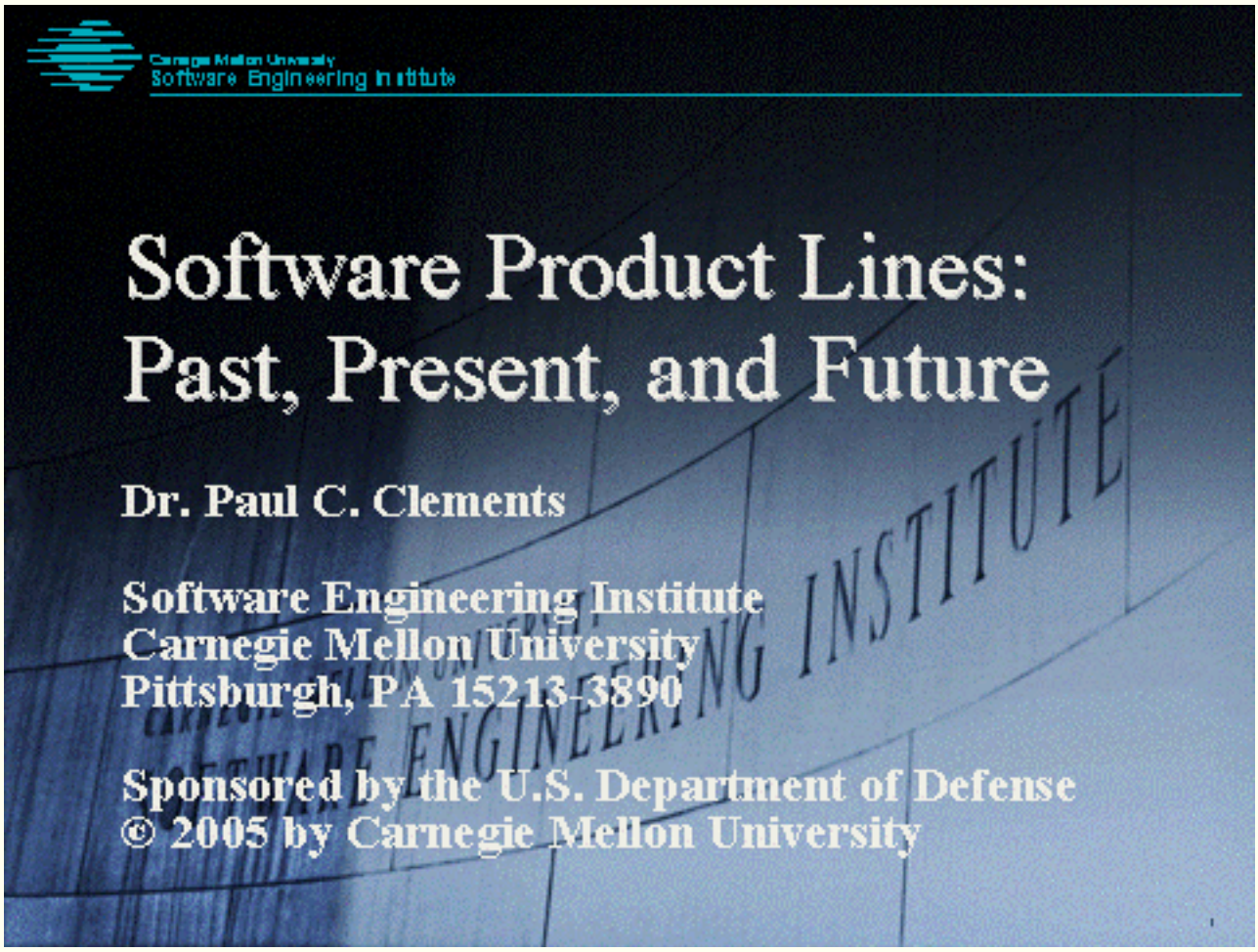

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Software Engineering Institute

Who We Are: Applied R&D laboratory situated as a college-level unit at Carnegie Mellon University, Pittsburgh, PA, USA

Purpose: Help others make measured improvements in their software engineering practices

First objective: Accelerate the introduction and widespread use of high-payoff software engineering practices and technology identifying, evaluating, and maturing promising or underused technology and practices.

We are a small organization. We have to pick these practices carefully.

One we have chosen is software product lines.

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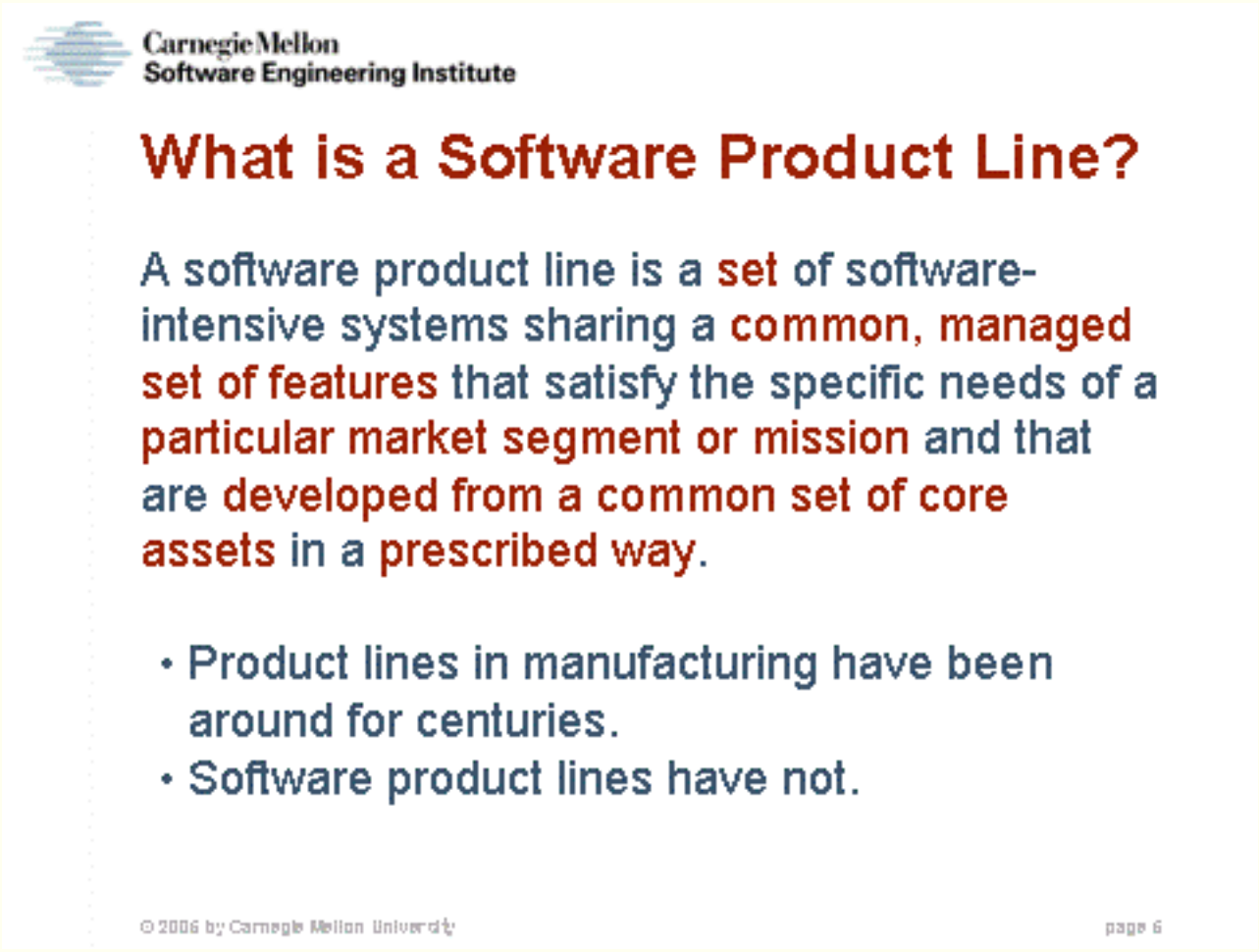

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Why software product lines?

Because of the high-payoff results they make possible in practice:

Improved productivity
by as much as 10x

Decreased time to market
by as much as 10x

Decreased cost
by as much as 60%

Decreased labor needs
by as much as 10X fewer software developers

Increased quality
by as much as 10X fewer defects

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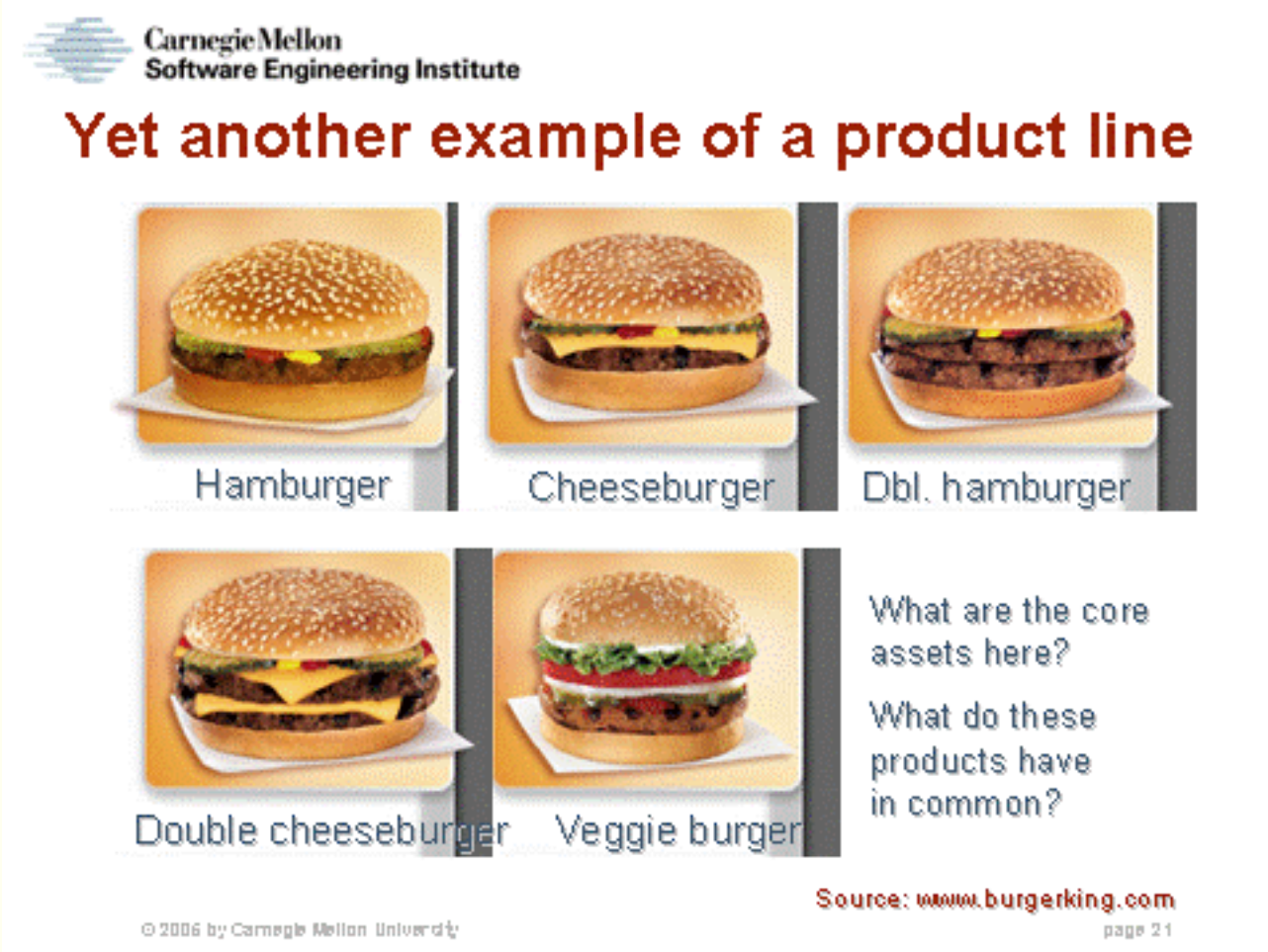

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Questions

What does a company gain from producing a product line of sandwiches? Of commercial passenger aircraft?

- Simplified production of components
- Simplified management of inventory
- Simplified training
- Streamlined production facilities and process
- Market recognition and mind share
- Flexibility – ability to add new products quickly

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Examples are everywhere!

Manufacturing technology – particularly the principle of interchangeable parts – makes the product line concept appear almost everywhere.

Look around this room. How many product lines do you see?

In 1964, IBM introduced the System/360 family of computers. Each model differed widely in performance and features, but they all ran the same programs. The operating system was also a family.

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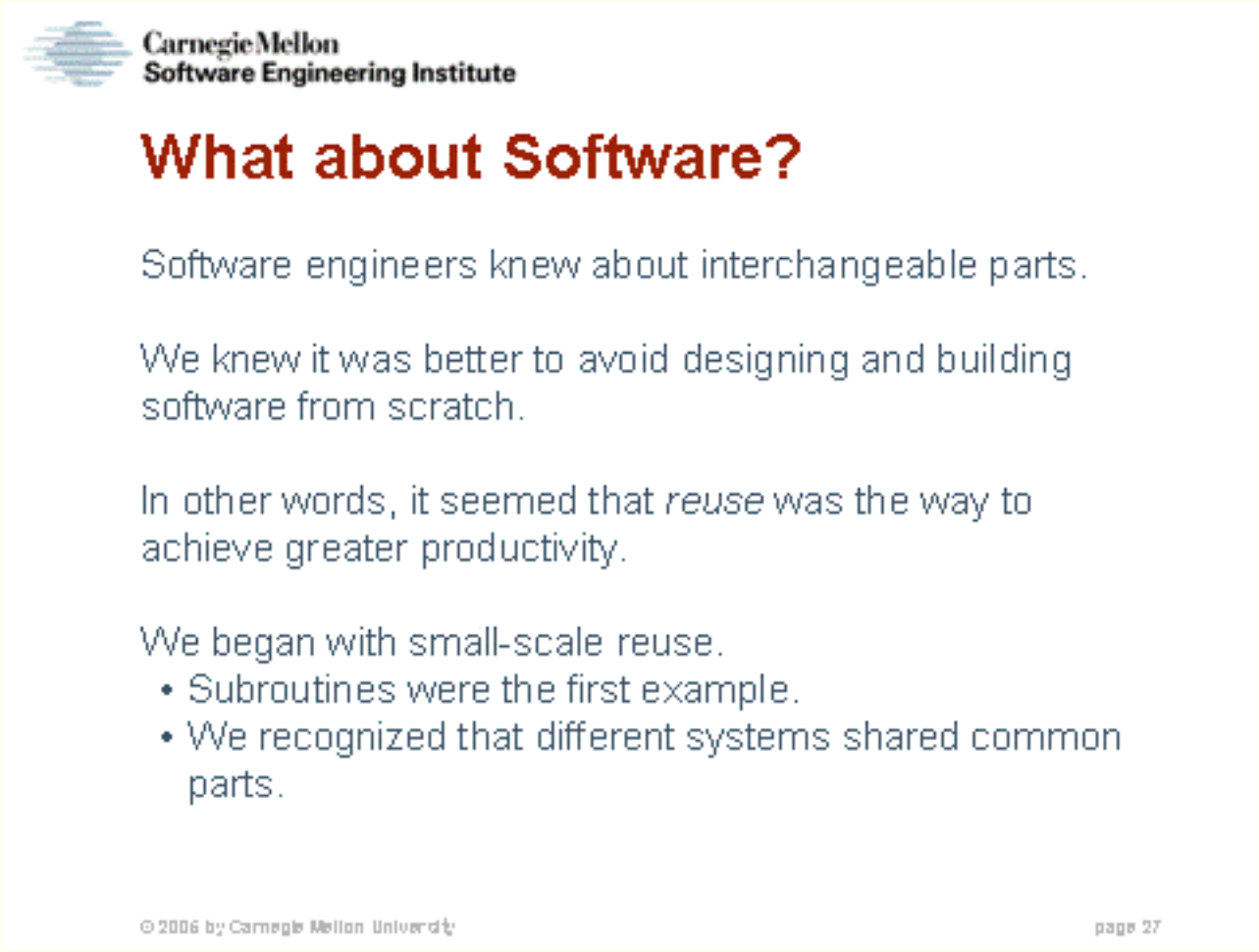

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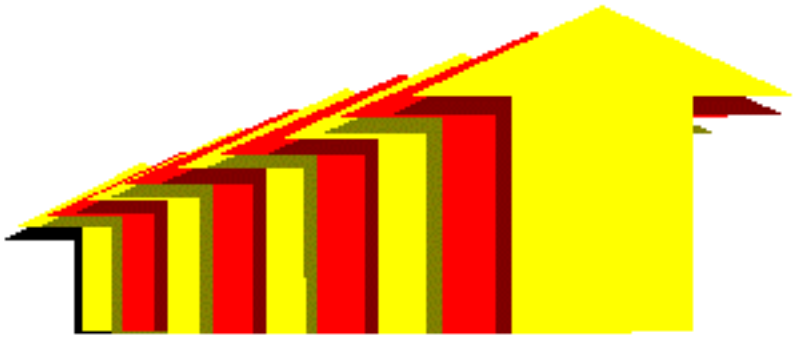
But reuse has a disappointing history



1960's Subroutines
1970's Modules
1980's Objects
1990's Components

Focus was small-grained and opportunistic.
Results fell short of expectations.

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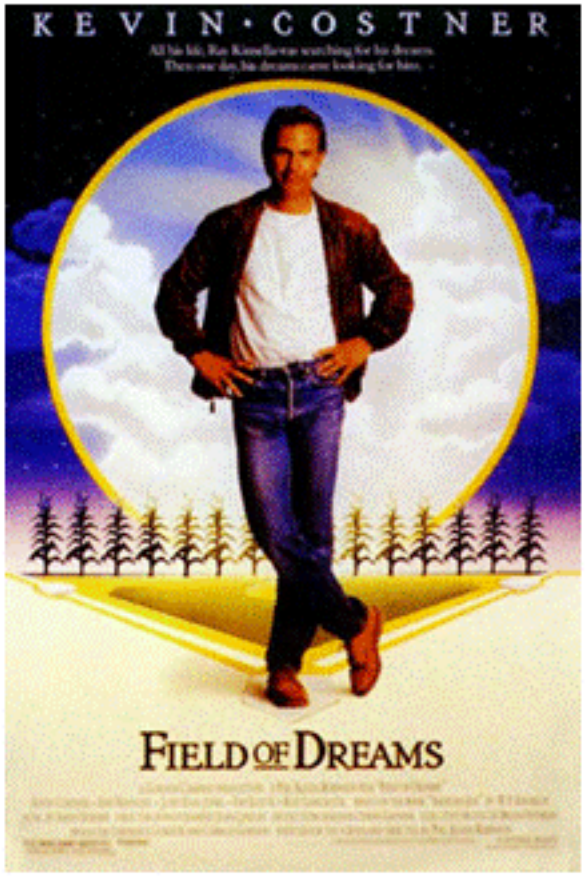
"If you build it...

...they will come."

It turns out they don't.

The *opportunistic* model of reuse has been a thorough failure.



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Some companies were trying a new approach

CelsiusTech's ShipSystem 2000: A family of 55 shipboard Command-and-control systems

- Began in 1985 with two systems
- Built from single core asset base
- Hardware-to-software cost ratio changed from 35:65 to 80:20
- Software staff went from 210 to 30
- Cycle time went from 7-10 years to 2-3.
- Reuse ~ 90%
- Integration test of 1-1.5 million SLOC requires 1-2 people
- Re-hosting to a new platform/OS takes 3 months
- Cost and schedule targets are predictably met
- Customer satisfaction is high

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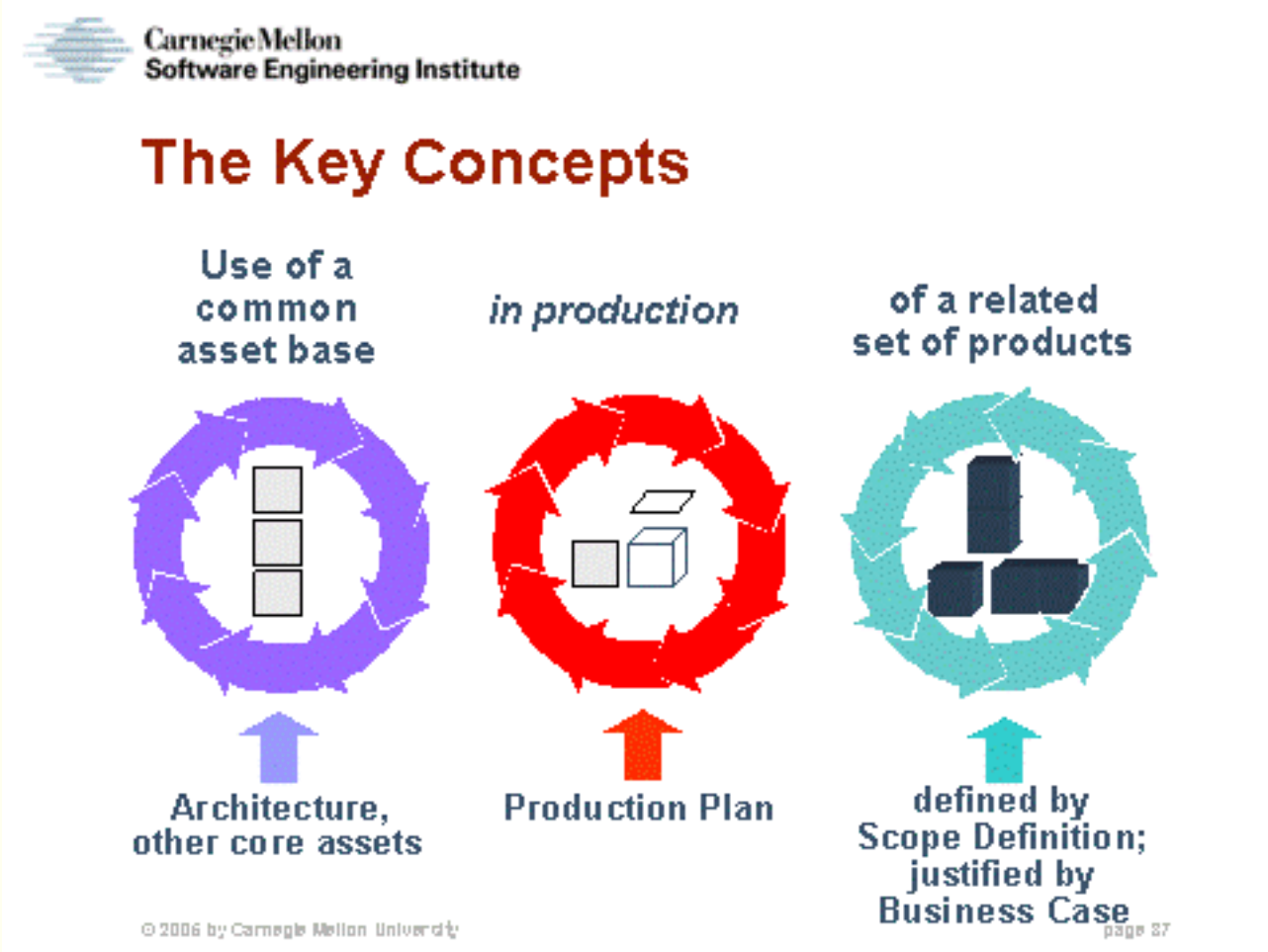

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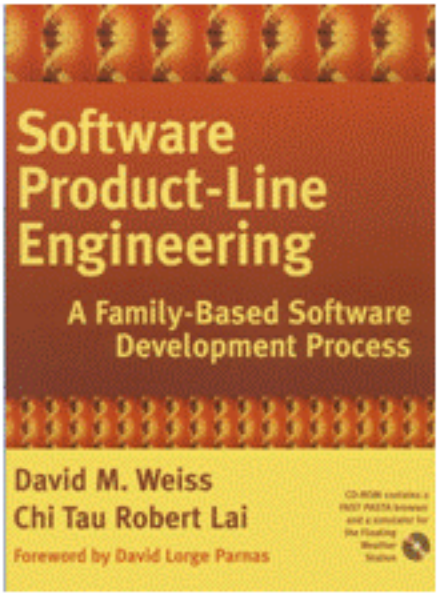
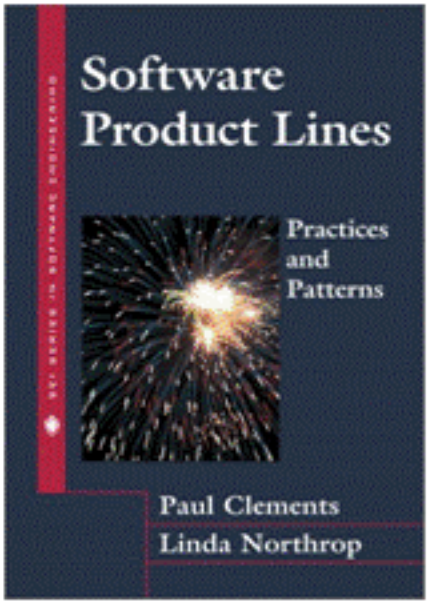
Knowledge began to be codified



1999



2002

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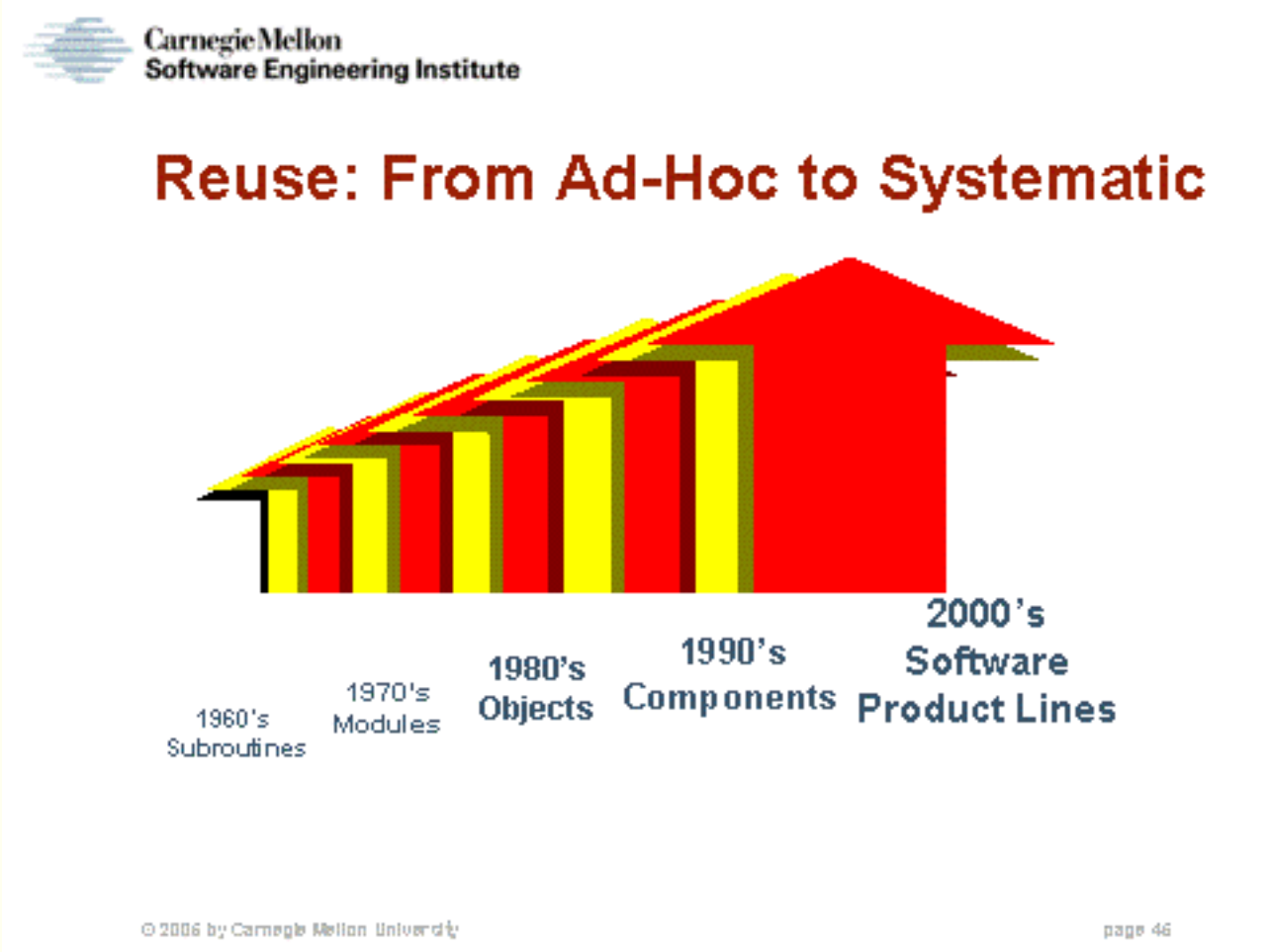

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What Do We Have Now?

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- Convincing evidence that software product line practice can bring about significant improvements in software development
- A body of knowledge and a set of standard models for software product lines
- A growing and energetic community of software product line practitioners

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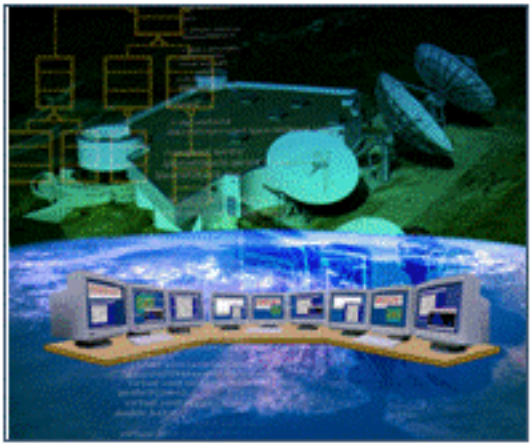
National Reconnaissance Office / Raytheon: Control Channel Toolkit

Ground-based spacecraft command and control systems

Increased quality by 10X
Incremental build time
reduced from months to weeks
Software productivity
increased by 7X
Development time and costs
decreased by 50%
Decreased product risk



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Cummins, Inc.

World's largest manufacturer of large diesel engines.

- 20 product groups launched, yielding over 1000 separate engine applications
- 75% reuse, 360% productivity gain
- Product cycle time has plummeted. Time to first engine start went from 250 person-months to a few person-months.
- Software quality is at an all-time high.
- Product line approach let them quickly enter and then dominate the *industrial* diesel engine market.

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Nokia Mobile Phones

Product lines with >30 new products per year. Before product line, only 5-10 products per year.

Software product line is so successful, Nokia is selling their core asset base as a product.

Across products there are
- varying keys, displays, features, protocols
- 58 languages and 130 countries
- need for backwards compatibility
- need for product behavior change after release

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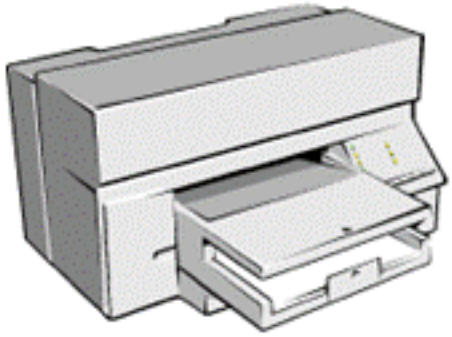
Hewlett Packard

Printer systems
- 2-7x cycle time improvement (some 10x)
- 400% productivity improvement
- Sample Project
  - –shipped 5x number of products
  - –that were 4x as complex
  - –and had 3x the number of features
  - –with 4x products shipped/person



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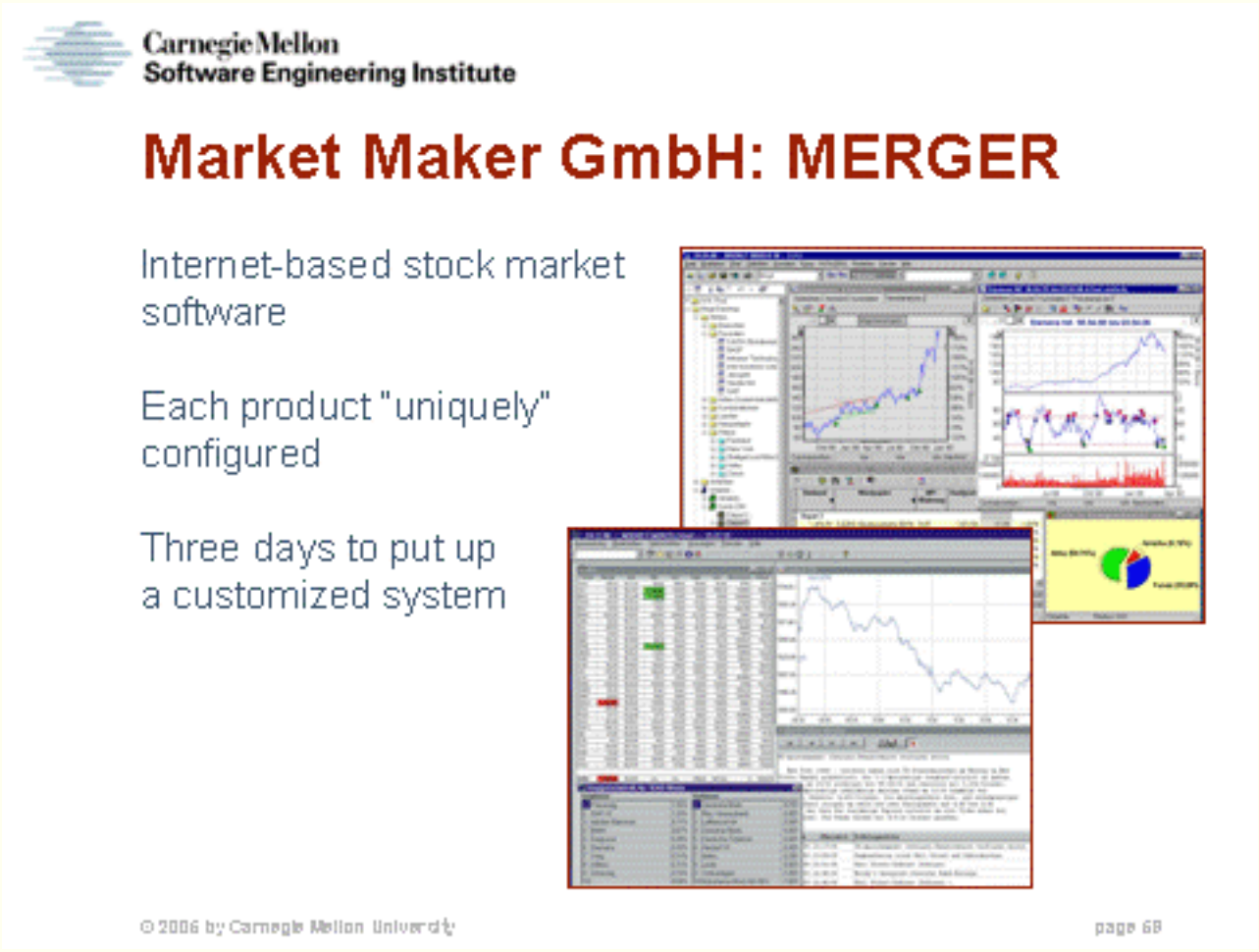

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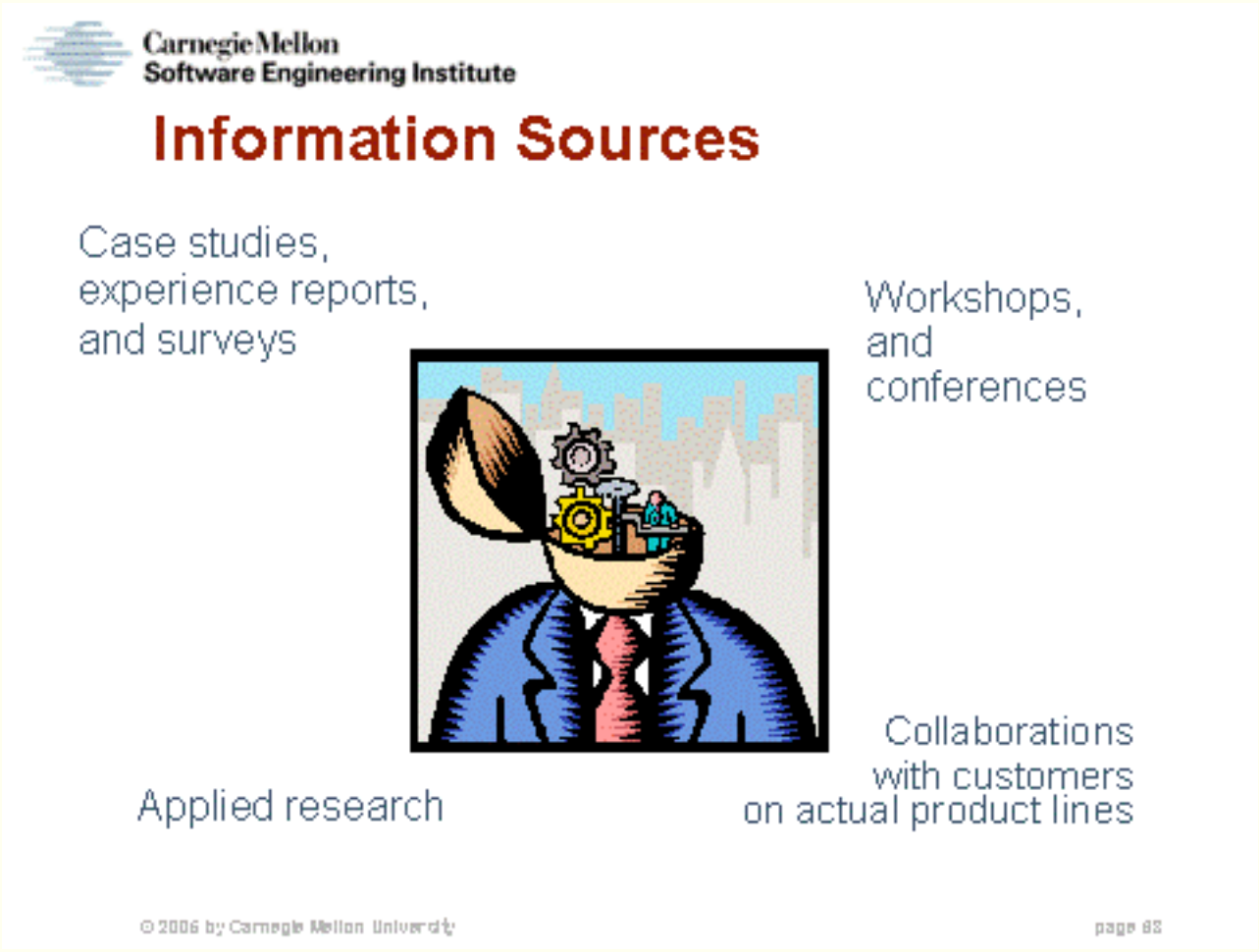

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Three Essential Activities

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The Nature of the Essential Activities

All three activities are interrelated and highly iterative.

There is no "first" activity.

- In some contexts, existing products are mined for core assets.
- In others, core assets may be developed or procured for future use.

There is a strong feedback loop between the core assets and the products.

Strong management at multiple levels is needed throughout. Management orchestrates the processes to make the three essential activities work together

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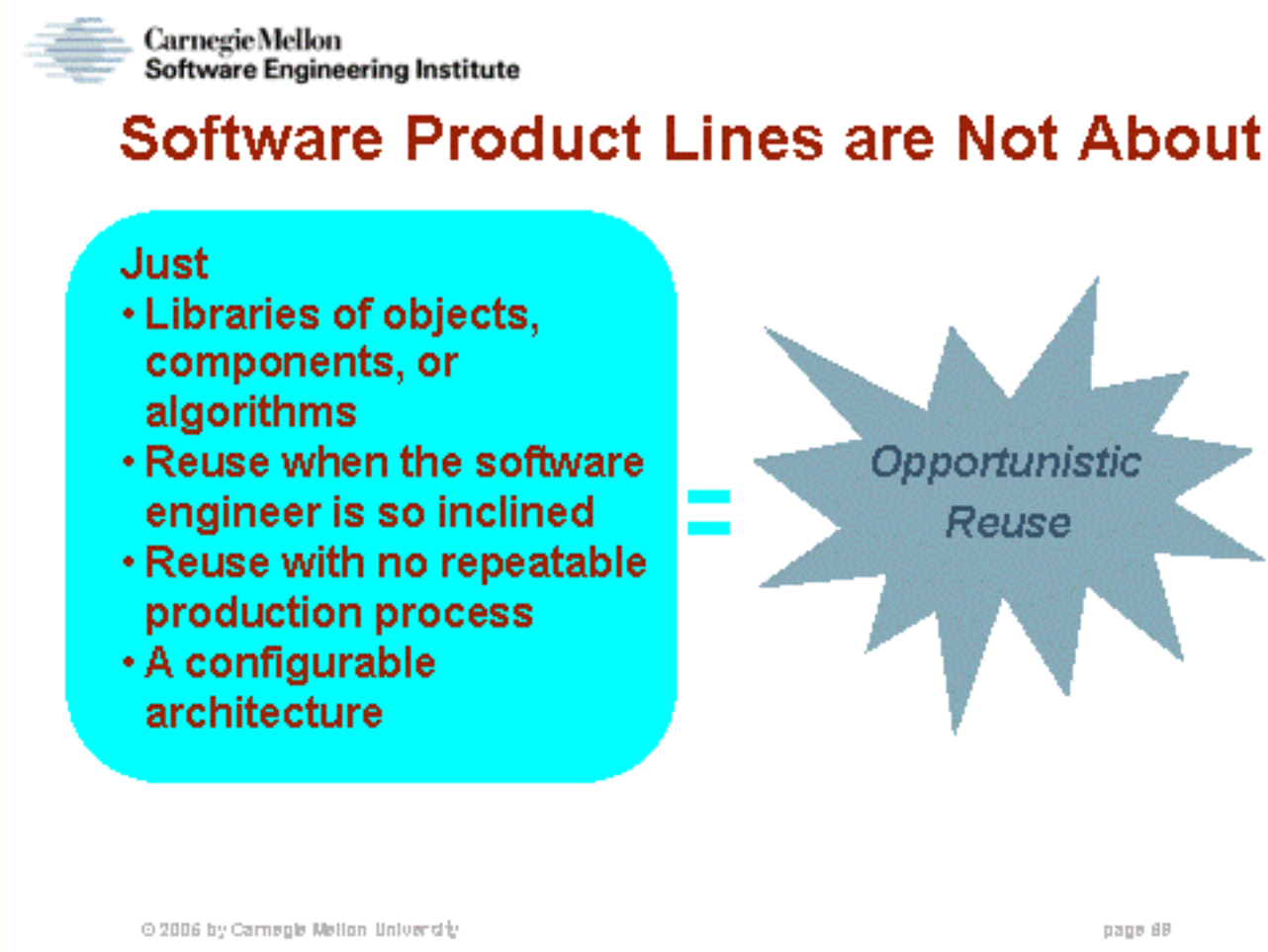

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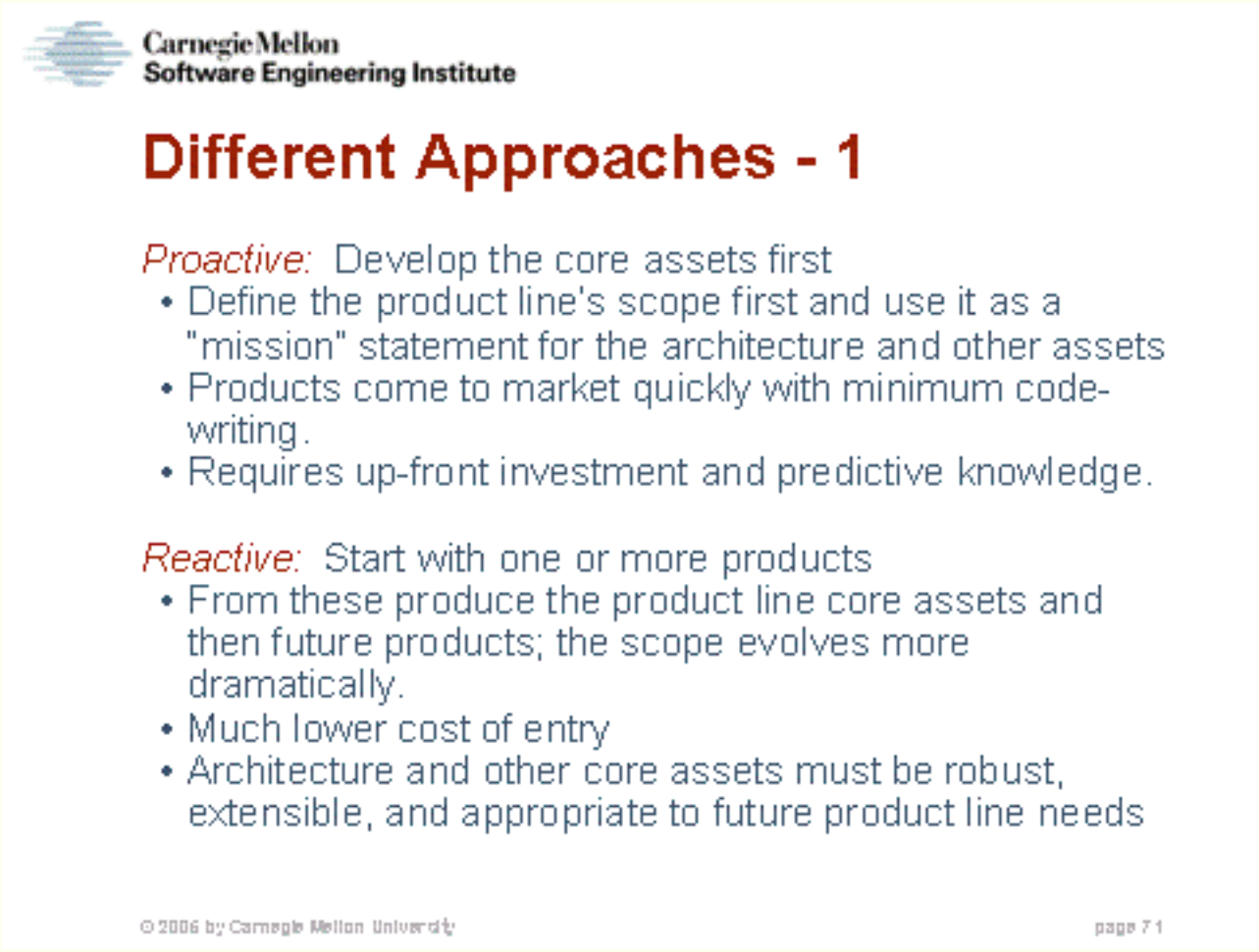

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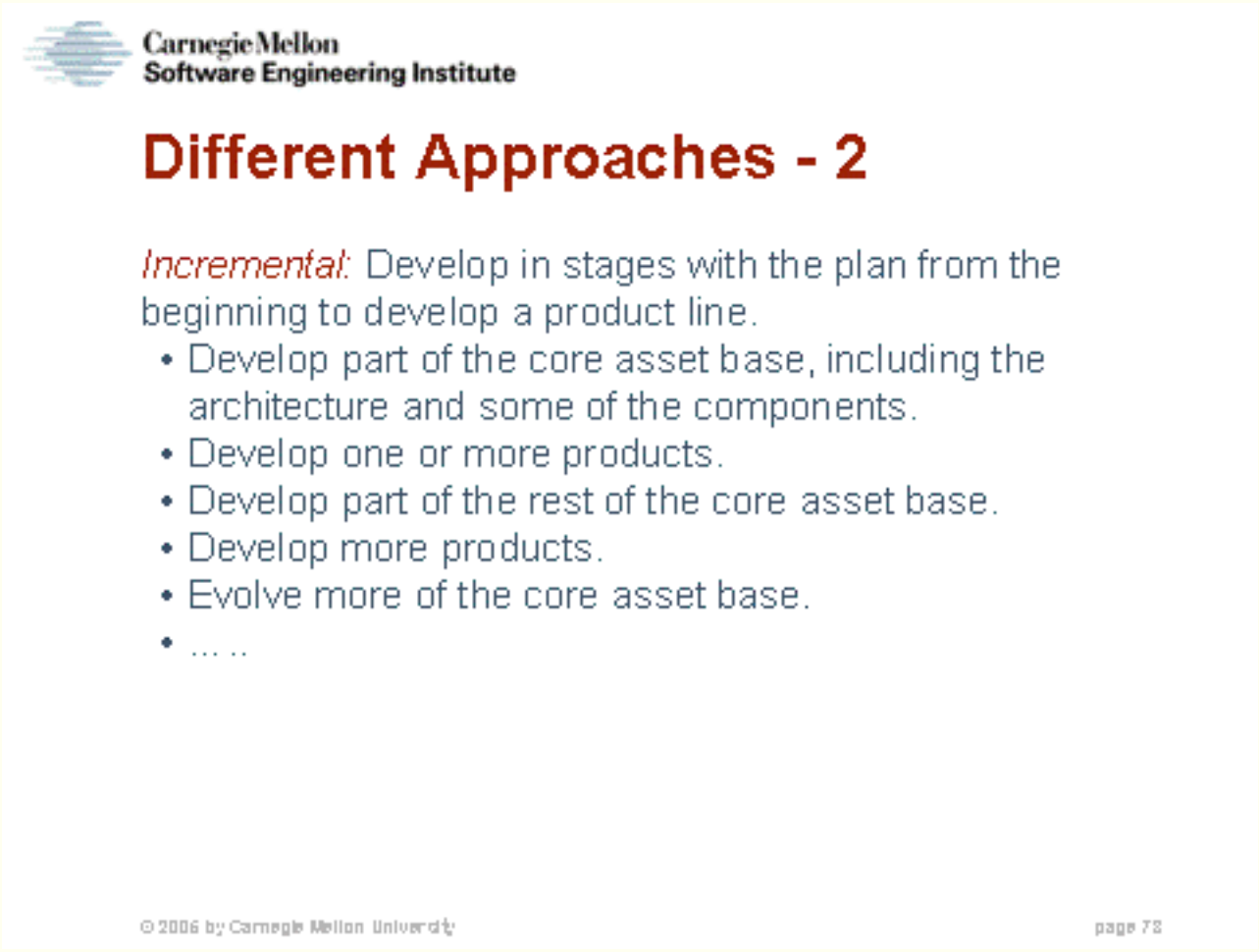

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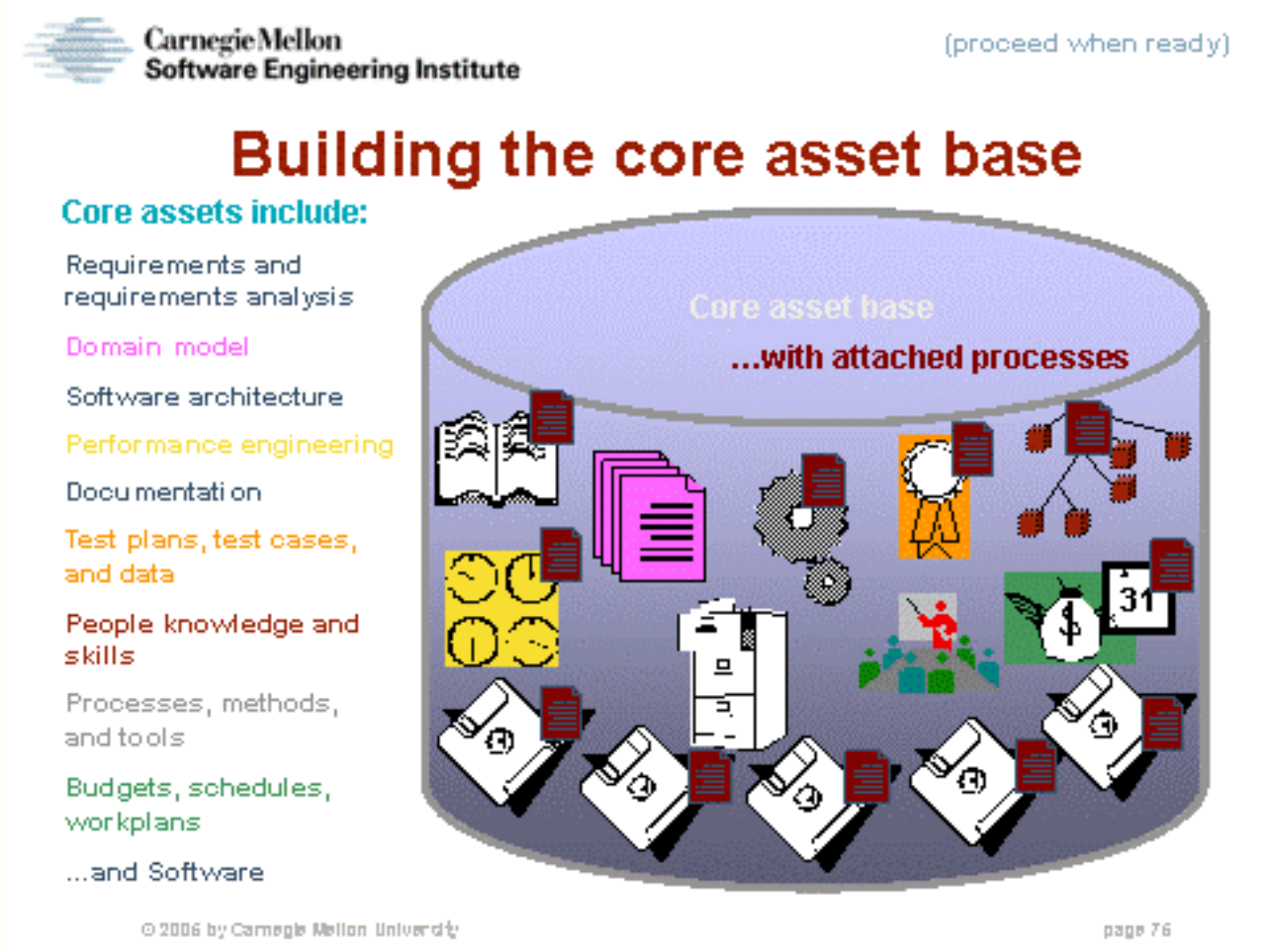

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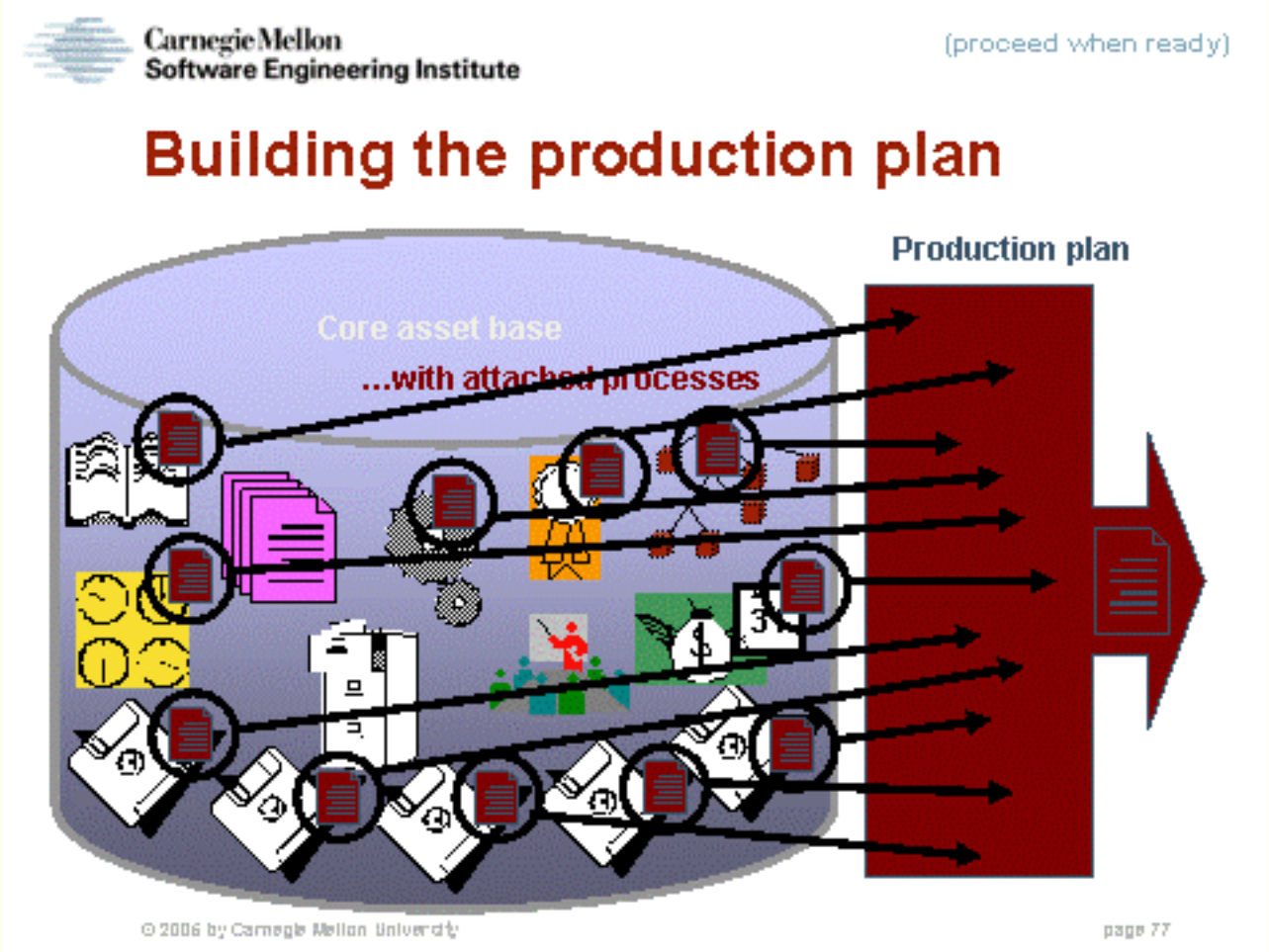

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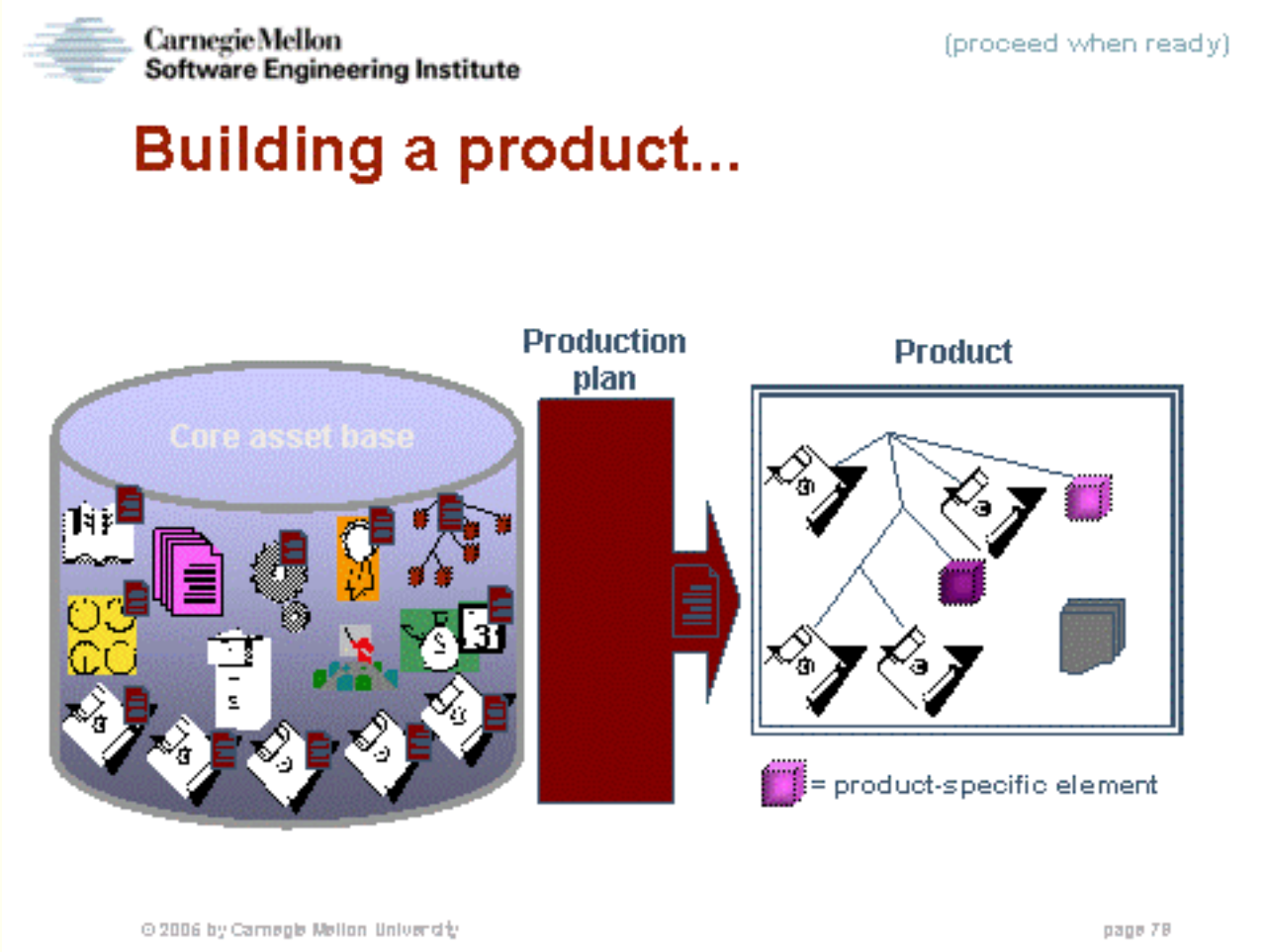

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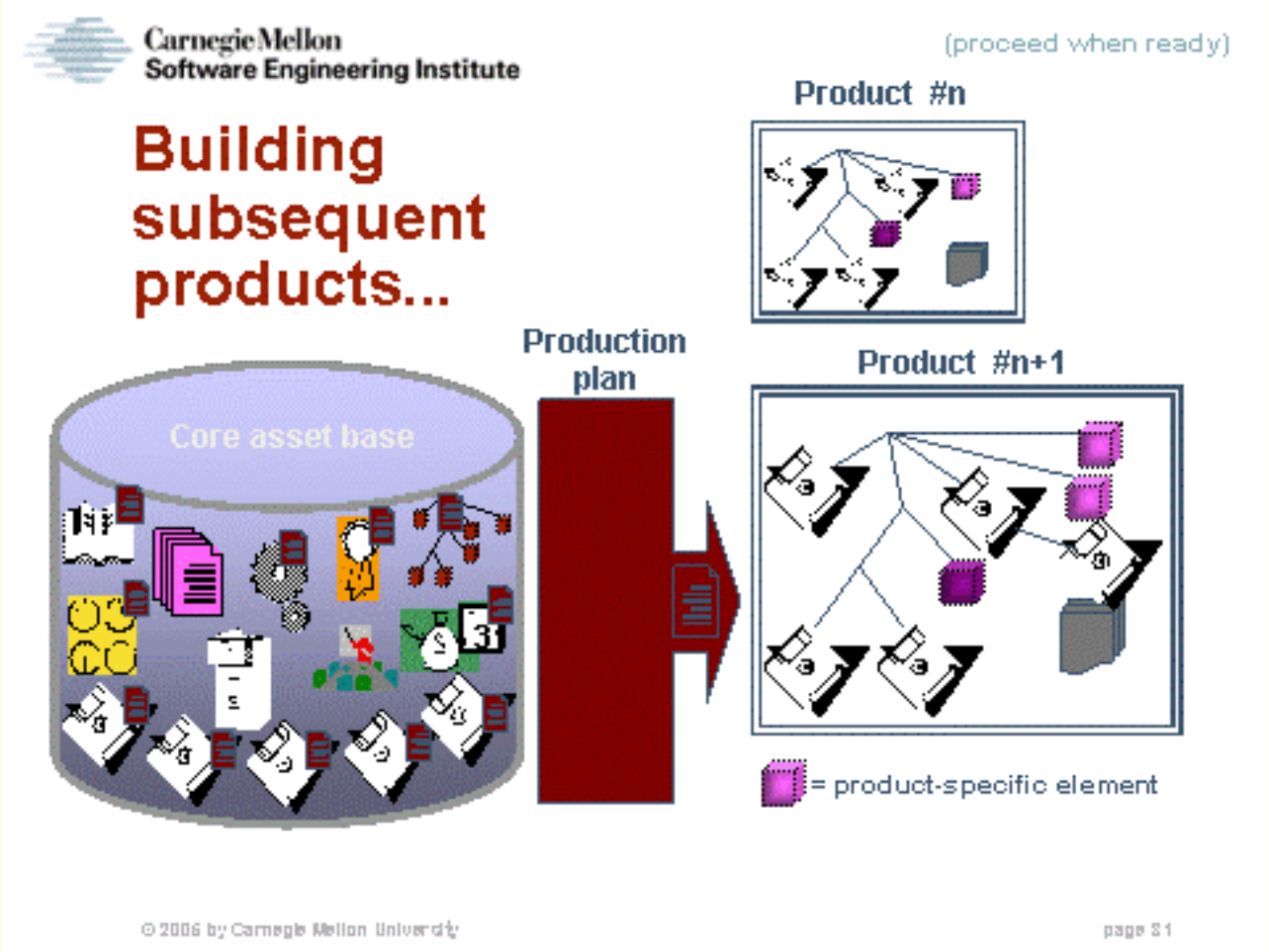

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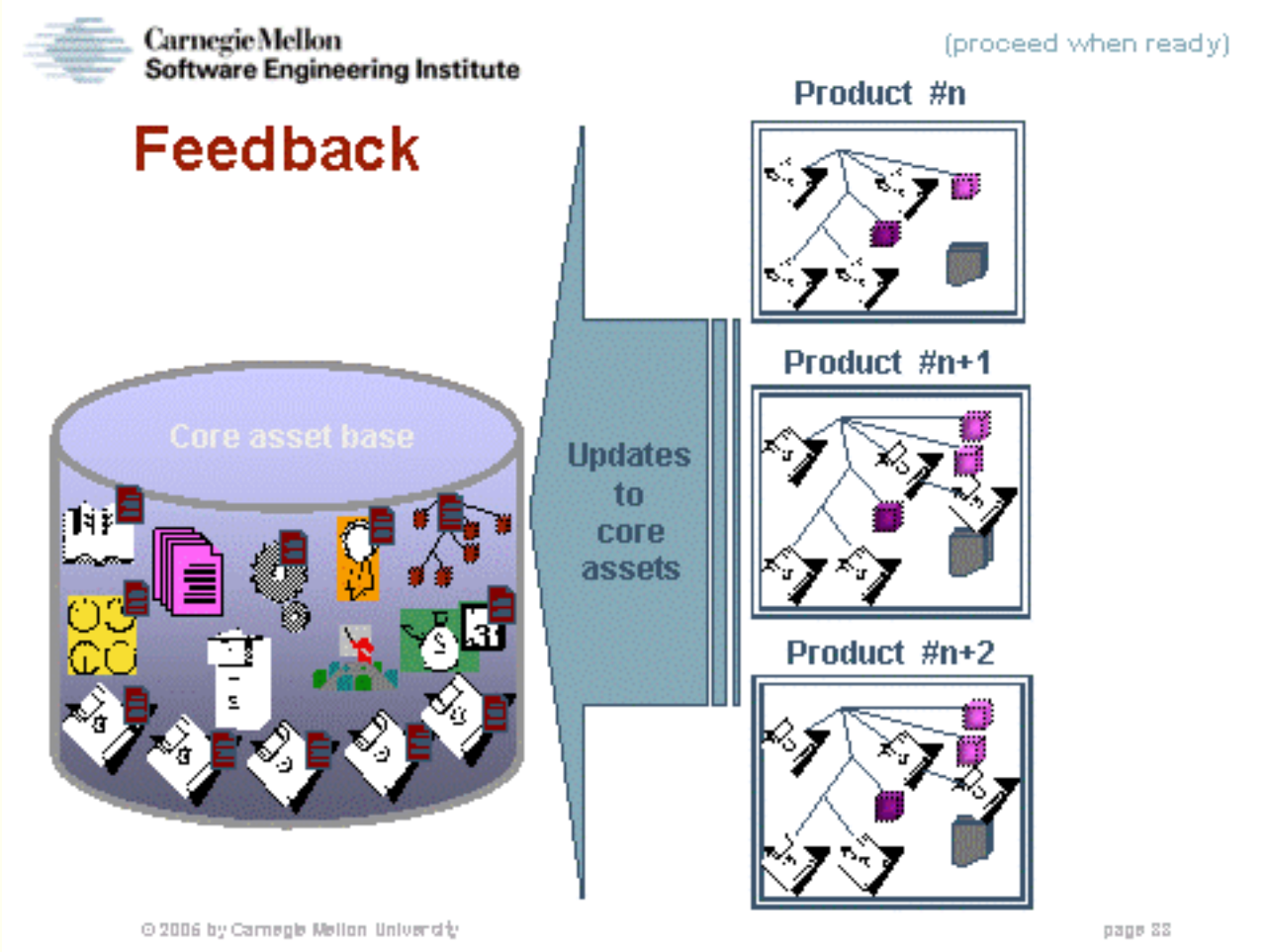

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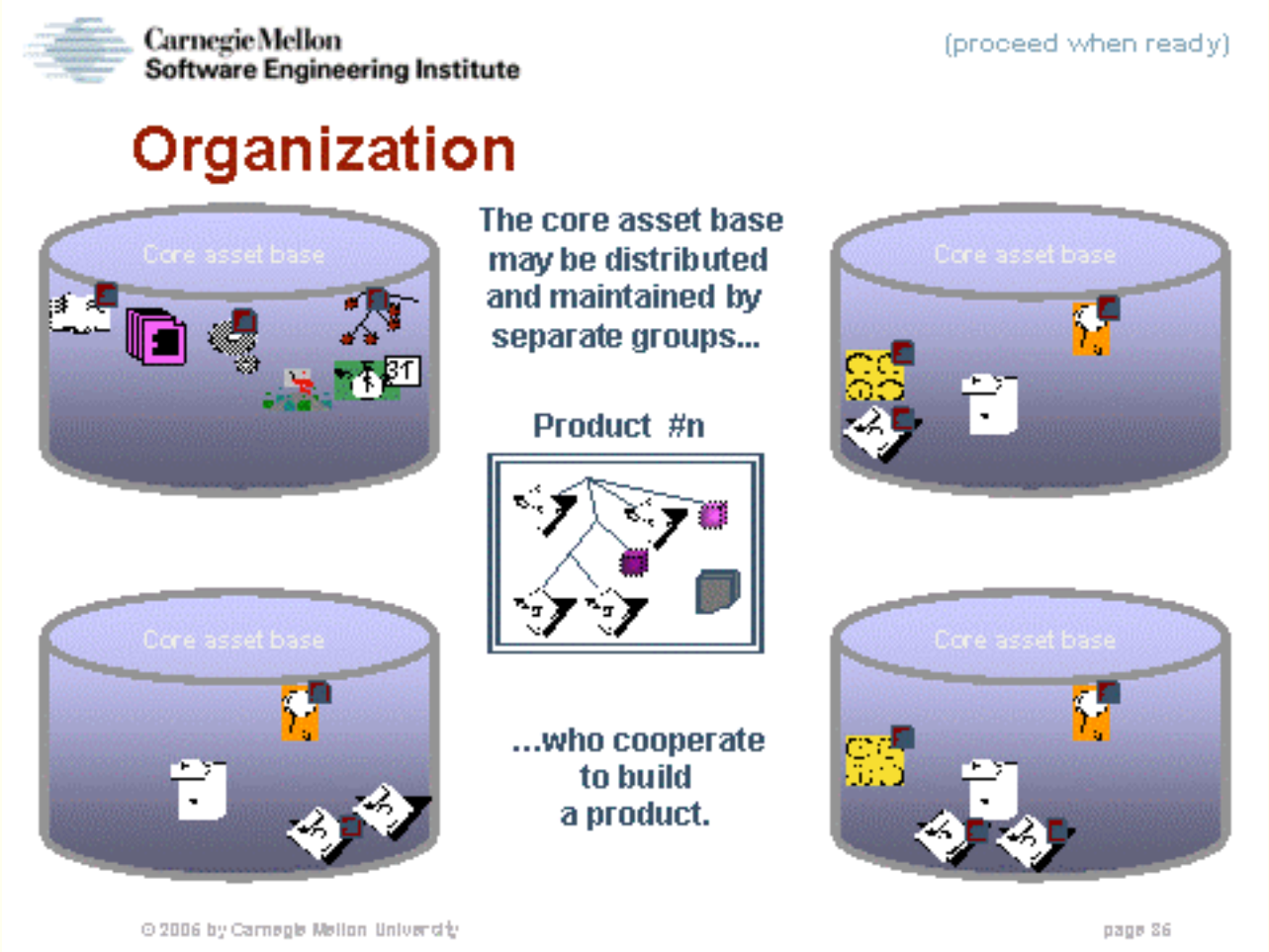

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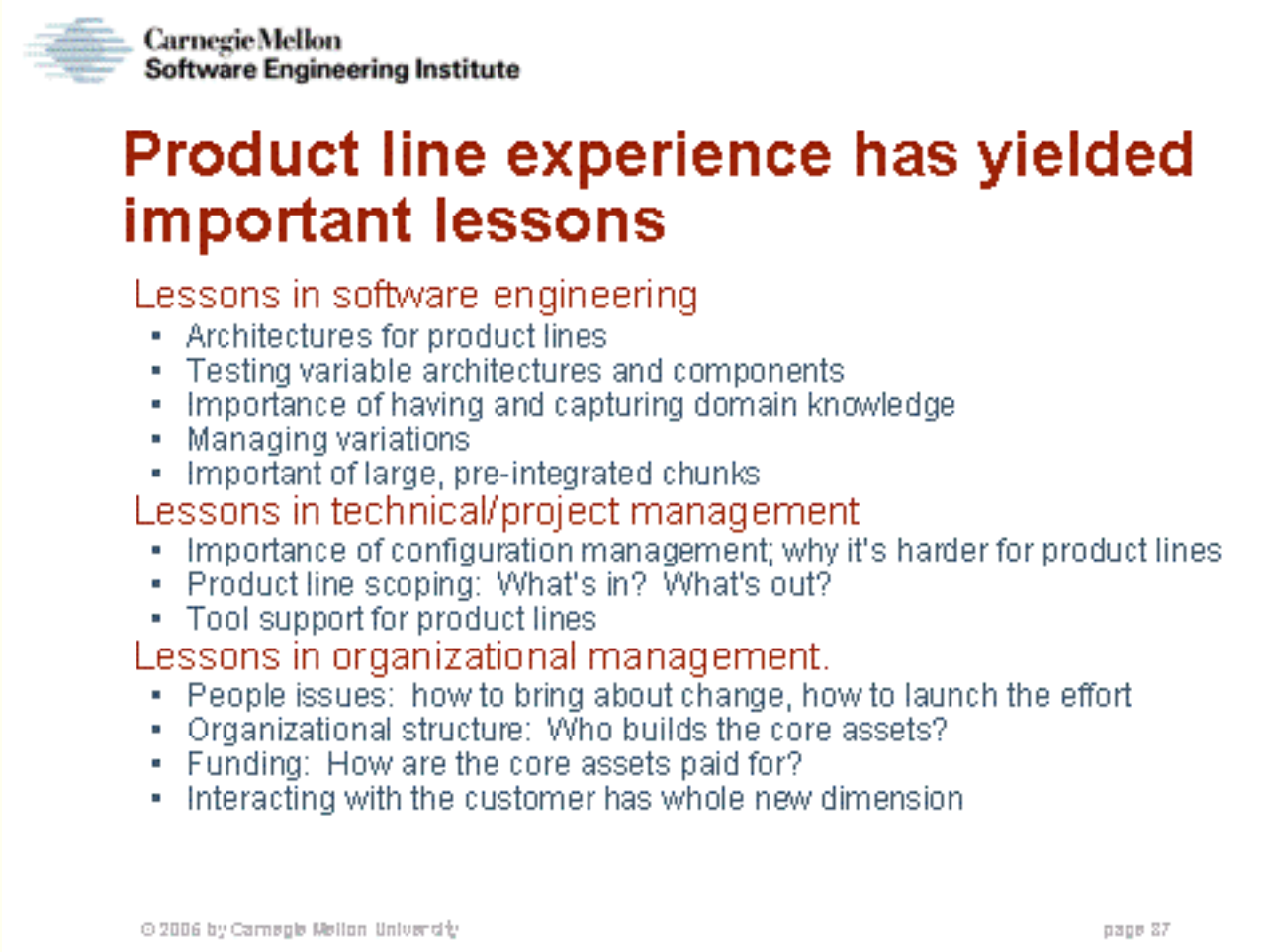

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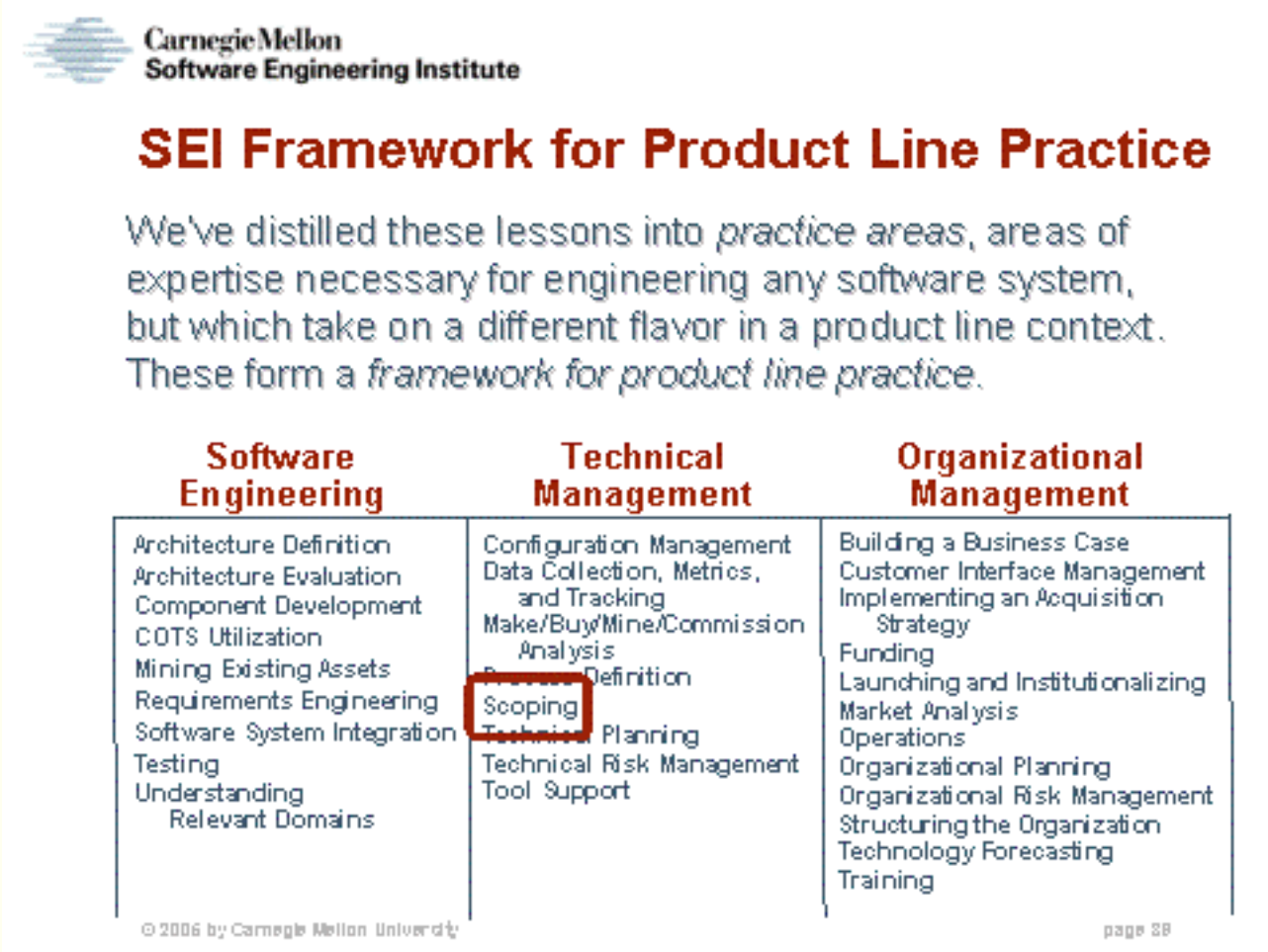

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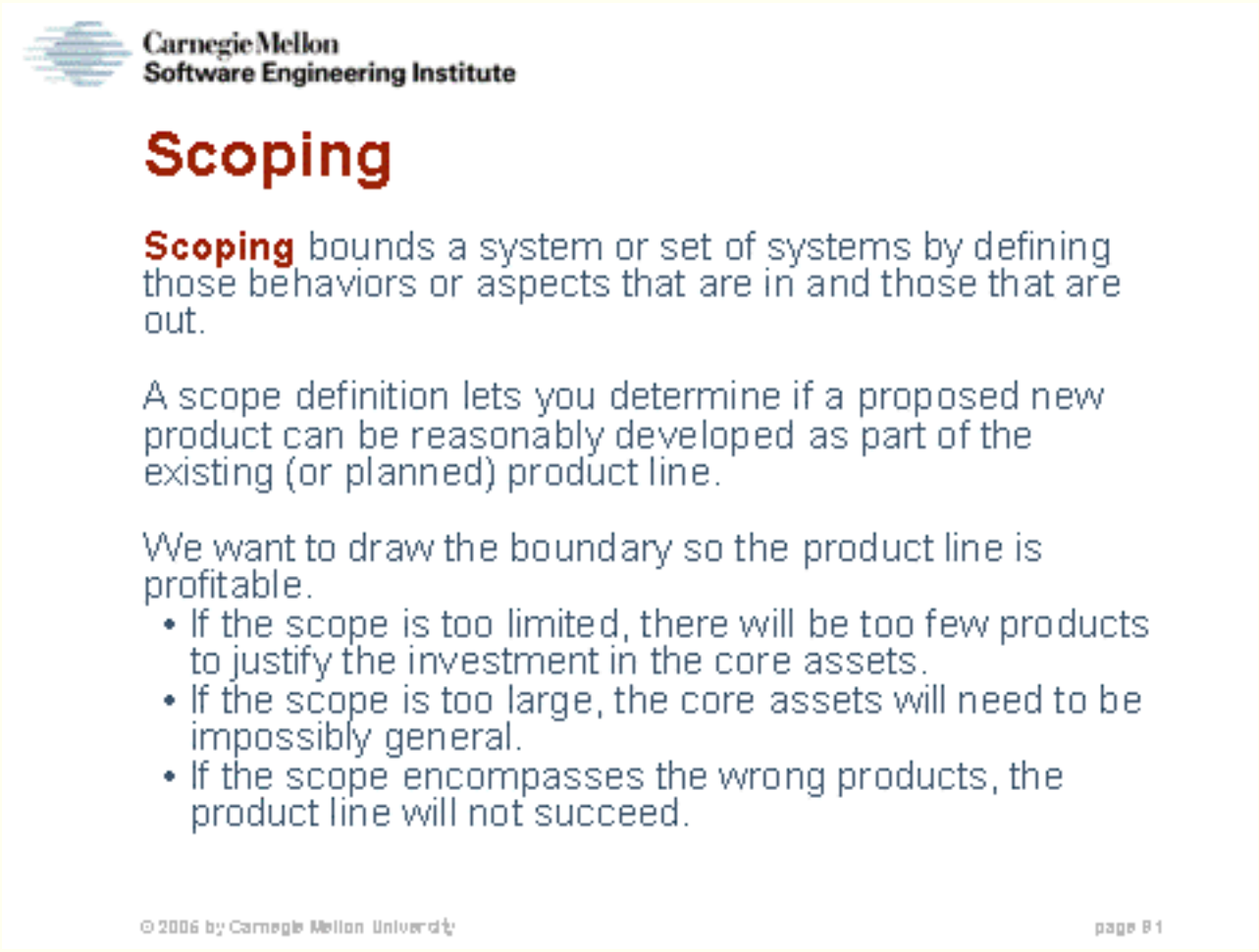

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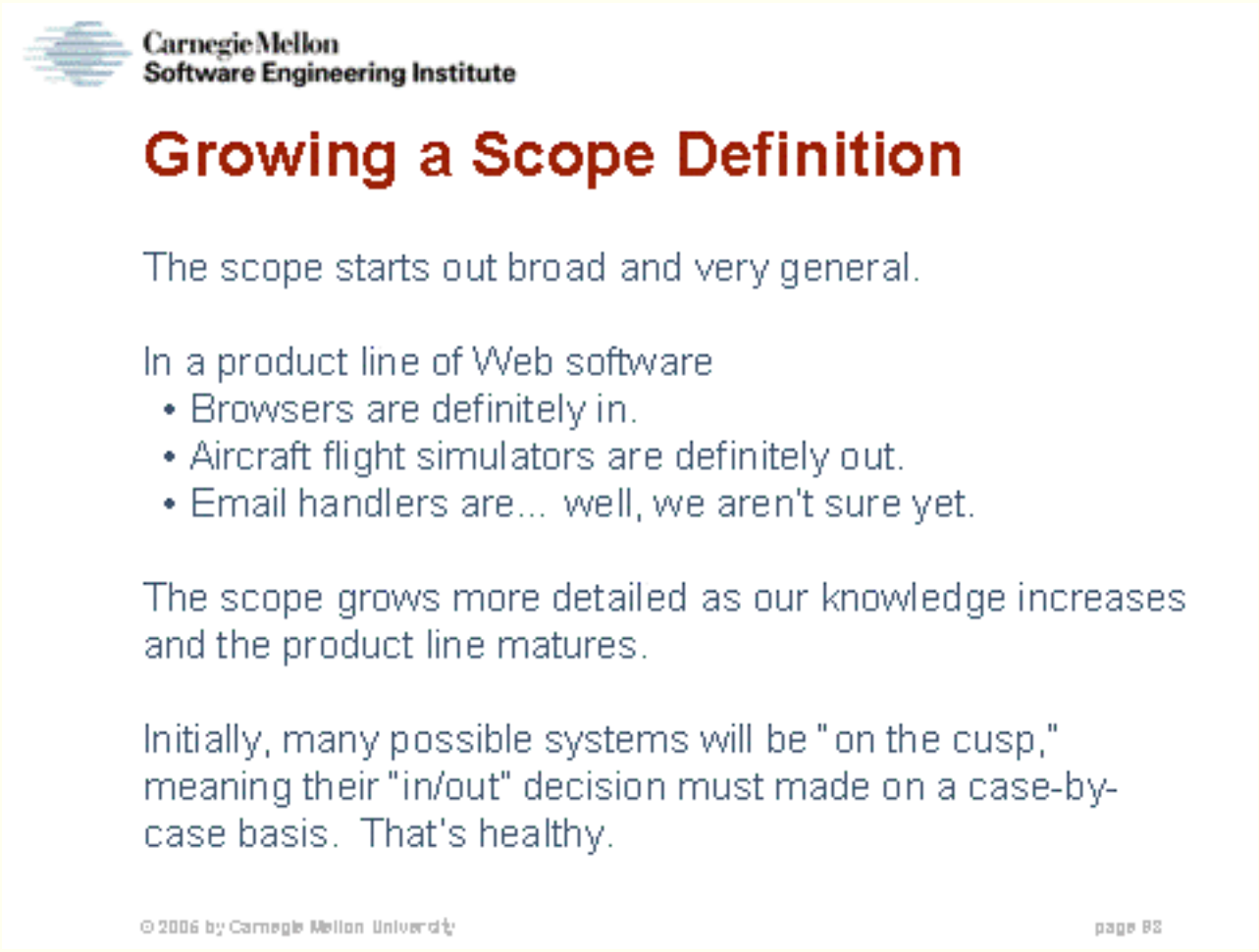

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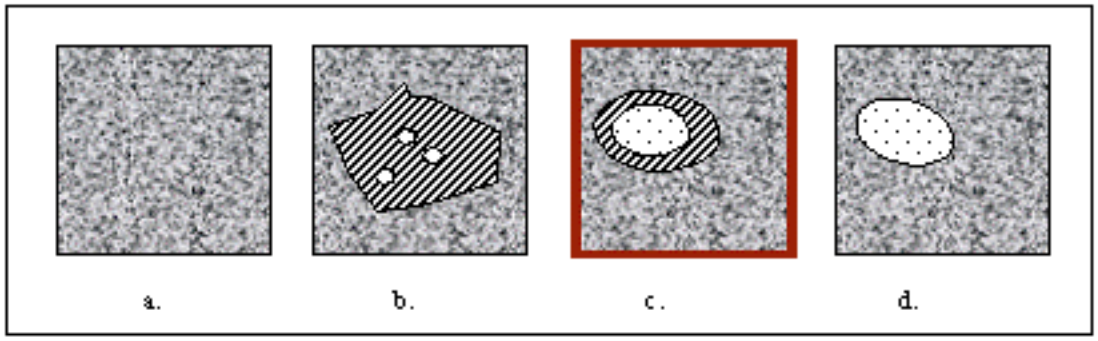
Scope precision increases as we learn more...up to a point.



a: space of all possible products
b: early, coarse-grained "in/out" decisions
c: product line scope with a healthy area of indecision
d: product line scope = product line requirements

If many products appear on the cusp over time, you may need to reactively adjust the scope.

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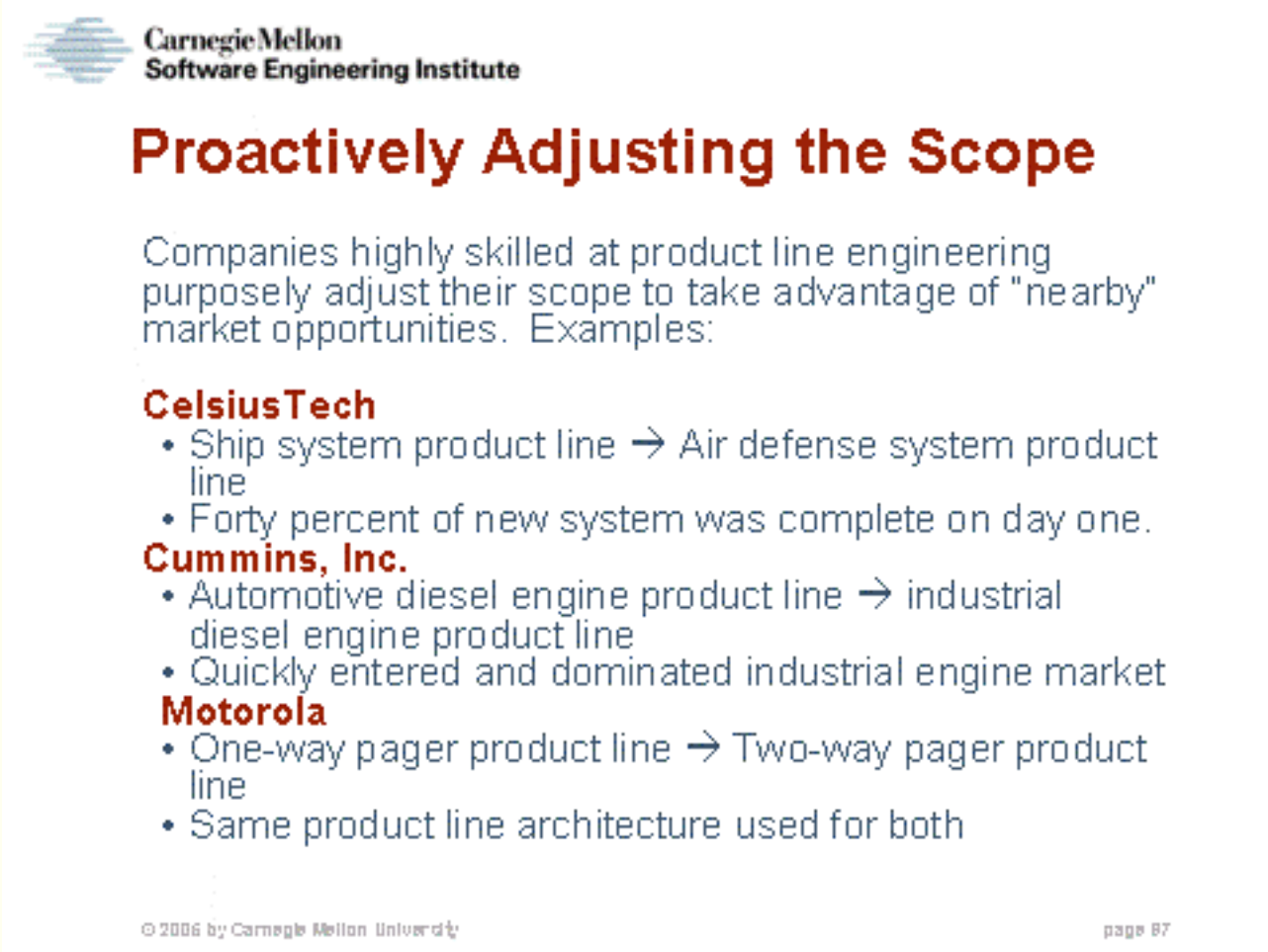

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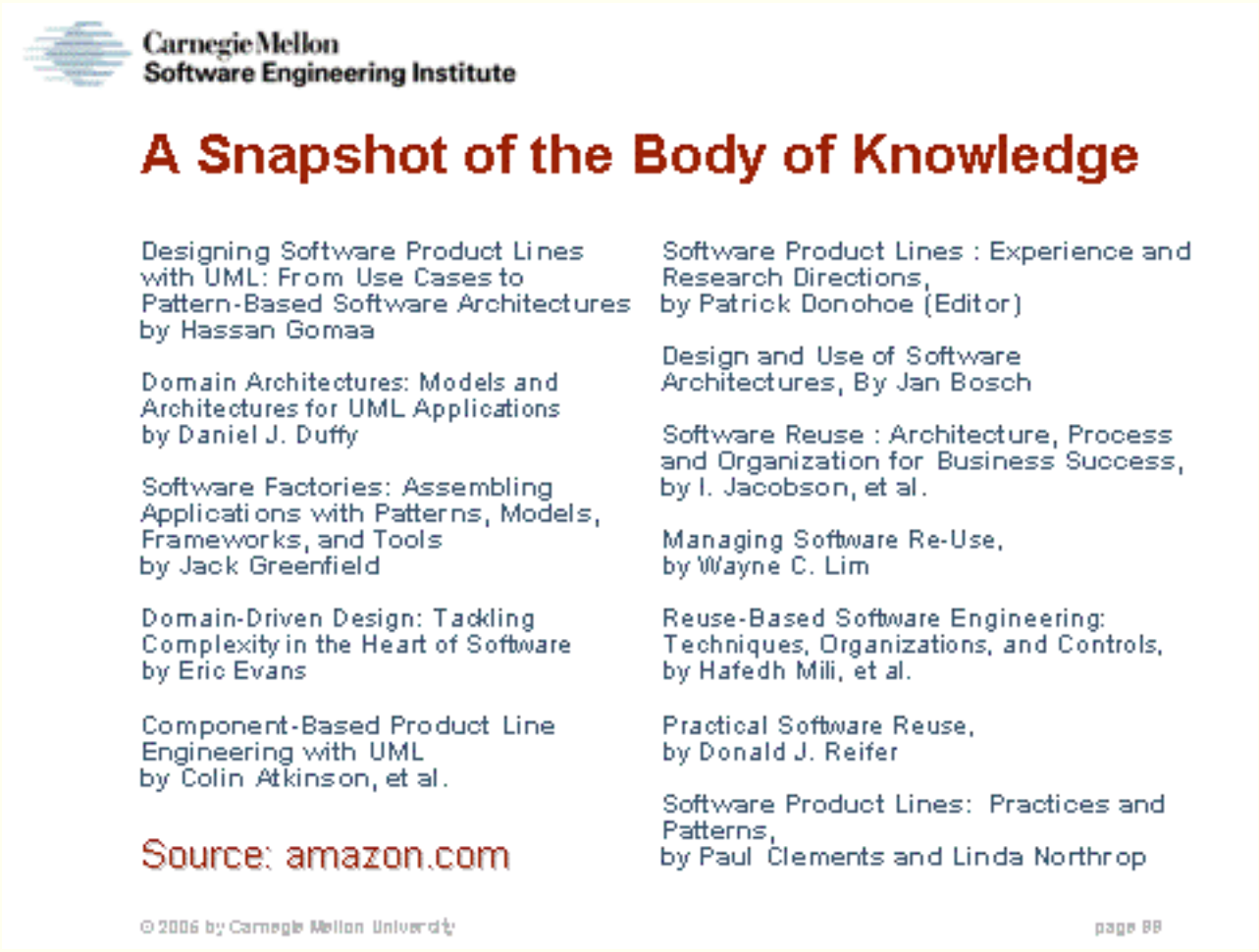

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What Do We Have Now?

Software product lines have emerged as an important, viable paradigm for software development.

- Convincing evidence that software product line practice can bring about significant improvements in software development
- A body of knowledge and a set of standard models for software product lines
- A growing and energetic community of software product line practitioners

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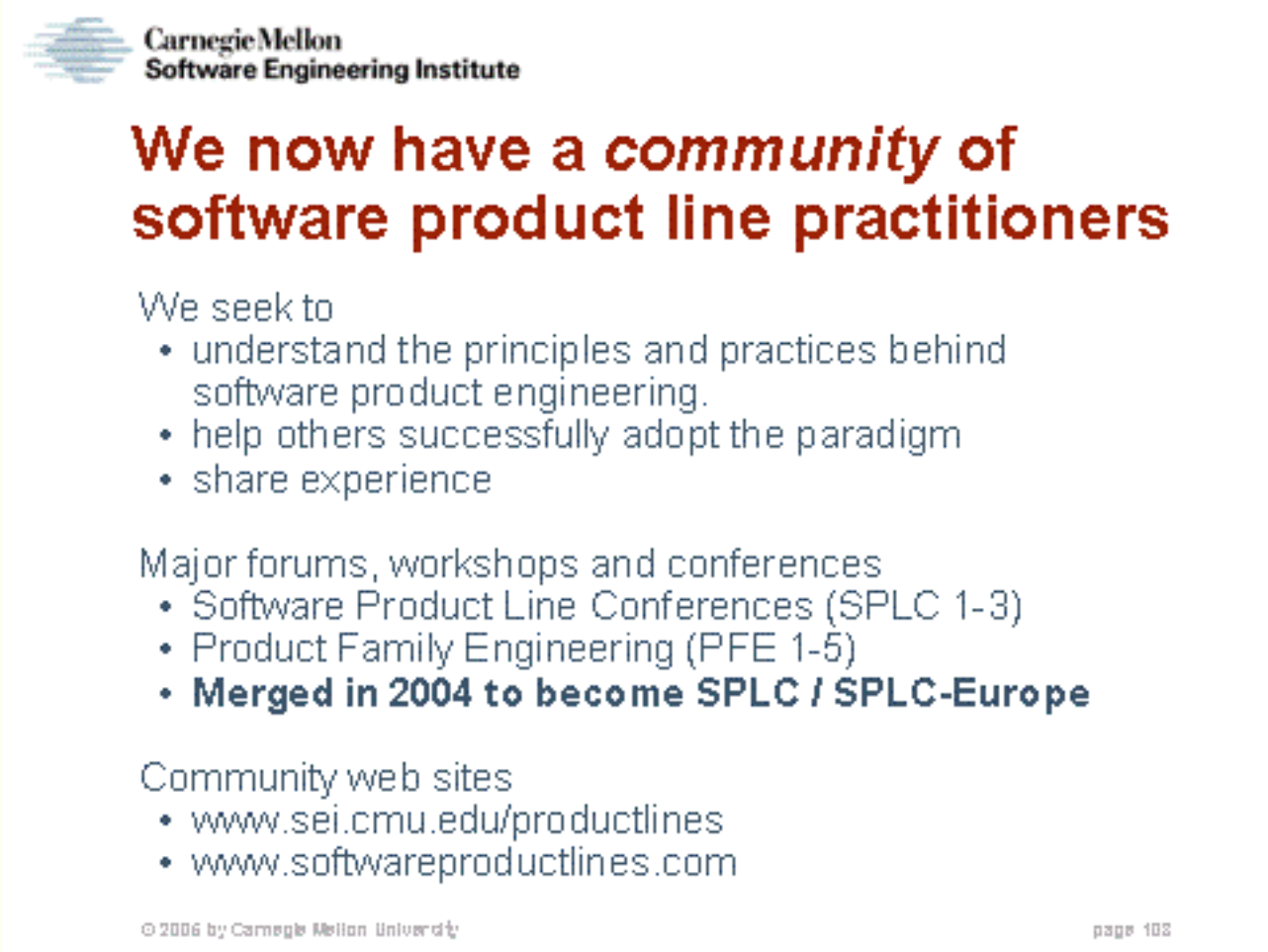

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SEI Software Product Line Curriculum

Five one- and two-day courses

- Software Product Lines
- Adopting Software Product Lines
- Developing Software Product Lines
- Product Line Technical Probe Team Training
- Product Line Technical Probe Leader Training

Three certificate programs

- Software Product Line Professional Certificate
- Product Line Technical Probe Team Member Certificate
- Product Line Technical Probe Leader Certificate

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Current research topics

Product lines and aspects

- An *aspect* is a concern that cuts across units of code in a program.
- Aspects represent a way to achieve multi-dimensional separation of concerns.
- Making a "global" change merely requires changing the aspect and then weaving the aspect through the code.
- Example: Changing a program's overall fault-handling approach

Can aspects be used to represent the variation points of a software product line?

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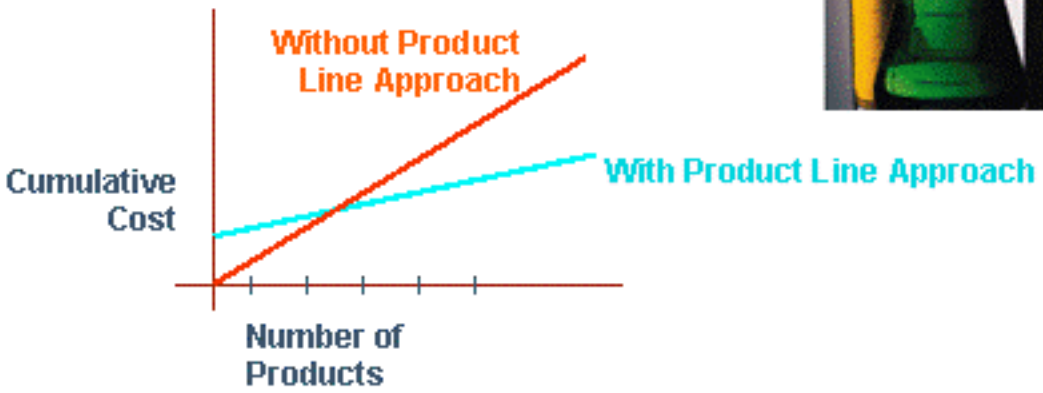
Current research topics

Product lines economic models

Here is our "classic" economic model:



This comes from a world where economic advantage is anecdotal, intuitive, and based on single data points.

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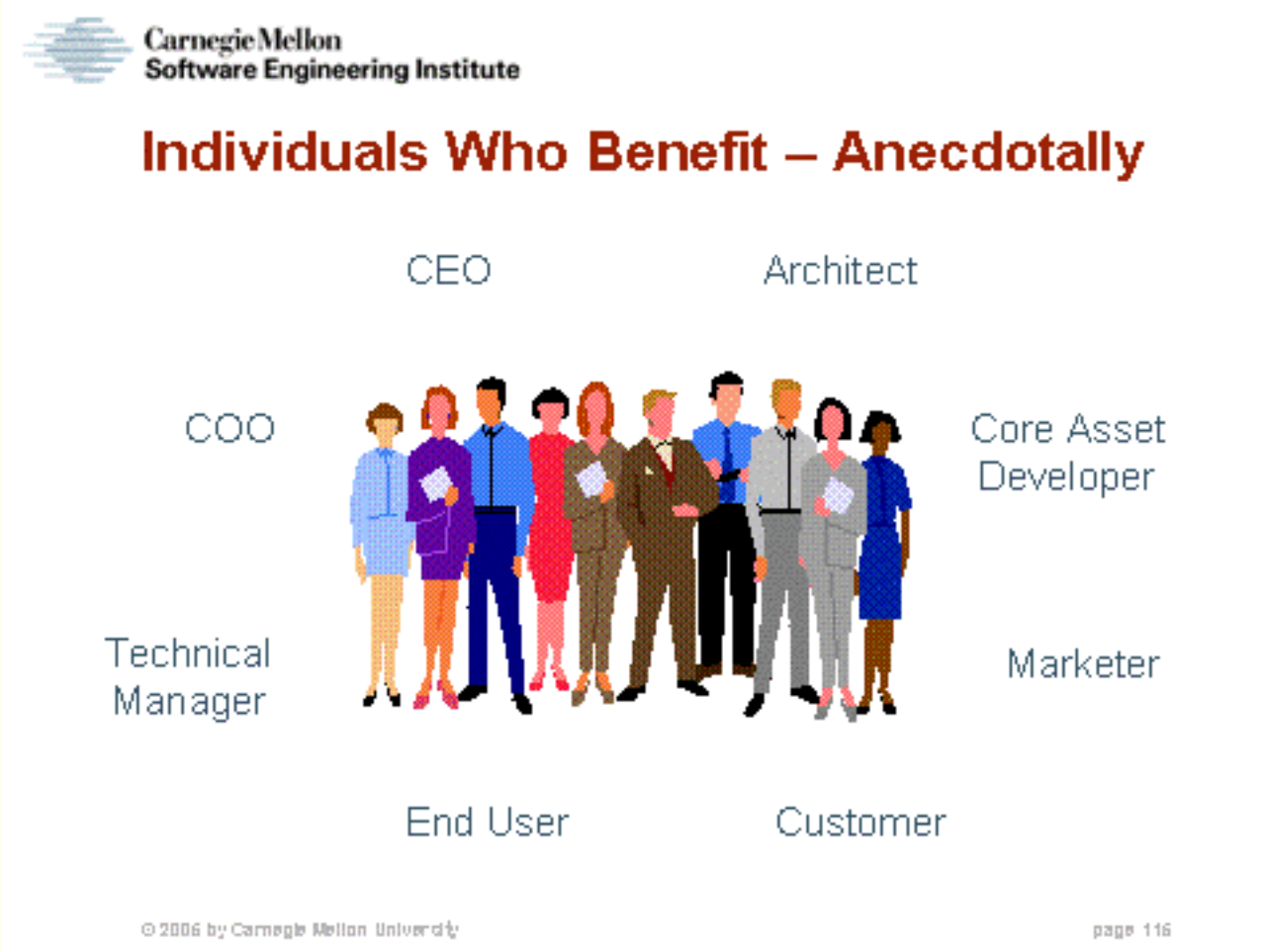

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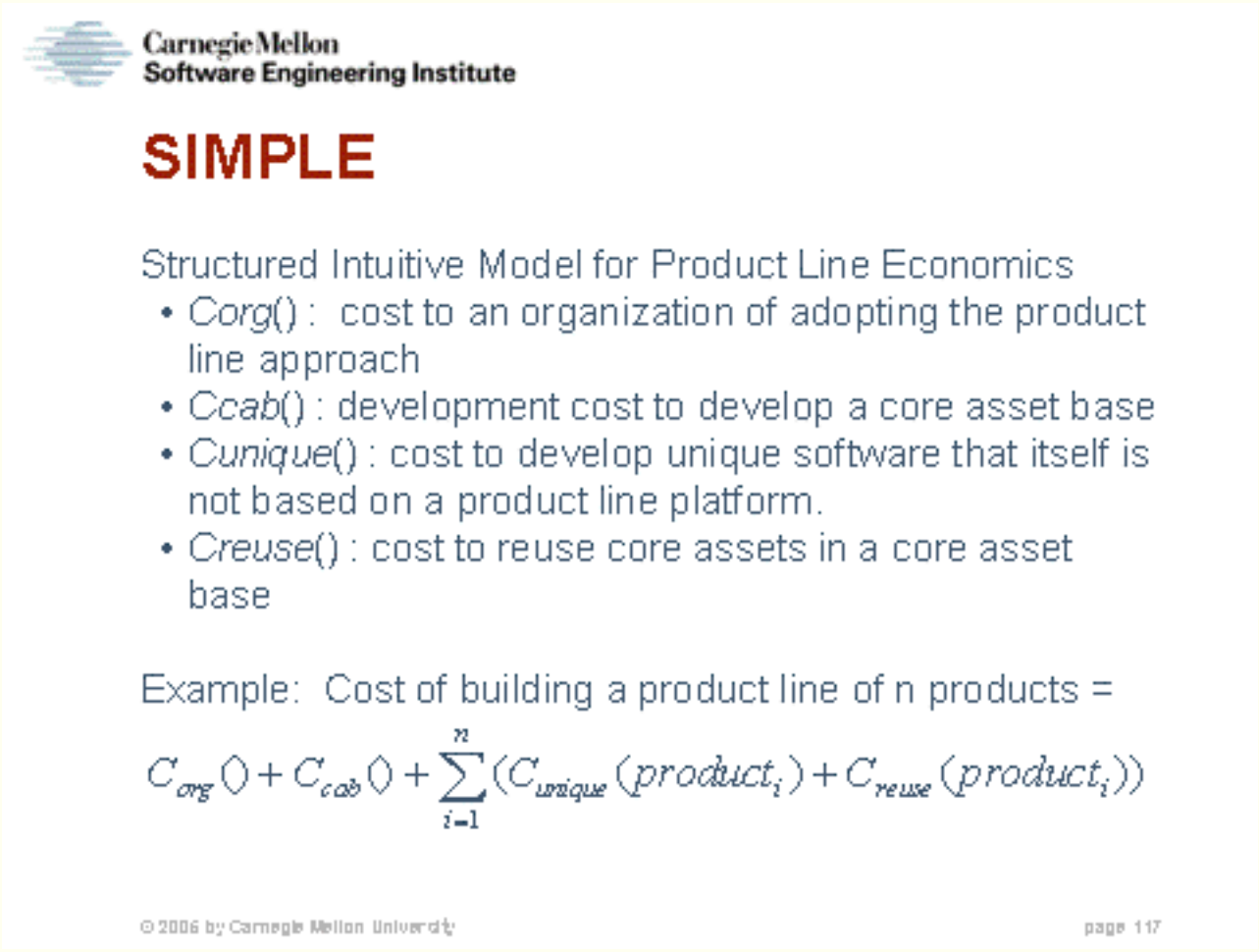

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Current research topics

Product line practice patterns

Patterns represent pre-packaged solutions to known problems.

Design patterns are well-known in software engineering.

Organizational or process patterns also provide solutions or solution strategies to attack recurring problems

- How do I determine the scope of my product line?
- How do I establish a production capability?
- How do I launch a product line effort?
- How do I adopt the product line approach across my whole organization?

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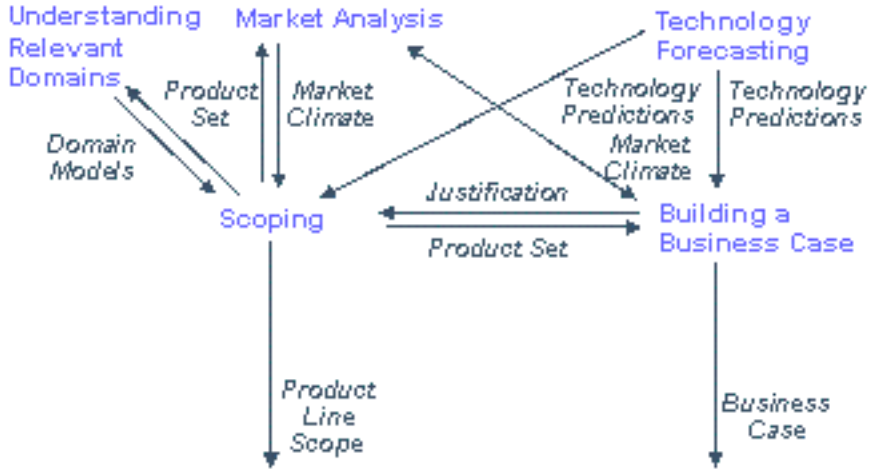
Example: "What to Build" Pattern



Patterns can provide
- Guidance for managers, blueprint for organizations
- Basis for process enactment, workflow and rules engines

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Other research topics

Product line testing

Variability mechanisms and product line architectures

Lightweight, low-cost, low-barrier product line approaches

"Non-traditional" product lines
- Product lines of components for other product lines
- Cross-organizational product lines

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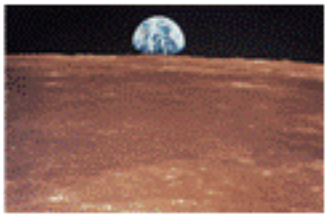
In the Future



Software product line practice will be come a first-class part of software engineering professional practice.

- Product line engineering will be a standard part of software engineering curricula
- Software architects will routinely consider building architectures for a family of systems, using variability mechanisms wisely
- Product/project managers will always ask whether a project being launched can be a product line.
- Decision-makers will have the tools, models, and experience base necessary to help them make the right decisions and carry them out.
- Development tools will handle the development of a family of systems built and maintained in parallel.

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Key Themes Among Successful Product Lines

Sophistication in the domain

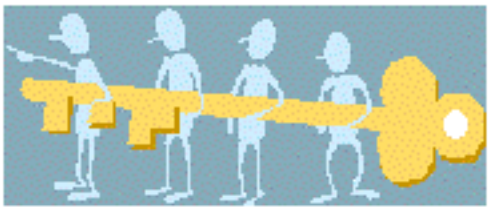
A legacy base from which to build

Architectural excellence

Process maturity

Management commitment

Capacity for introspection



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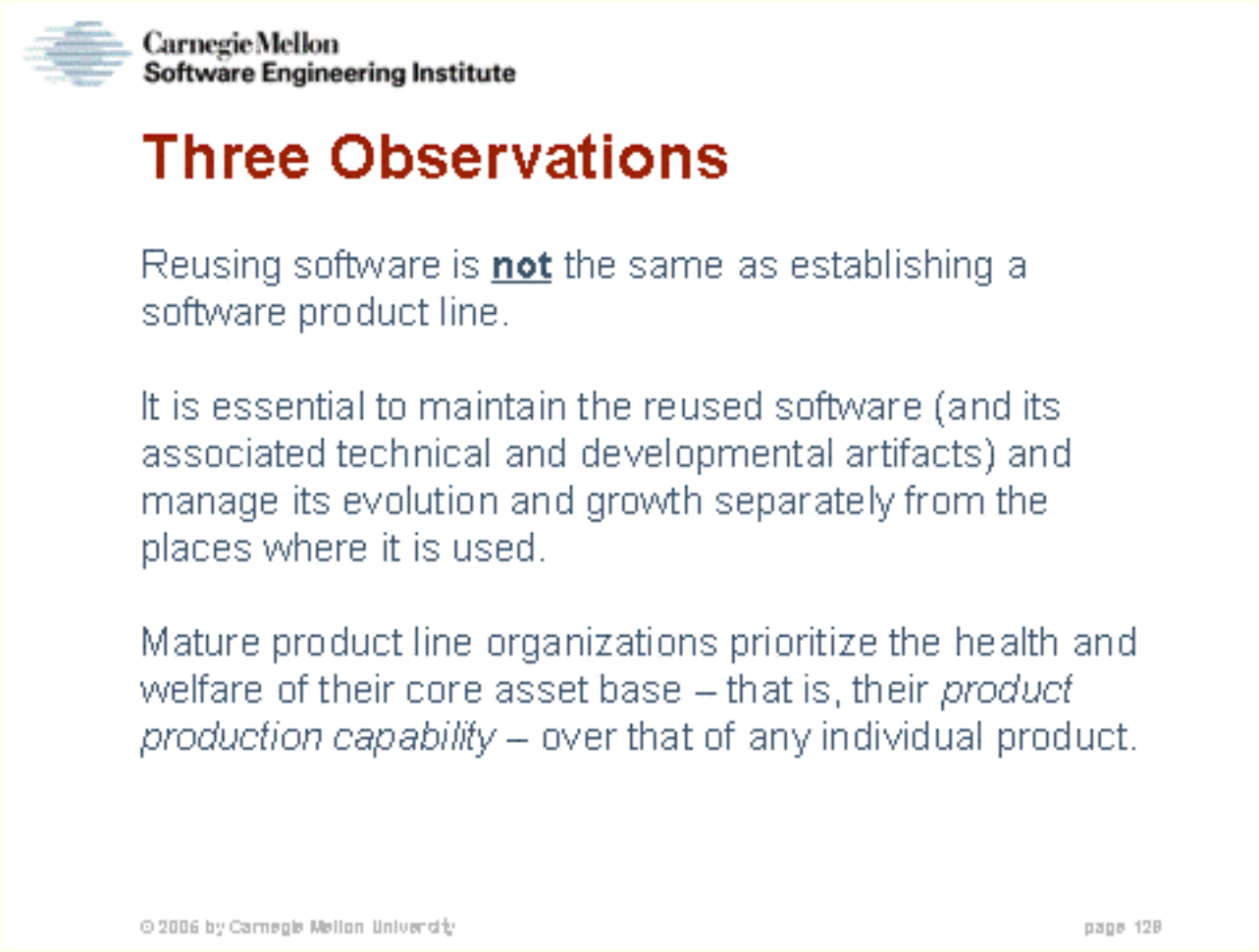

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