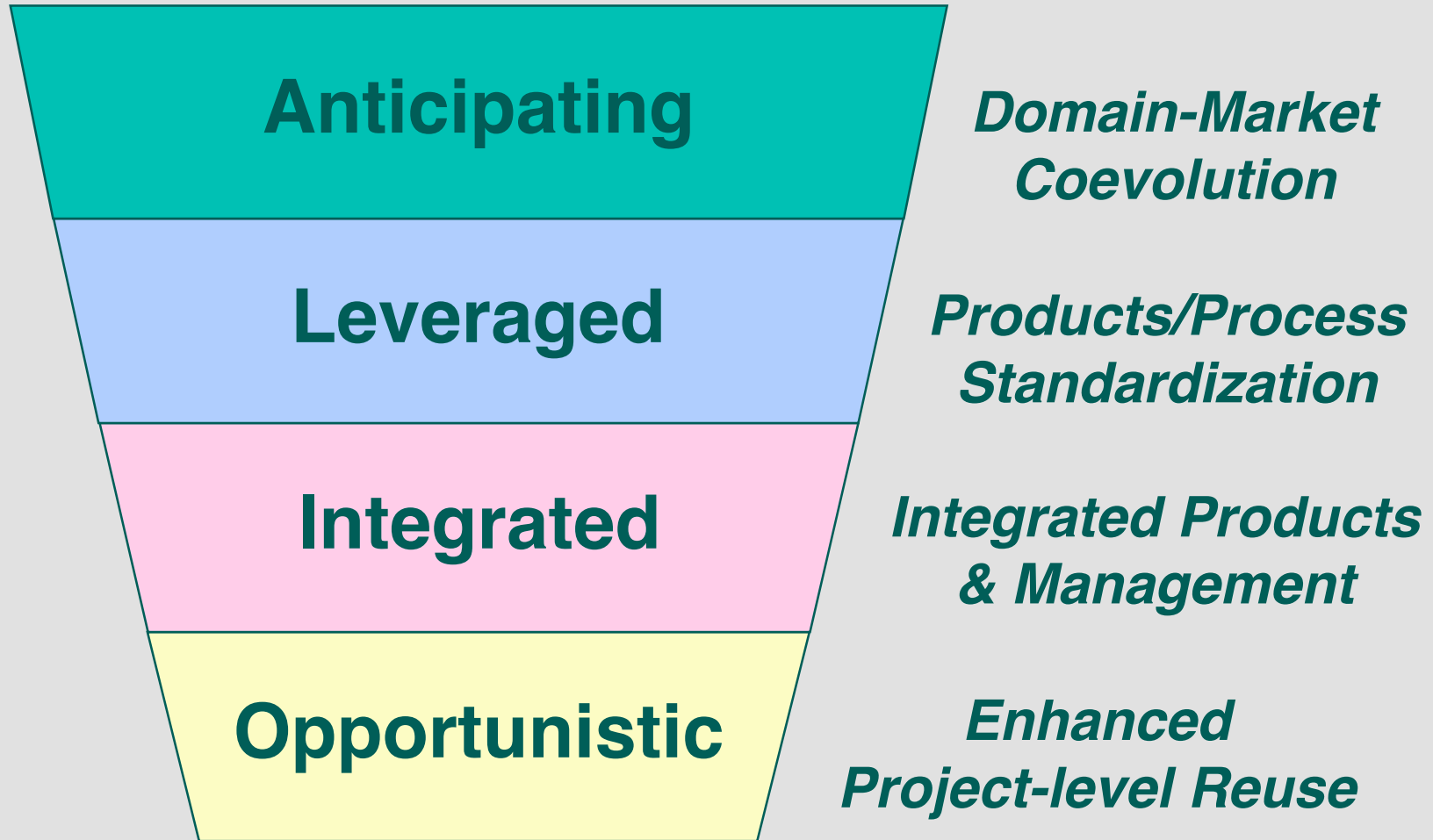
PI_r Tool for Defining a PL Strategy

Product Line Strategy

Reuse Capability

Process Maturity

Domain Viability

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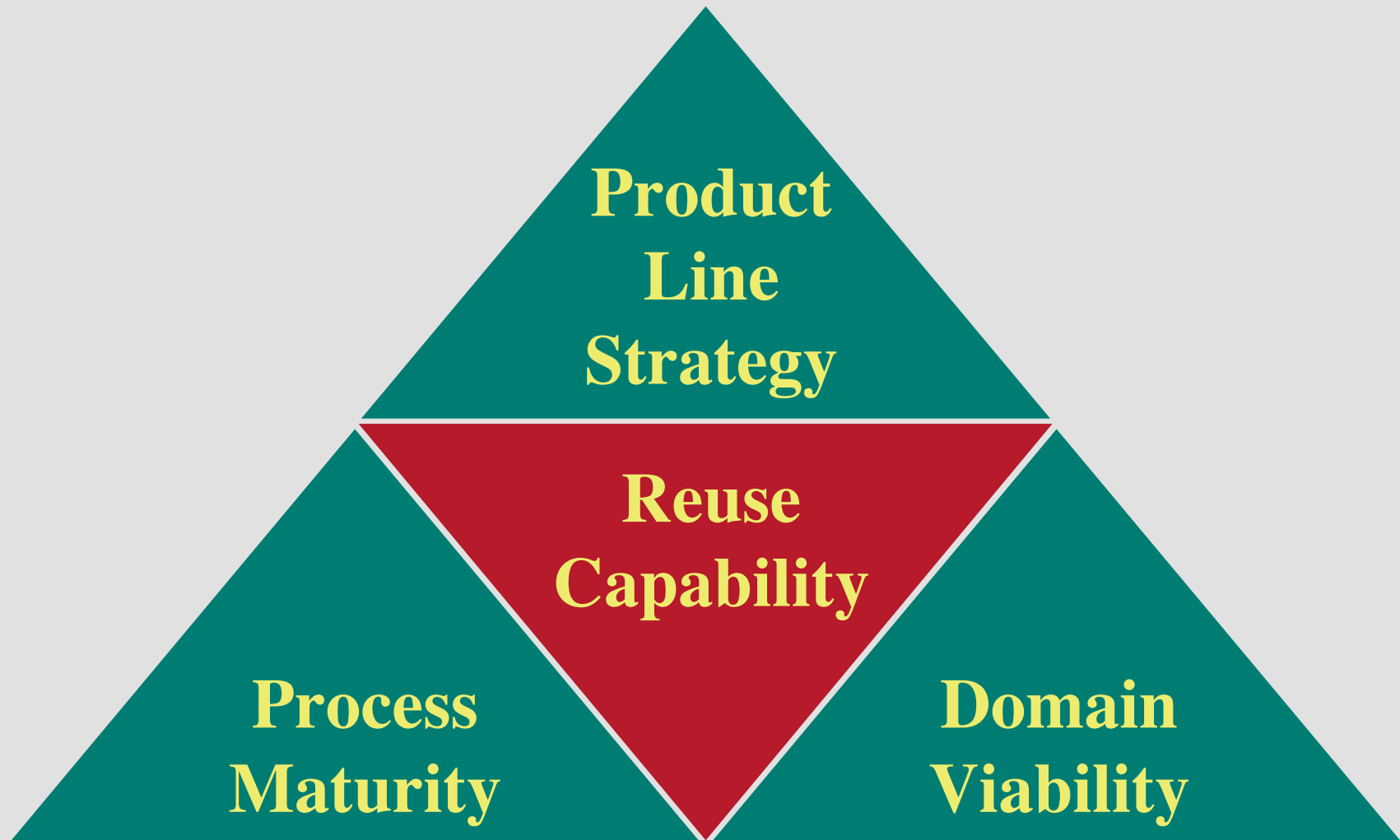
Reuse Capability

- **Prerequisites:**
    - **Targeted domain scope**
    - **Business objectives**

- **Purpose: Tailor product line approach to organizational needs and objectives**

- **Formulation: Key factors characterize 4 levels of capability**

- **Outcome: Highest capability level indicated by all key factors**

Reuse Capability
DsE Capability Levels

Anticipating — *Domain-Market Coevolution*

Leveraged — *Products/Process Standardization*

Integrated — *Integrated Products & Management*

Opportunistic — *Enhanced Project-level Reuse*

Reuse Capability
Key Factors

Management Integration

To what degree can projects' plans be coordinated?

Needs Orientation

Should domain efforts focus on project or customer needs,
and on quick or high-impact payback?

Product Integration

To what degree and at what level can products be integrated?

Stability–Optimization

To what degree can cultural stability be disturbed
to achieve an optimized process?

Reuse Capability
Opportunistic DsE

Theme: Increase project-level reuse for work products of a conventional process

- **Application engineering**
    - **Autonomous, independently planned projects**
    - **Each focused on satisfying one customer's exact needs**
    - **Planning adjusted to reflect the potential for work product component reuse by engineers**

- **Domain engineering**
    - **A shared resource of problem-solving knowledge and expertise**
    - **Develops work product component families that have highest value to current projects**

Reuse Capability
Integrated DsE

Theme: Collaborate across projects to enable similar solutions to similar problems

- **Application engineering**
  - Projects coordinate planning and priorities to reduce redundant efforts
  - Use of domain capabilities preferred over custom work whenever practical

- **Domain engineering**
  - Support oriented to creating tailorable whole work products, focusing on well understood areas
  - Projects' joint priorities and usage of assets guide planning of work

Reuse Capability
Leveraged DsE

Theme: **Standardize products and process to reflect the needs of a targeted market**

- **Application engineering**
  - **Use domain capabilities to rapidly derive a best-fit whole product for each project's customer**
  - **Apply hand tailoring only to remedy critical shortcomings of a domain-derived product**

- **Domain engineering**
  - **Gives precedence to strategic market needs over divergent needs of individual projects/customers**
  - **Optimize the application process based on product family concepts**
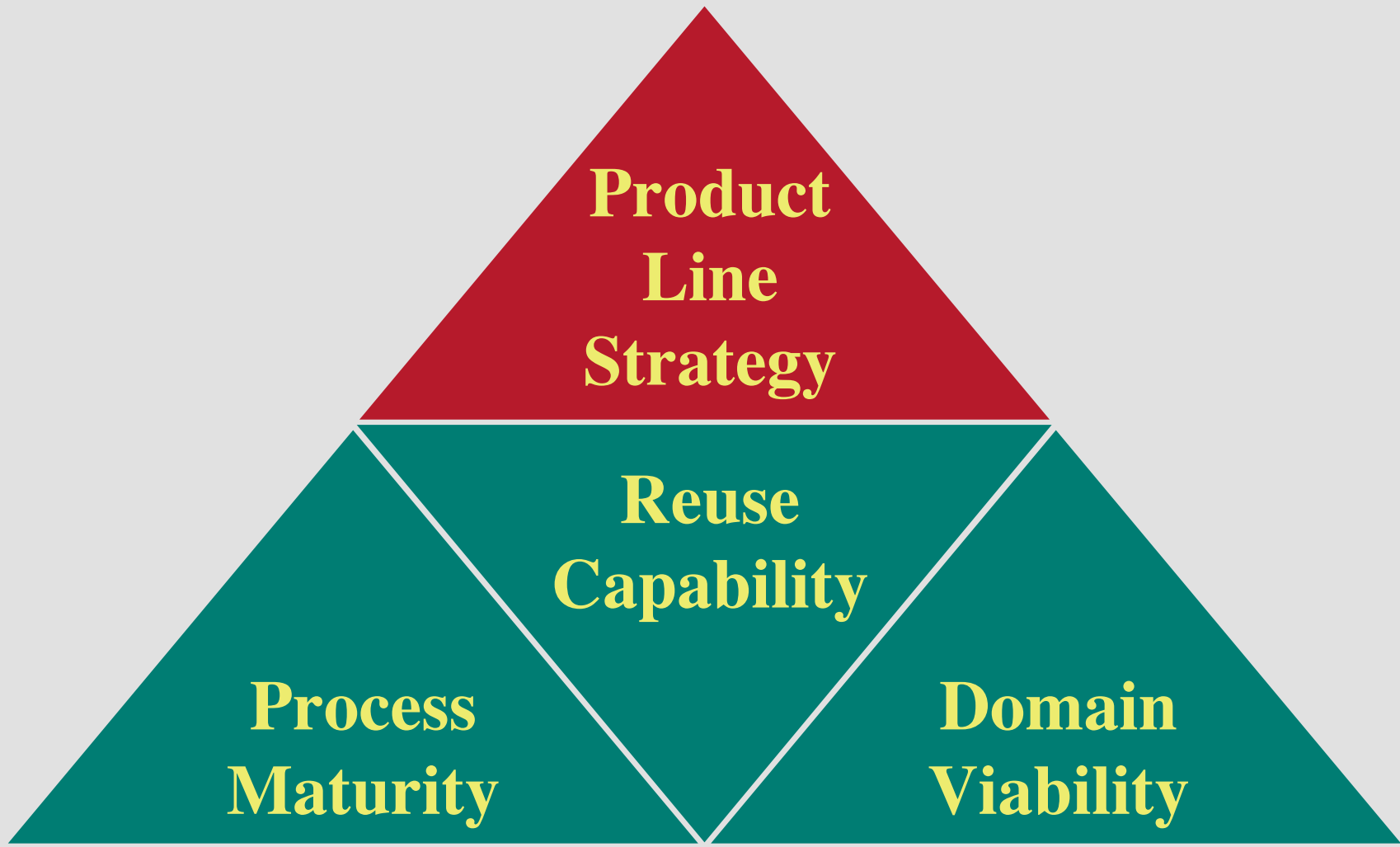
Reuse Capability
Anticipating DsE

Theme: Coordinate market and domain evolution to increase synergy

- **Application engineering**
  - Use domain capabilities to guide a customer in defining their needs
  - Focus projects on best exploiting domain capabilities
  - Refer unsupported needs as opportunities for domain evolution

- **Domain engineering**
  - Creates an evolving product family that anticipates changing market needs
  - Uses process efficiency to influence market evolution

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PI_r Tool for Initiating a DsE Effort

Product Line Strategy

Reuse Capability

Process Maturity

Domain Viability

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Product Line Strategy

- **Prerequisite:**
  - **Targeted domain scope**
  - **Business objectives**
  - **Targeted level of Reuse Capability**
- **Purpose: Provide a framework for instituting DsE**
- **Outcome: Decisions prerequisite to initiating a tailored DsE effort for a product line**

Composition

Market/products focus

Business model   **DsE process**

Organizational structure   **Support environment**

Transition strategy

Market/Products Focus

Identify:

- **Customers**
  - **Current**
  - **Prospective**

- **Products**
  - **Legacy**
  - **Projected**

- **Sources of diversity and change**
  - **Customer needs**
  - **Technology**

PL Strategy
Business Model Considerations

- **Domain funding/ownership?**
    - **R&D funds, project task orders, license fees?**
    - **Customer(s) funds, direct or via projects?**
- **Accounting/legal implications and constraints?**
    - **Domain funding as a capital investment?**
    - **Cost recovery from domain usage?**
- **Customer concerns:**
    - **Product source code rights?**
    - **Development environment (domain) rights?**
    - **Options for post-delivery product modifications?**
    - **Responsibility for defects?**

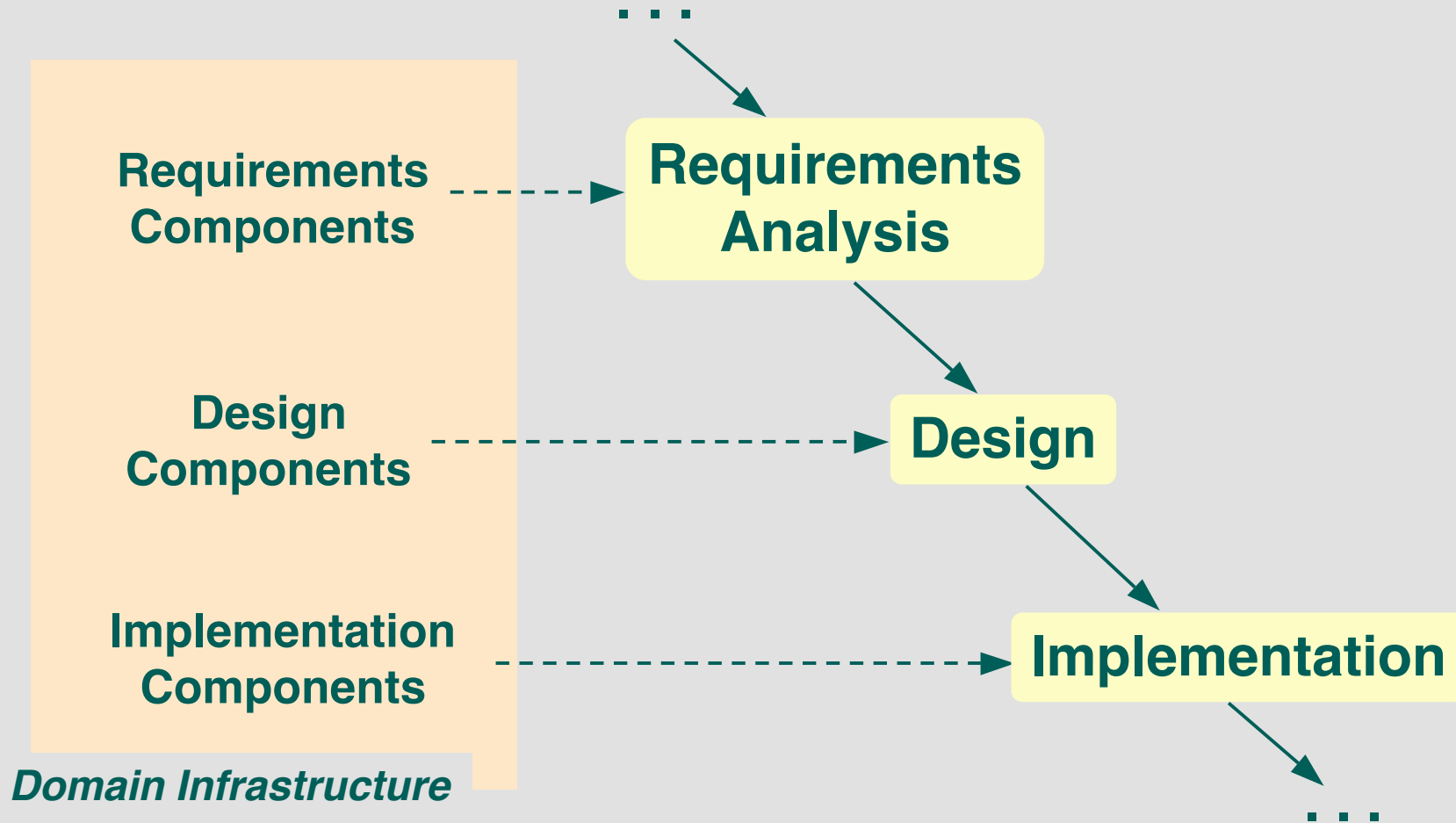# *Process Model Tailoring*

Basis: DsE process definition

Tailoring factors:
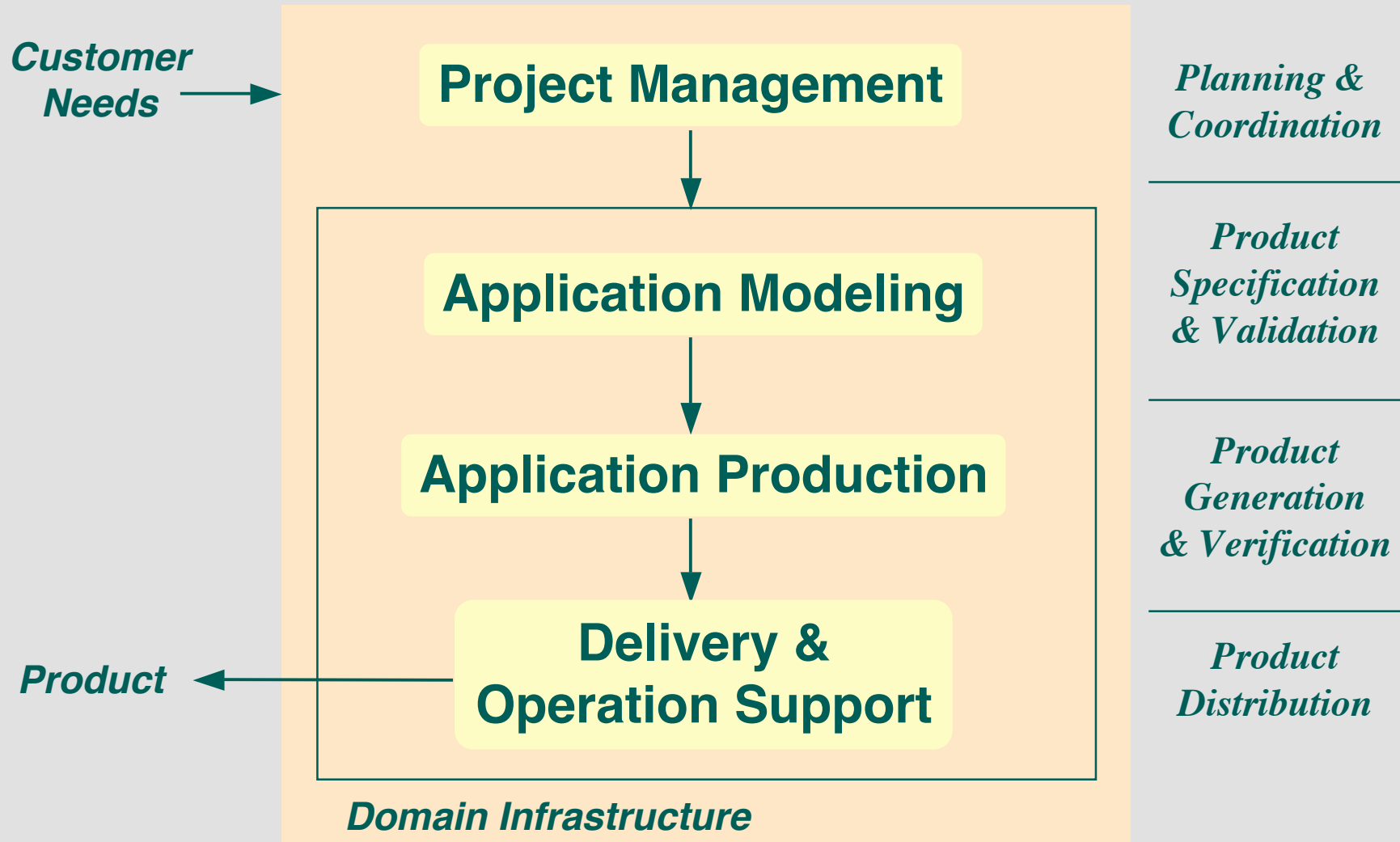
> **Targeted level of reuse capability**

> **Preferred management practices
> (after Process Maturity actions)**

> **Preferred engineering methods**

An Augmented
Application Engineering Process

. . .

Requirements Components - - - → **Requirements Analysis**

Design Components - - - → **Design**

Implementation Components - - - → **Implementation**

Domain Infrastructure

. . .

A Streamlined Application Engineering Process

Customer Needs →

Project Management — *Planning & Coordination*

↓

Application Modeling — *Product Specification & Validation*

↓

Application Production — *Product Generation & Verification*

↓

Delivery & Operation Support — *Product Distribution*

Product ←

Domain Infrastructure

PL Strategy
PL Organizational Functions

Management

Customer Relationships (Marketing & Sales)

Domain

Management

Engineering
        Product Family
        Appl. Process

Project support

Application

Management

Engineering
        Requirements
        Production

Customer support

PL Strategy
Organizational Structures

Opportunistic

Integrated

Leveraged/Anticipating
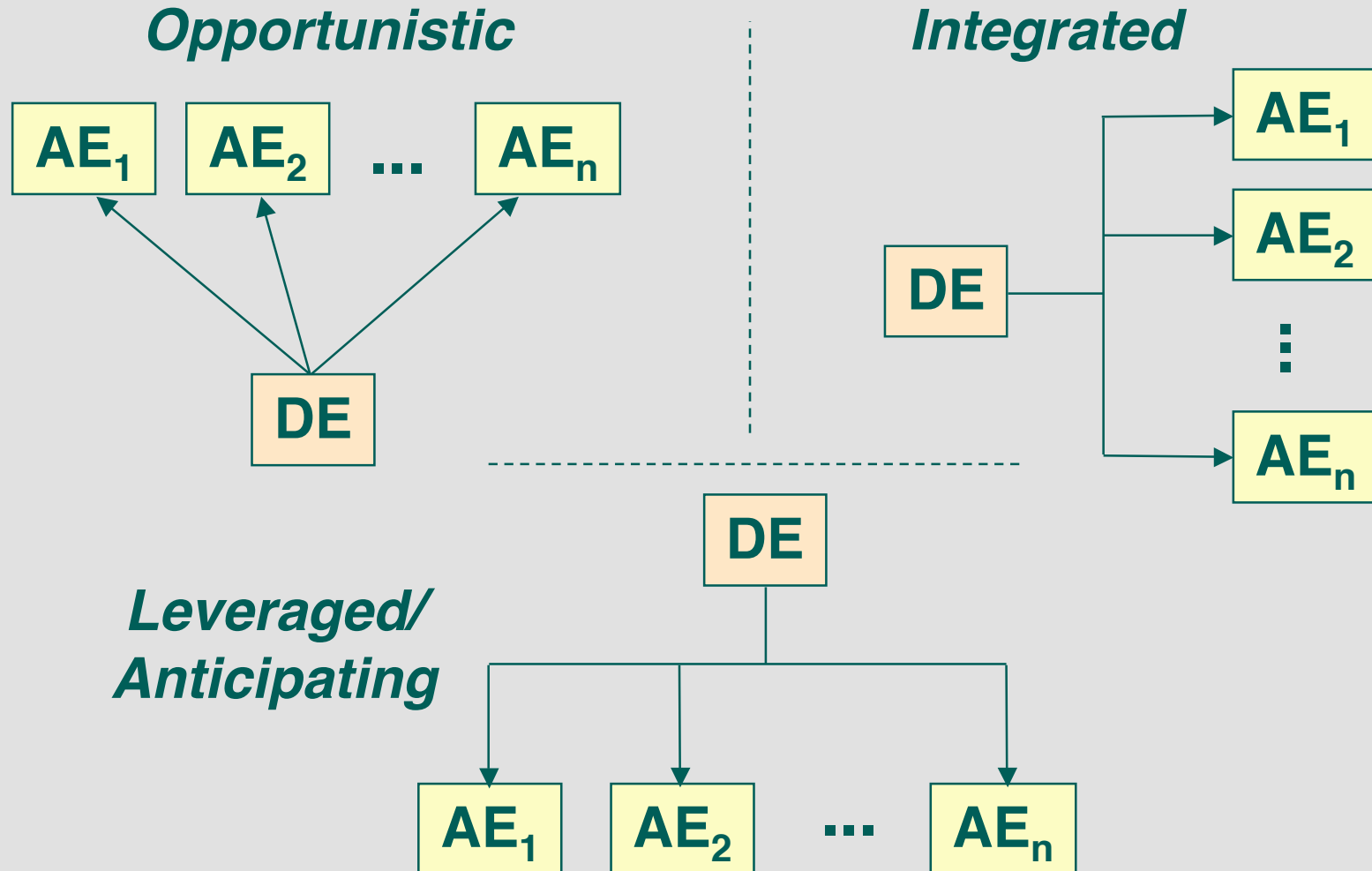
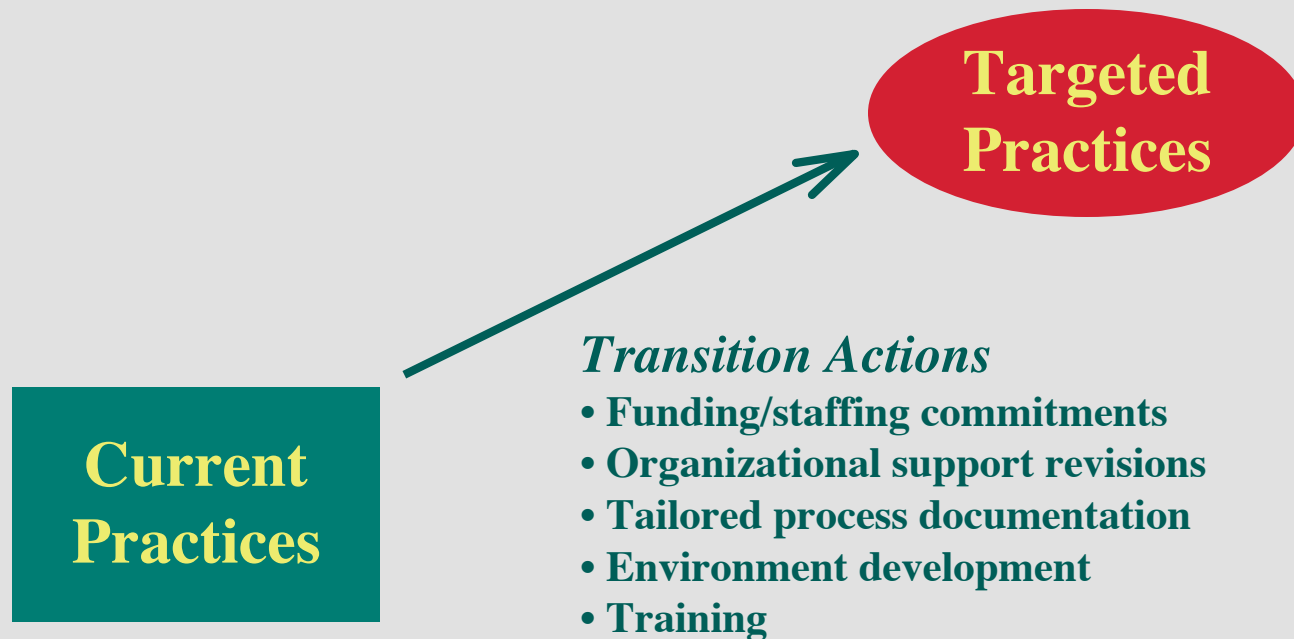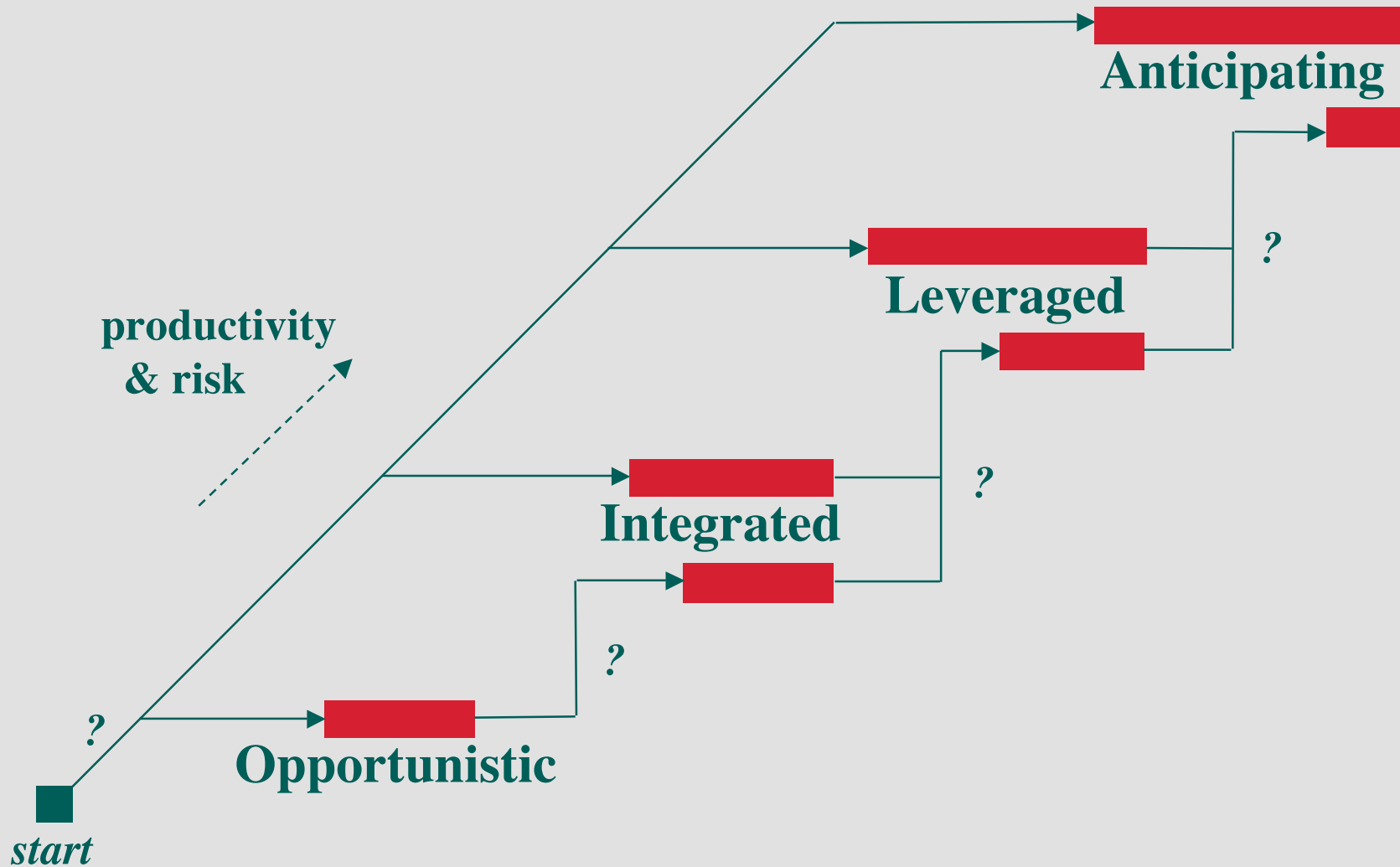# *Support Environment (for DE)*

- **Tools**
  - **Project management**
  - **Documentation**
  - **Configuration management**
  - **Software methods (design/code/test) support**
  - **AE process development**
  - **Integration test evaluation and installation support**
- **Infrastructure** (computers, communications, data storage)
- **Legacy products**

PL Strategy
Transition Strategy

Targeted Practices

Current Practices

Transition Actions
- **Funding/staffing commitments**
- **Organizational support revisions**
- **Tailored process documentation**
- **Environment development**
- **Training**

PL Strategy
Alternative Transition Strategies

productivity & risk

Anticipating

Leveraged

?

Integrated

?

?

Opportunistic

?

start

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Key Risk Factors of Transition

- **Diversion of key managers and engineers away from directly serving customers' current needs**

- **Need for substantial training and reorientation of managers, marketing/sales, and engineers**

- **Costs of long-term financial investment in software as a capital asset**

- **Resistance to coordinated planning and management of projects within the product line business**

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Future Directions

- **Evolution of process improvement standards**
    - **Selective inclusion of reuse factors in process maturity**
    - **Statistical process control relative to a product line**
- **Experience with PI$_r$ and DsE**
    - **Reformulated reuse factors for process maturity**
    - **Progressively refined and formalized assessment factors**
    - **Formalized derivation of tailored PL Strategies in terms of Reuse Capability factors**
    - **Tool support for PI$_r$ and DsE**
    - **Metrics for adoption and management of a PL**

For Additional Information on PI$_r$ and DsE

Prosperity Heights Software

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