

Design for Manufacturing

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3. Designers and Design Teams

- Early designs – iterative improvement based on repeated prototypes
  - Longer time for perfection and mature designs
  - Knowledge to be gained by actual fabrication and testing
  - Knowledge passed on by apprentice programs
- Complex products cannot use the same procedures
  - Knowledge to be gained by other means

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Human Information processing

- Information processing takes the interaction of
  - Internal environment
    - Human brain
  - External environment
    - Catalogs, paper and pencil, etc.

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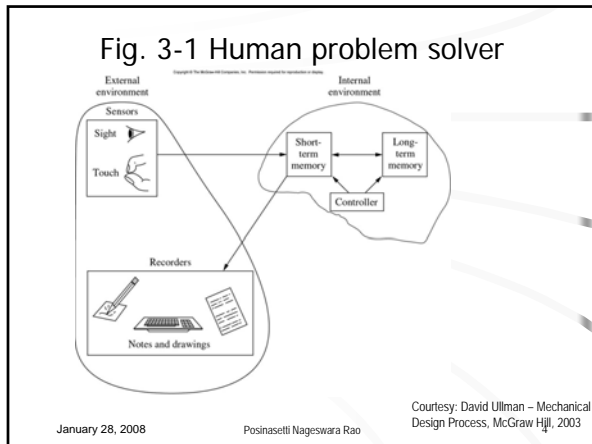
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- ### Human Information processing
- **General knowledge**
    - Gained through everyday experience and basic schooling.
  - **Domain specific knowledge**
    - Comes from study and experience in the specific domain. Formal education
    - It takes 10 years to gain enough specific knowledge in a domain
  - **Procedural knowledge**
    - Comes from experience.
    - But some may be based on general knowledge and some on domain specific knowledge
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- ### Short term memory
- It is quick (0.1 second)
  - Very small (7 chunks of information  $\pm 2$ )
  - Needs refreshing
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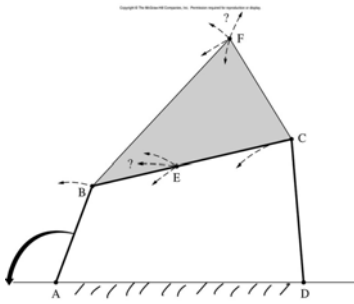
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Fig. 3-2 A four bar linkage



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Courtesy: David Ullman – Mechanical Design Process, McGraw Hill, 2003

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## Long term memory

- Unlimited capacity
- Slow (2 to 5 minutes)
- Speedy recovery (0.1 second)
- Retrieved at different levels of abstraction

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## THE FAR SIDE® By GARY LARSON



"Mr. Osborne, may I be excused? My brain is full."

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Courtesy: David Ullman – Mechanical Design Process, McGraw Hill, 2003

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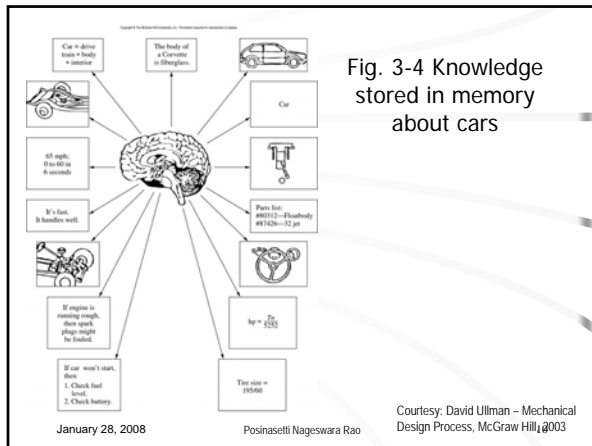


Fig. 3-4 Knowledge stored in memory about cars

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## Controller

- Helps in allowing the information assimilation and utilization process.

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## External Environment

- Extend short term memory
- Making notes and sketches
- Sketches are fast to make and are information-rich

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## Implications of the model

- All design and decision making is limited by human cognitive capabilities
- What is to be done?
  - Breakdown problems into finer sub problems

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## Mental processed during design

- Understand
- Generate
- Evaluate
- Decide

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## Understanding the problem

- Design a joint to fasten together two pieces of 1045 sheet steel, each 4 mm thick and 60 mm wide, which are lapped over each other and loaded with 100 N.
- Retrieve the information from the long term memory and compare

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## Generating a solution

- To generate a solution we retrieve information from our long term memory if an earlier similar design was made
- If the design is completely new, then we use the decomposition technique to solve it incrementally

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- If you try to think about what you are doing while you are doing it, you stop doing it.
- If you don't reflect on what you just did, you are doomed to repeat it.

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## Evaluation and Deciding

- Evaluation requires comparison between generated ideas and the laws of the nature, the capability of technology and the design requirements
- Once a problem is solved, a decision has to be made to accept the generated solution and go for another one.

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## Problem solving behavior

- **Introvert**
  - Listens, thinks and then speaks
  - Works alone to solve problems
- **Extrovert**
  - Sociable, speaks and then thinks
- About 75% Americans are
- About 48% of engineering students and top executives are
  - Extroverts

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## Problem solving behavior

- **People dealing with facts**
  - They are literal, practical and realistic
- **People dealing with possibilities**
  - They like concepts and theories
- About 75% Americans are
- About 66% of top executives are
- About 34% of engineering students are
  - Fact oriented
- **Design requires**
  - Facts and possibilities

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## Problem solving behavior

- **Decision making process**
  - Subjective, or
    - Decisions based on inter personal involvement, circumstances and the "right thing to do"
  - Objective
    - Logical, detached and analytical
- About 51% Americans are
- About 95% of top executives are
- About 68% of engineering students are
  - Objective decision makers

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## Problem solving behavior

- Need to make decisions
- Decisive
  - Makes with minimum stress, and likes an environment that is ordered, scheduled, controlled, and deliberate
  - Tend to jump to conclusions
- Flexible
  - Goes with the flow, is flexible, adaptive, and spontaneous, and finds making and sticking with decision difficult.

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## Characteristics of a creative Designer

- Natural talent
- No correlation with intelligence
- Visualizer, a hard worker, and a constructive nonconformist with knowledge about the domain and the ability to dissect things in his or her head.

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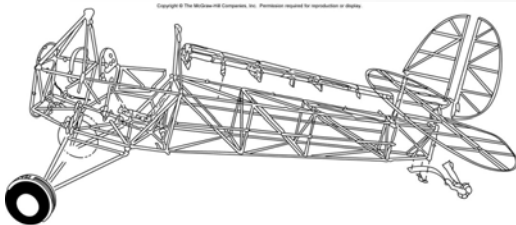
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Fig. 3-5 Airframe of a small aircraft



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Courtesy: David Ullman – Mechanical Design Process, McGraw Hill, 2003

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## Engineering design teams

- Complex products 
- Boeing 747
  - 5 million components
  - 10,000 person years of design time
  - 3 years
- Design teams 

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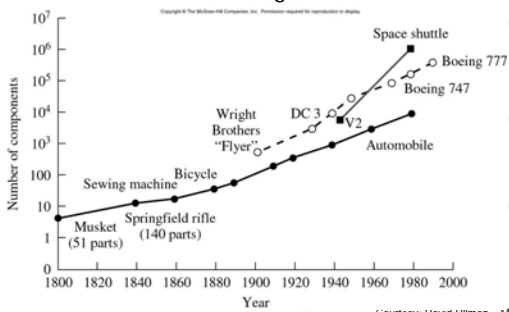
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Fig. 3-6 Increasing complexity in mechanical design



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Courtesy: David Ullman - Mechanical Design Process, McGraw Hill, 2003



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## Team goals

- A team is a group of people working toward a common understanding
- Team members should collaborate
- Team members must compromise
- Team members establish communication
- Team members are committed to the good of the team

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## Team roles

- **Organizer or Coordinator**
  - Mature, confident and trusting
  - Good at clarifying goals and promoting decision making
- **Creator**
  - Imaginative and can solve difficult problems
  - Impractical, have a disregard for protocol, and work with possibilities than facts

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## Team roles

- **Gatherer**
  - Good at Exploring and developing contacts
  - Very enthusiastic, but may lose interest when the details are reached
- **Motivator or shaper**
  - Dynamic, outgoing and assertive
  - Impatient with vagueness
  - Makes logical and objective decisions

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## Team roles

- **Evaluator**
  - Intelligent and shrewd
  - Accurate judgments but not a leader
- **Team worker**
  - Avoids friction in a team and subjective decision maker
- **Solver**
  - Turns ideas into practice
  - Disciplined, reliable, and efficient
- **Completer or pusher**
  - Delivers results on time
  - Works with facts than ideas

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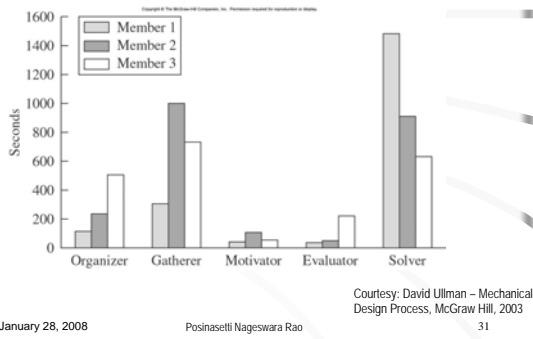
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Fig. 3-7 Team roles played by each team member (3 members working on a project for 57 minutes)




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## Building Team Performance

- Keep the team productive
  - All members understand the purpose
  - The members feel it is exciting
  - The goals are clear, simple and measurable
  - The goals are realistic
  - The approach is clear

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## Building Team Performance

- Select based on skills, primary and secondary
- Establish clear rules of behavior
- Set and seize upon a few immediate performance oriented goals and tasks
- Spend time together
- Develop a common understanding

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## Summary

- All design and decision-making is governed by human cognitive limitations.
- If you try to think about what you are doing while you are doing it, you stop doing it.
- If you don't reflect on what you just did, you are doomed to repeat it.
- A team is a group of people working toward a common understanding.

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## Questions and Comments

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