Computer integrated manufacturing: Technology trends 1974-1999

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Computer Integrated Manufacturing

Technology Trends 1974 – 1999

Reducing the Cost of Air Cushion Vehicle Development

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1988 Joint International Conference on Air Cushion Technology

Annapolis, Maryland U.S.A.
September 27-29, 1988

RÉSUMÉ

La méthode conventionnelle de production d'un produit nouveau faisait appel à trois niveaux ou départements distincts : conception, fabrication et moyens de production. Arrivé au niveau de la production, le produit devait subir plusieurs changements pour devenir compatible avec les moyens de production.

Aujourd'hui, grâce aux techniques de conception assistée par ordinateur (CAO), de fabrication assistée par ordinateur (FAO) et d'ingénierie assistée par ordinateur (IAO), tous les départements concernés se partagent une base de données commune qui leur permet d'agir chacun selon ses compétences, tout en poursuivant le même but ultime. La conception d'éléments de produits a donc cédé la place à la conception d'ensemble d'un produit.

Cette technique de production intégrée par ordinateur, par laquelle chaque département procède à ses études techniques, concurremment s'appuie sur un réseau de postes de travail sophistiqués où l'élément visuel prédomine et qui n'a cessé d'évoluer au cours des cinq dernières années.

Toutes ces technologies ont permis d'améliorer la qualité des matériels produits en réduisant les coûts de fabrication, les cycles de fabrication et le nombre de changements devant intervenir entre la conception d'un produit et sa réalisation finale.

1988 Joint International Conference on Air Cushion Technology

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Computer Integrated Manufacturing (CIM) Technology Trends Reducing the Cost of Air Cushion Vehicle Development

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ABSTRACT

In the traditional manufacturing environment, the design, manufacturing and production engineering processes have been separated into serial departments, with production making many changes to the prototype part designs to make them manufacturable.

Mechanical Computer Aided Engineering/Computer Aided Design/Computer Aided Manufacturing (MCAE/CAD/CAM) integrated simulation-analysis tools now share a central design data base. Concurrent communication allows a design/manufacturing/production team solution to evolve. Prototype part designs are now production part designs.

This concurrent engineering process is significantly enhanced by the highly visual graphic super workstation networks which have been developed over the past 5 years.

These technology trends have improved the quality of vehicles by reducing product development costs, production delivery time, and the form/fit changes between the prototype and production designs.

Topic **Trend:**

Subject: **Slide Title:**

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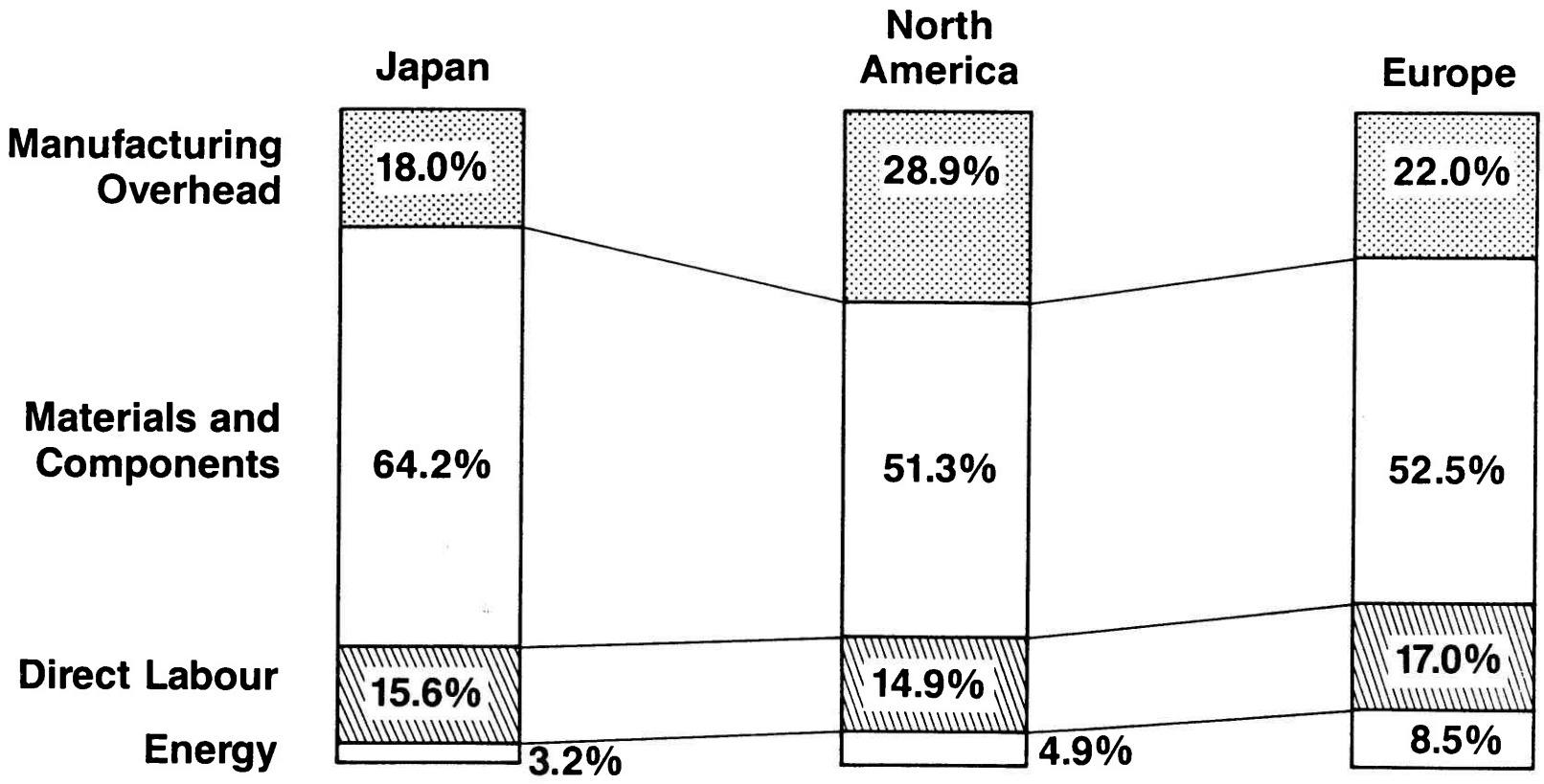
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			Numerical Control Programming	
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Computer Integrated Manufacturing Reducing the Cost

Technology Trends 1974 — 1999 Air Cushion Vehicle Development

A Breakdown of Overall Manufacturing Costs



Traditional accounting methods which compare overhead to direct labour must be replaced by new methods which trace individual activities to separate products.

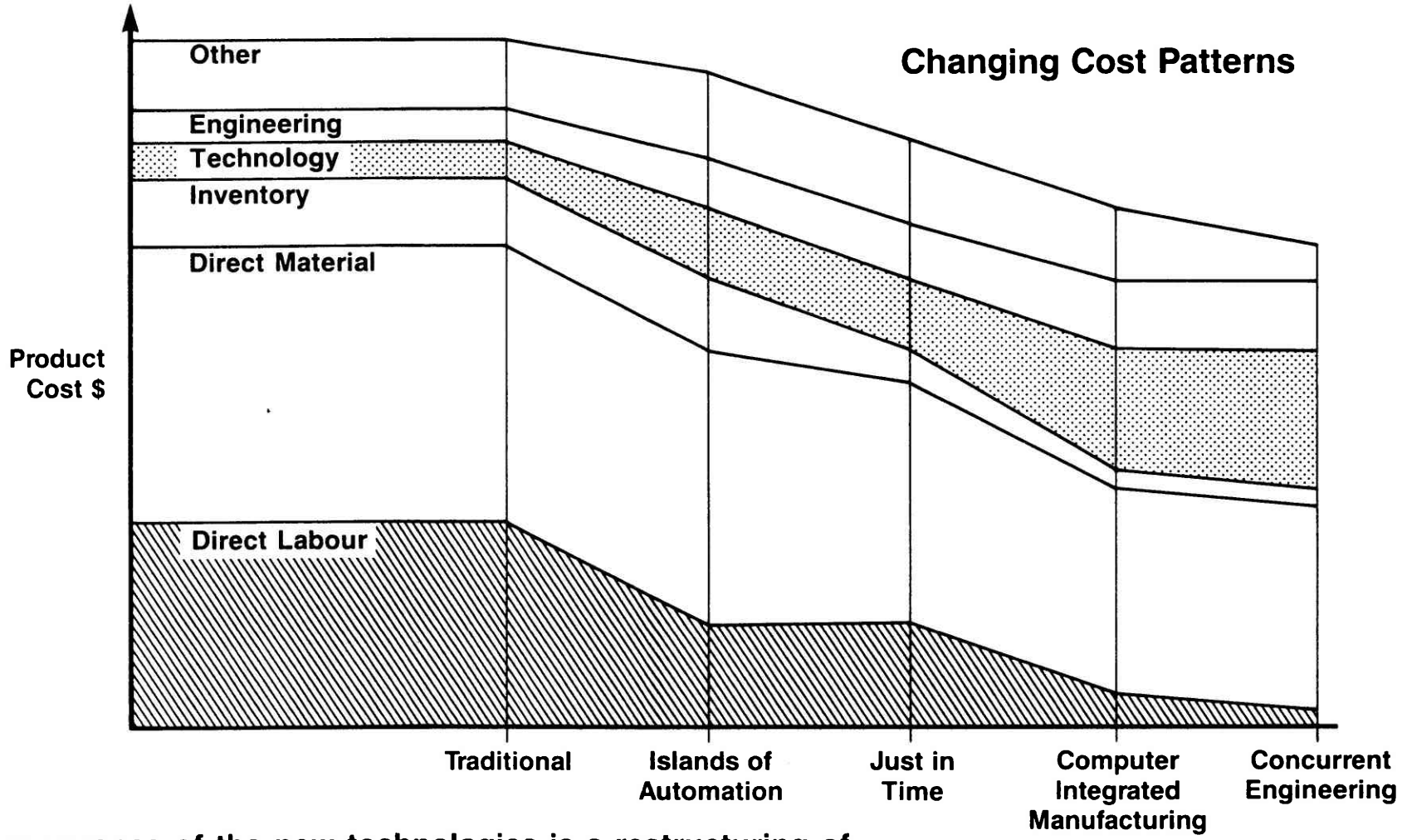
Source: Institute of Business Administration

CIM Technology Trends

Why CIM during the 80's ?

Reduce Product Cost

Cost Patterns



One consequence of the new technologies is a restructuring of manufacturing cost patterns forcing the new accounting methods to display the return on investment in technology.

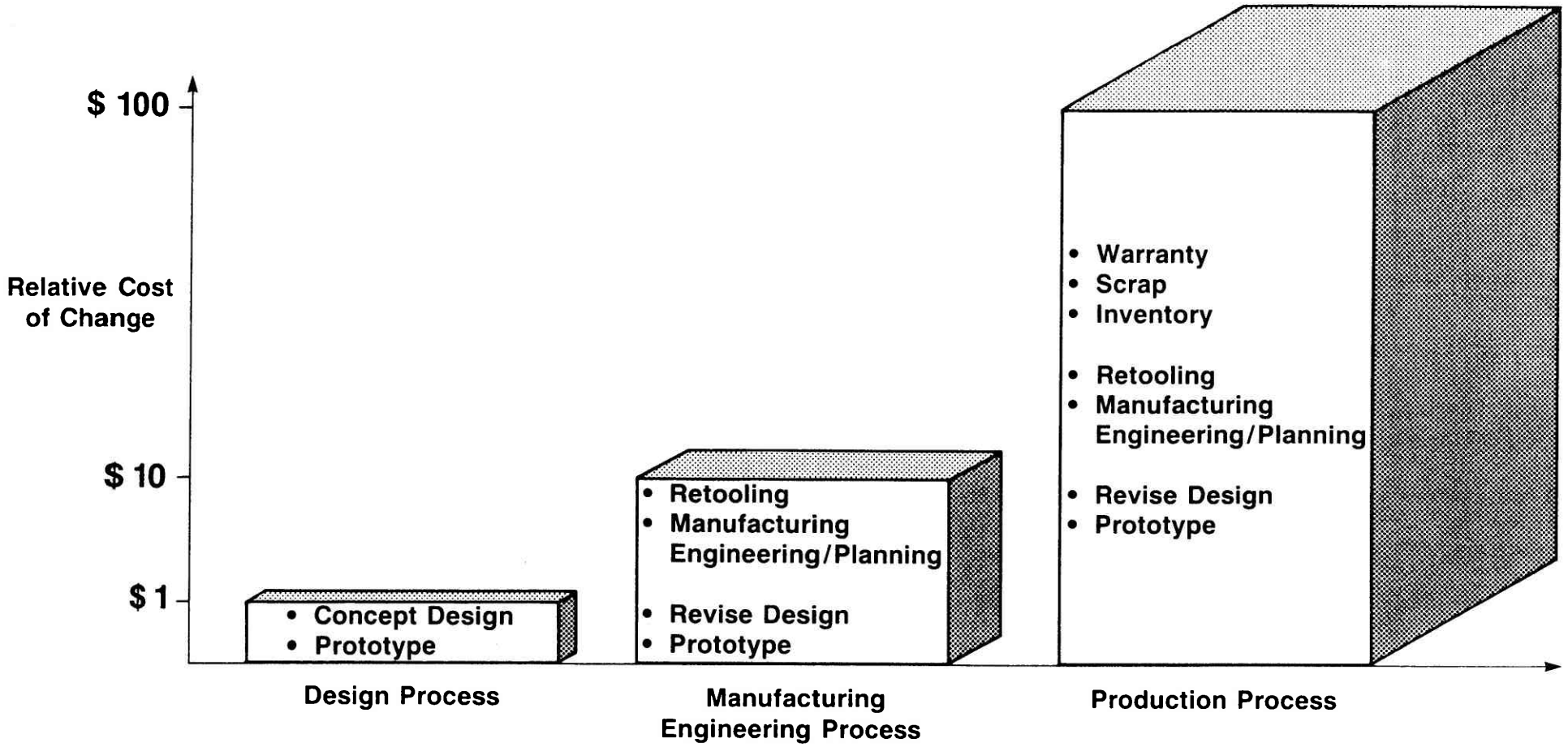
Source: Computer Aided Manufacturing – International Inc. Arlington, TX

CIM Technology Trends

Why CIM during the 80's ?

Reduce Product Cost

Cost of Change



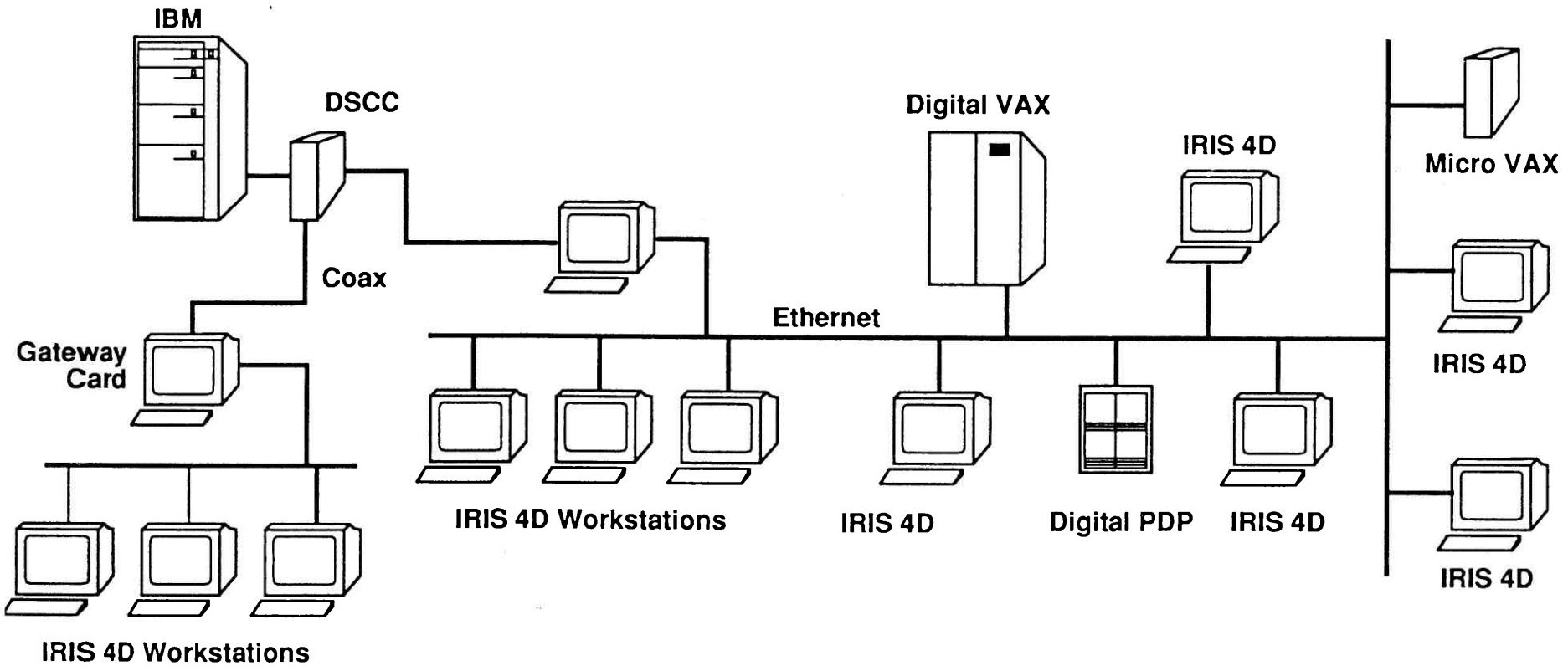
Mechanical Computer Aided Engineering (MCAE)/Computer Aided Design (CAD)/Computer Aided Manufacturing (CAM) helps organizations to develop improved quality products by focusing attention in the early stages of design — where problems can be avoided and when change is least expensive.

CIM Technology Trends

Why CIM during the 80's ?

Rapid Computer Development

Networked Computing Systems



The global pressure to reduce costs and product development time, along with rapid computer development centered around graphic workstations, has resulted in Computer Integrated Manufacturing being the most effective manufacturing method during the 1980's.

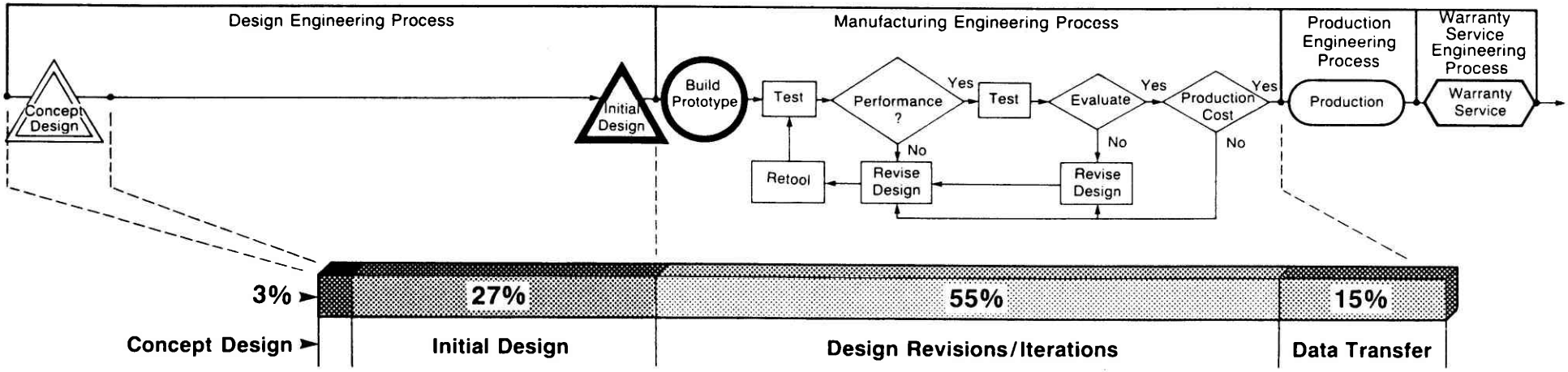
CIM Technology Trends

What is happening in the manufacturing process?

Product Life Cycle

Traditional Environment

Traditional Environment



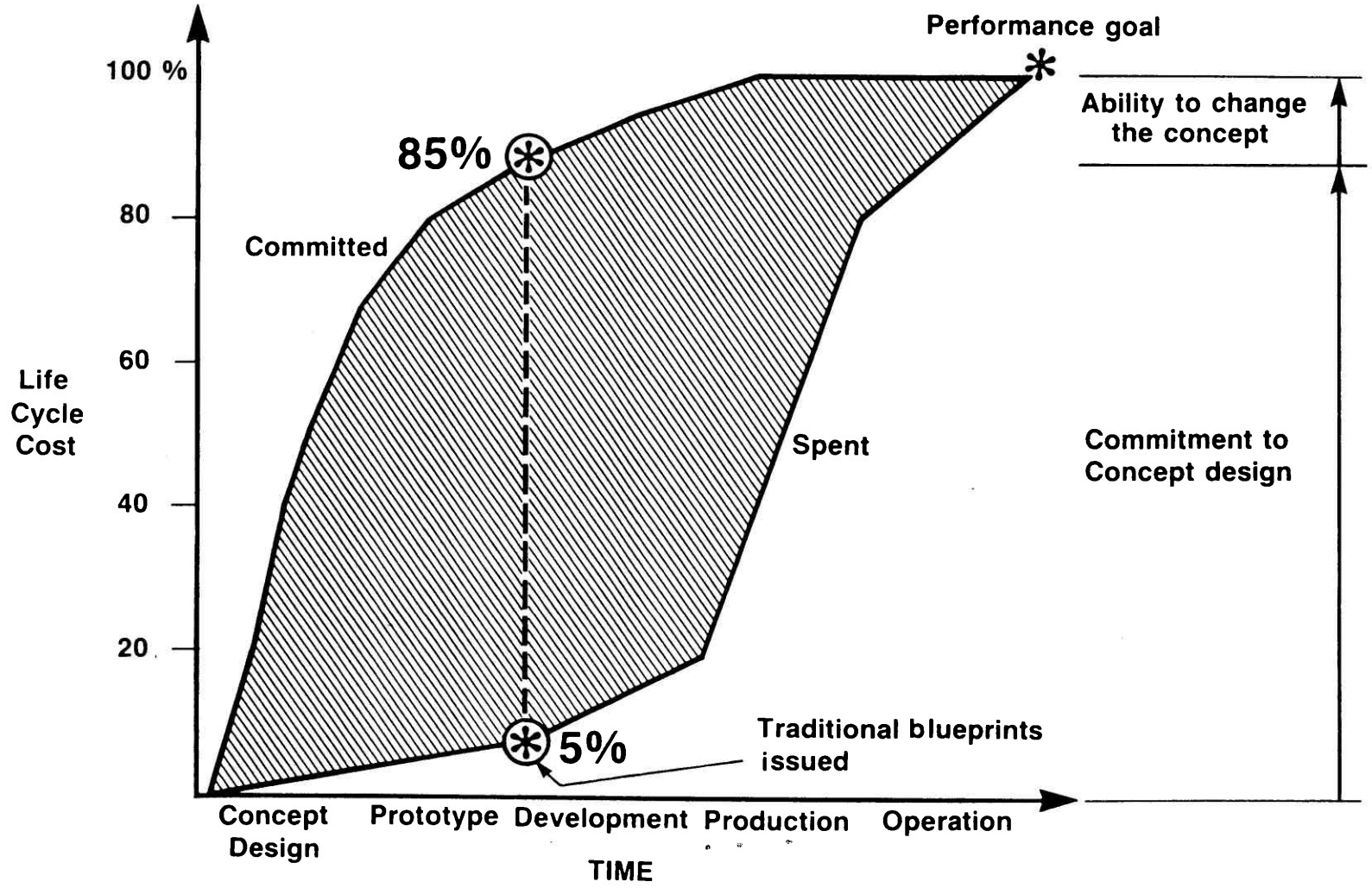
Organizations currently using the traditional product life cycle environment are forced to build then evaluate their new products.

CIM Technology Trends

What is happening in the manufacturing process?

Why the Gap?

Committed vs. Spent



Traditionally when only 5% of product development cost has been spent — 85% of the life cycle cost has been committed.

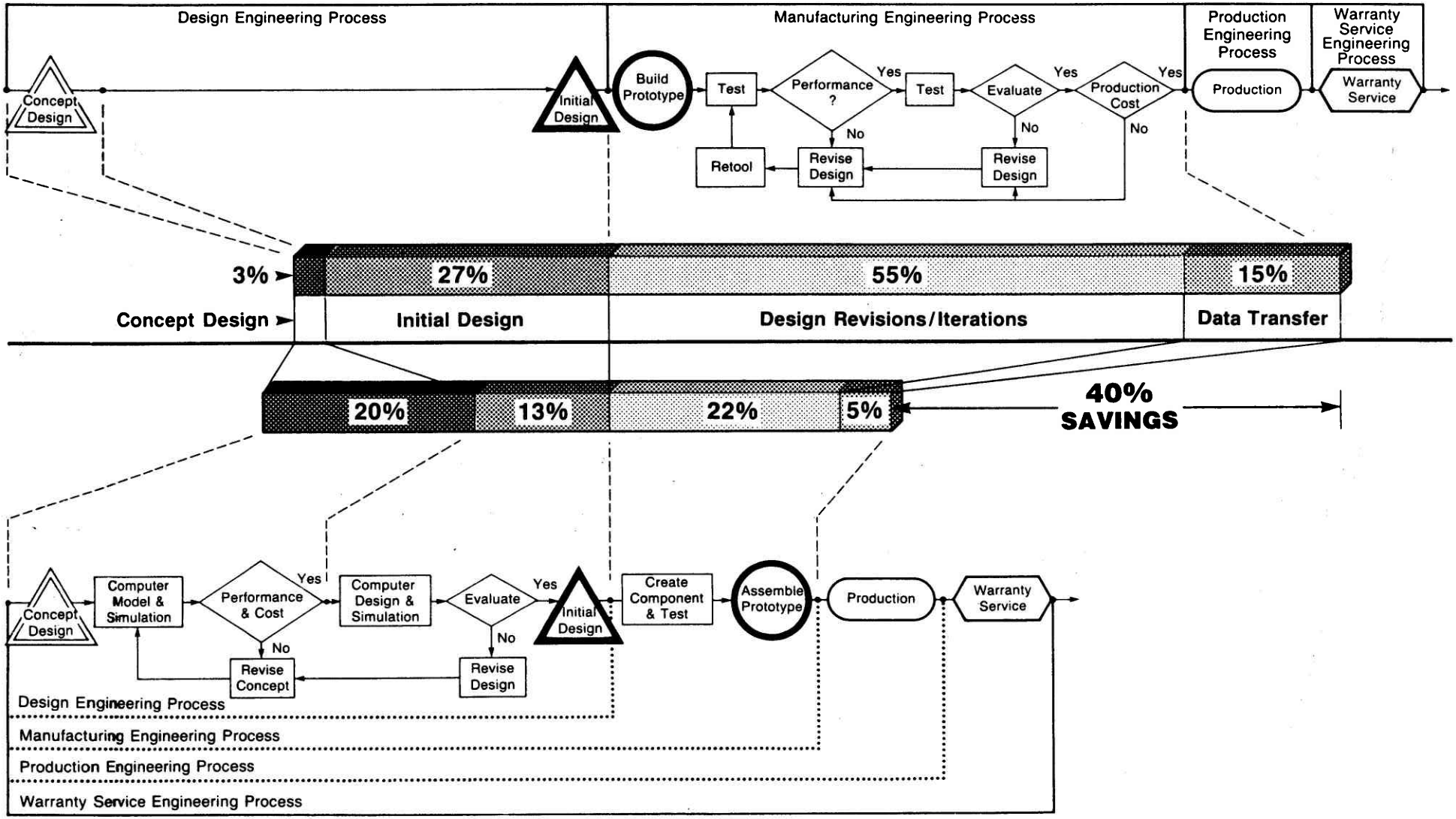
CIM Technology Trends

What is happening in the manufacturing process?

Product Life Cycle

CAE/CAD/CAM Environment

Traditional Environment



CAE/CAD/CAM Environment

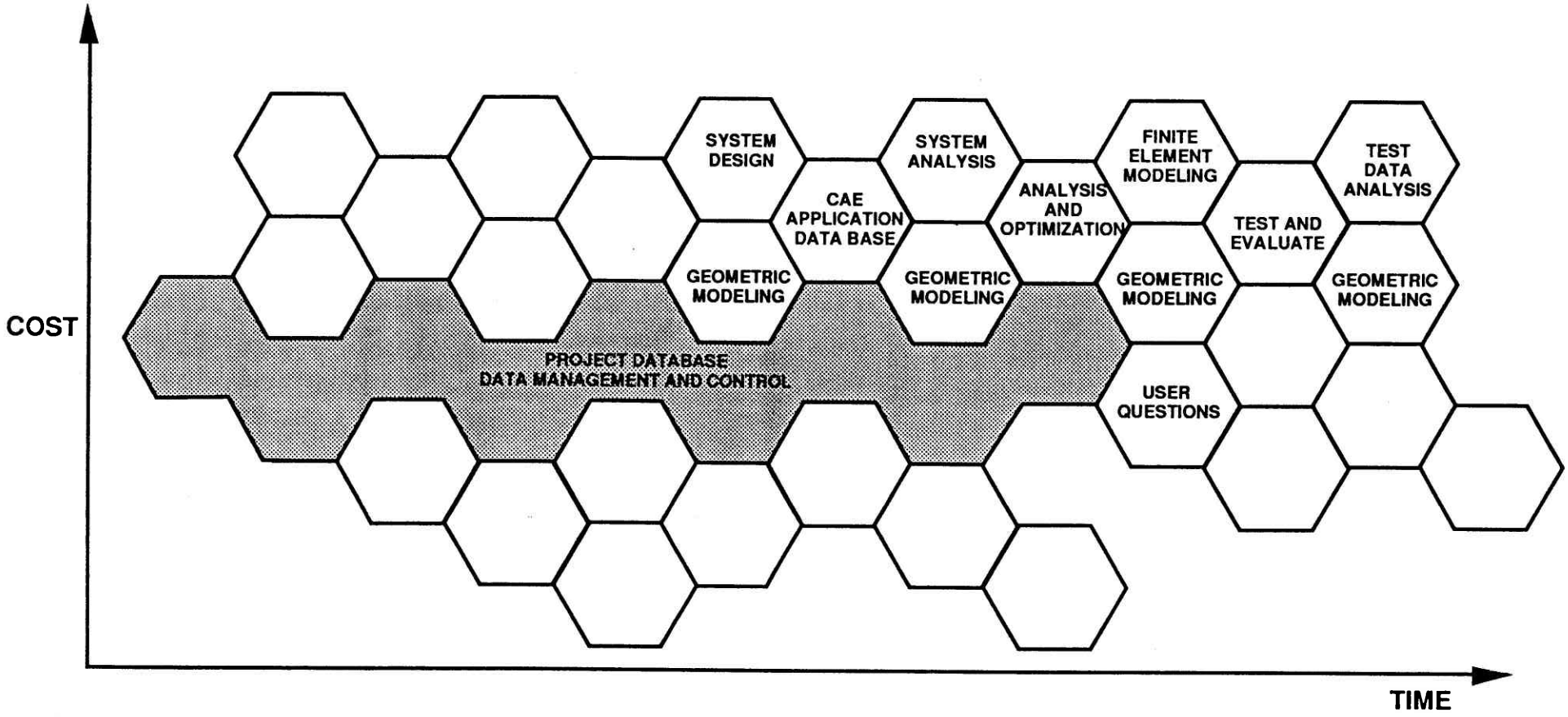
CAE/CAD/CAM Organizations evaluate then assemble their new products.

CIM Technology Trends

How is this change occurring?

Application Software

Fully Integrated



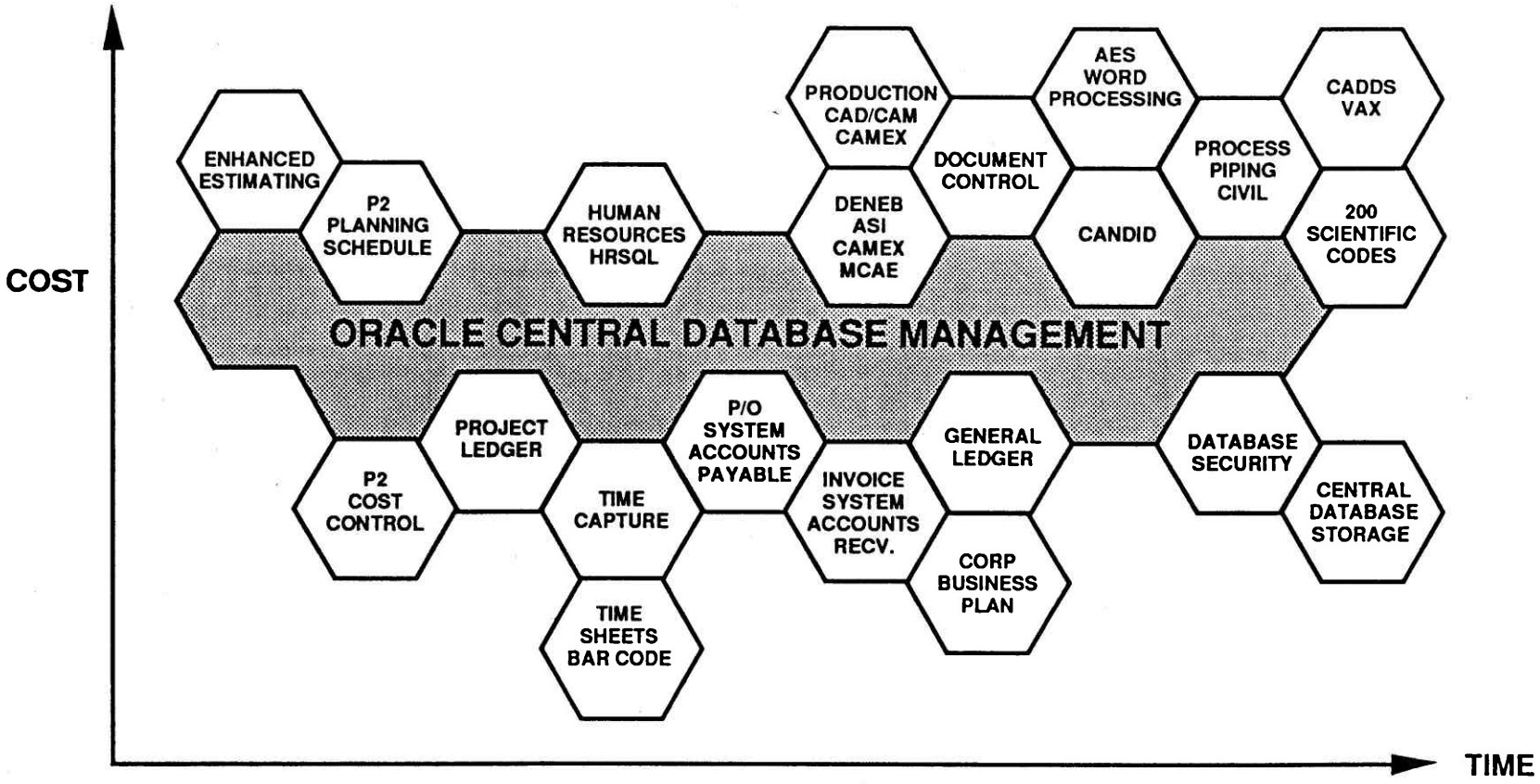
Intense competition has forced suppliers to fully integrate their specialized application software packages with central company databases.

CIM Technology Trends

How is this change occurring?

Project Management Software

Integrated Central Database



Management has been reluctant to accept the MCAE/CAD/CAM process without monitoring tools. The traditional feedback has been the growth of blue prints prior to initial design completion. Now fully integrated schedule and cost control software makes the growth of the invisible database visible on a daily basis.

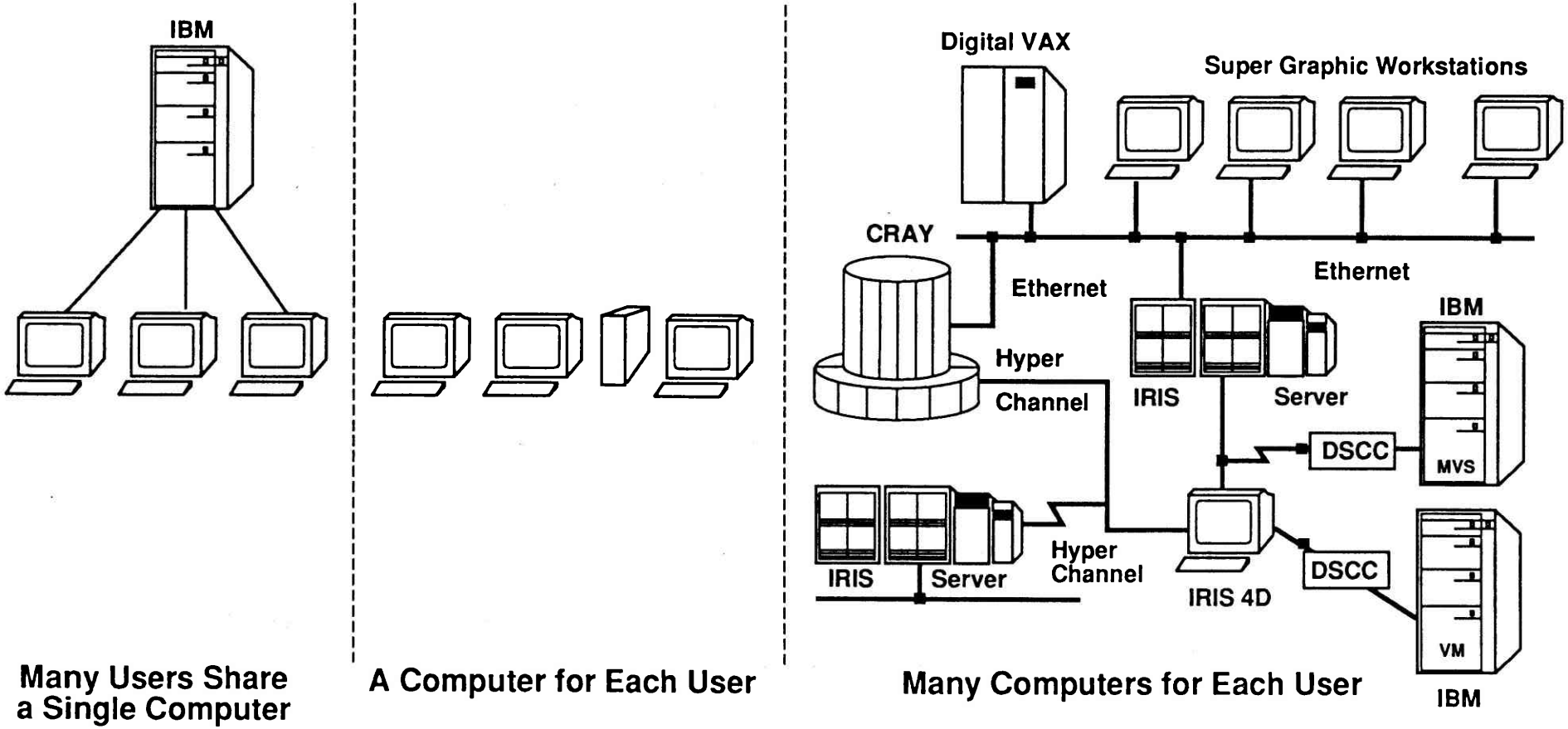
CIM Technology Trends

How is this change occurring?

Computer Hardware

Distributed Network

Timesharing → Workstations → Network Computing System



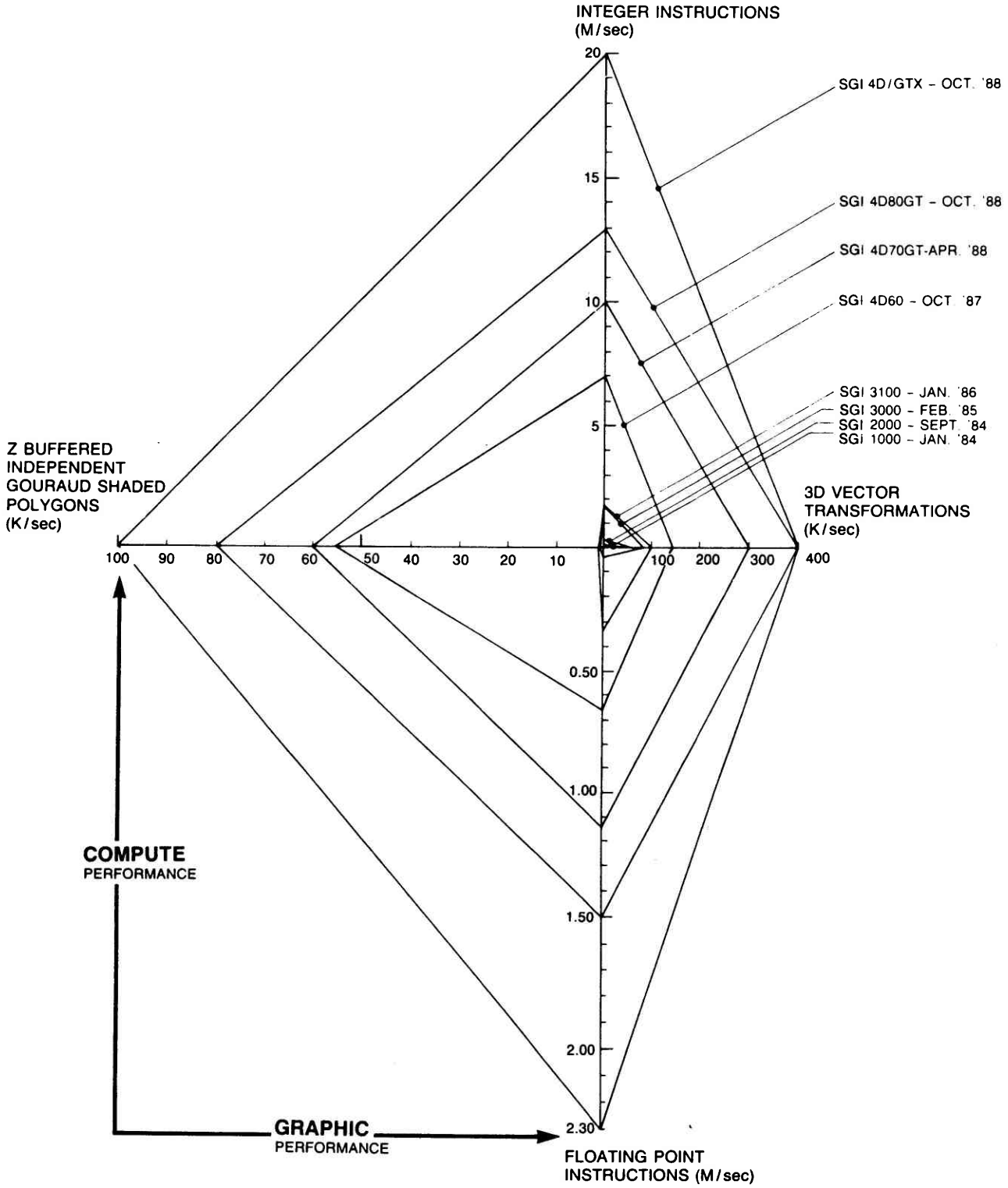
Many Users Share a Single Computer

A Computer for Each User

Many Computers for Each User

Diamonds of Performance

Compute vs Graphic Performance



Two separate computer developments, graphic performance and compute performance have been combined into individual super graphic workstations.

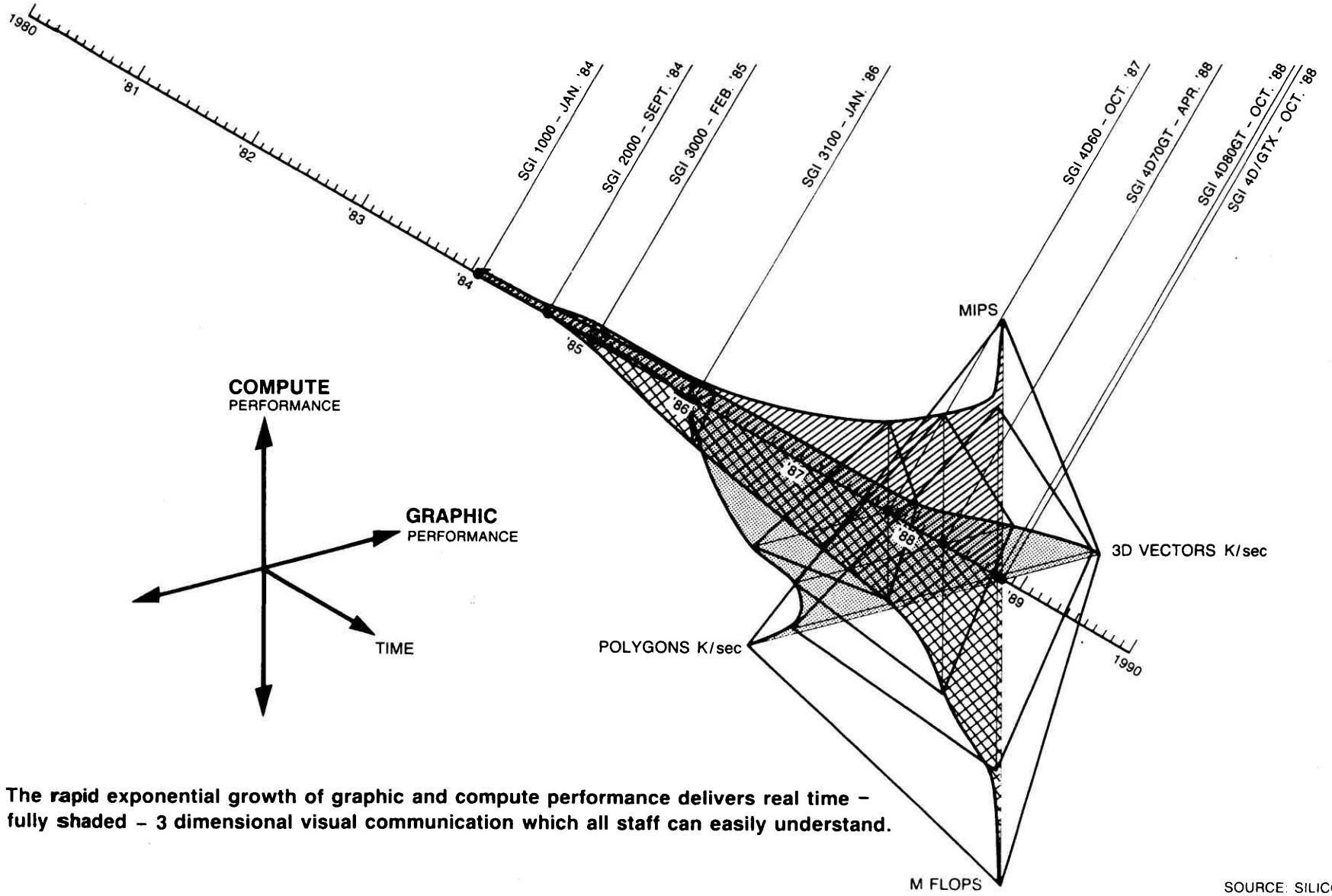
SOURCE: SILICON GRAPHICS

CIM Technology Trends

How is this change occurring?

Diamonds of Performance

Silicon Graphics History

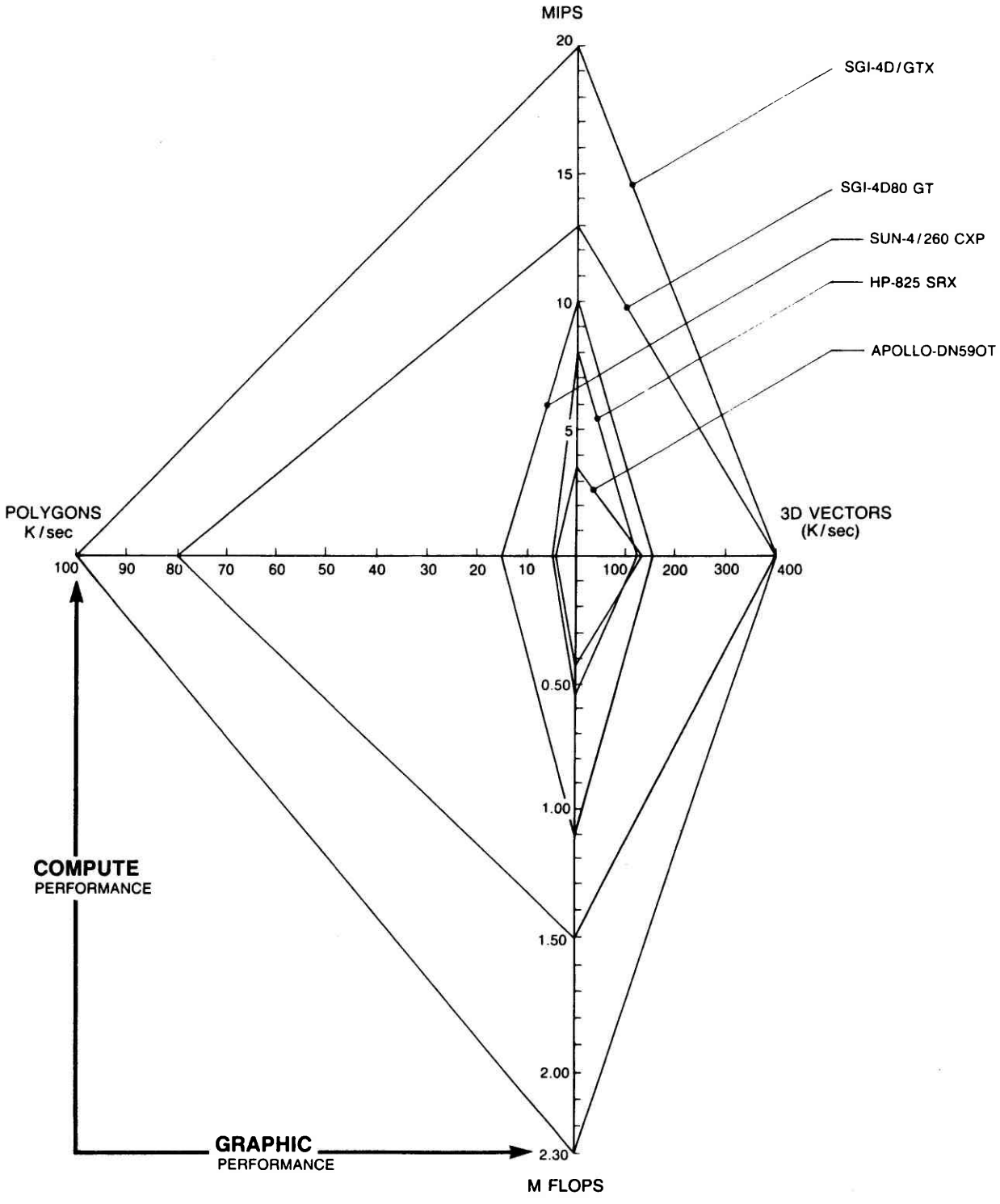


The rapid exponential growth of graphic and compute performance delivers real time – fully shaded – 3 dimensional visual communication which all staff can easily understand.

SOURCE: SILICON GRAPHICS

Diamonds of Performance

Competitive Performance



Several industry leaders are developing visual scientific computing standards in stand-alone super graphic workstations.

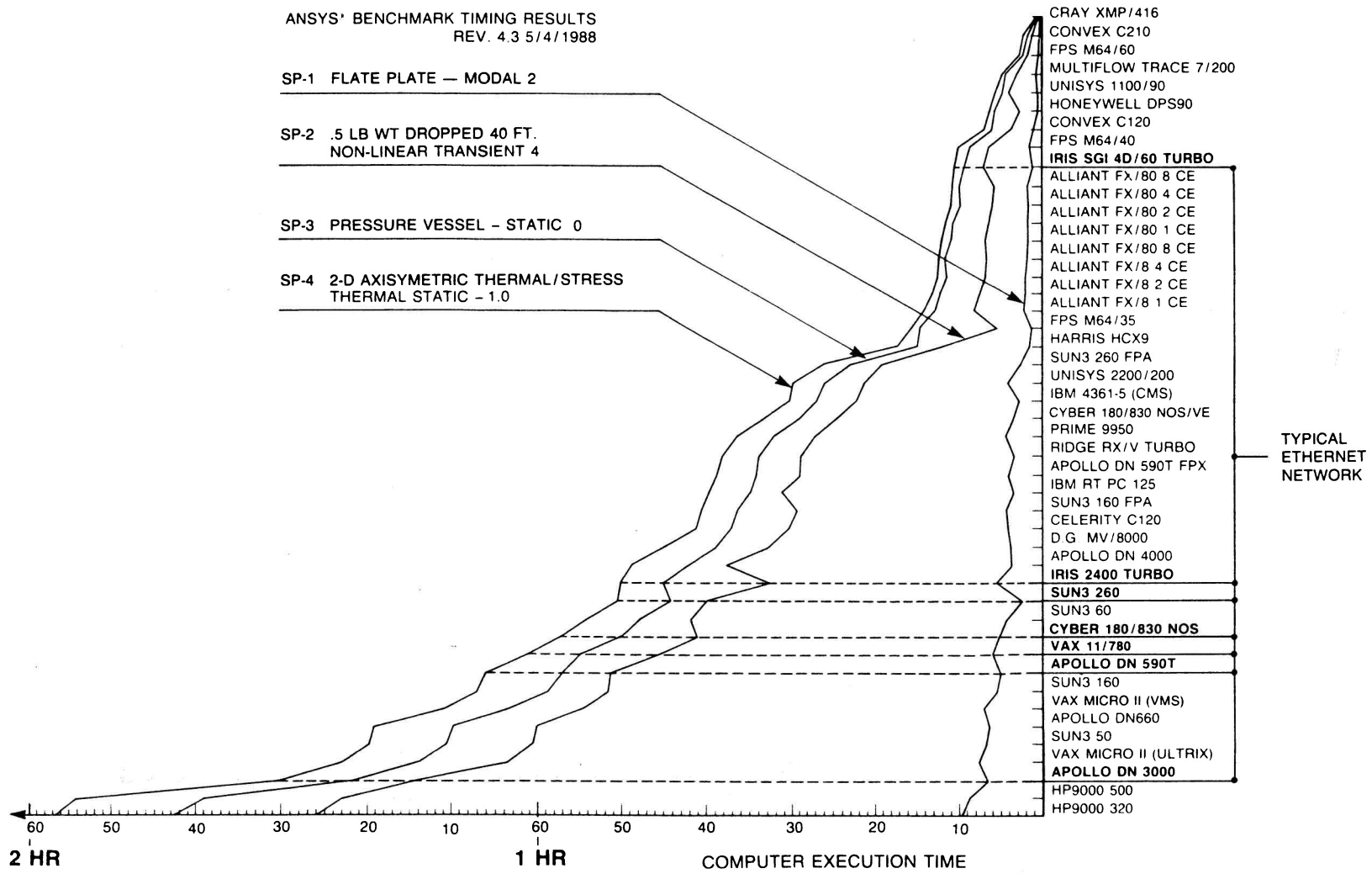
SOURCE: SILICON GRAPHICS

CIM Technology Trends

How is this change occurring?

Diamonds of Performance

Ansys® Benchmark



SOURCE: SWANSON ANALYSIS SYSTEMS INC. HOUSTON PA.

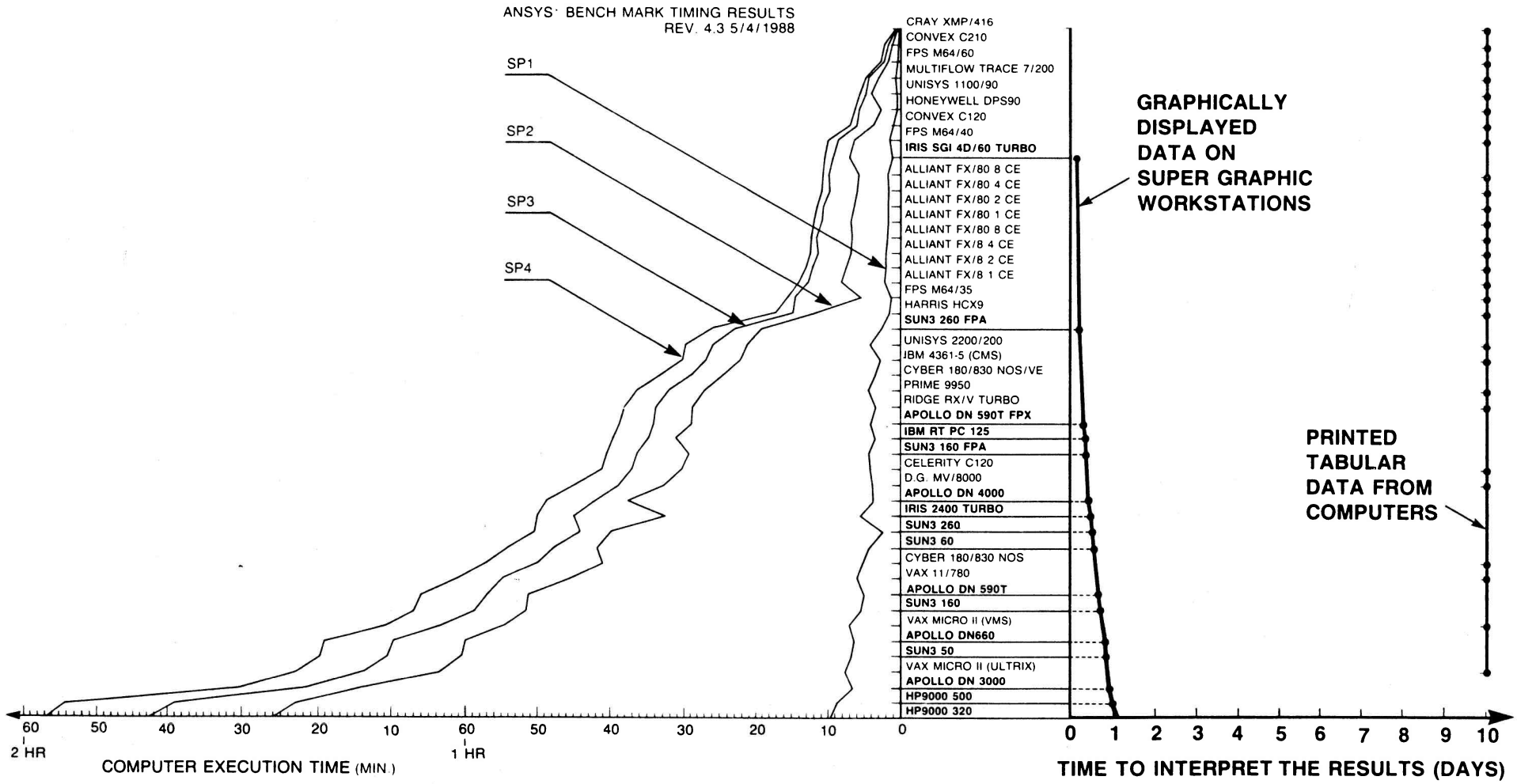
Relative compute power given four (4) standard finite element analysis problems.

CIM Technology Trends

How is this change occurring?

Diamonds of Performance

Results Interpretation



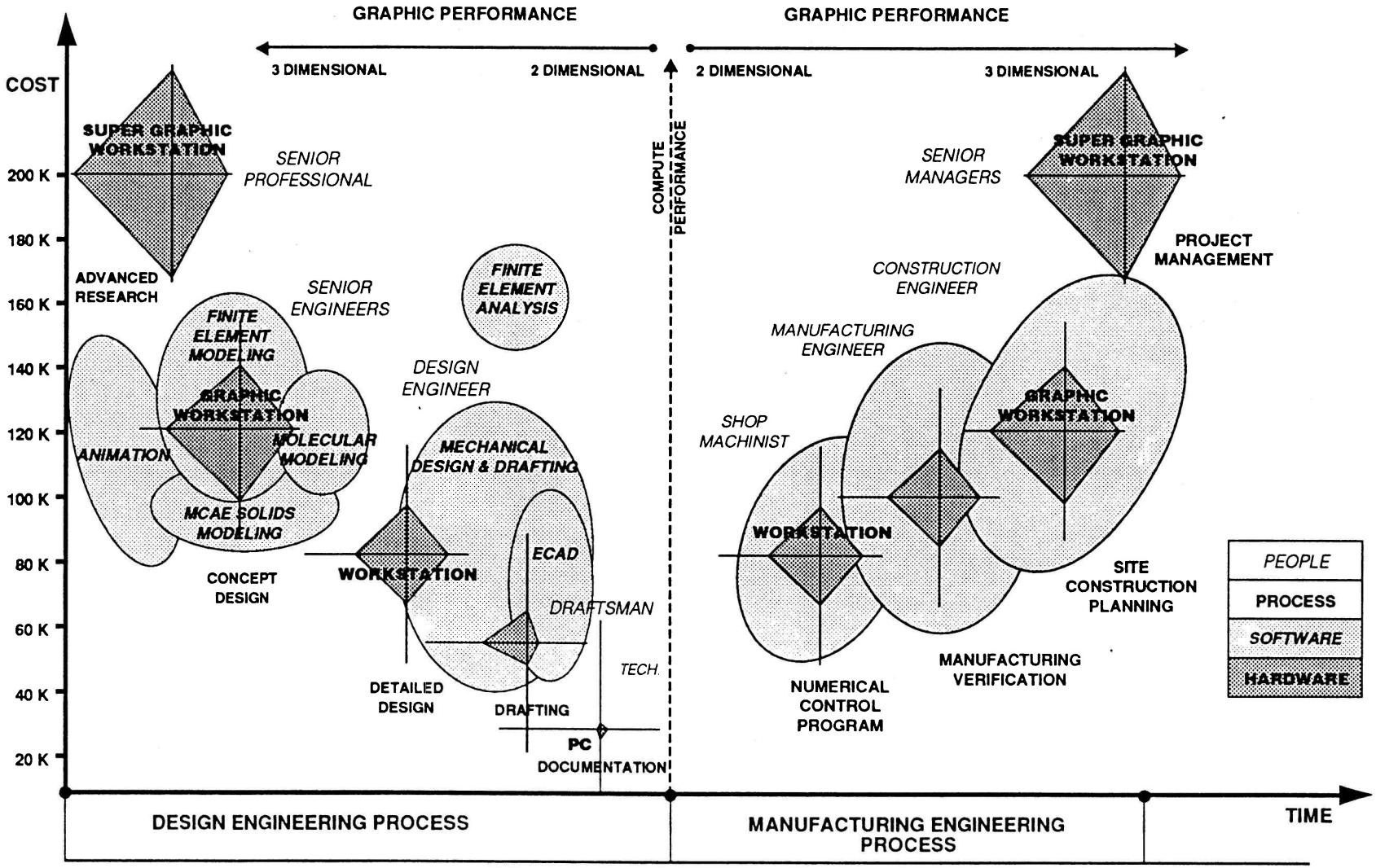
Approximately 50% of the brain's neurons are dedicated towards vision. Visual graphic workstations significantly reduce the time required to gain insight and interpret results of printed tabular data.

CIM Technology Trends

How is this change occurring?

Concurrent Communication

Traditional Environment



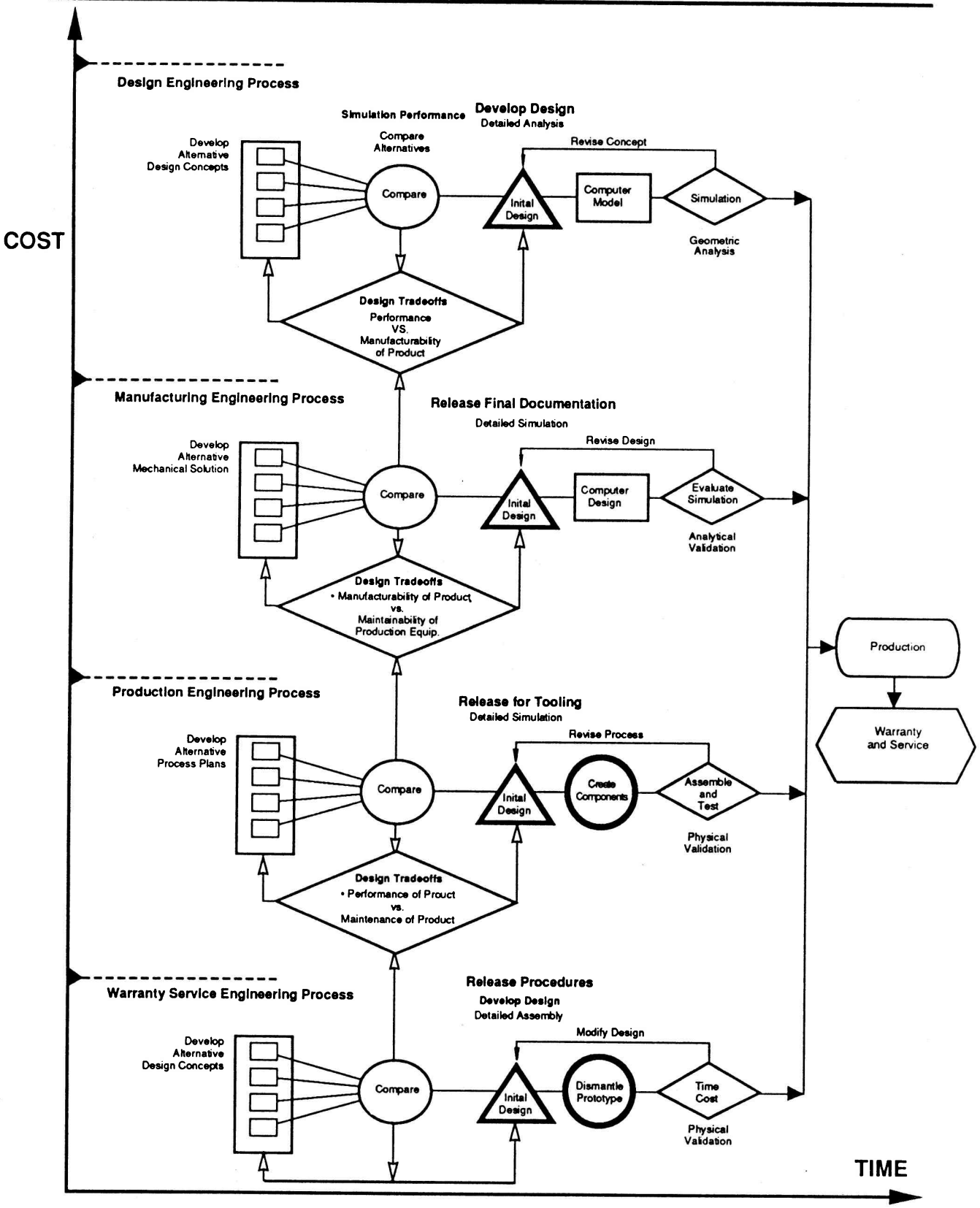
Hardware performance has met the demand of senior staff for visual communications at the speed of thought. Concurrent communications between departments is available through the computer Ethernet network.

CIM Technology Trends

How is this change occurring?

Concurrent Engineering

CAE/CAD/CAM Process



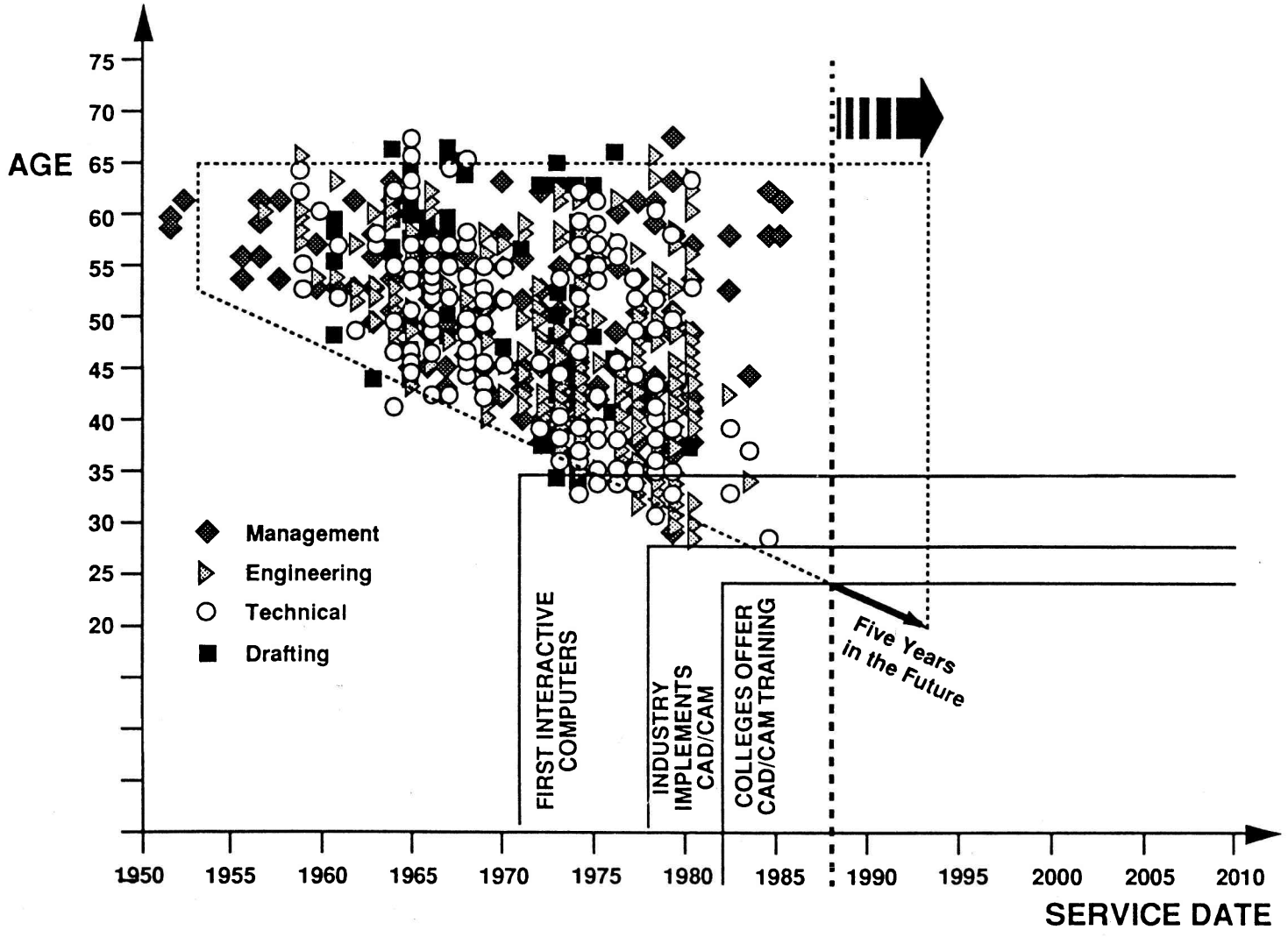
Through concurrent engineering all staff develop the initial design. Corporations must reorganize to realize the savings available through concurrent communications.

CIM Technology Trends

Who is affected?

Implementation Capacity/Rate

Staff Exposure



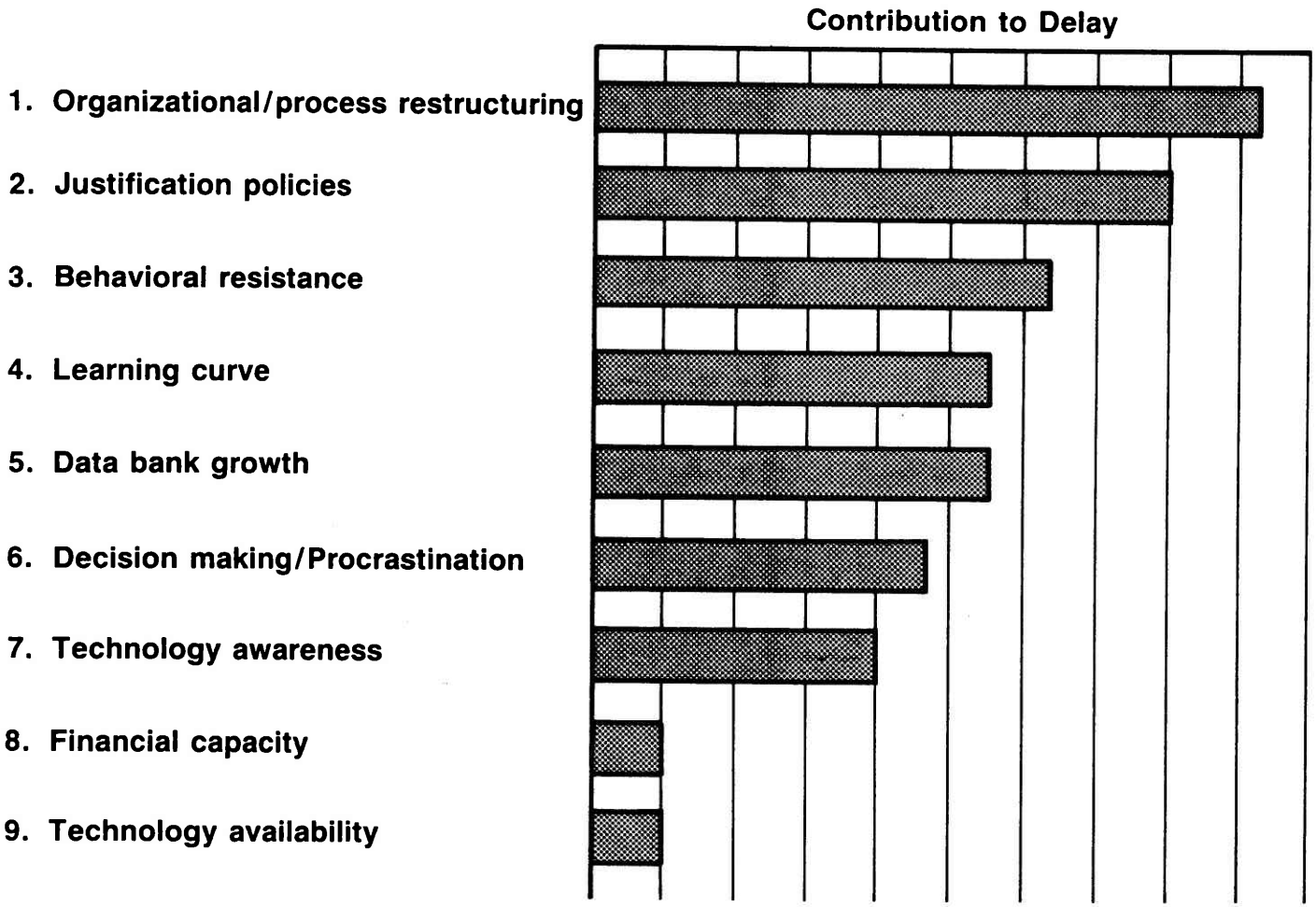
Staff exposure to CIM Technology — Less training is required as workstation become more visual

CIM Technology Trends

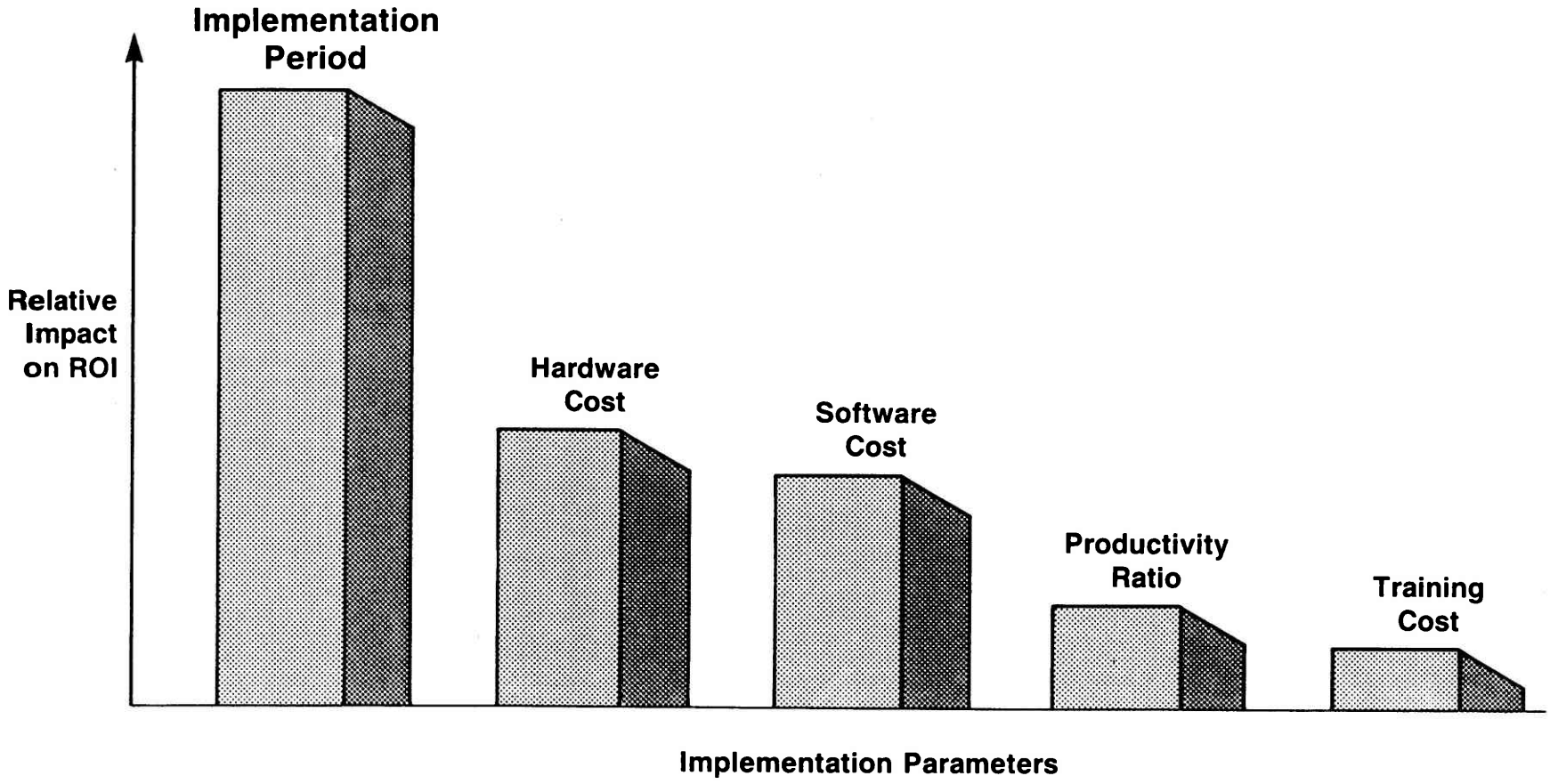
Who is affected?

Implementation Capacity/Rate

Delay Mechanisms



Senior management must actively champion the restructuring of the organization, then participate in executive CAE/CAD/CAM training.



Relative Impact on Return on Investment

The most rapid implementation occurs when organizations select one complete product — screen, dedicate and train one cross-functional project team under a new manager and remove all drafting boards.

Systems that SYNCHRONIZE the business
— one company database

DATA FEEDBACK to correct/validate the process
— fully integrated project management cost control

APPLICATION TOOLS to automate the process

CONVERGE all business units to standard system/tools

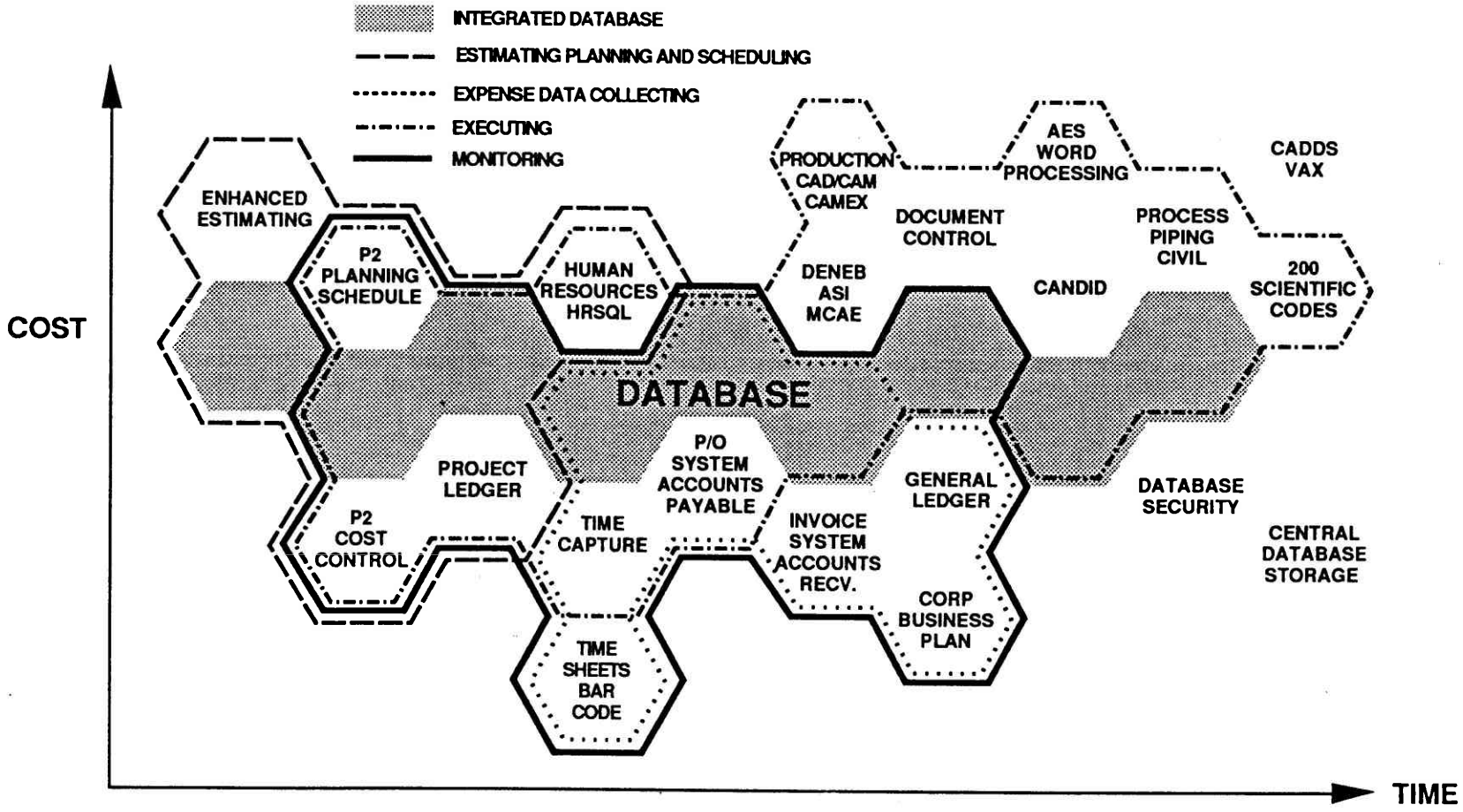
CONTINUOUS IMPROVEMENT of the systems
— software enhanced every 6-12 months
— hardware upgraded/replaced every 18-24 months

CIM Technology Trends

Who is affected?

Project Management

Integrated Monitoring



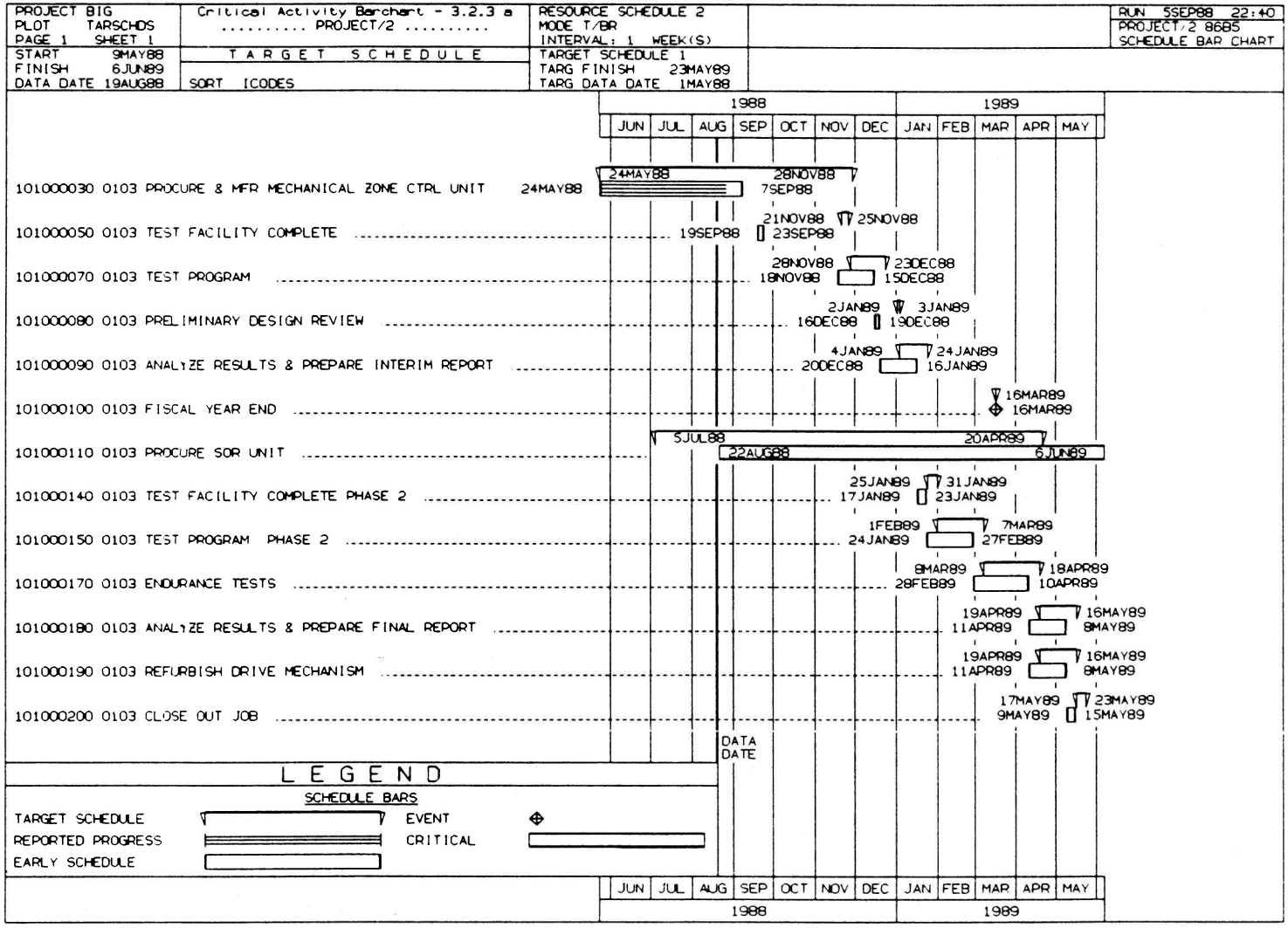
Fully Integrated Project Management Software enables managers to see the progress in the invisible database and exercise control through a disciplined execution of the work.

CIM Technology Trends

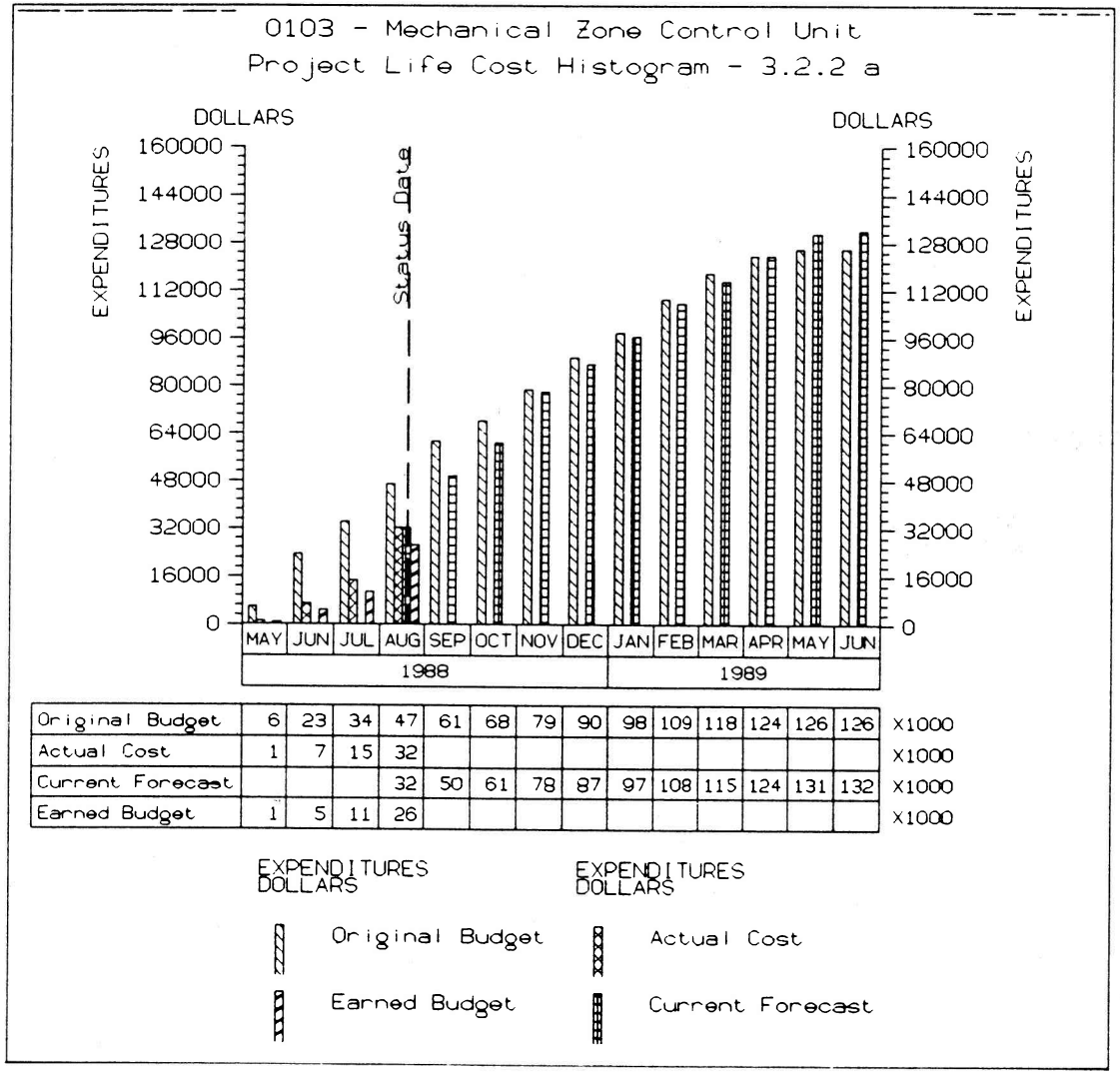
Who is affected?

Project Management

Schedule and Cost Control



The invisible made visible. Each activity is updated daily by each individual project member using bar coded job tickets and bar coded employee badges.



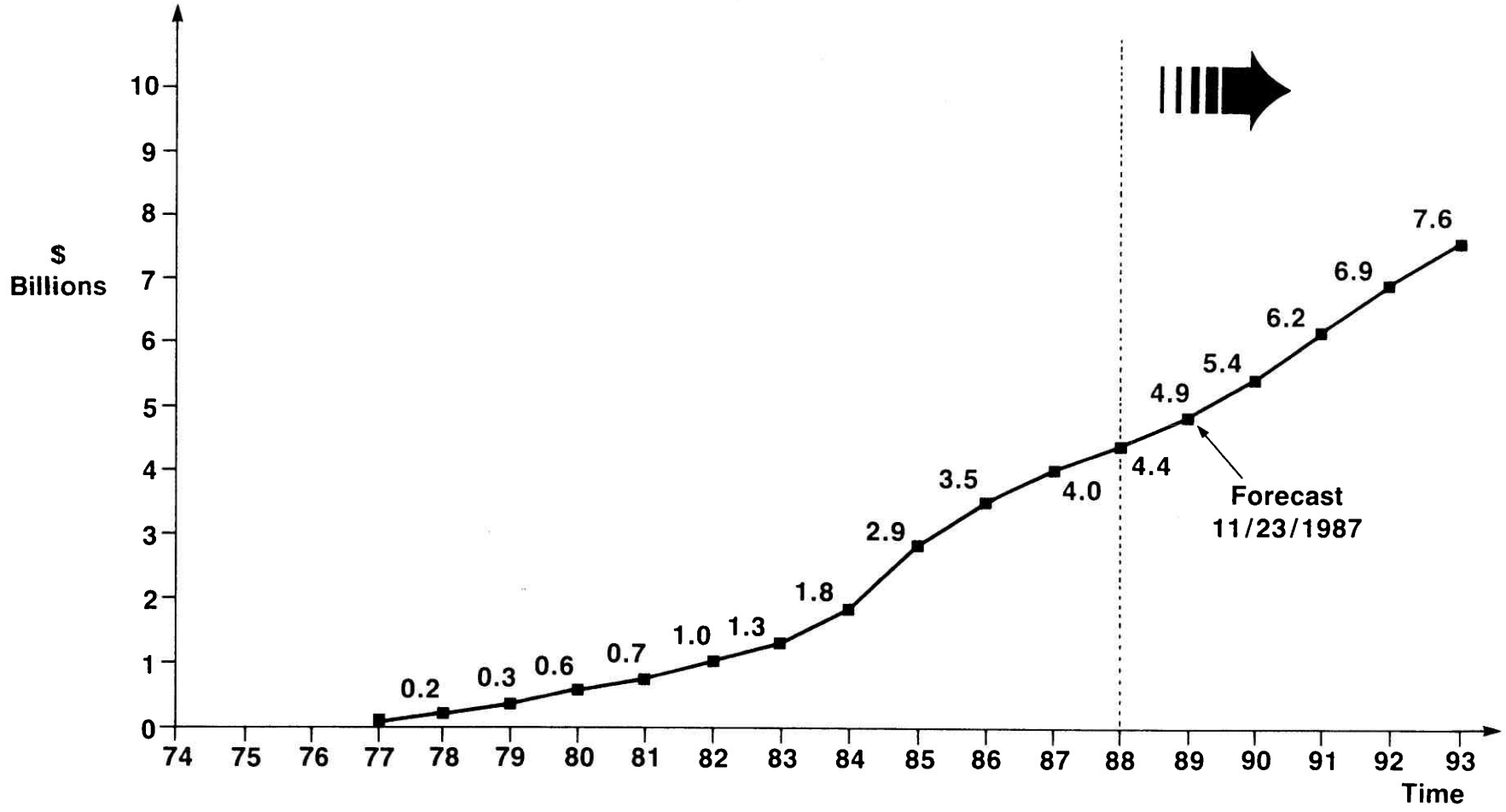
Over 83 types of reports are available on line to the project staff through their colour terminals – allowing them to manage by exception.

CIM Technology Trends

When was CIM purchased?

CAE/CAD/CAM Revenue

North American Industry History



CAE/CAD/CAM Industry Revenues

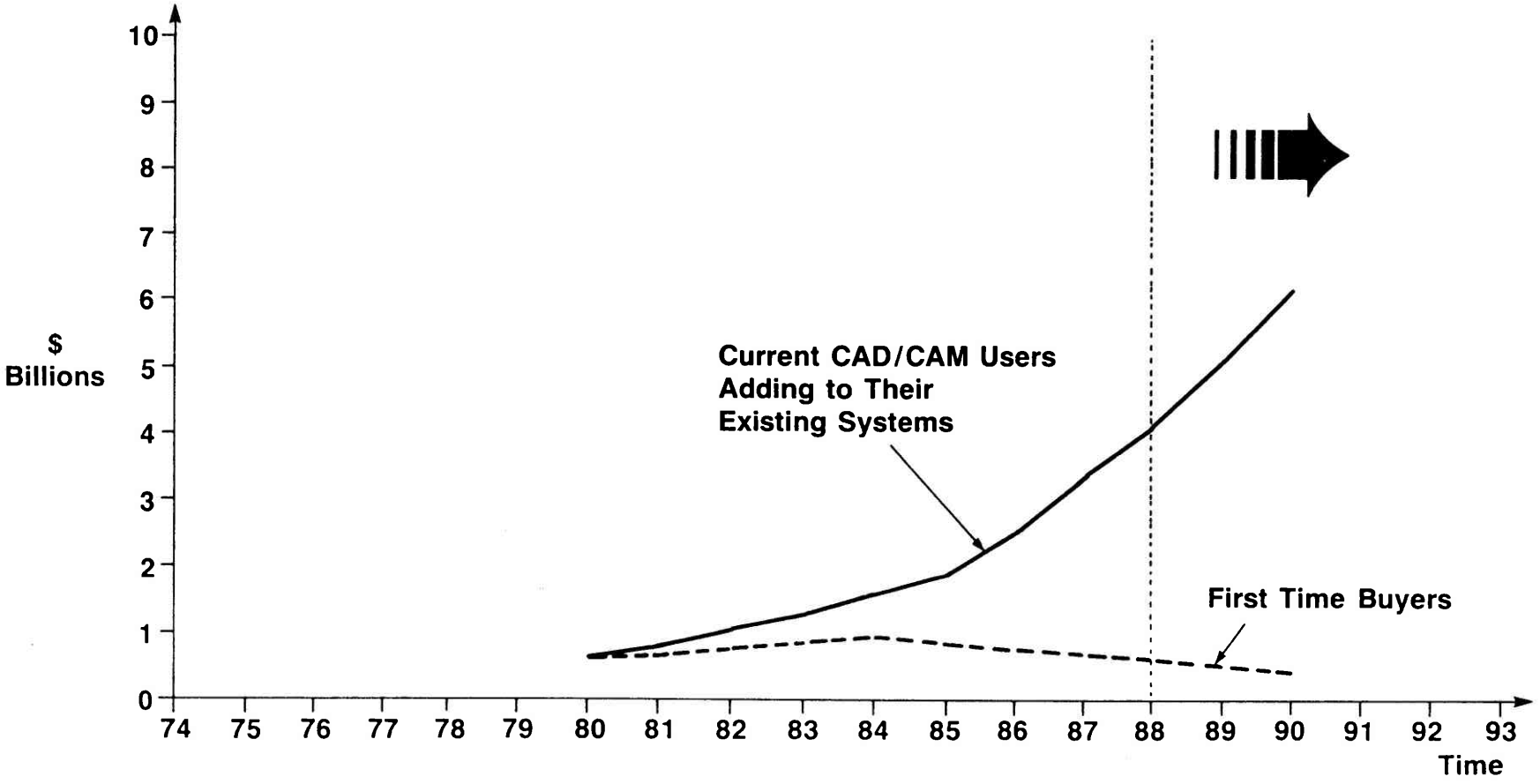
Source: Daratech Inc.; Cambridge, MA.

CIM Technology Trends

When was CIM purchased?

CAE/CAD/CAM Revenue

Current Users vs First Time Buyers



Composition of CAE/CAD/CAM System Purchases

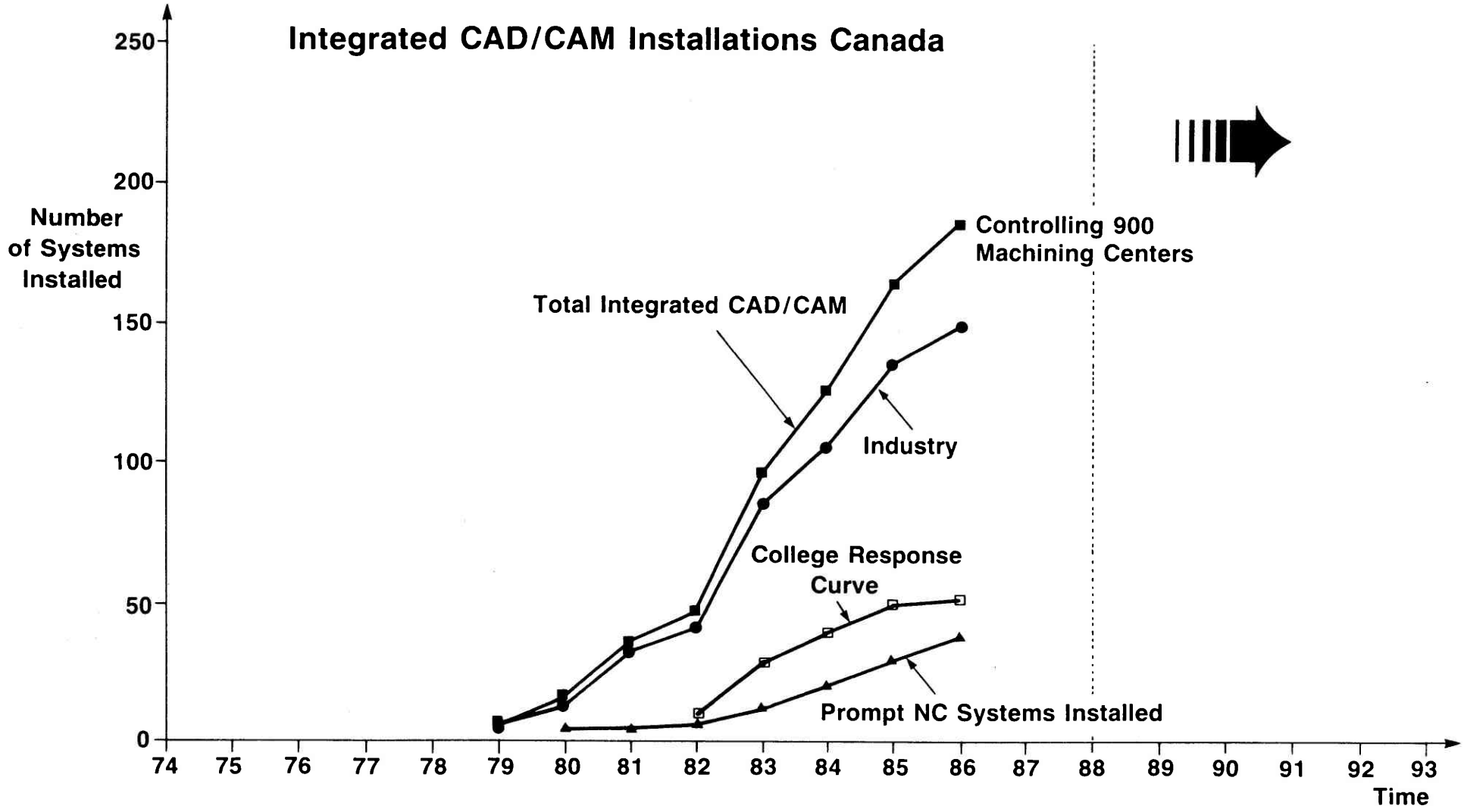
Source: SDRC; Milford, Ohio

CIM Technology Trends

Where is CIM located?

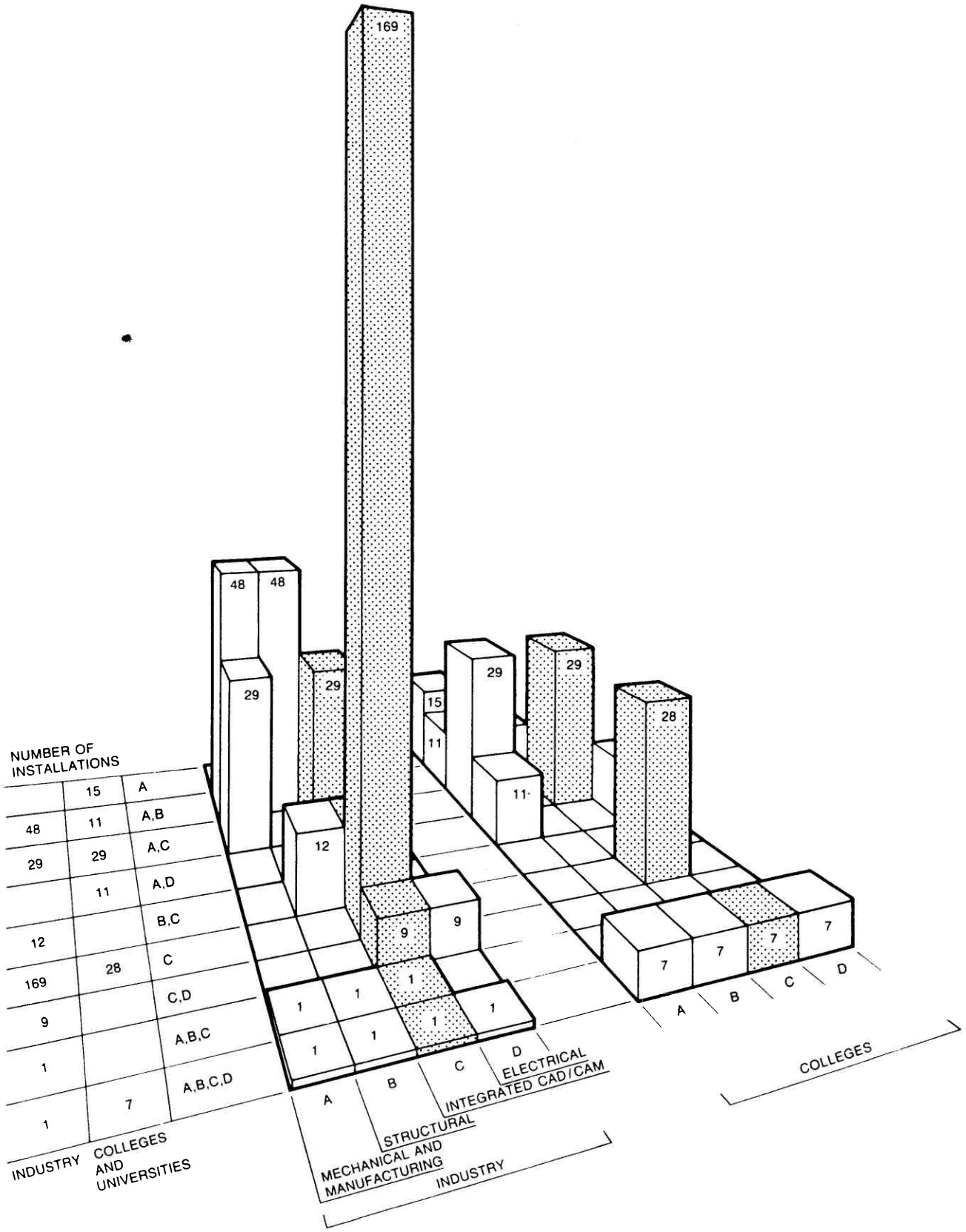
Integrated MCAE/CAD/CAM

Canadian Growth



Industry created the demand for staff trained in Mechanical Computer Aided Engineering (MCAE) and colleges responded.

Source: Canadian Machinery and Metalworking



Remote design departments can electronically transfer unambiguous part geometry to direct numerically controlled milling machine shops through International Geometry Exchange Standard files. (IGES)

SOURCE: CANADIAN MACHINERY AND METALWORKING

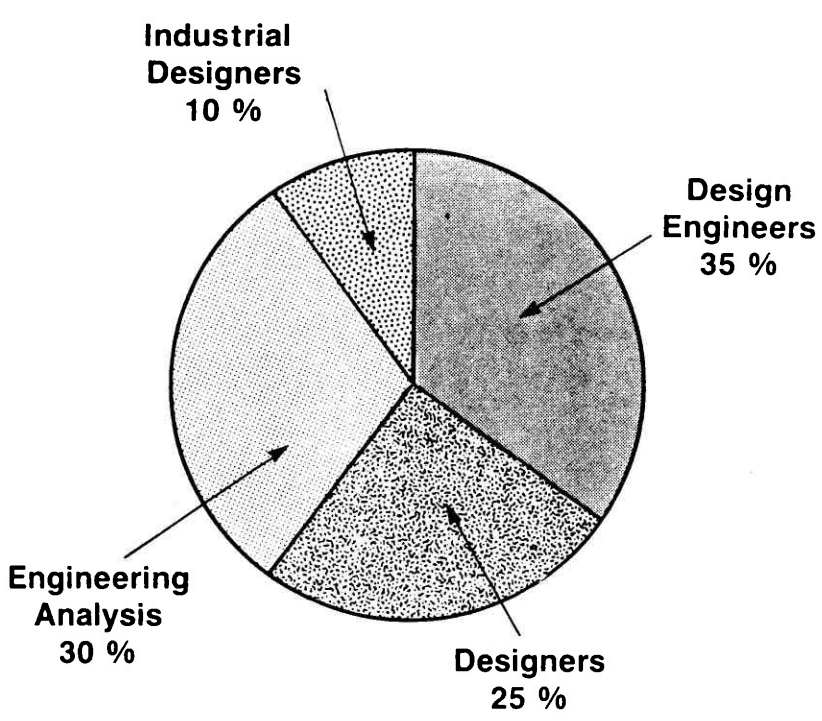
CIM Technology Trends

Where is CIM located?

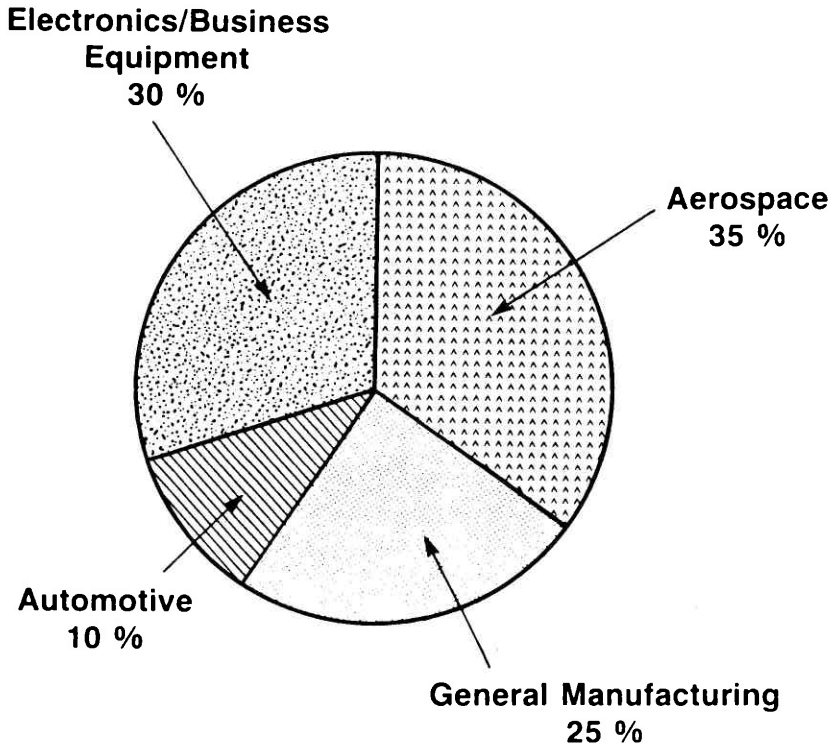
Integrated MCAE/CAD/CAM

Typical Users

Individuals



Companies/Industries



Organizations which develop – manufacture – market and service their own products have been the first to realize their Return on Investment in MCAE/CAD/CAM.

Tasks Addressed

The production MCAE System

The following list highlights the basic tasks addressed by a complete MCAE system:

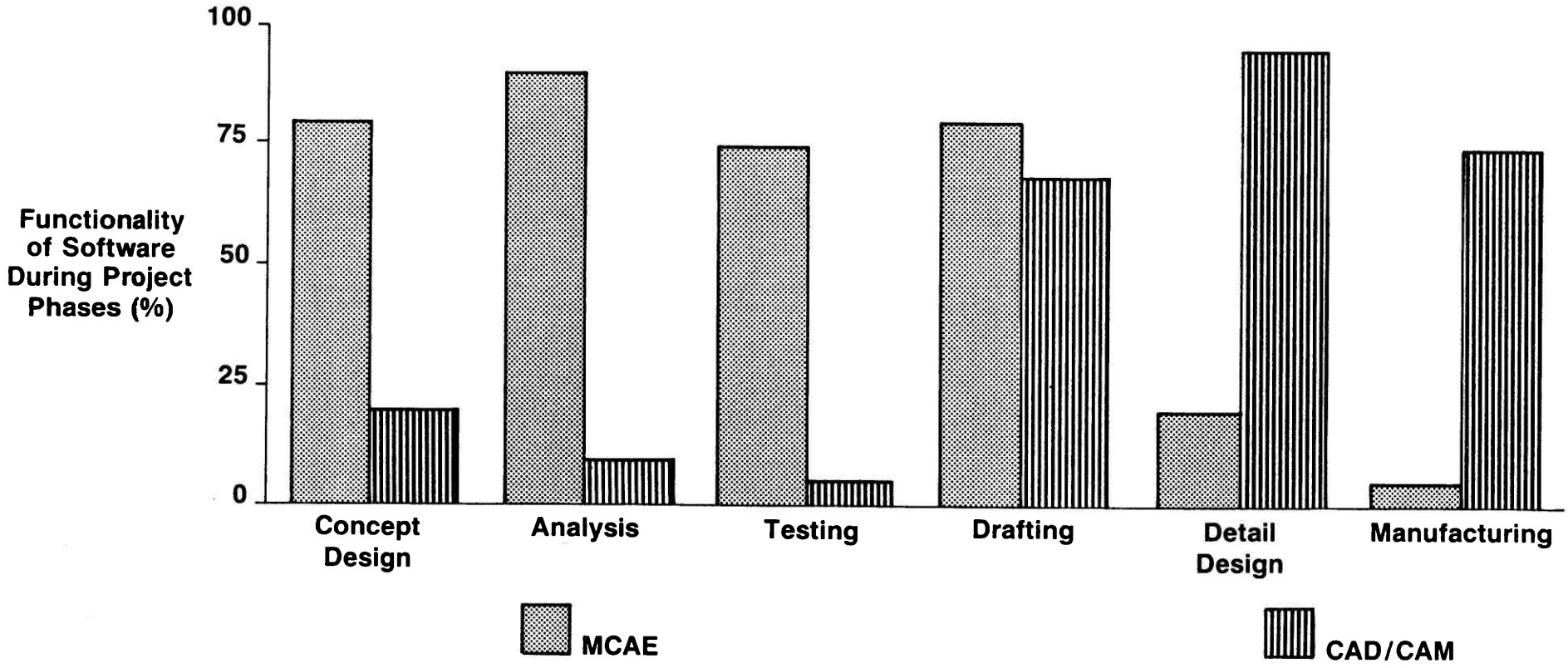
- PART DESIGN — 3-dimensional geometric modeling of parts to provide a data base for downstream analysis, drafting and manufacturing.
- ASSEMBLY LAYOUT and DESIGN — packaging of mechanical and structural components to meet volume and space constraints.
- DESIGN VISUALIZATION — functional and aesthetic characteristics can be examined visually to ensure compliance with marketing and manufacturing objectives and constraints.
- MECHANICAL ANALYSIS — dynamic and kinematic analysis of mechanisms and linkages.
- STRUCTURAL and THERMAL ANALYSIS — calculation of stress, deflection and thermal characteristics of new designs.
- MANUFACTURING and PRODUCIBILITY ANALYSIS — simulating manufacturing processes, such as plastic injection molding, to determine the effect of tooling and material decisions on part quality and cost.
- PRODUCTION DRAFTING and BILL OF MATERIALS CREATION — production engineering drawings and bills of materials are created according to ANSI and ISO standards.
- TESTING — collecting and analyzing structural response data allows for statistical data reduction, interpretation, and reporting.
- TECHNICAL REPORTS — word processing and technical publication capability should be provided for developing technical reports.
- MANUFACTURING DATA BASE — a "manufacturing ready" data base is available for tool design, process planning, quality assurance, and NC programming.
- DATA MANAGEMENT and CONTROL — Comprehensive data management facilities should be available for sharing technical data throughout the entire manufacturing enterprise, including critical capabilities for change notifications, access authorization and release control.

CIM Case Studies

Is CIM cost effective?

Impacting Product Design

MCAE vs CAD/CAM



The greatest return on investment is realized when an organization assigns its most senior staff with the most capable graphic workstations to the earliest stages of a project.

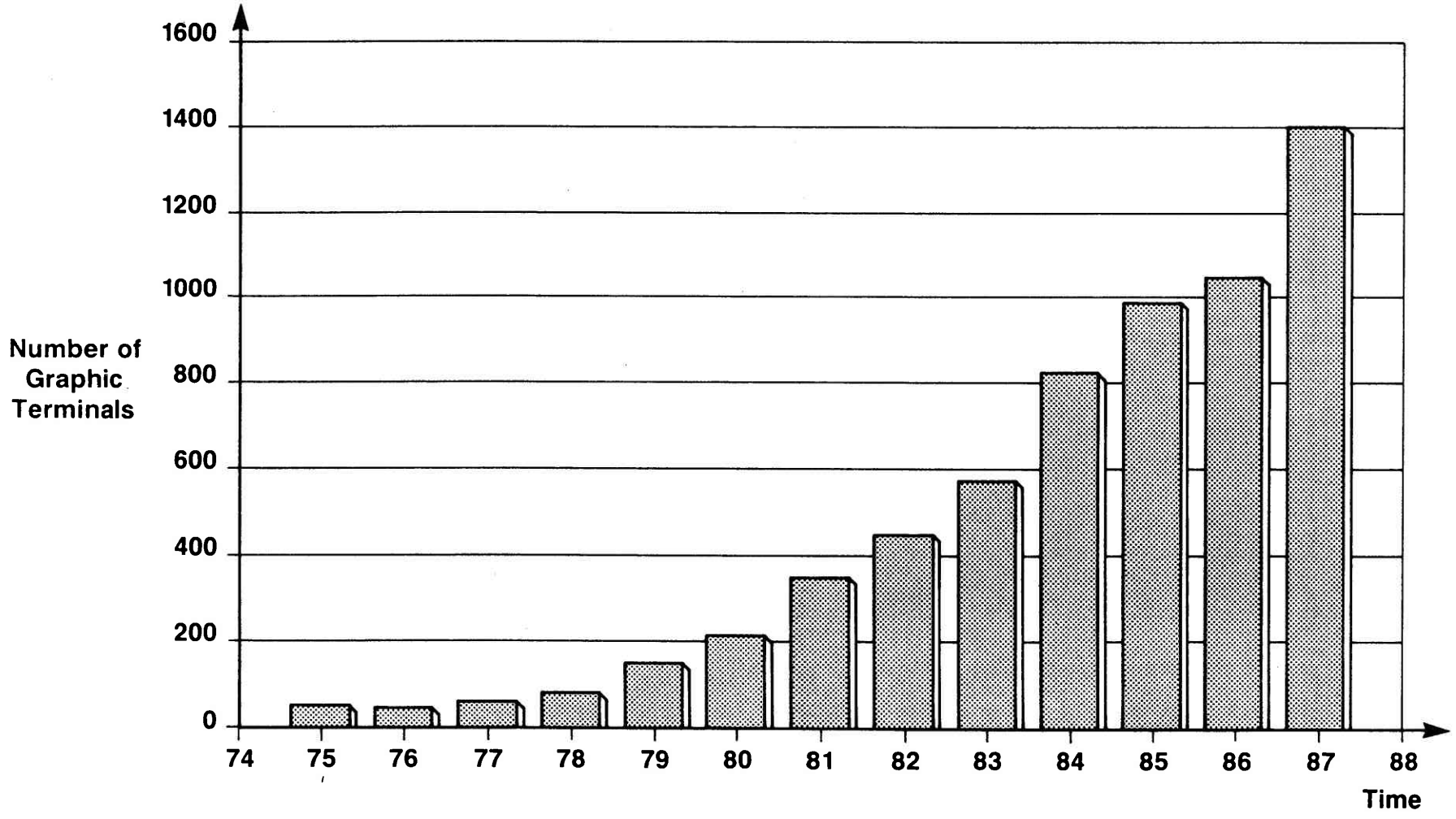
Source: Major Aerospace Firm

CIM Case Studies

Is CIM cost effective?

CAD/CAM Growth

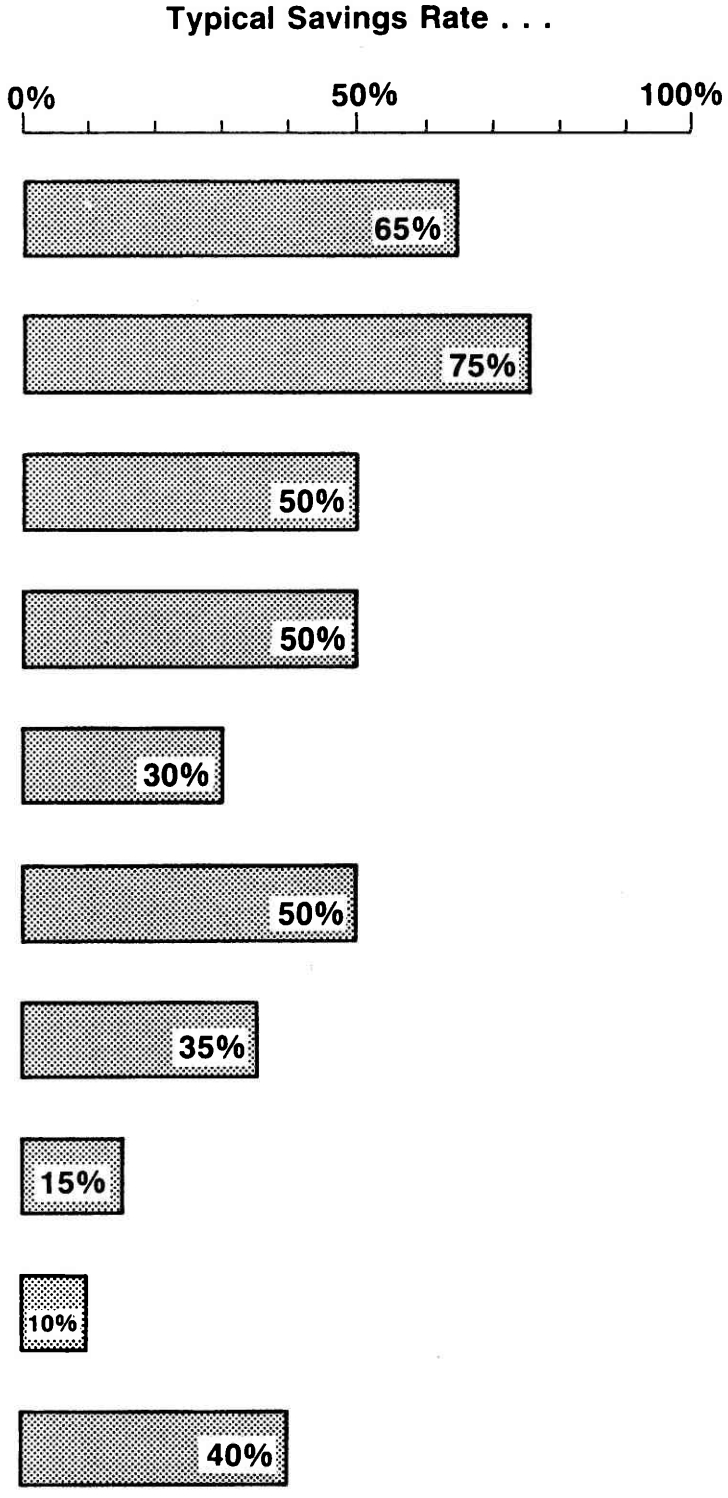
Number of Terminals



When the new accounting methods recognize and reward CAD/CAM quality improvement – rapid continuous corporate wide implementation occurs.

Source: Lockheed Corporation

The following examples pinpoint areas where other organizations have achieved short-term payback.

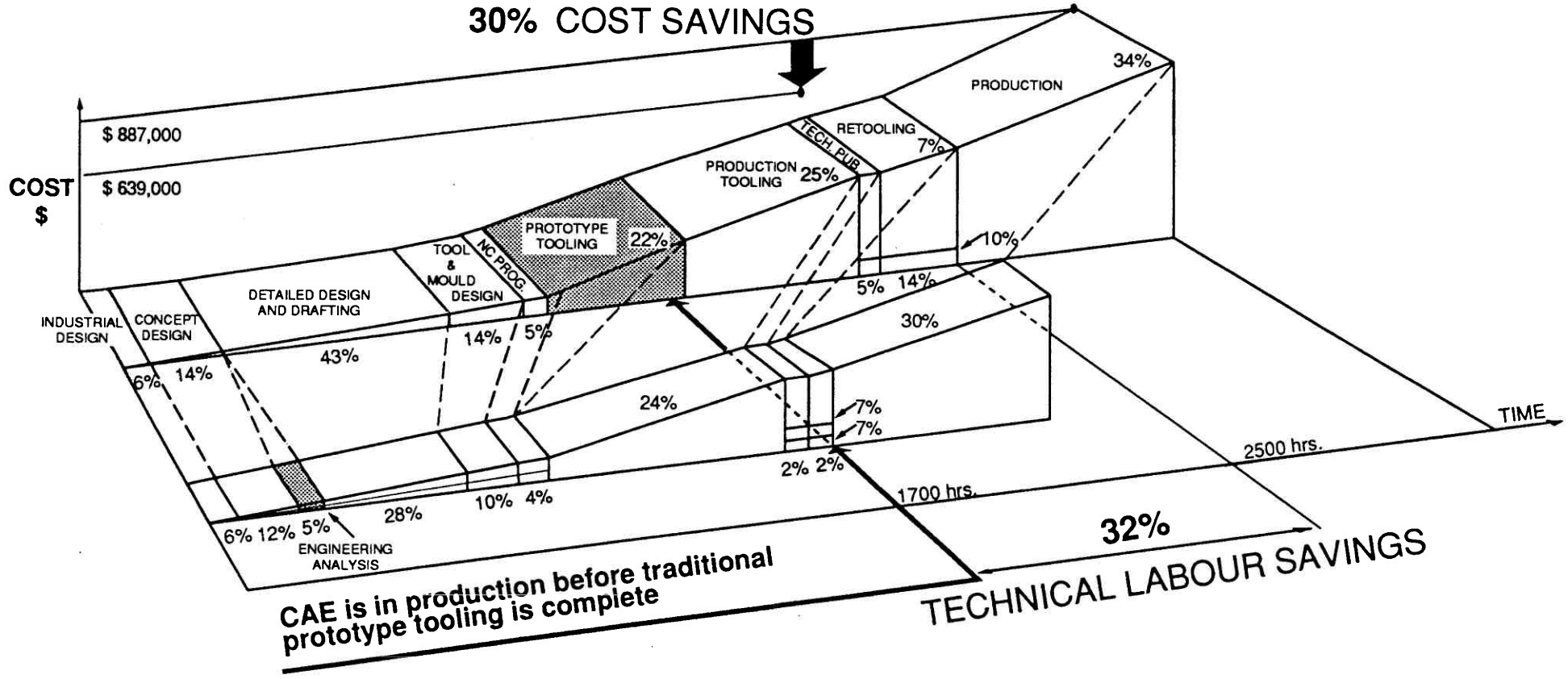


Source: SDRC; Milford, Ohio

Cost vs Time
Traditional vs MCAE/CAD/CAM

— 3 piece, 6 lbs. highly styled, portable, laptop computer
— Product life cycle — 50 000 units

Traditional Environment



MCAE/CAD/CAM Environment

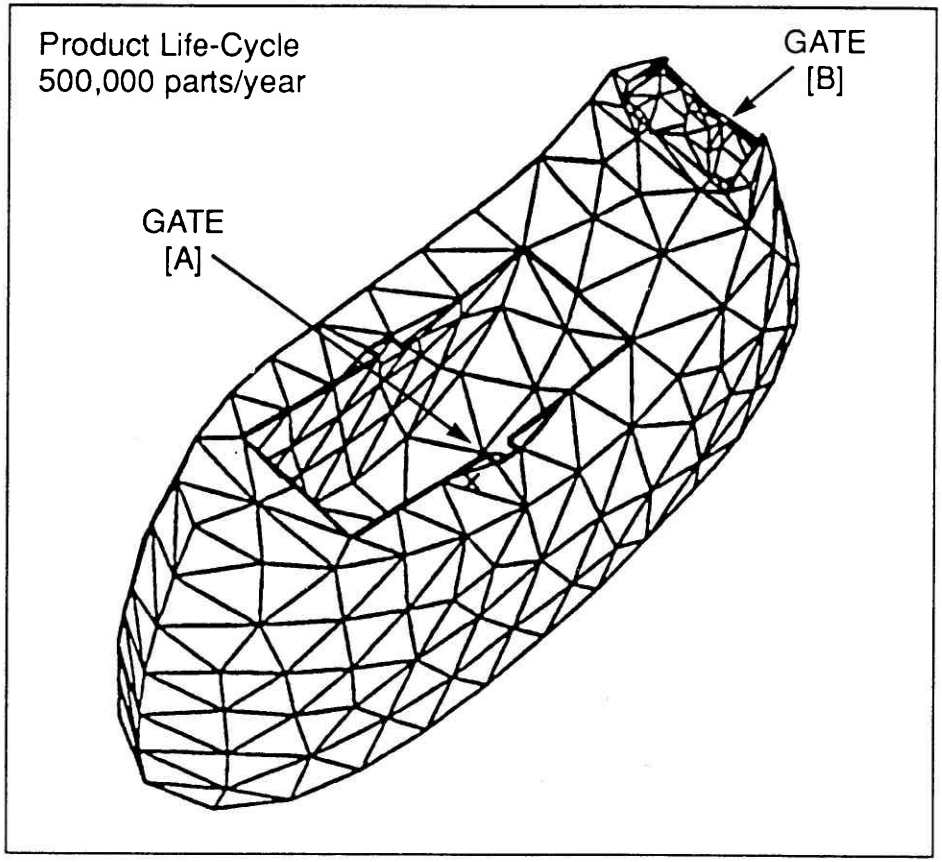
Source: SDRC Milford, Ohio

CIM Case Studies

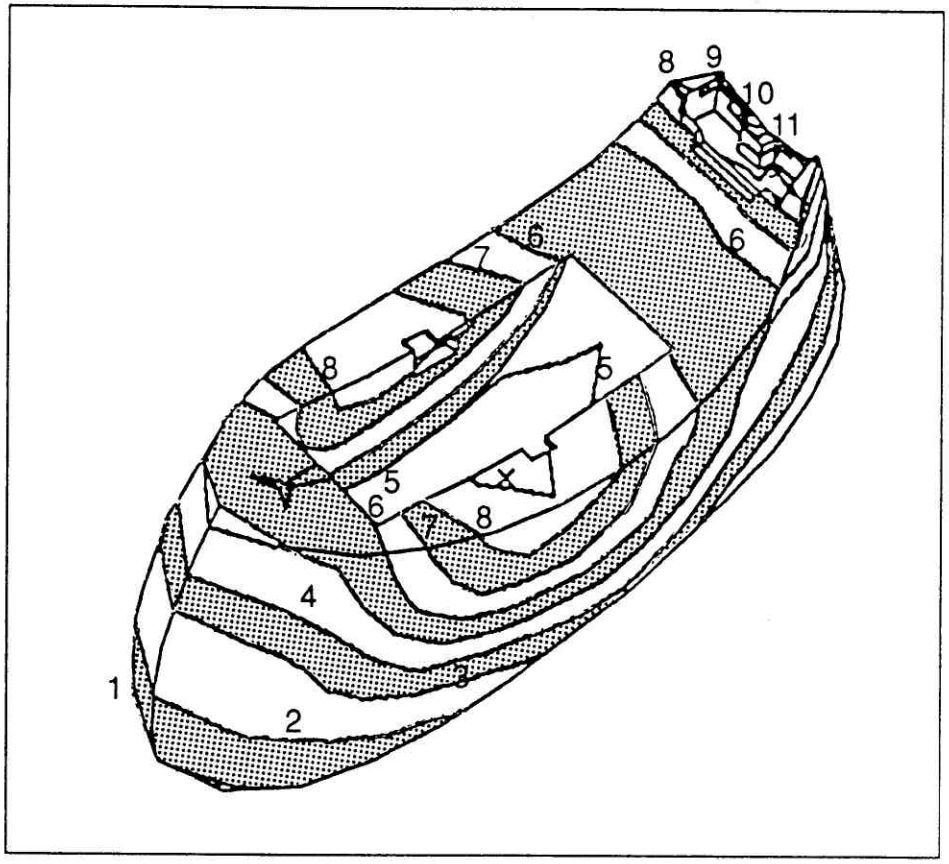
Visualization of Quality

Polyfill Analysis

Cycle Time Reduction



Thin-shell triangular mesh of a tape dispenser
Gate location [A] produced converging flow and trapped gas.
Gate location [B] produced smooth, uniform flow



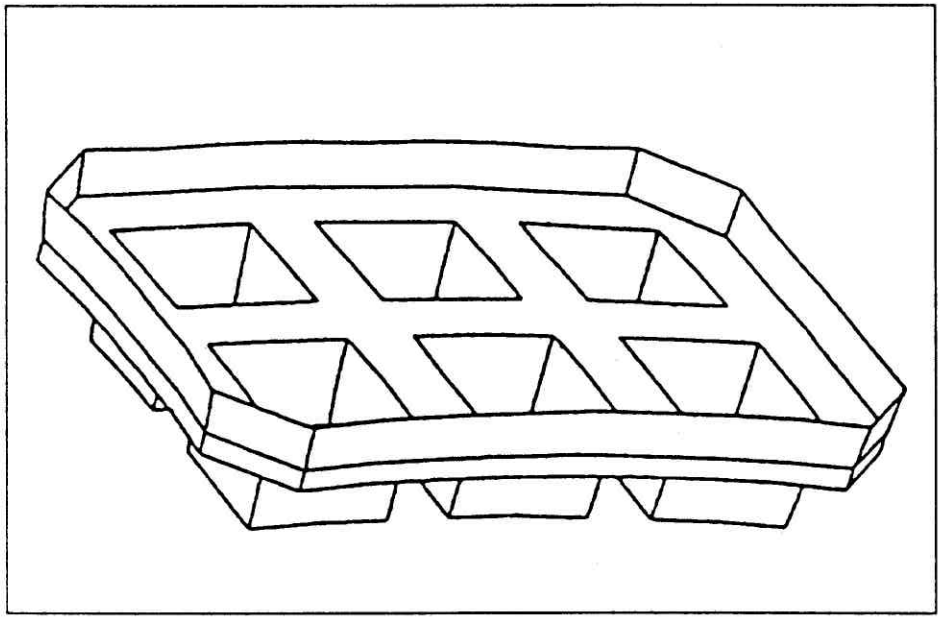
Peak plastic temperature at instance of ejection.
The contours range from (1) 60° to (11) 110°C in steps of 5°C.
Original part cycle time - 17.0 sec.
After polycool analysis - 10.5 sec.

Result 38% reduction in process time.

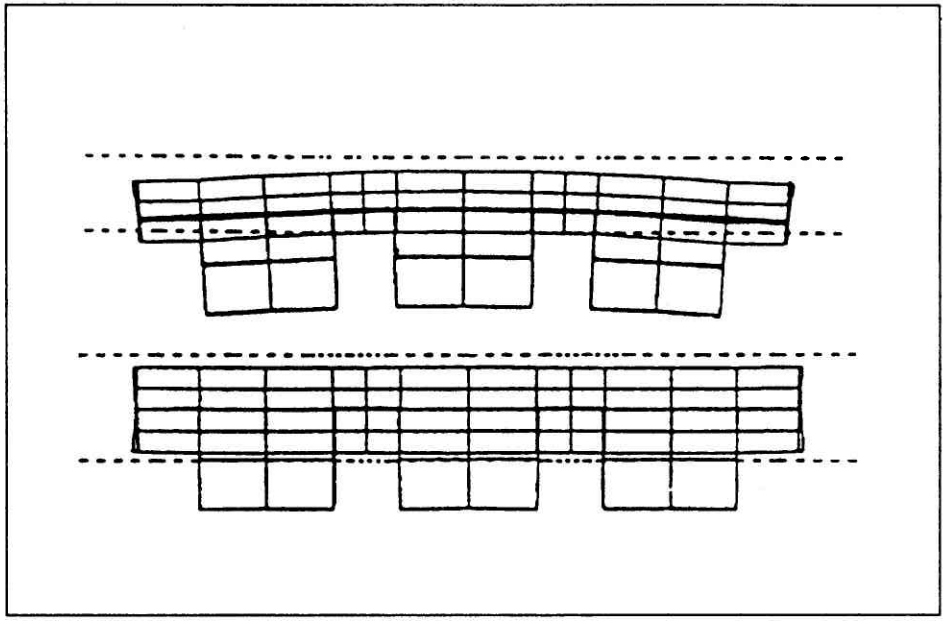
Source: SDRC Milford Ohio

Polycool Analysis

Warp Prediction



Solid model of a plastic coil tray for cast epoxy parts.



Warp prediction in injection molded tray
Surface temperature — cavity 90° C
— core 60° C

Unbalanced cooling and solidification produced unbalanced stresses which warped the part.
Solution: Reduce the coolant flow from the thermolator to the core.

Source: SDRC Milford Ohio

CIM Case Studies

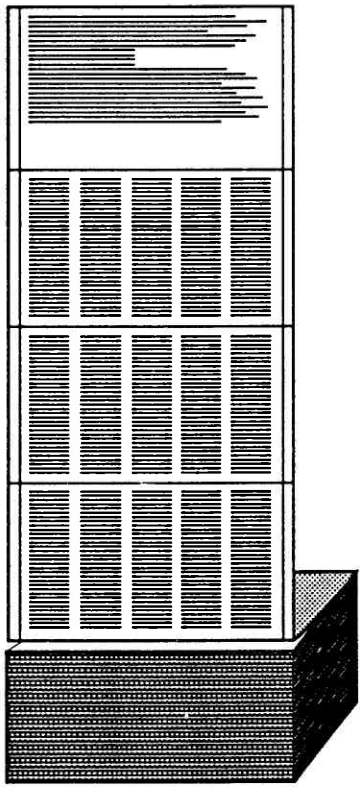
Visualization of Quality

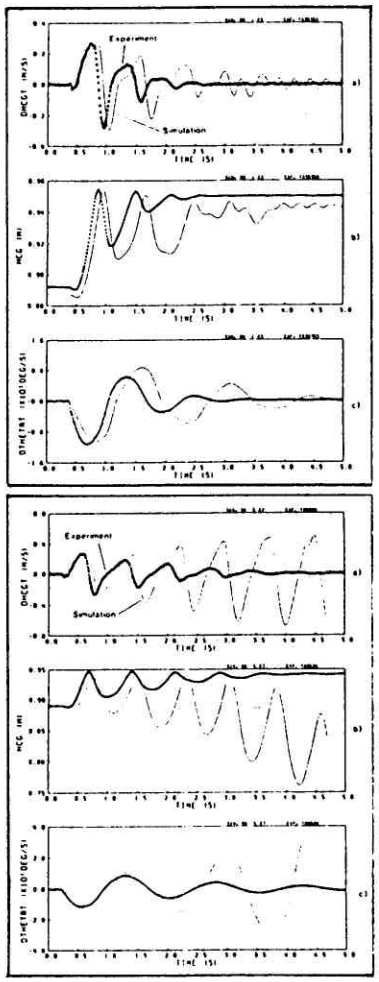
Laboratory Test Results

Experimental vs Simulation Data

Tradional Tabular Data

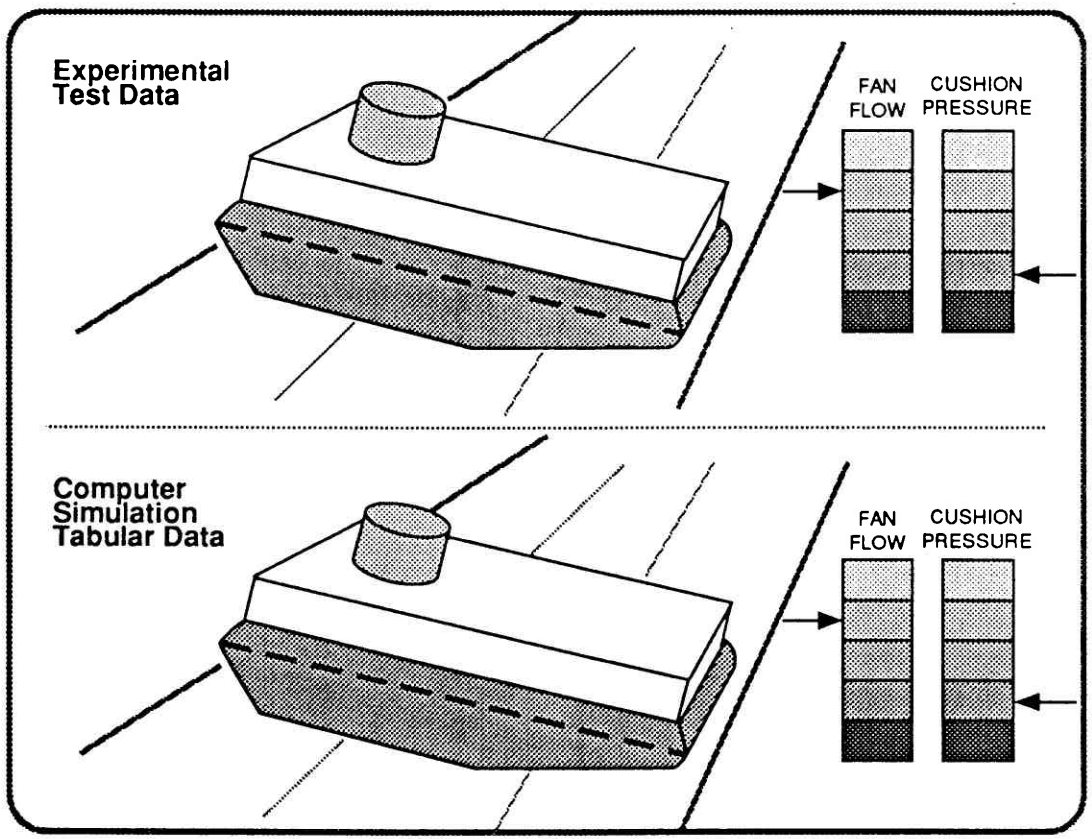
Program Tabular
Printout and 2D Plots





Source: Terence Graham,
Doctoral Thesis
UTIAS Toronto, Ontario

MCAE/CAD/CAM 3 Dimensional Super Graphic Workstation



Source: Carson Payne, William Chow
AECL, Toronto, Ontario

Graphically animated, laboratory test data and computer simulation data, displayed simultaneously on a split screen, significantly enhance the insight of the design team during the validation of computer models.