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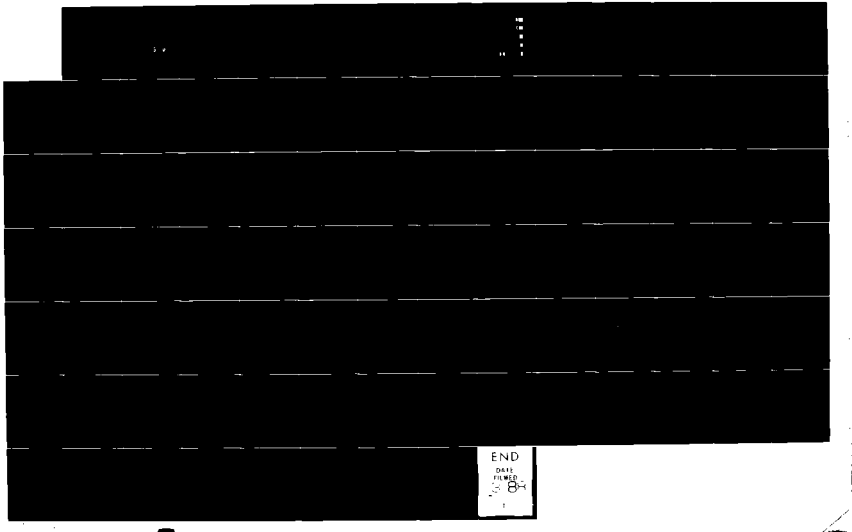

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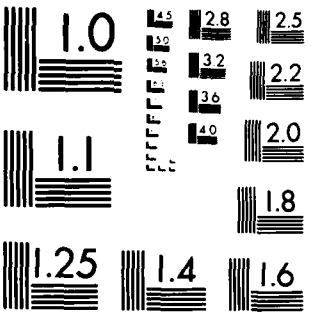

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Ada®

FROM A MANAGEMENT PERSPECTIVE FOR HIGH–LEVEL SECRETARIAT AND STAFF

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KEESLER AFB, MS.

3 DECEMBER 1986

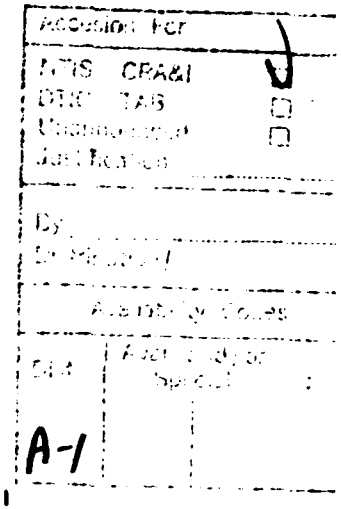
SPONSORED BY:

Ada JOINT PROGRAM OFFICE (AJPO)

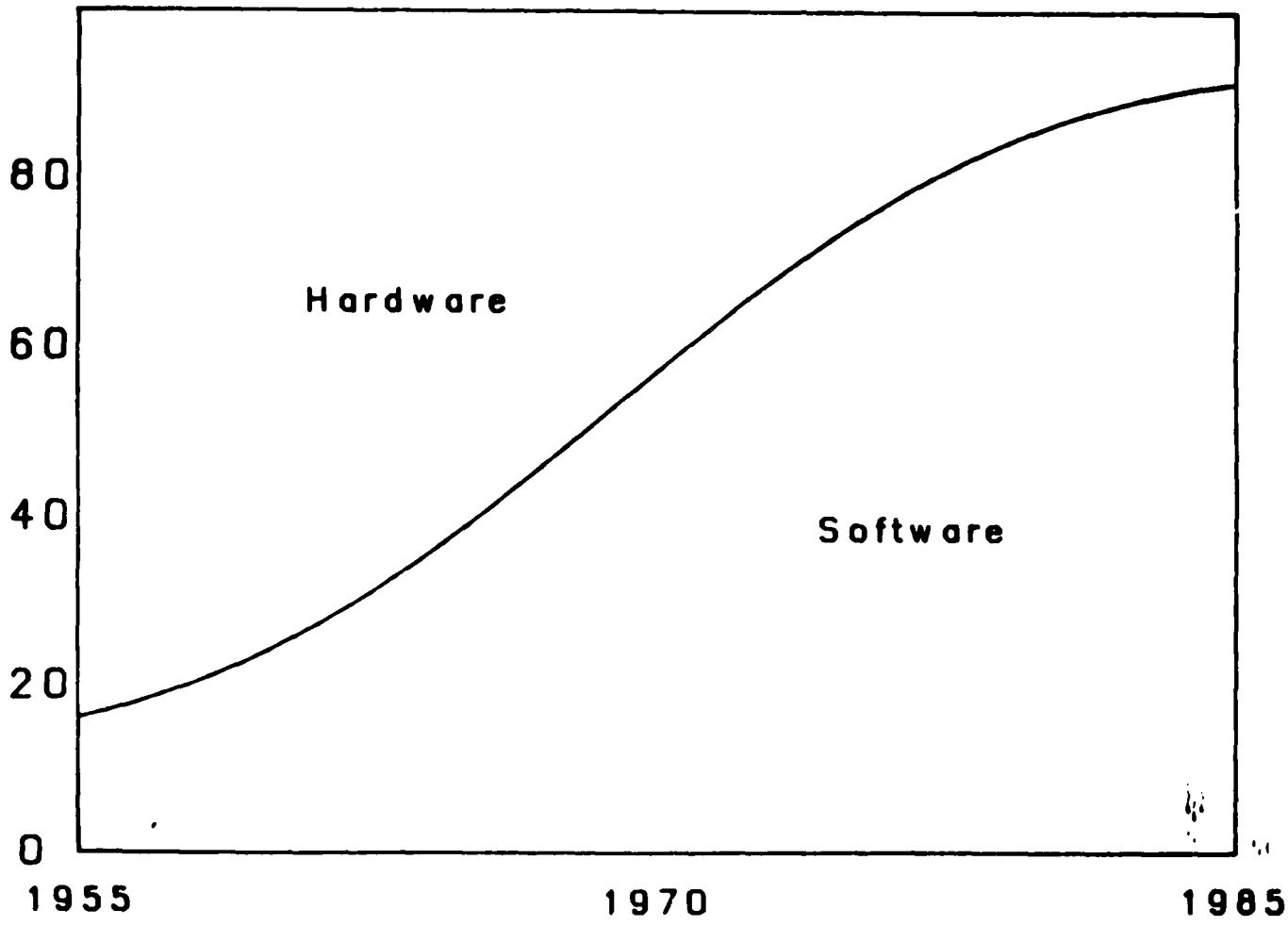
Ada SOFTWARE ENGINEERING EDUCATION AND TRAINING (ASEET) TEAM

WHAT YOU MAY HAVE HEARD ABOUT Ada

* It's a cure–all for DoD computing
* It's just another D---- acronym
* It's a programming language
* It's "just another programming language"
* Life cycle costs, support environments, STARS, Methodologies, SEI ?? !! It's everything



Software Crisis



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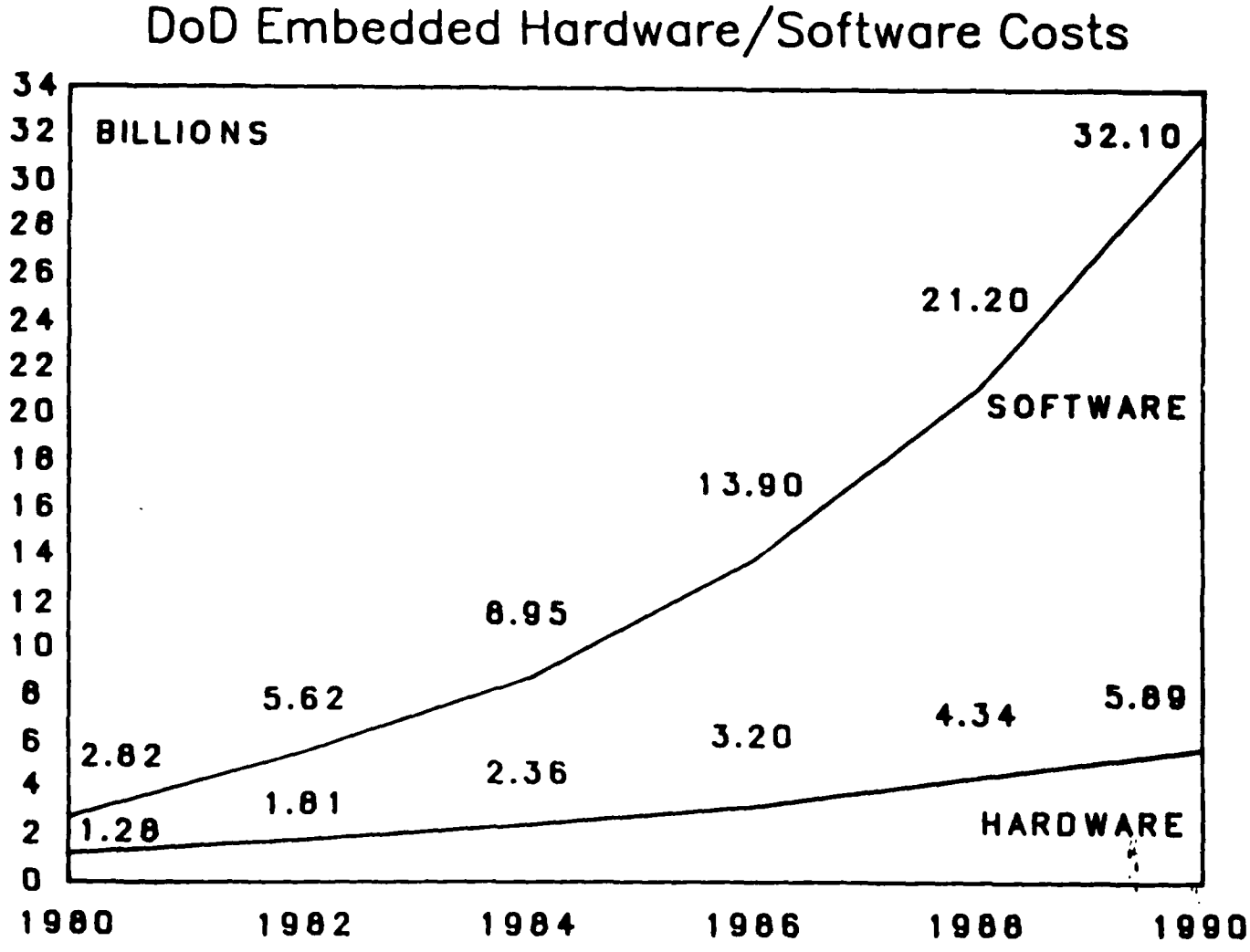

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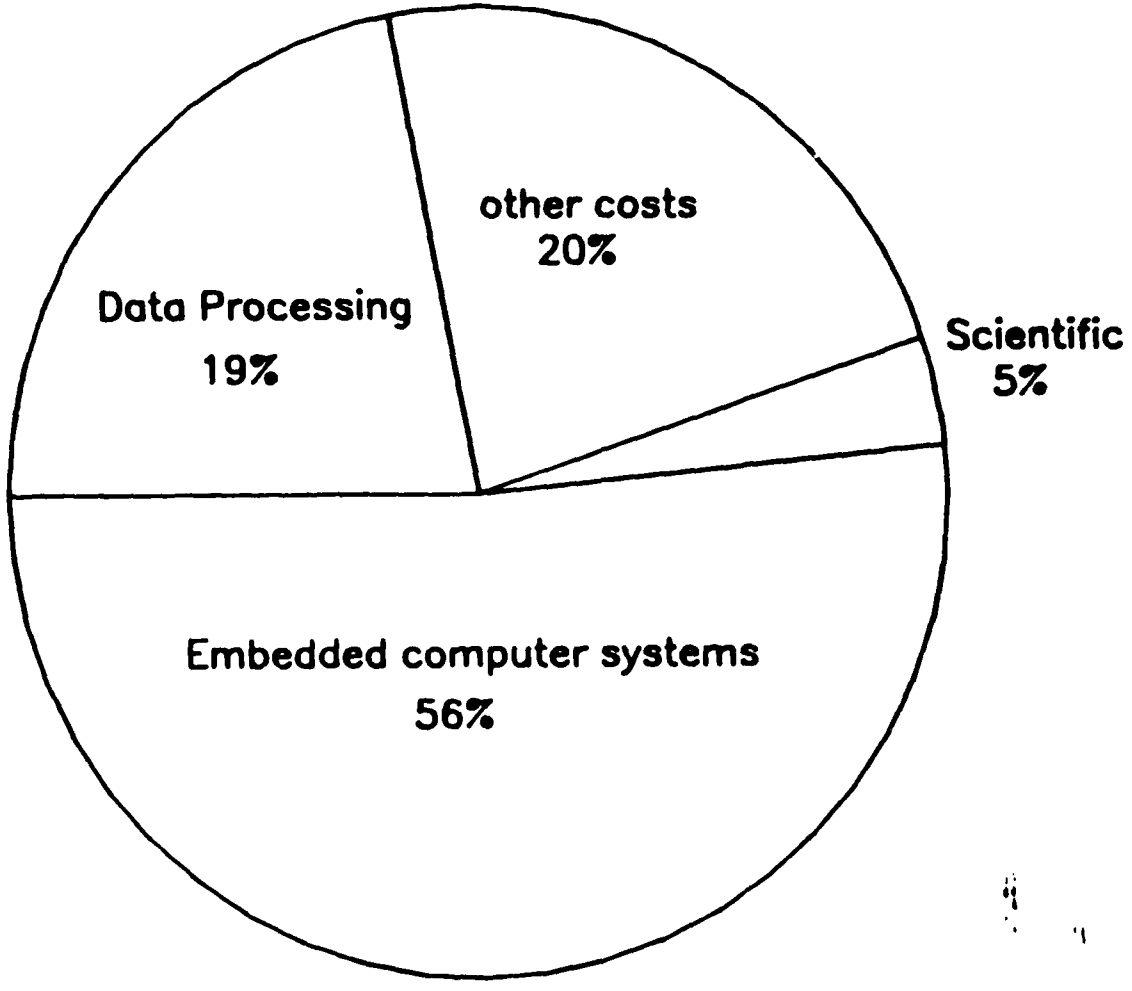

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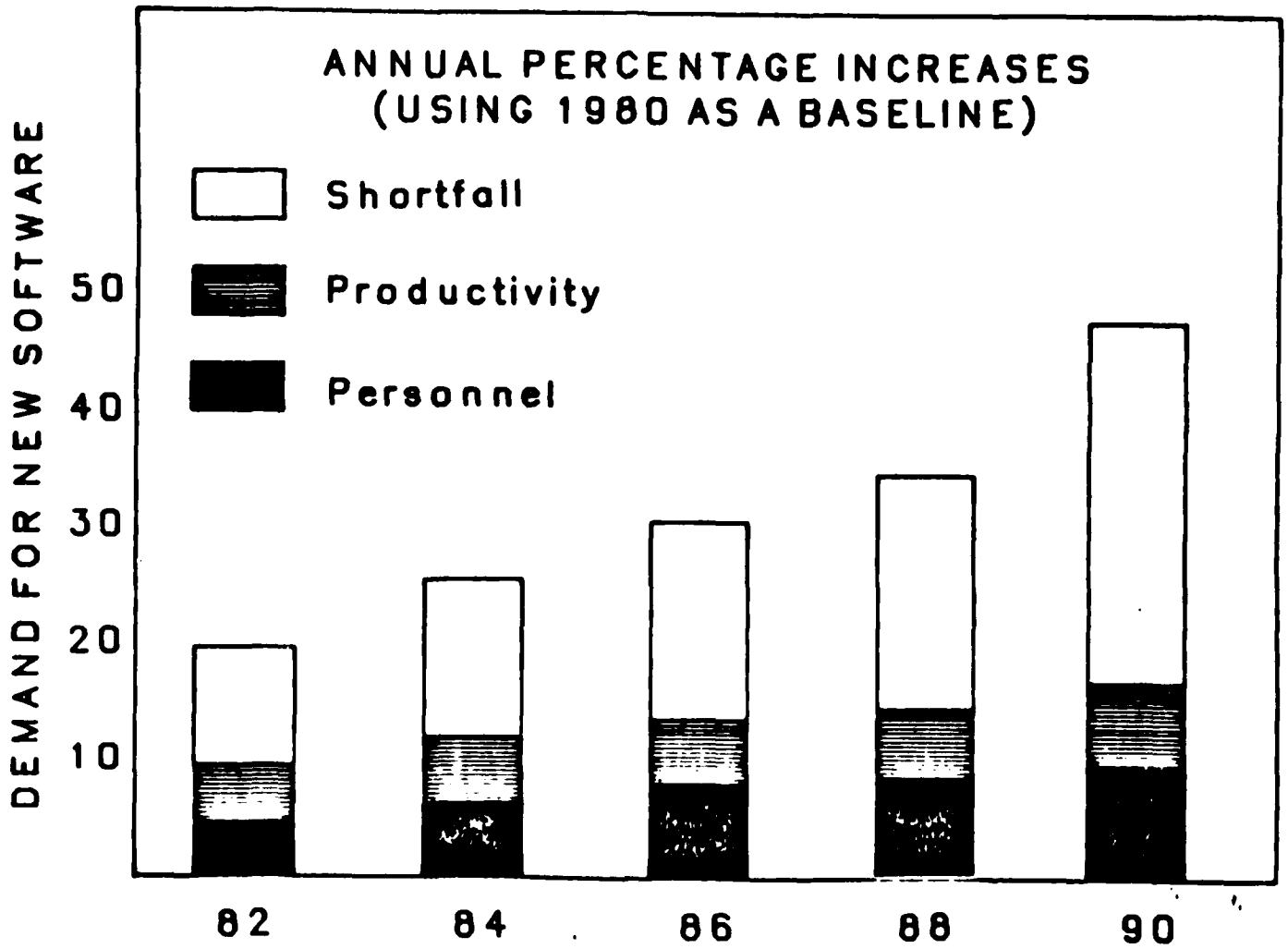


WHAT YOU NEED TO HEAR ABOUT Ada

Plain and simple ...

* Ada is a standardized computer programming language developed by the DoD for use in embedded computer systems

* Ada is the BEST tool available for meeting the software engineering requirements of the DoD

OVERVIEW

* Rationale for development
* Capabilities and advantages
* Life Cycle application

OVERVIEW

* Rationale for development
* Capabilities and advantages
* Life Cycle application

THE CRITICALITY OF SOFTWARE

* Hardware is no longer the dominant factor in the hardware/software relationship
  - Cost
  - Technology
* The demand for software is rising exponentially
* The cost of software is rising exponentially
* Software maintenance is the dominant software activity
* Systems are getting more complex
* Life and property are dependent on software

CHARACTERISTICS OF DoD SOFTWARE

* Expensive
* Incorrect
* Unreliable
* Difficult to predict
* Unmaintainable
* Not reusable

FACTORS AFFECTING DoD SOFTWARE

* Ignorance of life cycle implications
* Lack of standards
* Lack of methodologies
* Inadequate support tools
* Management
* Software professionals

CHARACTERISTICS OF DoD SOFTWARE REQUIREMENTS

* Large
* Complex
* Long lived
* High reliability
* Time constraints
* Size constraints

TRADITIONAL APPROACH TO SOFTWARE

* A necessary evil

* A black art

* Guru's and magicians in a dark room

(with due respect to sofware professionals)

THE FUNDAMENTAL PROBLEM

* Our inability to manage the COMPLEXITY of our software systems

* Lack of a disciplined, engineering approach

SOFTWARE ENGINEERING

THE ESTABLISHMENT AND APPLICATION OF SOUND ENGINEERING ==>

* Environments

* Tools

* Methodologies

* Models

* Principles

* Concepts

SOFTWARE ENGINEERING

COMBINED WITH =>

* Standards

* Guidelines

* Practices

SOFTWARE ENGINEERING

TO SUPPORT COMPUTING WHICH IS =>

* Understandable
* Efficient
* Reliable and safe
* Modifiable
* Correct

THROUGHOUT THE LIFE CYCLE OF A SYSTEM

(C. McKAY, 1985)

PROGRAMMING LANGUAGES AND SOFTWARE ENGINEERING

* A programming language is a software engineering tool

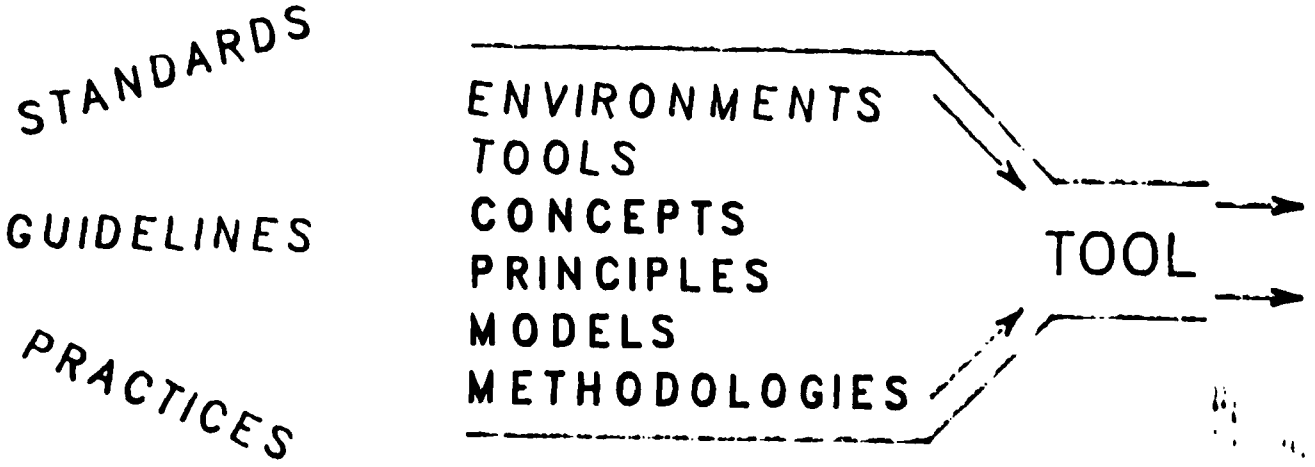
* A programming language EXPRESSES and EXECUTES design methodologies

* The quality of a programming language for software engineering is determined by how well it supports a design methodology and its underlying models, principles, and concepts.

TRADITIONAL PROGRAMMING LANGUAGES AND SOFTWARE ENGINEERING

Programming Languages

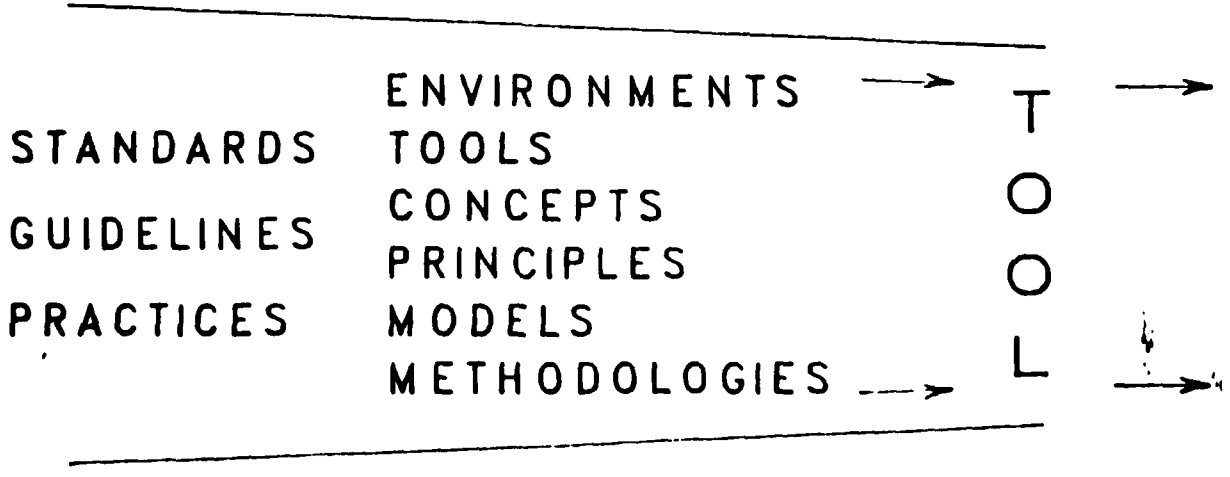
* Were not engineered
* Have lacked the ability to express good software engineering
* Have acted to constrain software engineering



Ada
AND
SOFTWARE ENGINEERING

Ada

* Was itself "engineered" to support software engineering
* Embodies the same concepts, principles, and models to support methodologies
* Is the best tool (programming language) for software engineering currently available



PRINCIPLES OF SOFTWARE ENGINEERING

* Abstraction
* Modularity
* Localization
* Information hiding
* Completeness
* Confirmability
* Uniformity

ABSTRACTION

* The process of separating out the important parts of something while ignoring the inessential details

* Separates the "what" from the "how"

* Reduces the level of complexity

* There are levels of abstraction within a system

MODULARITY

* Purposeful structuring of a system into parts which work together

* Each part performs some smaller task of the overall system

* Can concentrate and develop parts independently as long as interfaces are defined and shared

* Can develop hierarchies of management and implementation

LOCALIZATION

* Putting things that logically belong together in the same physical place

INFORMATION HIDING

* Puts a wall around localized details

* Prevents reliance upon details and causes focus of attention to interfaces and logical properties

COMPLETENESS

* Ensuring all important parts are present
* Nothing left out

CONFIRMABILITY

* Developing parts that can be effectively tested

UNIFORMITY

* No unnecessary differences across a system

OVERVIEW

* Rationale for development
* Capabilities and advantages
* Life Cycle application

MAJOR FEATURES OF Ada

* Standardization
* Readability
* Program Units
* Separate Compilation
* Subprograms
* Packages
* Strong Typing
* Typing Structures
* Data Abstraction
* Tasks
* Exceptions
* Generics

MAJOR FEATURES OF Ada

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STANDARDIZATION

* Ada is an exact standard
  - ANSI/MIL-STD-1815A
  - No subsets, no supersets

* Conformance to the standard is required
  - Trademark control
  - Ada Compiler Validation Capability (ACVC)

* Standardization allows for portability

* Standardization promotes reusability

* Standardization shifts focus from the mundane to the important

MAJOR FEATURES OF Ada

* Standardization
* Readability
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READABILITY

* Ada was engineered with the understanding that programming is a human activity

* Features are provided that allow a maintenance person to quickly grasp the meaning of a particular program and to understand its structure

* Readability is more than just a language issue

MAJOR FEATURES OF Ada

* Standardization
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SYSTEMS ENGINEERING

* Analyze problem

* Break into solvable parts

* Implement parts

* Test parts

* Integrate parts to form total system

* Test total system

REQUIREMENTS FOR EFFECTIVE SYSTEMS ENGINEERING

* Ability to express architecture

* Ability to define and enforce interfaces

* Ability to create independent components

* Ability to separate architecture issues from implementation issues

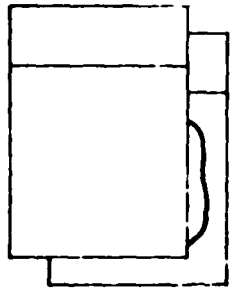
PROGRAM UNITS

* Components of Ada which together form a working Ada software system

* Express the architecture of a system

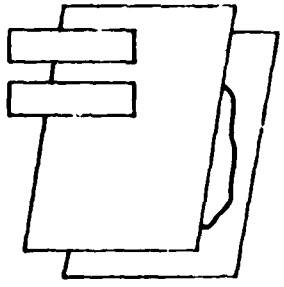
* Define and enforce interfaces

PROGRAM UNITS



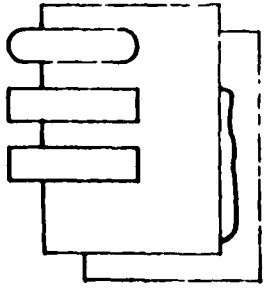
SUBPROGRAMS

Working components that perform some action



TASKS

Performs actions in parallel with other program units



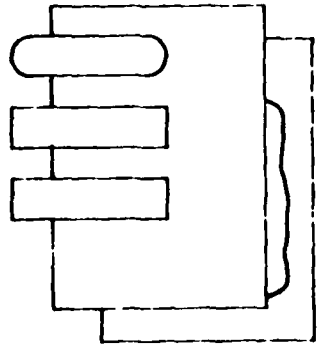
PACKAGES

A mechanism for collecting entities together into logical units

PROGRAM UNITS

* Consist of two parts: specification and body

SPECIFICATION: Defines the interface between the program unit and other program units (the **WHAT**)



BODY: Defines the implementation of the program unit (the **HOW**)

PROGRAM UNITS

* The specification of the program unit is the only means of connecting program units

* The interface is enforced

* The body of a program unit is not accessible to other program units

* There is a clear distinction between architecture and implementation

MAJOR FEATURES OF Ada

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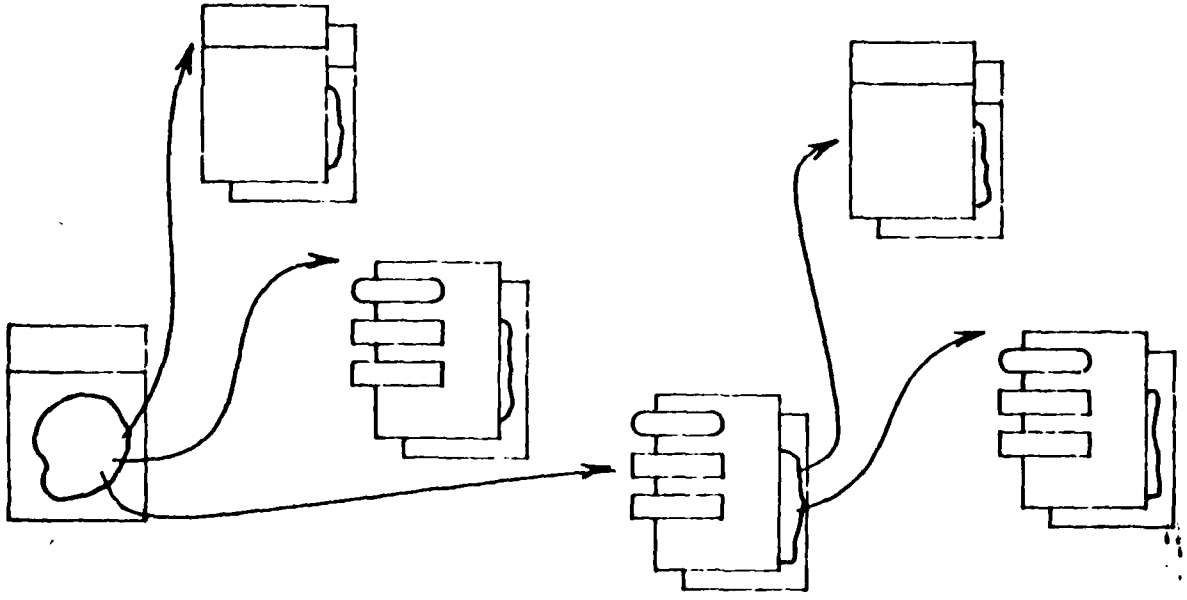
SEPARATE COMPILATION

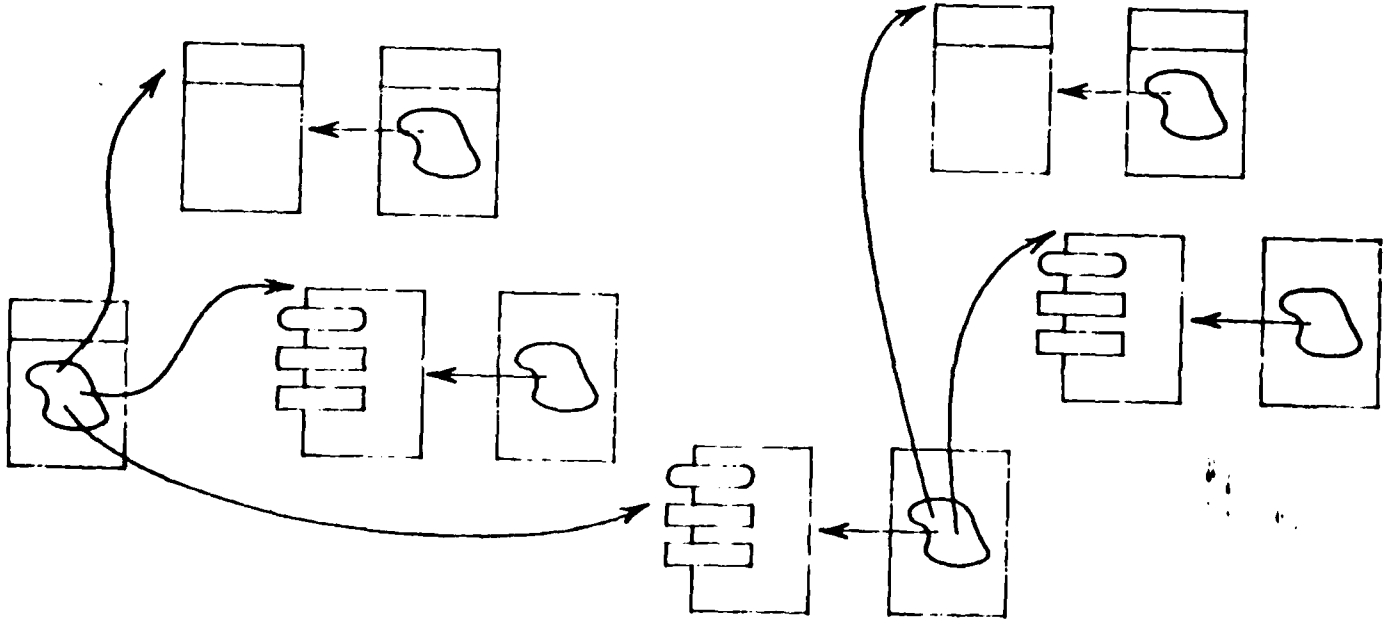
* Program units may be separately compiled
* Separate compilation is possible because of the separation of specification and body
* A system is put together by referencing the specifications of other program units



SEPARATE COMPILATION

* A program unit's specification may be compiled separately from its body

* Realizes not only a logical distinction between architecture and implementation, but also a physical distinction



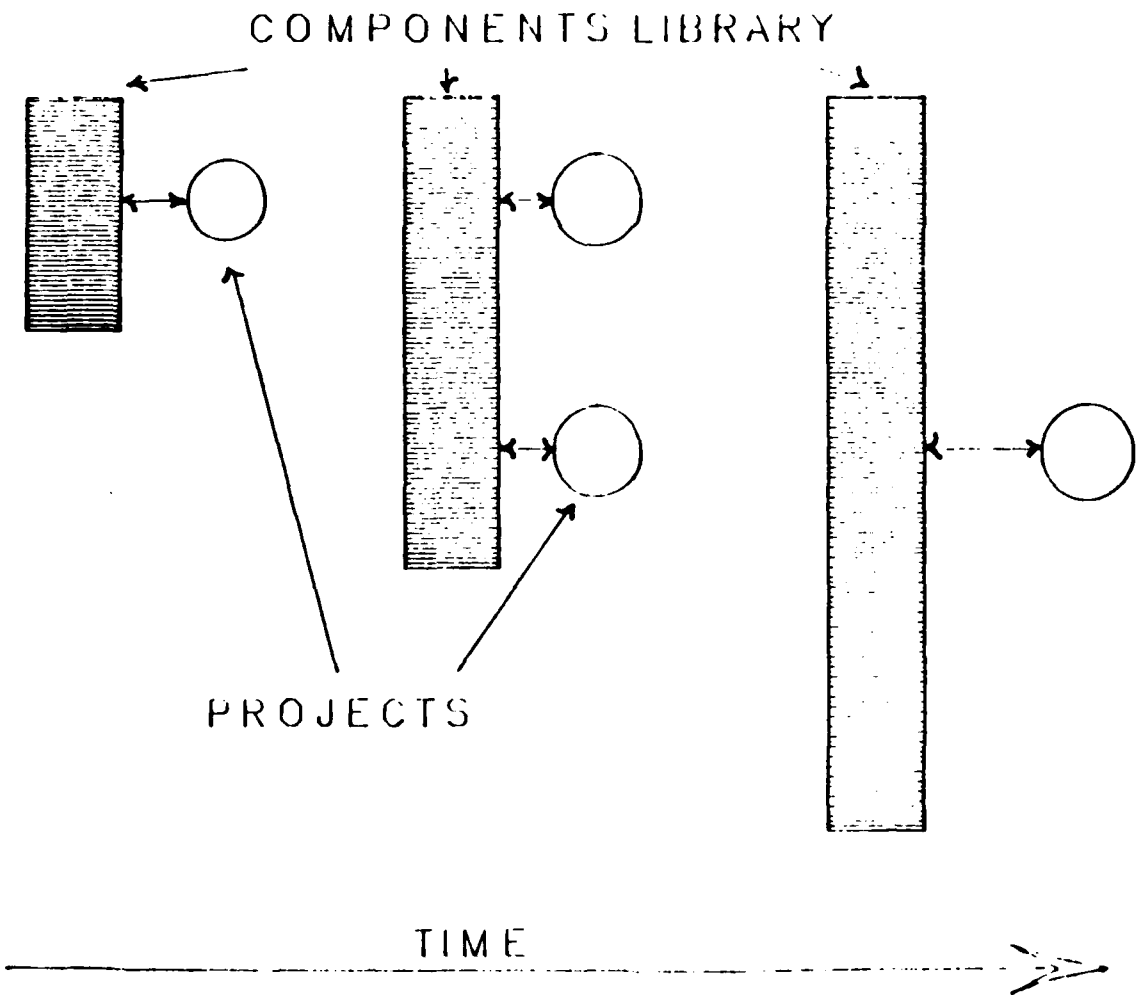
SEPARATE COMPILATION

* Allows development of independent software components

* Currently we all but lose the human effort going into software; it is disposable

* Separate compilation allows us to reuse components and keep our investment

SOFTWARE COMPONENTS



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DISCRETE COMPONENTS

* Allow a system to be composed of black boxes

* Provide clear, understandable functions

* Black boxes can be more effectively validated and verified

* Prevalent across engineering disciplines

SUBPROGRAMS

* A program unit that performs a particular action
  - Procedures
  - Functions

* Contains an interface (parameter part)
  mechanism to pass data to and from the subprogram

* The basic discrete component which acts like
  a black box

* Gives ability to express abstract actions

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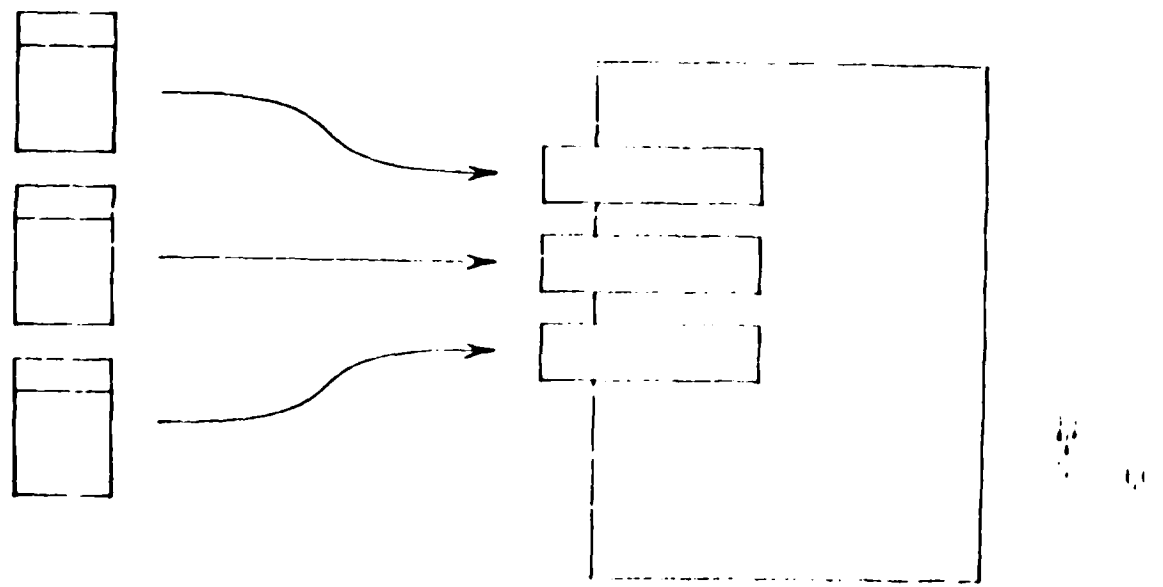
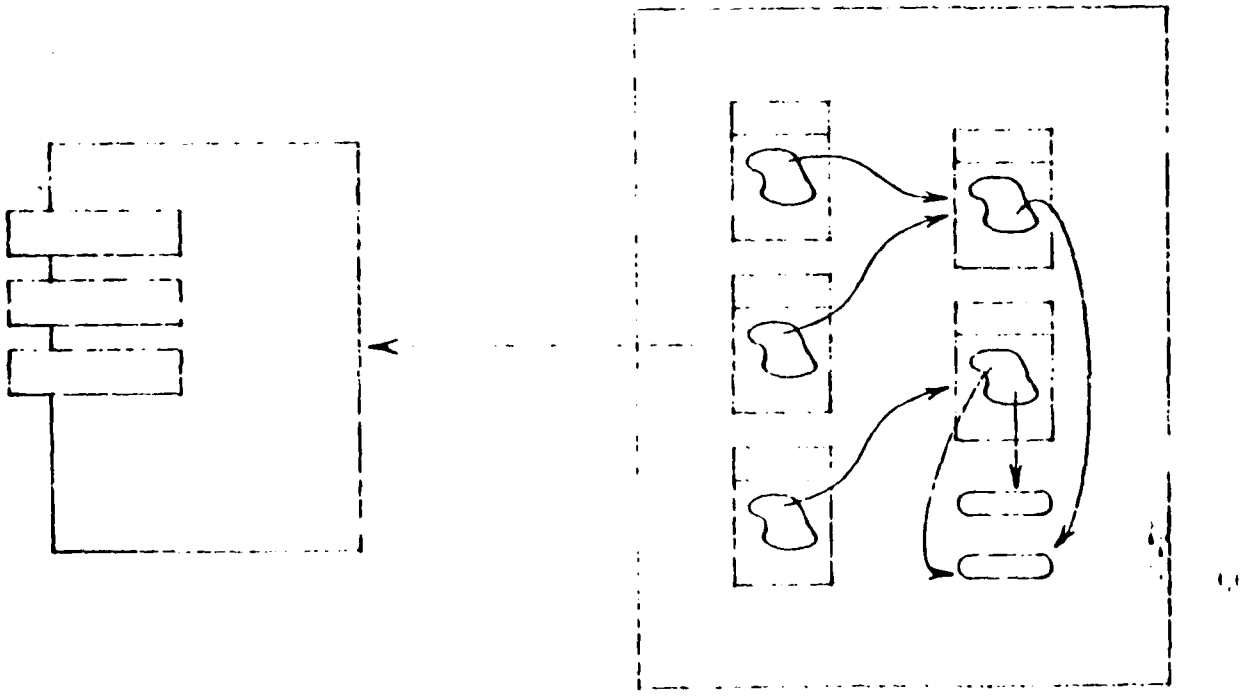
PACKAGES

* Program units that allow us to collect logically related entities in one physical place
* Allow the definition of reusable software components/resources
* A fundamental feature of Ada which allow a change of mindset
* An architecture–oriented feature



PACKAGES

* Place a "wall" around resources
* Export resources to users of a package
* May contain local resources hidden from the user of a package



PACKAGES

DIRECTLY SUPPORT:

* Abstraction
* Information hiding
* Modularity
* Localization

* Understandability
* Efficiency
* Reliability and safety
* Modifiability
* Correctness

MAJOR FEATURES OF Ada

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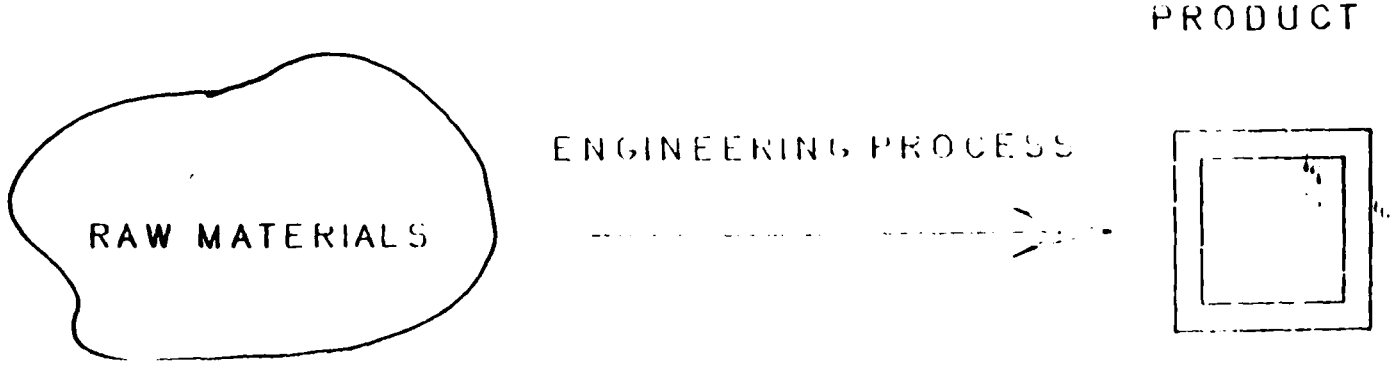
THE RAW MATERIALS OF ENGINEERING

* All engineering disciplines shape raw materials into a finished product

* The materials and methods combine to define different disciplines



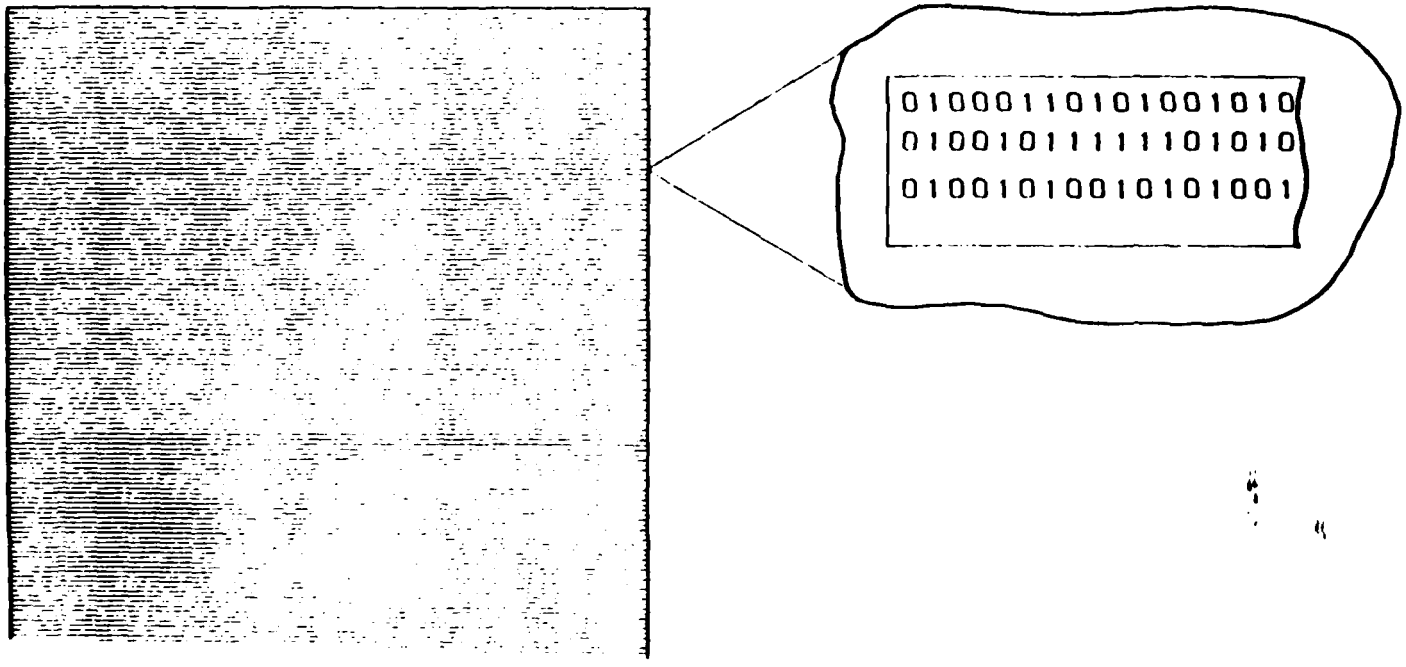
STRUCTURING RAW MATERIALS

* There is a requirement to structure raw materials
  - To quantify
  - To manage
  - To test
  - To validate

* Methods of structuring vary across disciplines

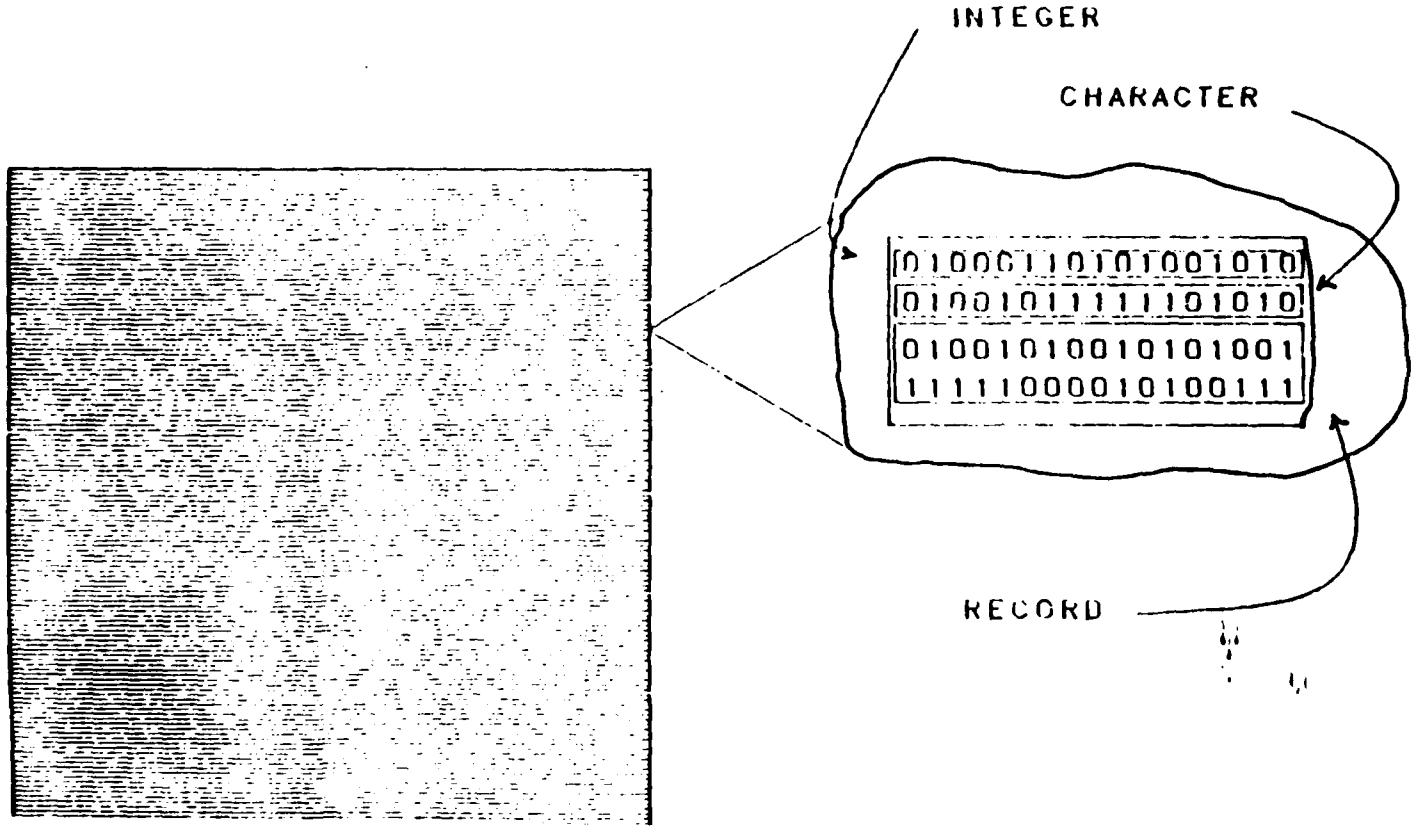
SOME RAW MATERIALS OF SOFTWARE ENGINEERING

* Binary switches
* Computer memory locations
* Data



STRONG TYPING

* Defines structure of data (mapping)
* Enforces structure of data



STRONG TYPING

* Enforces abstraction of structure on data

* Increases confidence of correctness

* Increases reliability and safety

* Promotes understandability and maintainability

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TYPING STRUCTURES

* Variety of problems requires a variety of structuring capabilities

* Ada provides a rich variety or types

TYPING STRUCTURES IN Ada

* Discrete data
  - Enumeration
  - Integer

* Real data
  - Fixed point (absolute error)
  - Floating point (relative error)

* Composite data
  - Arrays (homogeneous)
  - Records (heterogeneous)

* Dynamic data
  - Access types

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DATA ABSTRACTION

* Combines primitive raw materials to form higher level structures

* Levels of abstraction

* Enforces an abstraction on a higher level structure

* Prohibits use of implementation details

* Promotes understandability

* Promotes modifiability

DATA ABSTRACTION AND PRIVATE TYPES

* Private types directly implement data abstraction

* Directly implement information hiding

```
package B_R is
   type NUMBERS is range 0..99;
   procedure TAKE ( A_NUMBER : out NUMBERS );
   function NOW_SERVING return NUMBERS;
   procedure SERVE ( NUMBER : in NUMBERS );
end B_R;
package body B_R is
   SERV_A_MATIC : NUMBERS := 1;
   procedure TAKE ( A_NUMBER : out NUMBERS ) is
   begin
      A_NUMBER := SERV_A_MATIC;
      SERV_A_MATIC := SERV_A_MATIC + 1;
   end TAKE;
   function NOW_SERVING return NUMBERS is separate;
   procedure SERVE ( NUMBER : in NUMBERS ) is
                                                  separate;

end B_R;
```

```
with B_R; use B_R;
procedure ICE_CREAM is
   YOUR_NUMBER : NUMBERS;
begin

   TAKE ( YOUR_NUMBER );
   loop
      if NOW_SERVING = YOUR_NUMBER then
         SERVE ( YOUR_NUMBER );
         exit;
      end if;
   end loop;

end ICE_CREAM;
```

```
with B_R; use B_R;
procedure ICE_CREAM is

   YOUR_NUMBER : NUMBERS;

begin
   TAKE ( YOUR_NUMBER );
   loop
      if NOW_SERVING = YOUR_NUMBER then
         SERVE ( YOUR_NUMBER );
         exit;
      else
         YOUR_NUMBER := YOUR_NUMBER – 1;
      end if;
   end loop;

end ICE_CREAM;
```

```
package B_R is

   type NUMBERS is private;

   procedure TAKE ( A_NUMBER : out NUMBERS );
   function NOW_SERVING return NUMBERS;
   procedure SERVE ( NUMBER : in NUMBERS );

private

   type NUMBERS is range 0..99;

end B_R;
```

```
with B_R; use B_R;
procedure ICE_CREAM is

  YOUR_NUMBER : NUMBERS;

begin

  TAKE ( YOUR_NUMBER );
  loop

    if NOW_SERVING = YOUR_NUMBER then
      SERVE ( YOUR_NUMBER );
      exit;
    else
      YOUR_NUMBER := NOW_SERVING;
    end if;
  end loop;

end ICE_CREAM;
```

```
package B_R is
   type NUMBERS is private;

   procedure TAKE ( A_NUMBER : out NUMBERS );
   function NOW_SERVING return NUMBERS;
   procedure SERVE ( NUMBER : in NUMBERS );

private
   type NUMBERS is range 0..99;
end B_R;
```

```
with B_R; use B_R;
procedure ICE_CREAM is

   YOUR_NUMBER : NUMBERS;

begin

   TAKE ( YOUR_NUMBER );
   loop

      if NOW_SERVING = YOUR_NUMBER then
         SERVE ( YOUR_NUMBER );
         exit;
      else
         YOUR_NUMBER := NOW_SERVING;
      end if;
   end loop;

end ICE_CREAM;
```

```
package B_R is

   type NUMBERS is limited private;

   procedure TAKE ( A_NUMBER : out NUMBERS );
   function NOW_SERVING return NUMBERS;
   procedure SERVE ( NUMBER : in NUMBERS );
   function "=" ( LEFT, RIGHT : in NUMBERS ) return
                                                  OOLEAN;

private

   type NUMBERS is range 0..99;

end B_R;
```

```
with B_R; use B_R;
procedure ICE_CREAM is

   YOUR_NUMBER : NUMBERS;
   procedure GO_TO_DQ is separate;

begin
   TAKE ( YOUR_NUMBER );
   loop
      if NOW_SERVING = YOUR_NUMBER then
         SERVE ( YOUR_NUMBER );
         exit;
      else
         GO_TO_DQ;
         exit;
      end if;
   end loop;

end ICE_CREAM;
```

MAJOR FEATURES OF Ada

* Standardization
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TASKS

* Program unit that acts in parallel with other entities

* Directly implements those parts of embedded systems which act in parallel

* Takes advantage of move toward parallel hardware architectures

  - Fault tolerance
  - Distributed systems

* Eliminates need to introduce additional complexity into a system

MAJOR FEATURES OF Ada

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SOFTWARE RELIABILITY AND SAFETY

* Errors will occur
  - Hardware
  - Software
* Real time systems must be able to operate in a degraded mode
* Reliablity and safety must be engineered into a system
* Traditional languages lack specific features for dealing with errors and exceptional situations

EXCEPTIONS

* Deal specifically with errors and exceptional situations

* When an exception is raised processing is suspended and control is passed to an appropriate exception handler
  - Try again
  - Fix error
  - Propogate exception

* Increase reliability

* Reduce complexity

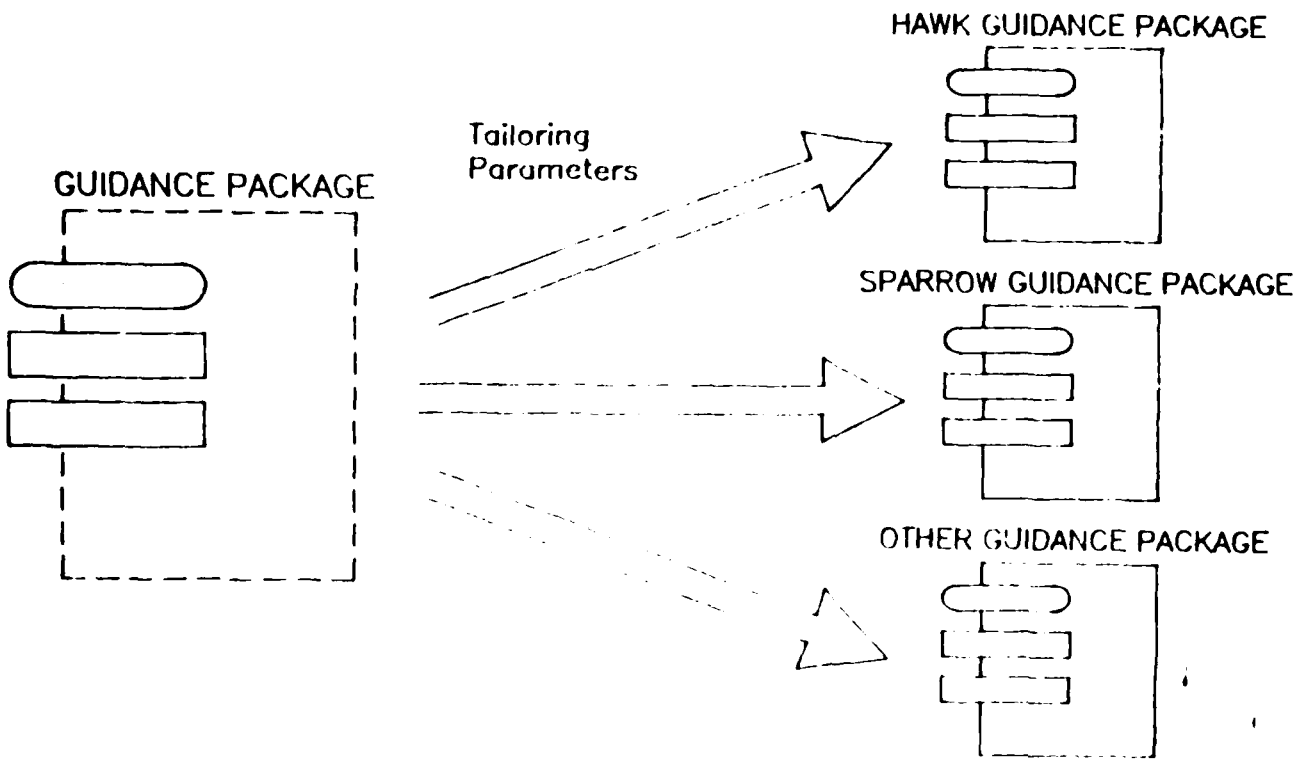
MAJOR FEATURES OF Ada

* Standardization
* Readability
* Program Units
* Separate Compilation
* Subprograms
* Packages
* Strong Typing
* Typing Structures
* Data Abstraction
* Tasks
* Exceptions
* Generics

GENERICS

* A generic is a tailorable template for a program unit

* Increases reusable software component capability by an order of magnitude



GENERICS

* Reduce size of program text

* Reduce need to reinvent the wheel

* Increase reliability by allowing reuse of known reliable components

OVERVIEW

* Rationale for development
* Capabilities and advantages
* Life Cycle application

SOFTWARE LIFE CYCLE

* Requirements analysis
* Preliminary design
* Detailed design
* Coding and unit testing
* Computer Software Component (CSC) integration and testing
* CSCI testing

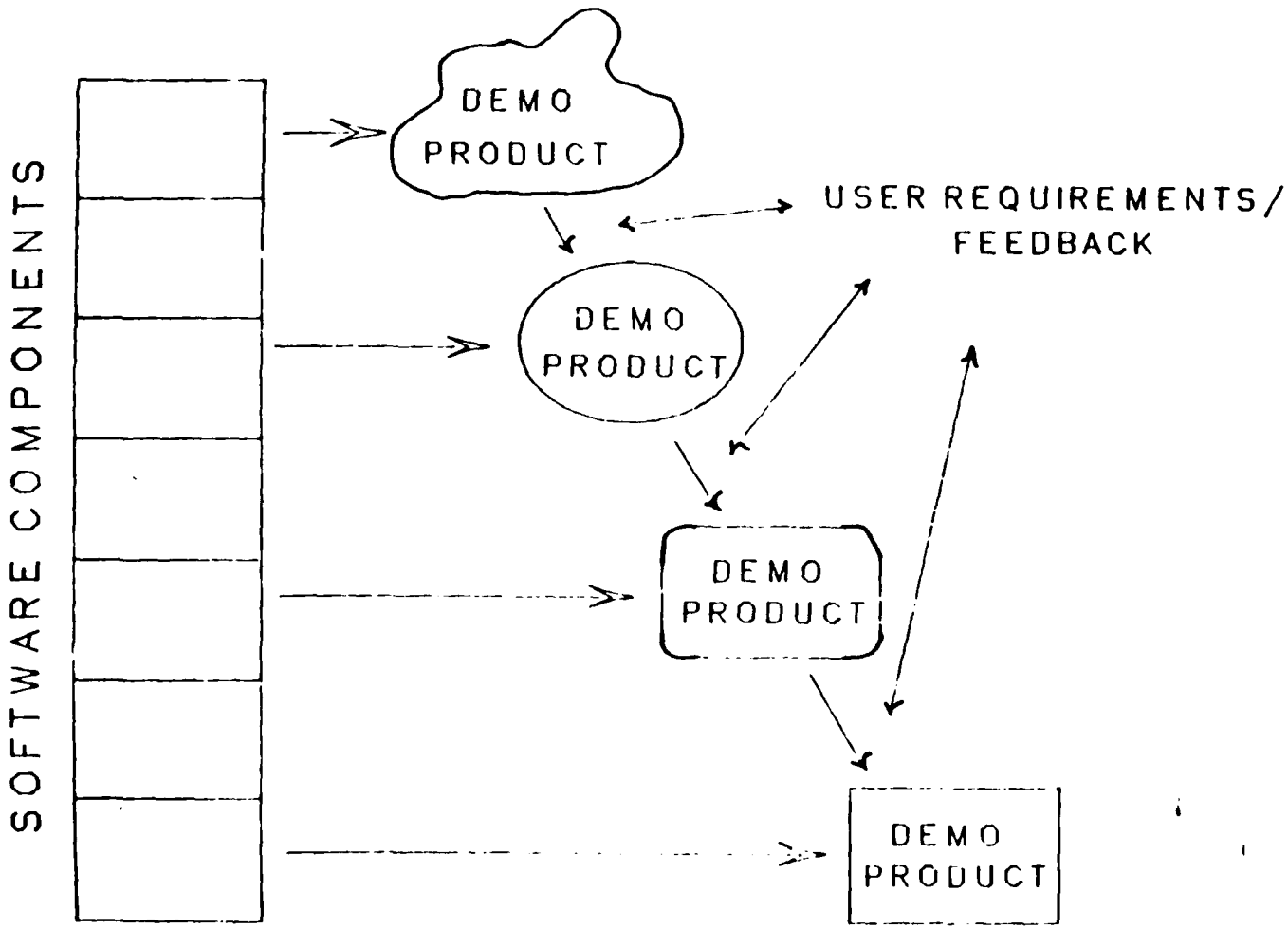
* Maintenance

REQUIREMENTS ANALYSIS

* Standardization brings a much higher level of predictability
  - Ada language itself
  - Existing Ada software components

* Ada supports rapid prototyping very well

RAPID PROTOTYPING



DESIGN

* Ada features support architectural design

* Can actually express design in terms of PDL
  (Program Design Language)

  - Compilable
  - Allows other automated tool support

* Can enforce design through compilable PDL

* Ada supports varied methodologies

* Ada features reduce need to squeeze design
  into a programming language

CODING

* Ada features ensure original design is not violated

* Using PDL reduces amount of coding activity

* Readability of Ada code promotes productivity

TESTING

* The ability of Ada to support independent components allows more effective testing

* Exceptions allow "built-in" testing facilities

INTEGRATION AND TESTING

* Ada PDL ensures interfaces are correct

* More effective time can be spent testing the system rather than fixing integration errors

MAINTENANCE

* Readability makes maintenance much easier

* Proper software engineering using Ada will reduce maintenance costs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