

# International Workshop On Software Reuse

Brussels - 8 June 94

**REBOOT (ESPRIT P7808)**

**REuse Based on Object Oriented Techniques**

## The REBOOT Approach to Software Reuse

**Jean-Marc MOREL / BULL S.A.**

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## Why not Reuse Software ?

**One of the biggest breakthroughs in the industrialization of society came when people started to put together standardized components.**

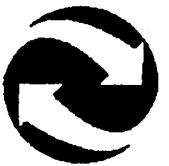
**People effortlessly combine thousands of predefined pieces to put together totally new objects.**

**Therefore one of our key jobs is to devise and promote standards and mechanisms to make standardized software componentry possible.**

**Graham Samuel    ESF Project Director, Sema Group UK, Berlin**

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## Some Pioneering Software Projects

### ▶ Common Ada Missile Packages (CAMP)

- Conducted by McDonnell Douglas under contract to the Dod STARS program.
- Example of an early domain-specific software reuse library.

### ▶ Magnavox's AFATDS project (1987)

- 700 KLS of Ada (100 KLS reused). OO techniques and incentives.

### ▶ NASA Goddard Space Flight Center

- 32 percent of software reused or modified in 25 software systems for unmanned spacecraft control in Fortran.
- Subsequent efforts at GSFC with Ada code indicate higher reuse averages.

### ▶ Raytheon Missile Systems Division

- Experience in business applications: 60% reuse, productivity up by 50%.
- Improvement in maintenance due to a consistent style for all software.

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## A mature reuse organisation

### • Example: TASKON A/S Norway (office automation, tailored end-user system)

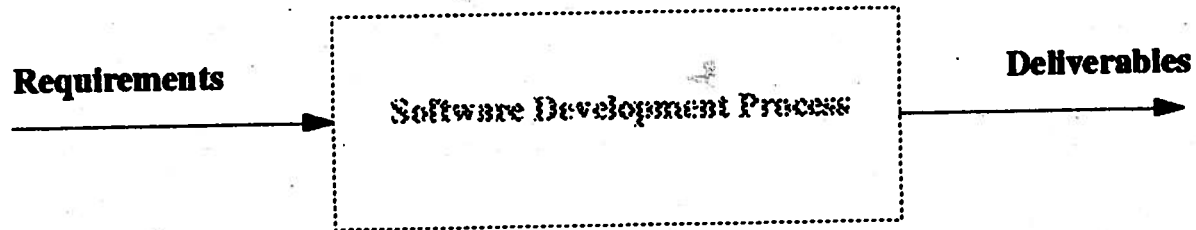
- Strong management commitment and knowledge about software reuse.
- Entire product development based on reuse philosophy.
- Reuse penetrates the entire organisation.
- Development process supports object-orientation and reuse.
- Applications engineered from reuse repository of about 1500 Smalltalk classes.
- Re-engineering of class hierarchies occurs regularly ("back-room" activity).
- The company incrementally increases its reuse assets.

**Their need:** *A reuse repository with support for classification to manage the ever growing number of components.*

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# Classical Software Development Process

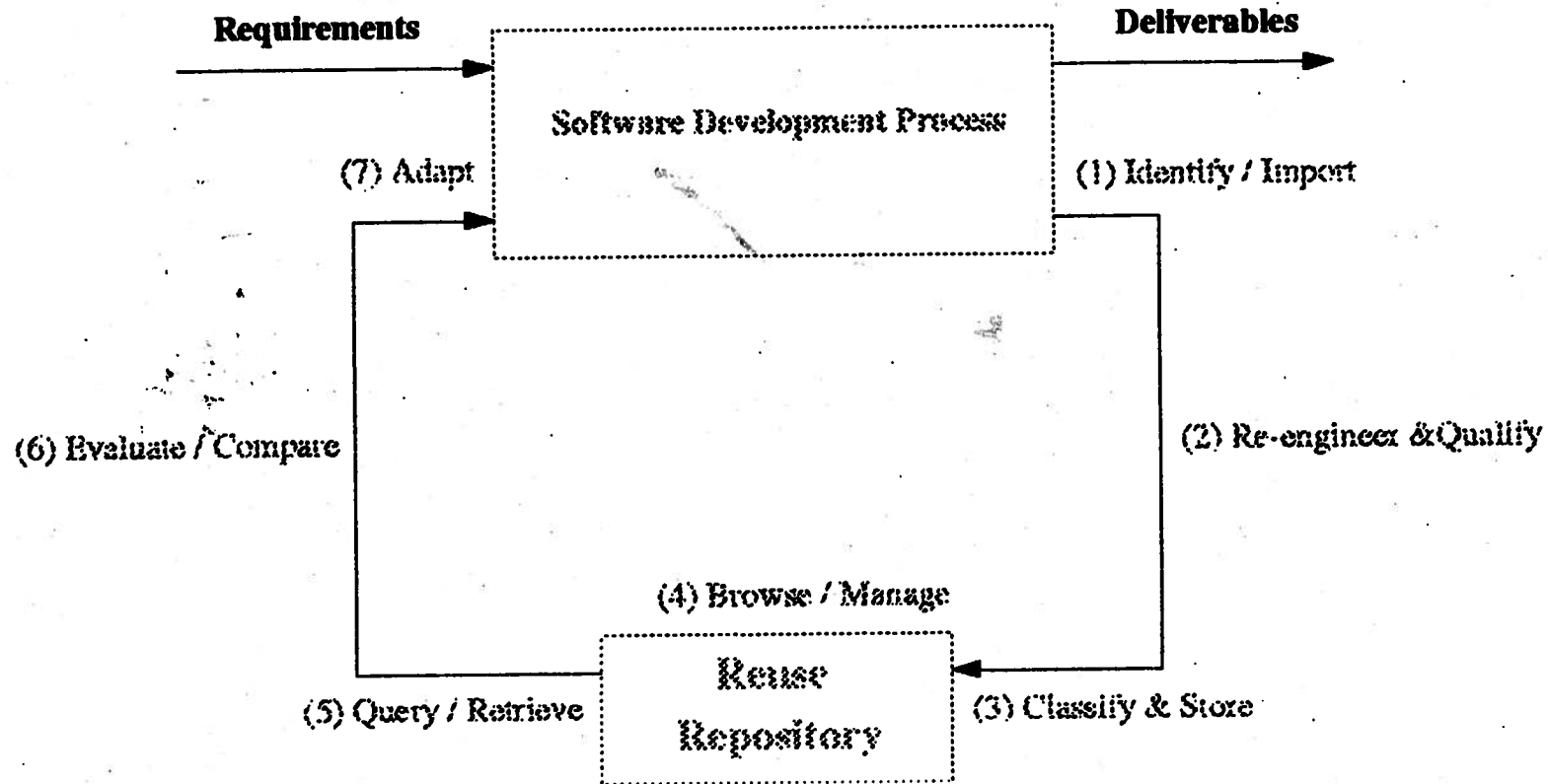


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# Reuse oriented Software Development Process



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## Reuse Advantages

- ▶ **Reduced development time (time-to-market).**
- ▶ **Improved software quality (functionality, reliability, usability, efficiency).**
- ▶ **Reduce complexity (maintainability, portability).**
- ▶ **Increased productivity.**
- ▶ **Risk reduction.**
- ▶ **Spread and sharing of knowledge across organizations and projects.**
- ▶ **Facilitates education in good system architecture.**
- ▶ **Psychological reuse satisfaction: subjective measure.**

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## Reuse Impediments

- **Problems in locating suitable components.**
- **Problems in understanding such components.**
- **Lack of confidence in such components. (Not Invented Here).**
- **Problems in adapting such components.**
- **Problems with over-generalized components, inefficiency ?**
- **Conversion cost to a "reuse situation" (tools, training, culture).**
- **Problems with licencing rights and responsibilities (wrt. errors).**

**==> The objectives of the REBOOT project (REuse Based on Object-Oriented Techniques) are to help overcome these problems.**

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## The REBOOT Project

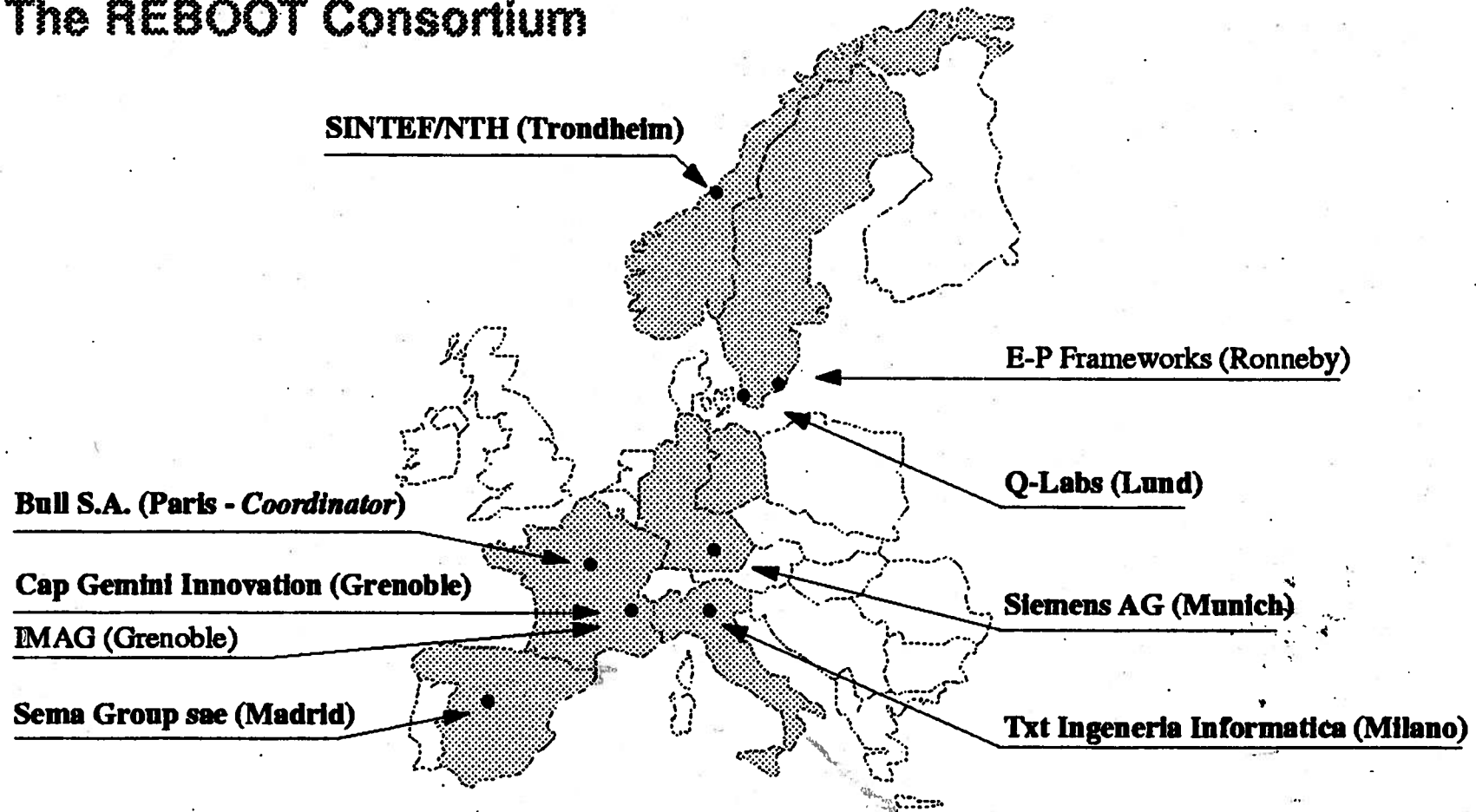
# To enhance Productivity & Quality in Software Development by *promoting and assisting* Reuse

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## The REBOOT Consortium



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## The REBOOT Program: An Holistic Approach

- **Define a Methodology**
  - How to adapt the organization ?
  - How to manage a reuse project ?
  - How to develop reusable components ?
  - How to adapt the development process to reuse ?
  - How to manage a library of reusable components ?
  - How to measure the cost and benefit ?
  - How to introduce reuse in a software organization ?
  
- **Develop a Reuse Repository & Reuse tools**
  
- **Experiment with Industrial Applications.**
  - Both to better understand the problems and assess proposed methods and tools.
  
- **Transfer the Technology.**

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## Some Applications

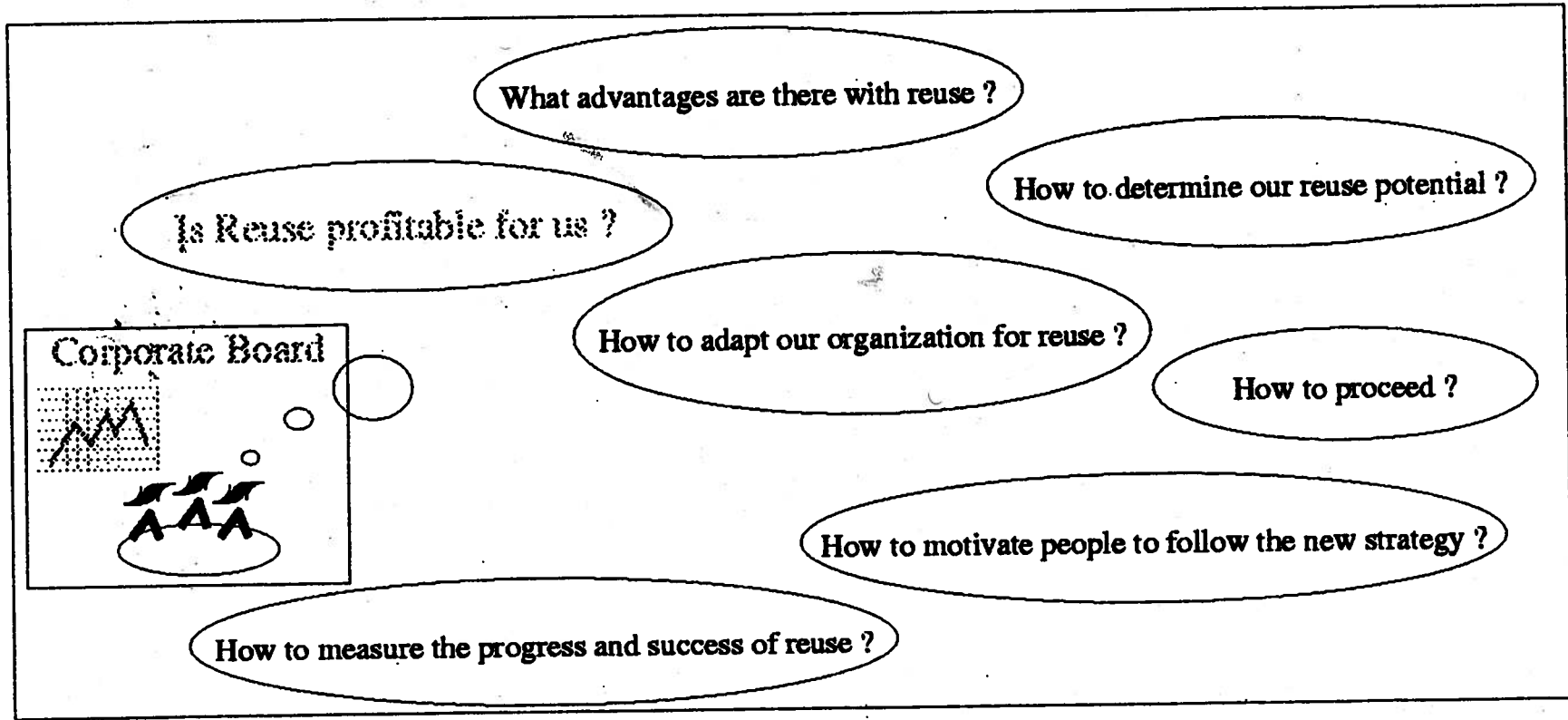
Partner	Application	Focus
Bull	Workflow	Development WITH reuse in the large
Cap	Resource allocation	Development of reusable components
Q-Labs	Telecommunication	Adaptation of existing methodology to reuse
E-P Frameworks	Real time inspection	Development FOR reuse
	Fire alarm system	Development FOR reuse: OO framework
	Gateway system for telecom.	Development FOR reuse: OO framework
Siemens	Material flow control	Development of reusable components
	Telecommunication	Re-engineering for reuse
Txt	Factory planning	Development FOR & WITH reuse
	Embedded systems for aeronautic	Introduction of Reuse in Ada real-time applications
Garex (Sintef)	Voice communication systems	Reuse of role model (OORAM) & Finite State Machine components

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# Organizing Reuse



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## Various reuse approaches

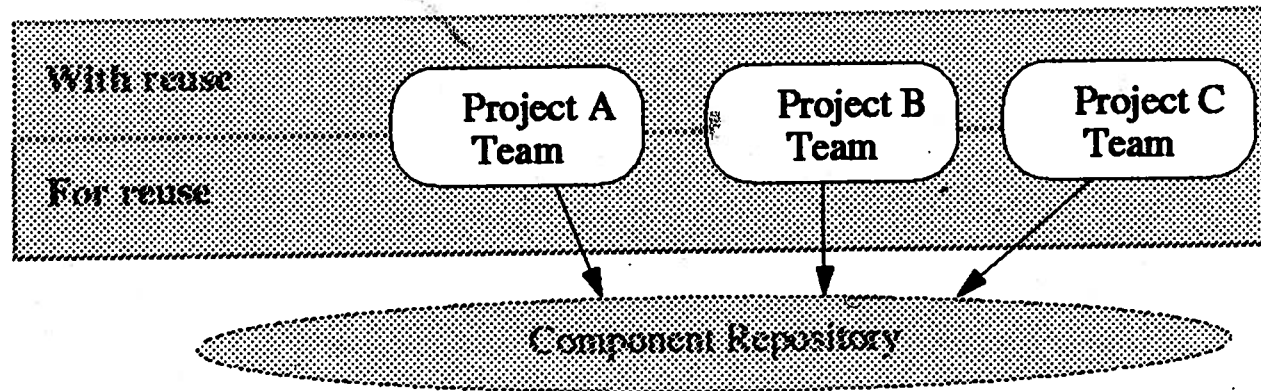
- **General purpose reuse**
  - **Small components (e.g. Abstract Data Types, GUI functions, mathlibraries))**
  
- **Domain reuse**
  - **Domain-specific components or sub-systems (e.g. financial service libraries, Syntax edit.)**
  
- **Product line reuse**
  - **Components common to several products of the same product line**

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## Different reuse organizations

- **Project-oriented**



**This requires:**

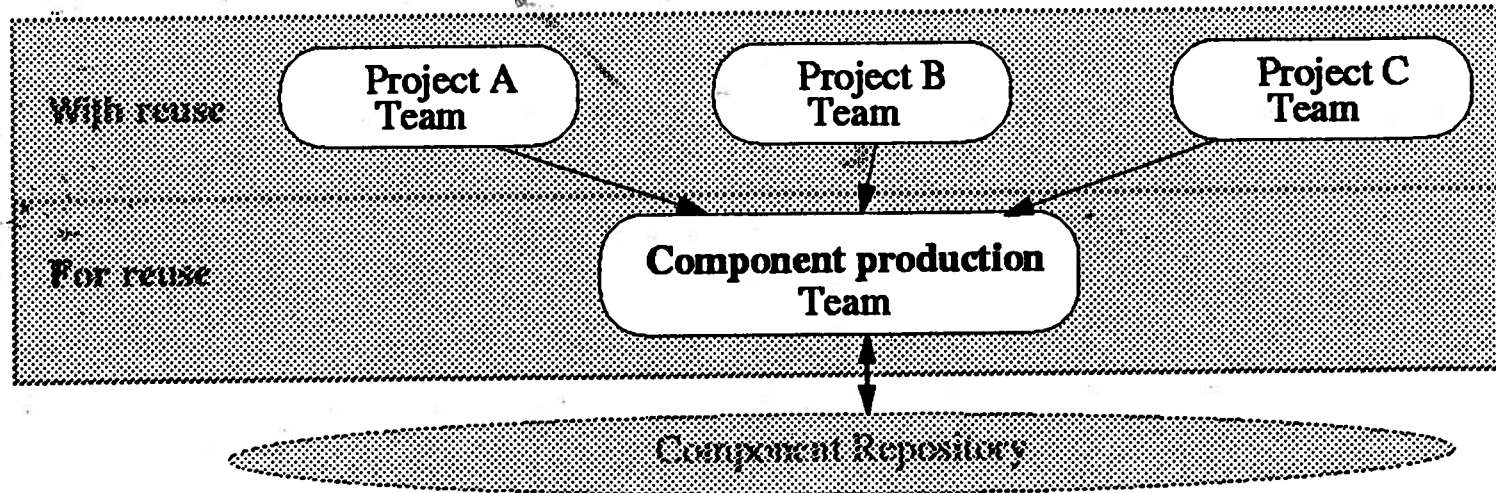
- **Strong management**
- **Strict programming norms**
- **Efficient inter-team communication**
- **Support for configuration**

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## Different reuse organizations (cont'd)

- **Component-oriented**

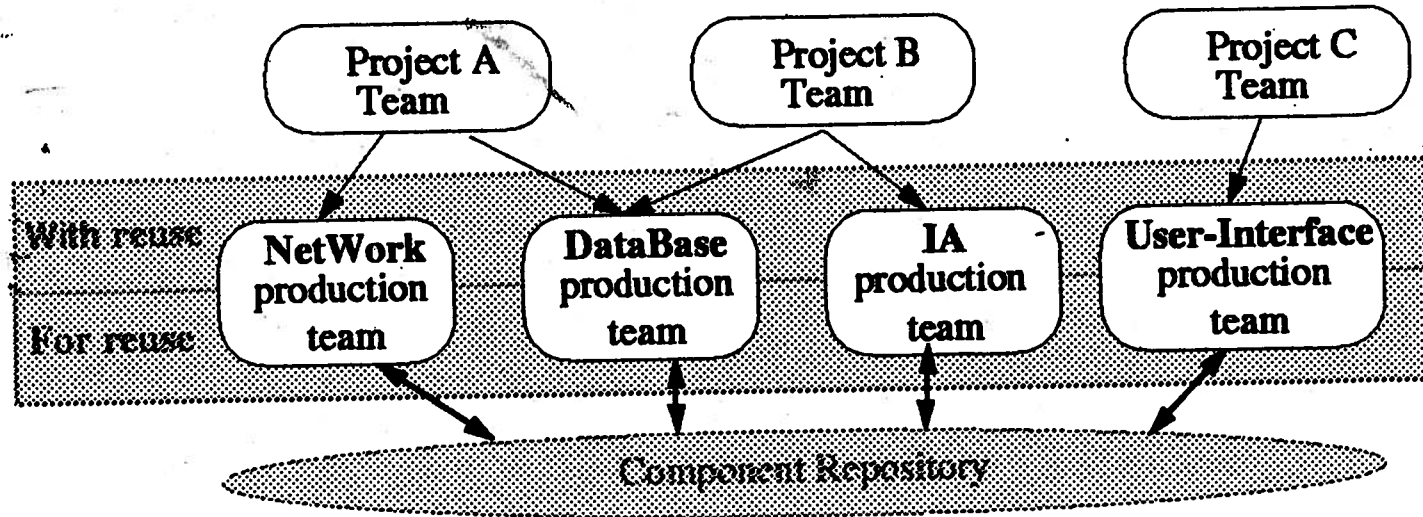


**This requires:**

- **Efficient domain analysis**

## Different reuse organizations (cont'd)

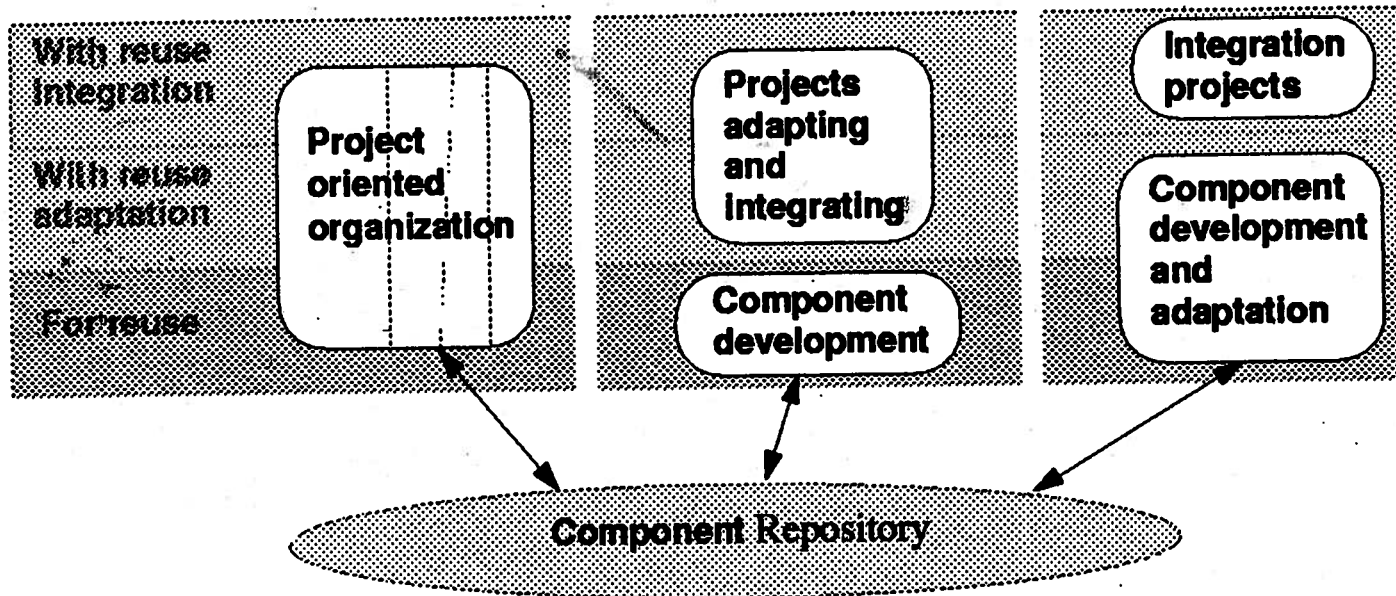
- **Domain-oriented**



**This requires:**

- **Group planning**

## Different reuse organizations (summary)



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## Key factors for success

- Managerial involvement
- Strong technical leadership
- Efficient communication between teams
- Explicit integrations of reuse activities in development process
- Effective standardizations of product and process
- Repository and tools to support reuse
- Accurate training and motivation of people

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## Management issues

- **Extended project interface: more negotiations**
- **Increased complexity of planning**
- **Cost-benefit analysis**
- **Extended and new roles: domain expert, component developers, librarians**
- **Development process**
- **Communication inter teams**
- **Additional documentation**
- **Maintenance of reusable components**

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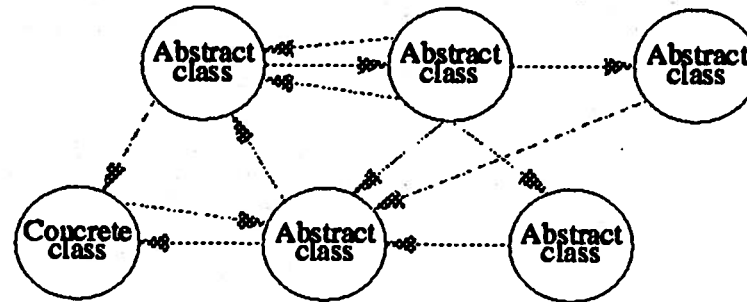


## Various Reuse Approaches

### • Object-oriented techniques

- Reusability is one of the most enticing "promises" of object-oriented techniques
- Abstract data types, inheritance, information hiding, classes.

### • Domain Specific Software Architectures or Frameworks



### • Application generators

- Report generators
- Expert-system generators
- Parser and Compiler generators
- Graphical User Interface generators

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## **Reusable Software is more than source code**

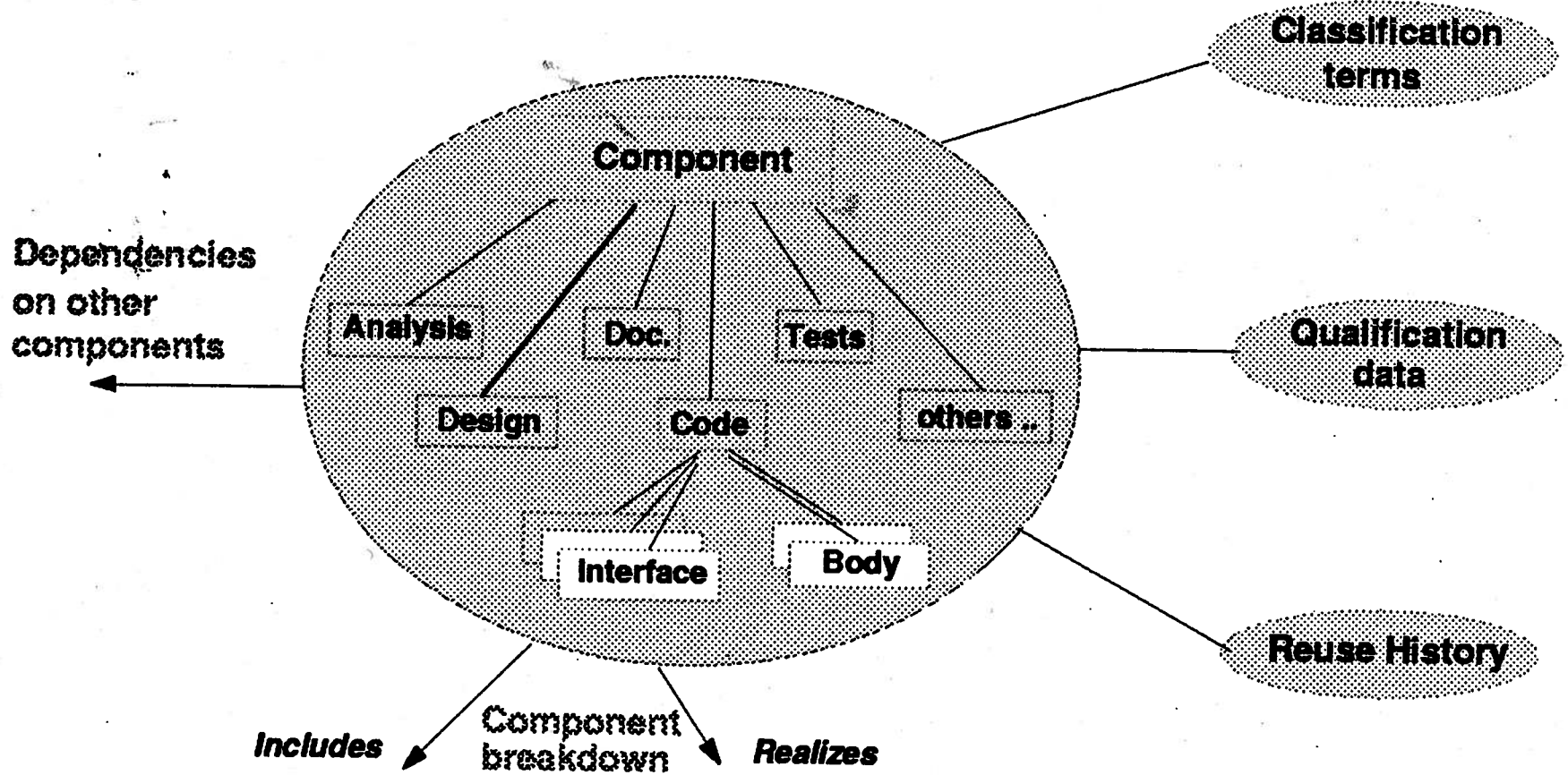
- **To maximize the benefit, reuse must be considered from the beginning of, and throughout, the software life-cycle.**
  - **Requirements**
  - **Analysis**
  - **Design**
  - **Coding**
  - **Testing & Integration**
  - **Maintenance**
  
- **The entire product line should be engineered with reuse in mind.**
  
- **Policies, procedures, guidelines, and standards must be 'reuse friendly'.**

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# Overview of the Reusable Component model



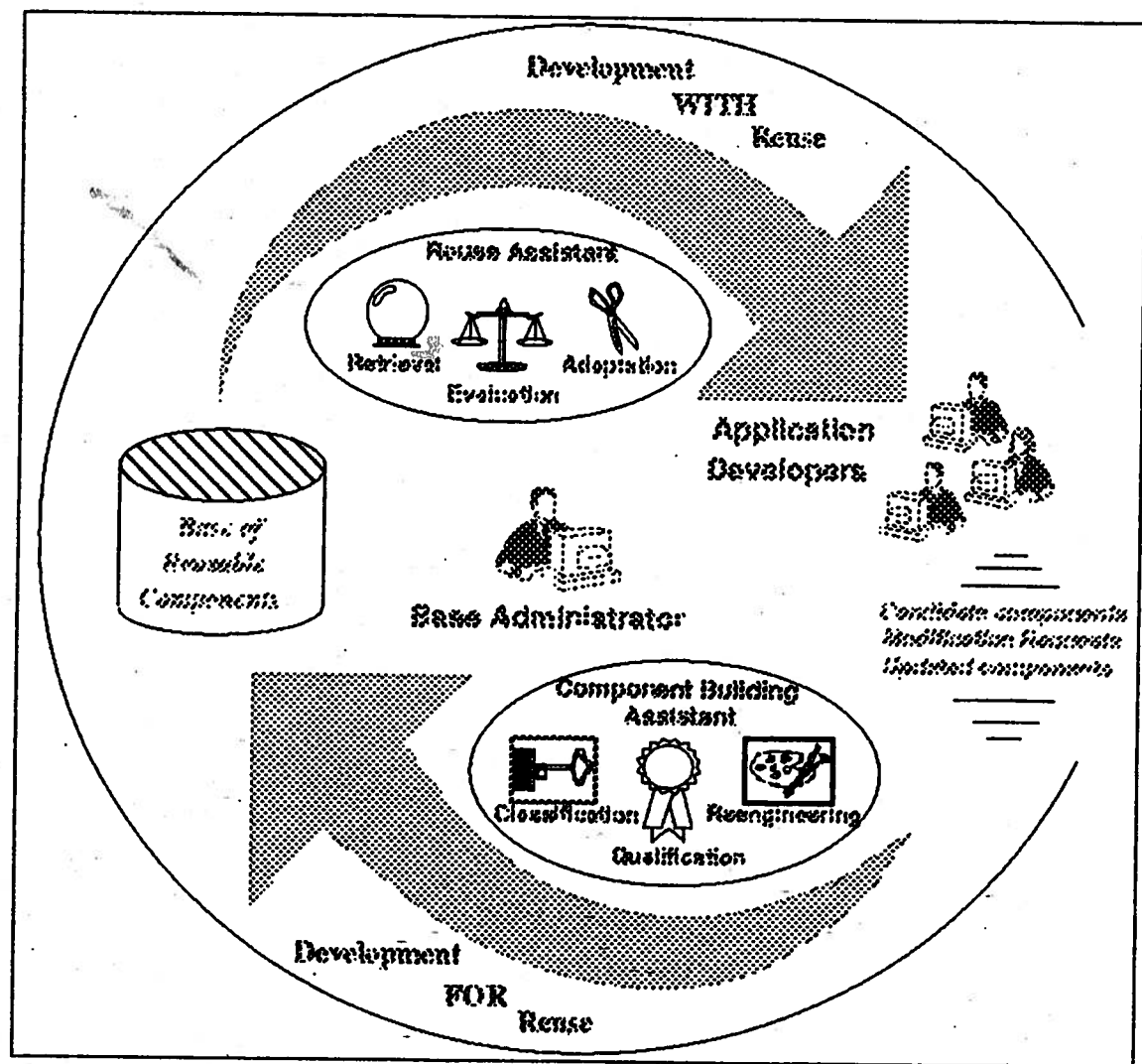
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## Reusable component life cycle

- Development FOR reuse is the planned activity of constructing a component for reuse in contexts (systems) other than the one for which it was initially intended.
- Development WITH reuse is the search for, evaluation, adaptation and integration of existing components in a new context (system).

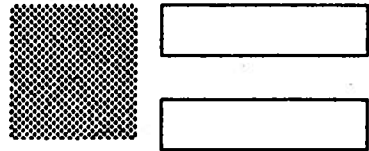


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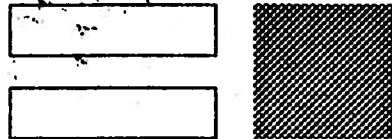
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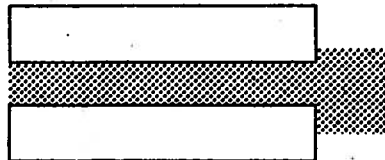
## Development FOR reuse strategies



- A priori Development FOR Reuse



- A posteriori Development FOR Reuse  
= RE-ENGINEERING  
= Reverse + Forward Engineering



- Development FOR Reuse while developing an application

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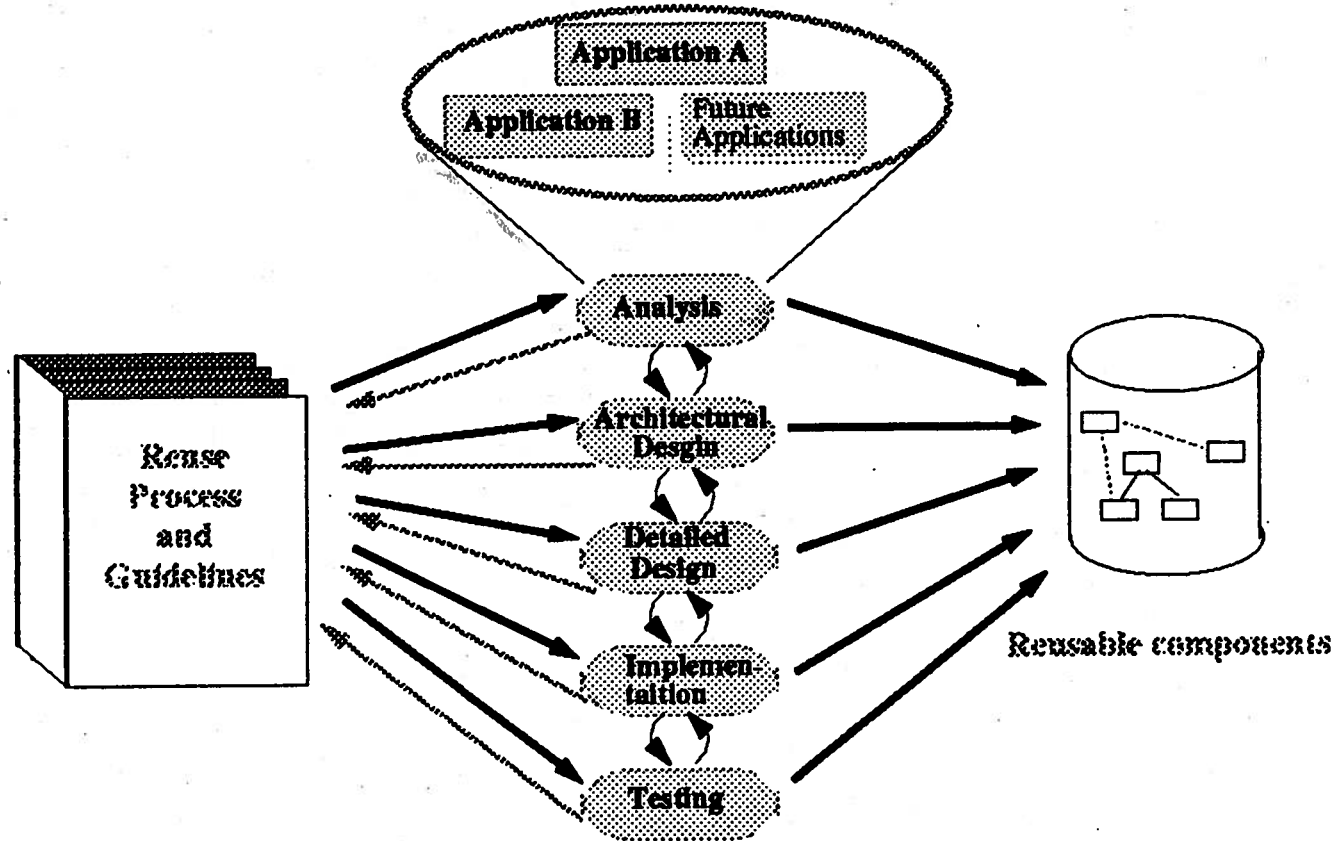
## Development FOR reuse activities

- Identify potential generality
- Identify potential reuse customers
- Collect additional requirements with benefit estimates
- Analyze requirements for specificity and conflicts
- Identify subsystems which can be developed for reuse
- Determine design alternatives and their costs
- Decide on design alternative and development for reuse timing

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# Overall development FOR reuse process

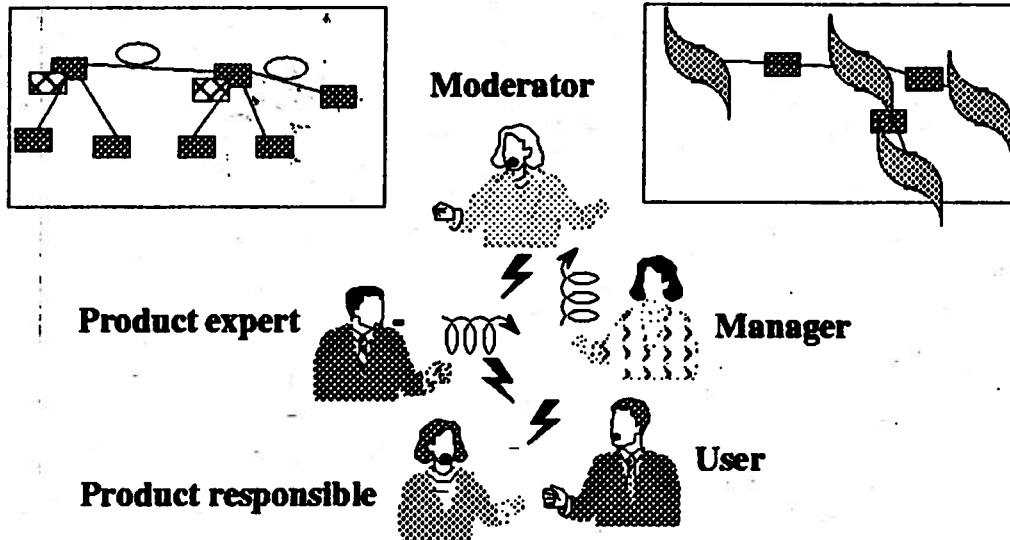


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## Why Domain Analysis ?

- To discover and define models and architectures common to a family of applications with the purpose of making them reusable.



### Group dynamic modeling process

- Models are developed jointly with people (experts, users, managers, designers, etc.) who otherwise would have been interviewed separately.

==> Models completed in shorter time  
Inconsistencies can be dealt with immediately

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## Domain Analysis method [Arango 93]

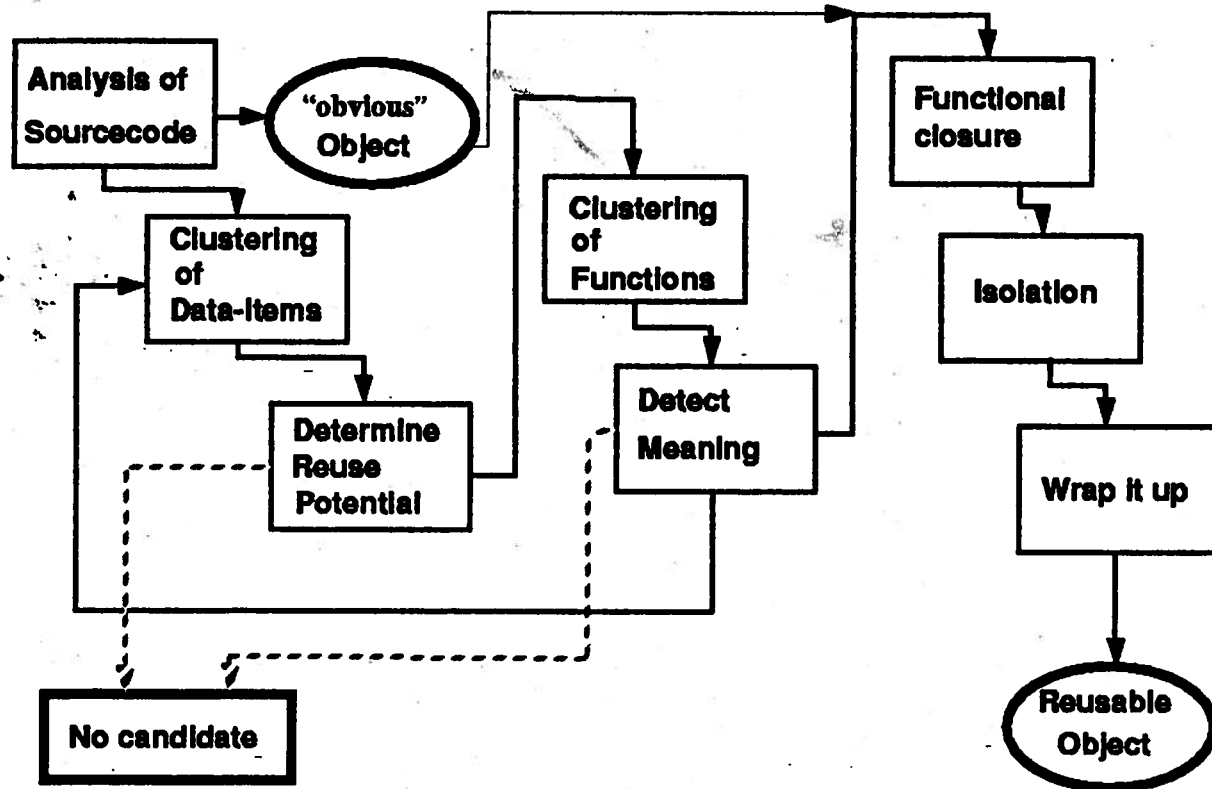
1. **Domain characterization**
  - **Business analysis**
  - **Risk analysis**
  - **Domain description**
  - **Data identification**
  - **Inventory preparation**
2. **Data collection**
  - **Abstraction recovery**
  - **Knowledge elicitation**
  - **Literature review**
  - **Analysis of context and scenarios**
3. **Data Analysis**
  - **Ident. of entities, operations & rels.**
  - **Identification of decisions**
  - **Modularization**
  - **Analysis of similarity**
  - **Analysis of variation**
  - **Analysis of combinations**
  - **Trade-off analysis**
4. **Taxonomic classification**
  - **Clustering**
  - **Abstraction**
  - **Classification; generalization**
  - **Vocabulary construction**
5. **Validation - Evaluation**

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# Re-engineering for reuse method



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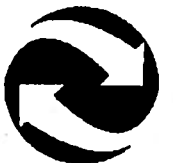


## Development WITH reuse strategies

- Reuse in the large
  - Identify large reusable components early in the software life cycle
- Reuse in the small
- Instantiate Object-Oriented Framework

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## Development WITH Reuse Activities

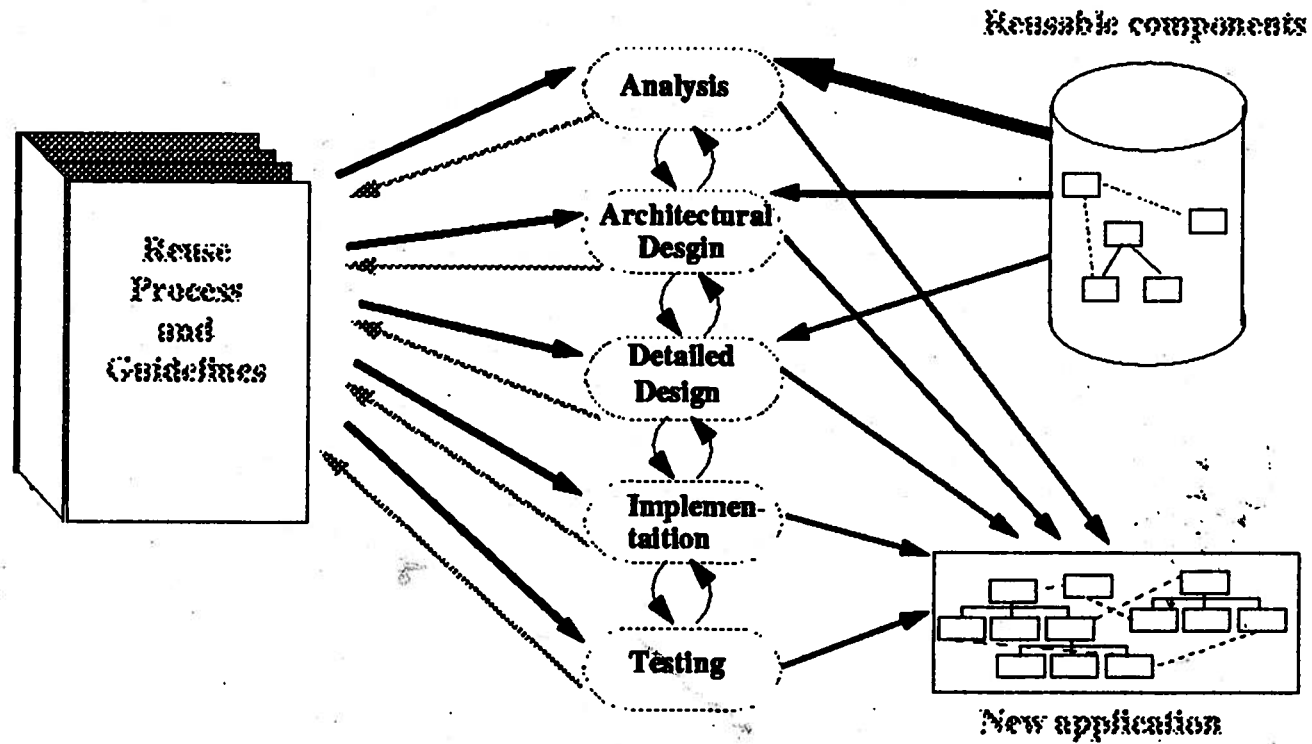
- Identify components and subcomponents to be developed
- Search for potential reusable components
- Evaluate identified reusable components
- Negotiate customer requirements on the basis of candidate components
- Adapt and integrate selected components in design

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# Overall development WITH reuse process

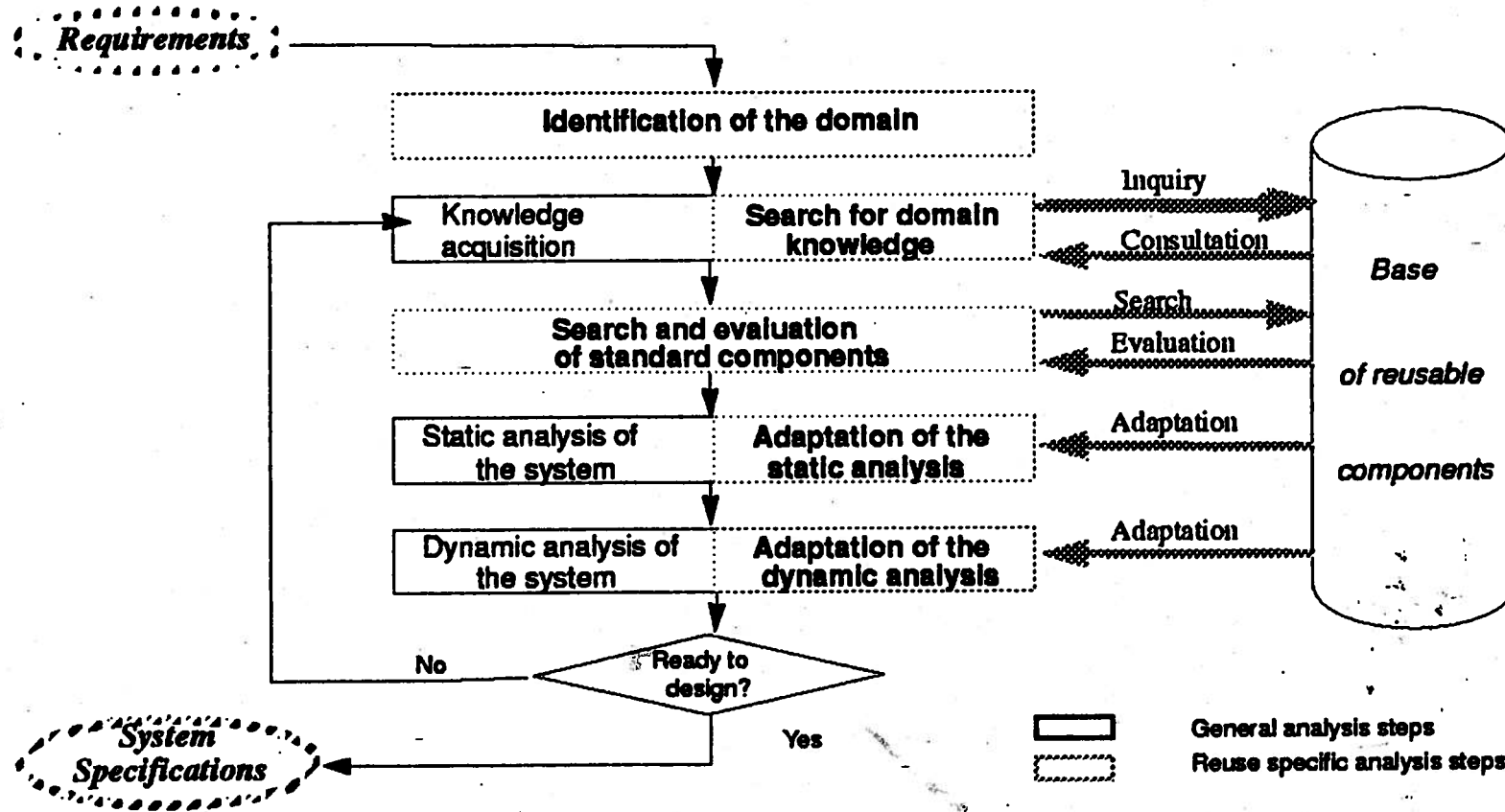


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# Development WITH reuse process: The Analysis phase



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## Classification

**“The manner in which the assets are organized for ease of search and extraction within a reuse library”**

**“... Only the librarian knows from the collocation of the volume, from its degree of inaccessibility, what secrets, what truths or falsehoods, the volume contains. Only he decides how, when, and whether to give it to the monk who requests it.”**

**“The Name of the Rose” by Humberto Ecco**

## Classification and Retrieval

- + Classification is essential for meaningful organization of the collection
- + Search and Retrieval of components must be effective  
(Mapping of wanted versus existing functionality)
- + Selection of similar components depends on how collection is organized

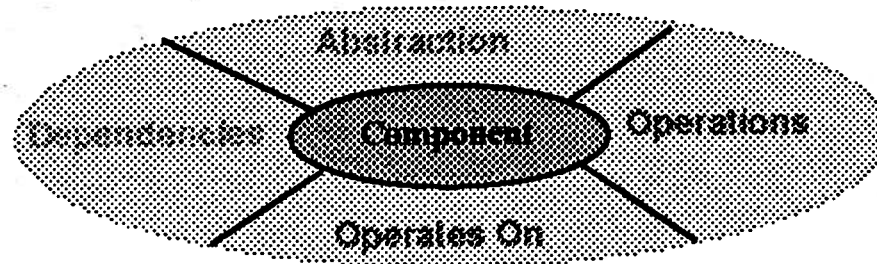
==> We have chosen a faceted classification scheme



# The REBOOT Classification scheme

- **Facet-based:** Ideas of Ranganathan and Prieto-Díaz adapted to the classification of object-oriented components.  
  
One term-space per facet.

- **Four facets:**



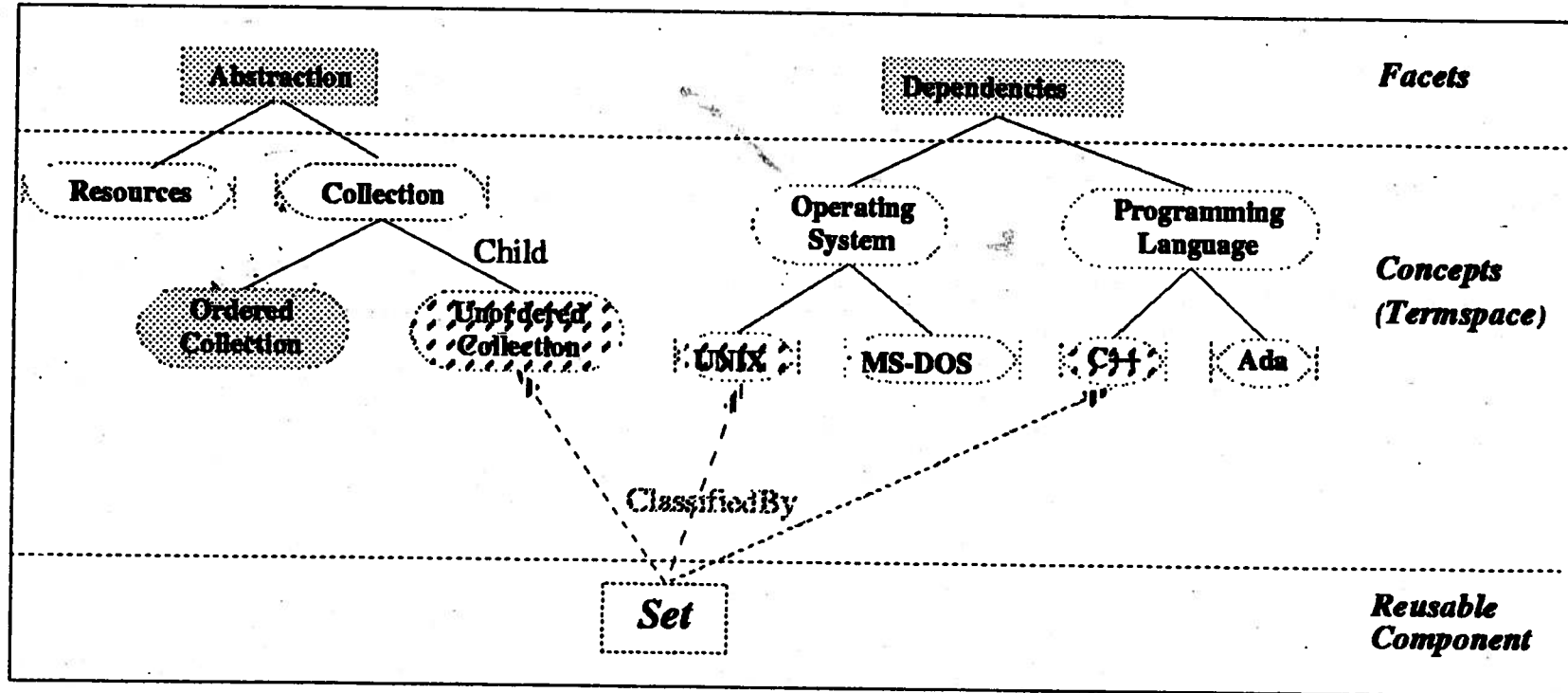
- **Abstraction:** Noun characterizing a component (stack, flight reservation)
- **Operations:** Operations of the component (push etc., reserve etc.)
- **OperatesOn:** Entities the component acts on (integers, seats)
- **Dependencies:** Non-functional characteristics (Unix-based, C++)

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# An example of classification (with the specialize / generalize hierarchy of the termspace)

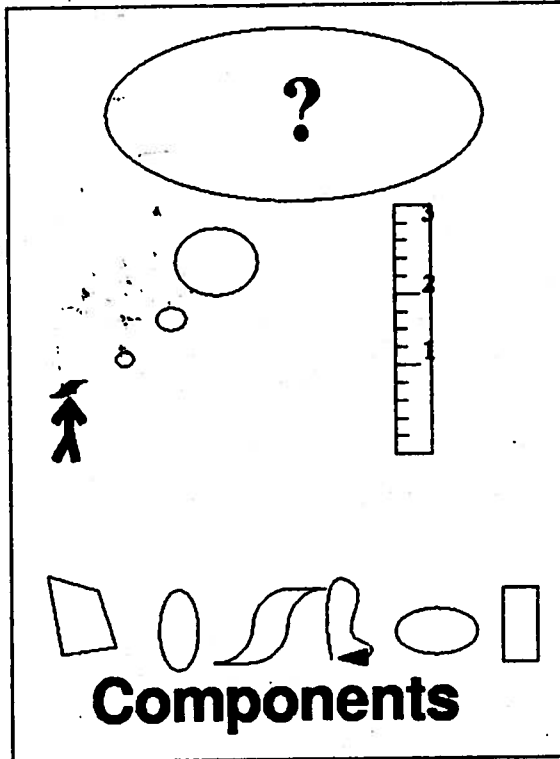


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# Reuse Product Metrics



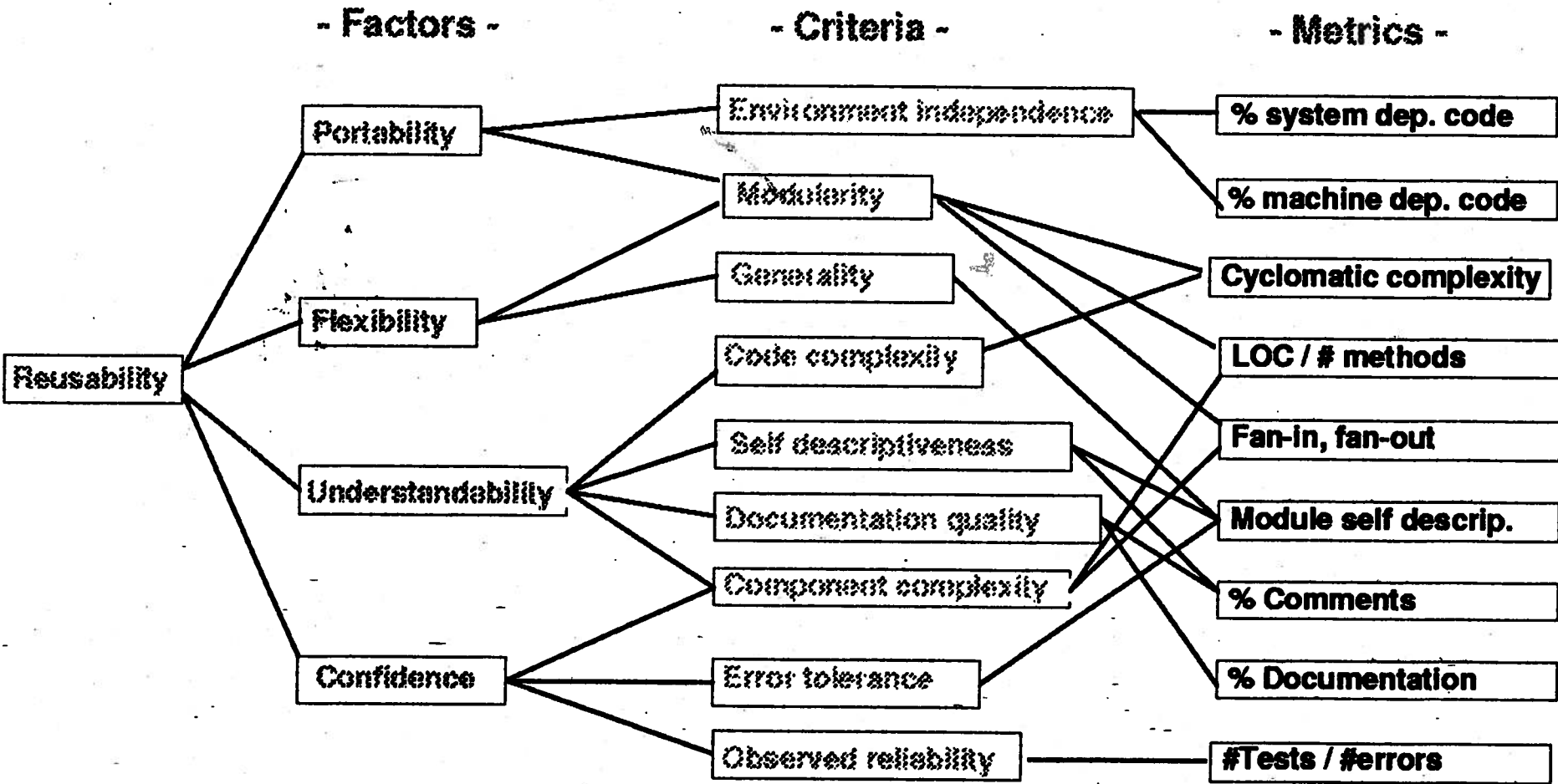
**To measure**

- Reusability
- Quality

**of potential reusable components**

**and to compare different components**

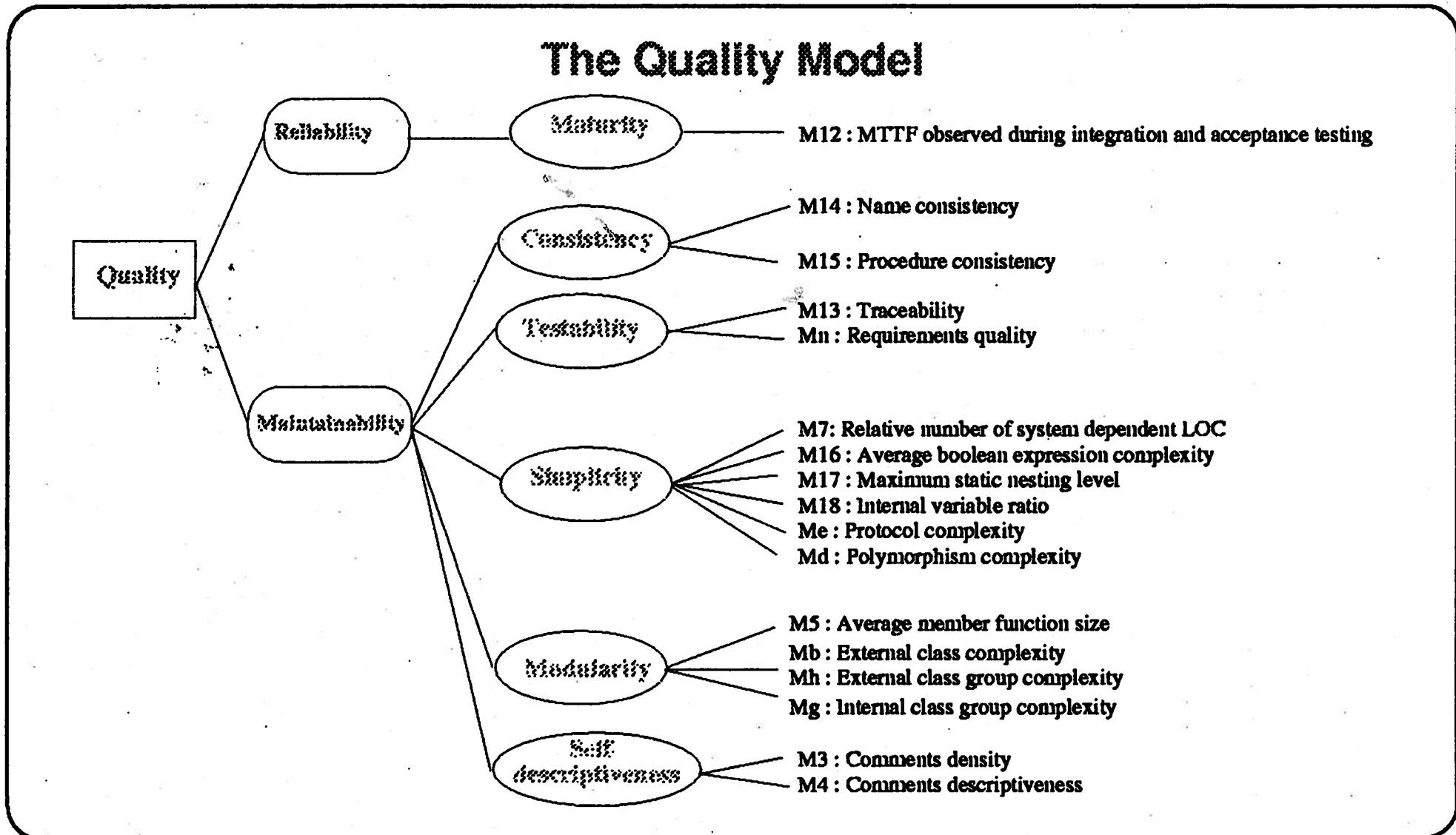
# The Reusability Model



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## A posteriori factor estimates

$$Reliability(t) = e^{-t/maturity}$$

$$Maintainability = \frac{Maintenance\ productivity}{Development\ productivity}$$

$$Portability = 1 - \frac{Cost\ to\ port}{Cost\ to\ develop}$$

$$Flexibility = \frac{Change\ productivity}{Development\ productivity}$$

$$Understandability = 1 - \frac{Cost\ to\ understand}{Cost\ to\ develop}$$

$$Confidence = Reliability + (1 - Reliability) \text{ Fault tolerance}$$

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## Reuse Process Metrics

- **To measure:**

- a. **The effort spent in reuse-specific activities (costs)**

- **additional effort to develop reusable component**
    - **effort to document for reuse, to qualify and classify**
    - **effort to search, evaluate, retrieve and incorporate.**
    - ...

- b. **The improvements due to reuse (savings)**

- **Saved work by reuse of components**
    - **Reduced number of errors**
    - **Reduced maintenance costs**
    - **Reduced rework because of better analysis and design**
    - **Increased standardization**
    - ...

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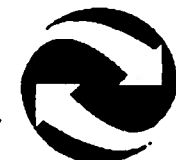


## Example of collected cost data

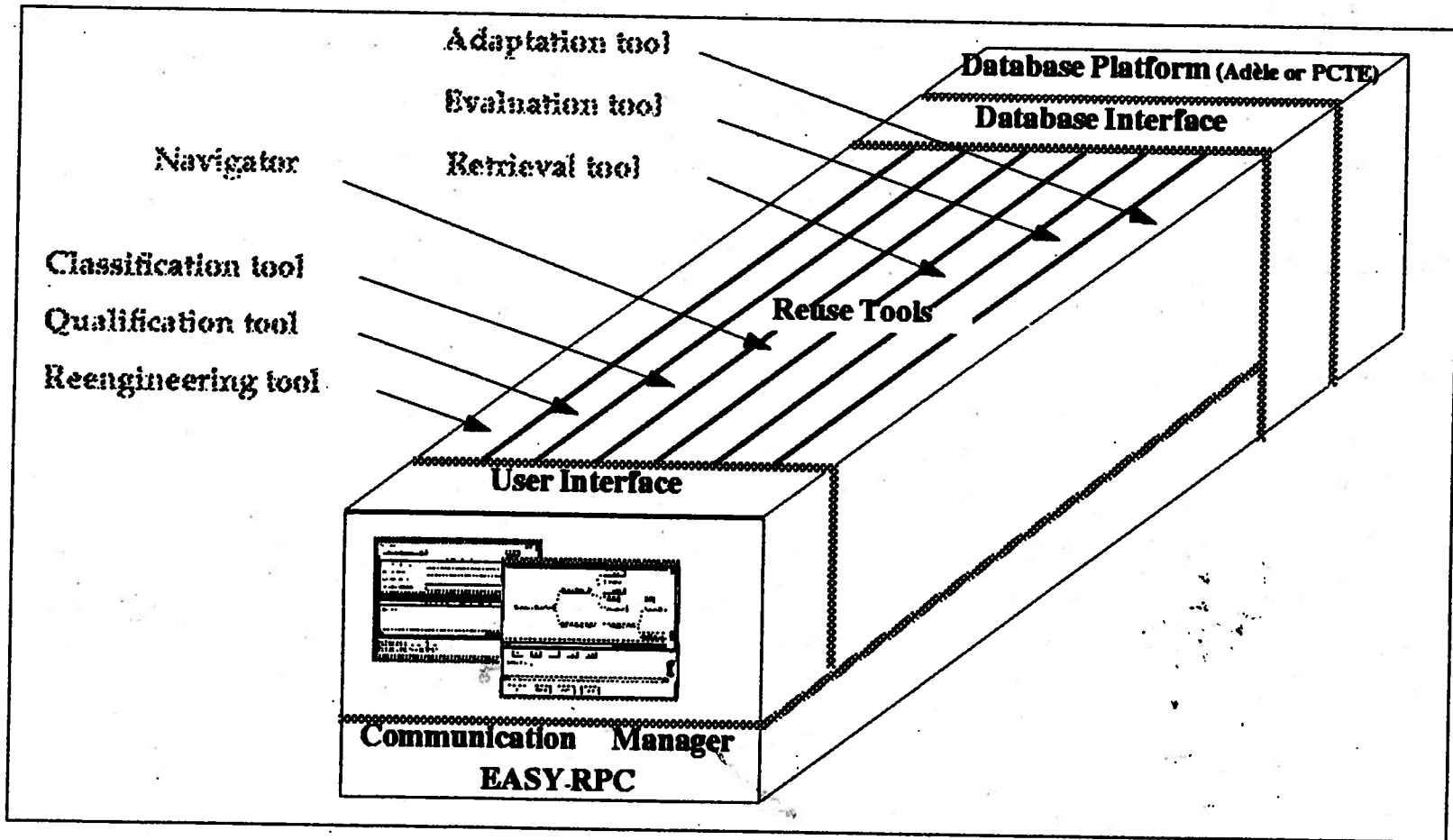
Data carrier	Data value	Comments
The domain where the reused component was developed - title	<i>Time management</i>	<i>Framework for time management</i>
Type of component (method, class, framework, etc.)	<i>framework</i>	
Size of reusable component - Lines Of Code (LOC)	<i>3000</i>	
Cost of development for reusable component - person-days	<i>120</i>	
Estimated costs for making non-reusable component - person-days	<i>80</i>	<i>However this module has supported several changes in requirements of the general system. Most time would have been necessary if it were not reusable.</i>
Effort spent on documentation - person-days	<i>10</i>	
Development costs spent on design - person-days	<i>30</i>	<i>the hierarchy has been changed several times.</i>
Development costs spent on coding - person-days	<i>30</i>	
Development costs spent on testing - person-days	<i>40</i>	
Number of errors found during testing	<i>3</i>	

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# The Architecture of the REBOOT Environment



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## The REBOOT Environment

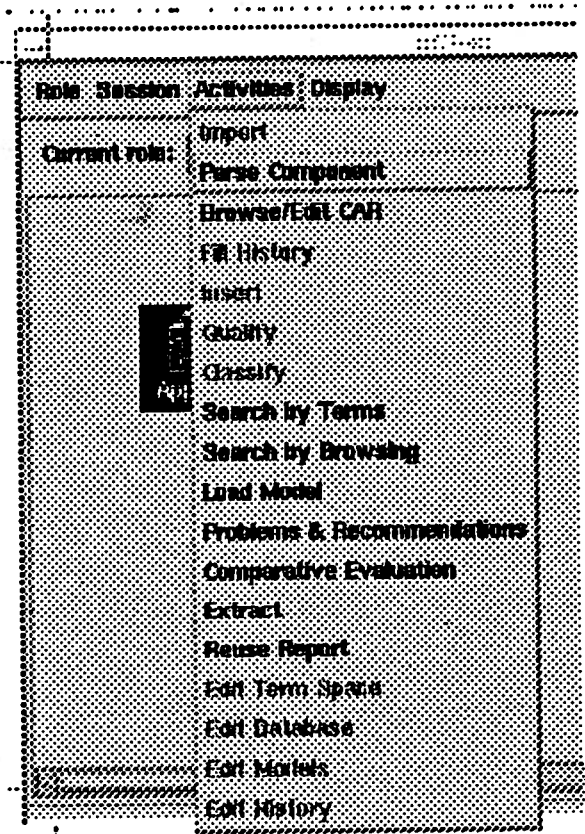
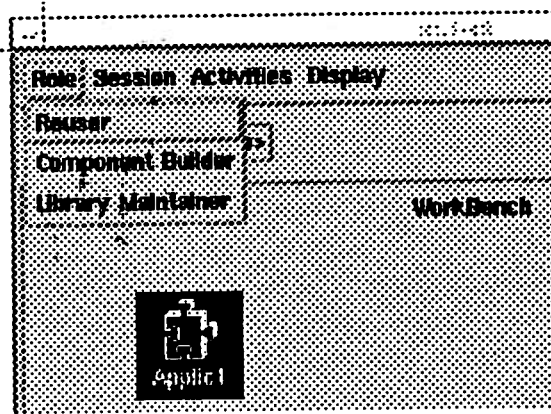
- **Runs on UNIX (currently on Sun Sparcstations).**
- **Compliant with standards (OSF/MOTIF, ...).**
- **Designed to be easily integrated in Soft. Dev. Evt. (e.g. ISD).**
- **Written in C++ (more than 100.000 lines).**
- **Portable onto other database platforms (e.g. RDBMS, OODBMS).**
- **Available for experimentation under non-disclosure agreement.**

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# The Reuse Coordinator

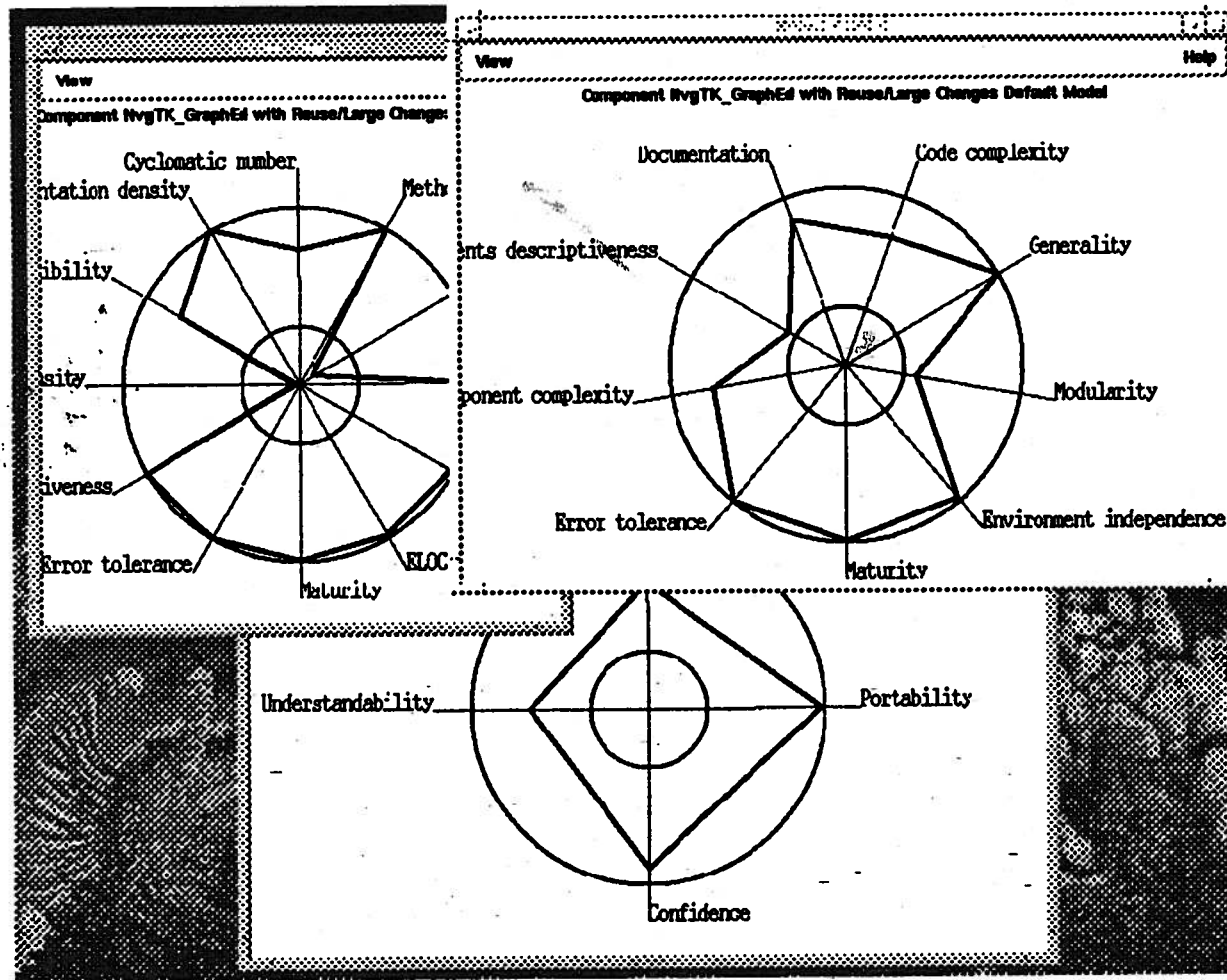


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# The Qualification tool: Display of Kiviat graph

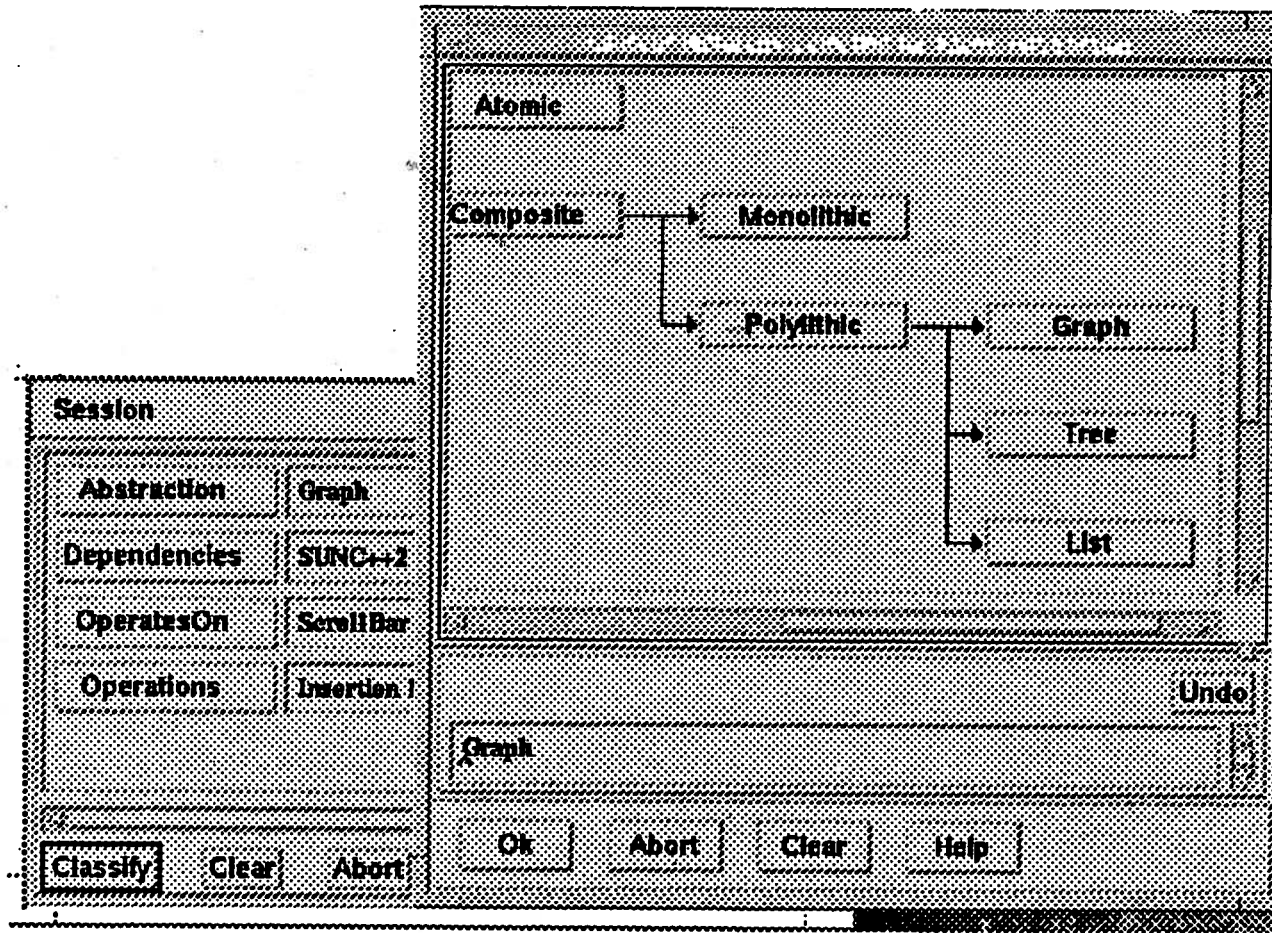


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# The Classification-Retrieval service

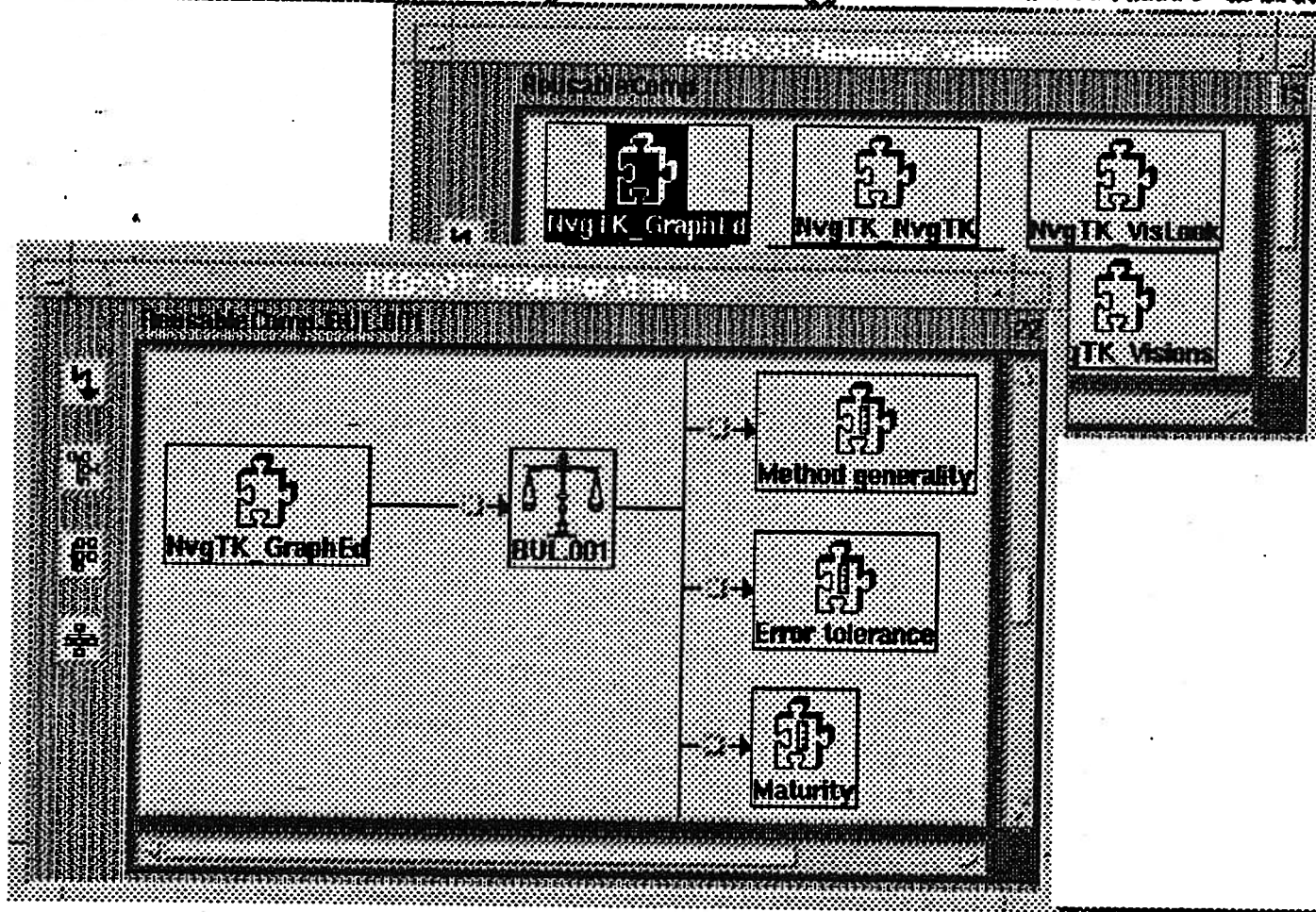


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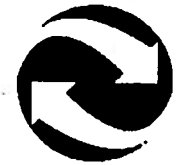


# The Navigator (to search by browsing and maintain database)

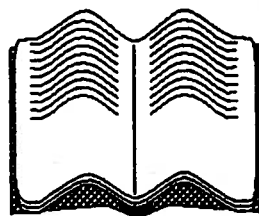


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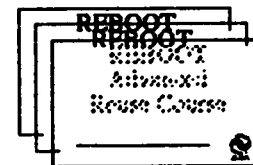
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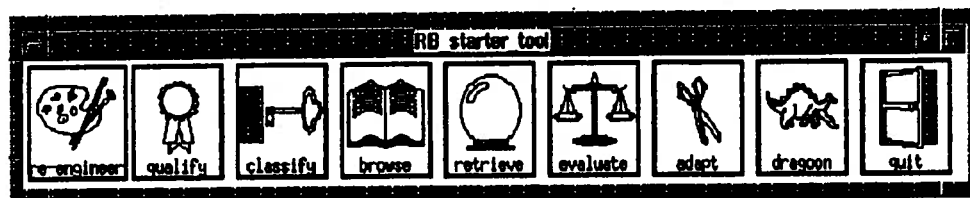
# The REBOOT Offer



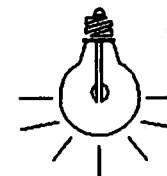
The Methodology Handbook



The Training package



The REBOOT Environment



The Know-How

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# The REBOOT Methodology Handbook

## □ The audience

- **High level manager:** Model to evaluate costs and benefits of reuse in an organization, and outline of the ideal organization.
- **Project manager:** Support to analyse reuse potential, to organize, to manage and to measure.
- **Reuse champion:** Guide to incremental introduction of reuse.
- **Methodologist:** Guidelines and examples to adapt the existing software development to reuse.
- **Software engineer:** Guidelines to develop FOR and WITH reuse.

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# The REBOOT Methodology Handbook

## □ The contents

- **Chapter 1: Organizing and managing reuse**
  - Benefits of reuse - Success stories
  - Mature reuse organization - Keys reuse area
  
- **Chapter 2: Managing a reuse project**
  - How to organize - Roles and tasks
  - Adaptation of the software development process to reuse
  
- **Chapter 3: Development FOR and WITH reuse**
  - OO development FOR and WITH reuse
  - Re-engineering for reuse - Cleanroom adaptation
  
- **Chapter 4: Library organization**
  - Classification - Component library management
  
- **Chapter 5: Metrics** - Product metrics - Process metrics - Cost estimation
  
- **Chapter 6: Introducing reuse into an organization**

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## The REBOOT Methodology Handbook (cont'd)

- **The version V1.5 (400 pages) has been delivered mid-April 94,**
- **It will be finalized (version V2) by the end of August 1994, and should be published by John Wiley & Son by the end of 1994.**
- **V2 will take into account Reviewers' comments and include:**
  - **additional examples**
  - **an extended version of the Re-engineering methodology**
  - **a more detailed questionnaire to assess the Reuse Maturity Level**

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## The REBOOT Courses

- **Based on the contents of the Methodology Handbook + Experience**
  
- **For various audiences:**
  - **Management:** (2 hours) **Non-technical aspects (i.e Organization, Management, etc.).**
  - **Project Managers:** (1 day) **Non-technical aspects + High level technical aspects**
  - **Developers:** (2 days) **Technical aspects: How to develop FOR and WITH reuse**
  - **Library Manager:** (1 day) **The Reuse tools**
  
- **Generic courses to be adapted to the audience and context**

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## Conclusion

**We are ready to help you introduce REUSE in your organization**

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