Contents

1. This is clearly a subjective situation. Different people may have different preferences. I've already tipped my hand by selecting the ABET definition as the basis for our earlier discussion. So it is not surprising that I prefer the definitions from this list that have similar features as the ABET definition. Here are some comments on each of the definitions.

A. The phrase "purposeful activity" is too vague for my taste. Activities such as selling, repairing, or writing about a technological system that fulfills human needs appear to be covered by this definition. I do not consider these activities, by themselves, to be design.

B. If we omit the word "mechanical", this definition is pretty good. My major reservation with it is the requirement that the system perform its functions with "maximum economy and efficiency". This is too restrictive, since many good engineering designs involve conscious tradeoffs of economy and efficiency with other attributes such as safety, aesthetics, environmental impact, etc..

C. My major reservation with this definition is the vague phrase "applying various techniques".

D. One of the problems I have with this definition is its total focus on simulation. I think of simulation as one of the analysis tools that are available for use during the design process. To my mind, design consists of many other activities besides simulation.

E. This is too vague because it allows for non-engineering solutions. I also have reservations about the exclusive focus on an optimum solution. Many excellent engineering designs are the result of compromises and tradeoffs between competing pressures.

F. As with Definition E, this definition can be used to describe many kinds of activities other than engineering design (landscape design, architectural design, interior design, etc.)

G. Almost any kind of artistic endeavor (pottery, composing music, etc.) is a creative activity that involves bringing into being something new and useful that has not existed previously.

H. It seems to me that there are many activities other than engineering design (such as sky-diving) that can be described as "performing of a very complicated act of faith".

I. This definition also is overly broad. Working a crossword puzzle is an example of a goal-directed problem-solving activity.

J. This definition appeals to me, except its focus on information ignores the use of creative processes and scientific principles (in comparison to Definition B which explicitly includes these other aspects).

If I could modify Definition B by removing the word "mechanical", that would be my choice from this list. If not, my choice would be Definition J.

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2. Here are six design-oriented professions. There are many other possibilities.

a) architecture: design buildings with emphasis on shape, aesthetics, and being people-friendly

b) interior decorating: design interior furnishings of buildings, including colors; selection of fabrics, furniture, and accessories

c) landscaping: select and arrange trees, shrubs, flowers etc. to create an aesthetically pleasing, functional, and easily maintained park or open space adjacent to buildings or other structures.

d) industrial or product design: design shape and appearance of industrial or consumer products to enhance their visual appeal and usability.

e) urban planning and design: design urban spaces and form, including overall layout of city streets, public transit systems, and parks; limits on building size and location.

f) advertising: design product packages and commercials to enhance their appeal to consumers.

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3. Don Lambert is a talented machinist and a dedicated tinkerer. However, designing and building a steam engine that can run on scrap wood as fuel is not a particularly remarkable feat. Steam engines are a quite mature technology and there is sufficient published material on how to build one. Large steam engines are used today to generate electricity in power plants, but they have been shown to be uneconomical in comparison to other technologies in many applications. For example, they lost out a long time ago to the internal combustion engine for powering automobiles. Nevertheless, a good machinist with access to inexpensive scrap metal and the proper machine tools, and with enough time to "tinker", should be able to build a small working steam engine. Don's estimate of the costs of developing his engine do not include the cost of his time to build the machine, to gather the scrap wood, and to feed and maintain the engine (it has to be stoked every 40 minutes). As long as Don has the time to devote to this project, his engine will probably serve his needs quite well. But it is unlikely to be a commercially successful product.

It is not surprising that engineers from Boeing and Washington State University have not shown a great deal of interest in Don's work. It does not contain any technological breakthroughs and its prospects for successfully competing in the market place with existing commercially available technologies are very slim.

It is a stretch to call Don's activities "backyard engineering". A more accurate description would be backyard tinkering, supported by many years of experience as a machinist, and plenty of time on his hands to devote to the project. Real engineering, the kind that is practiced by engineers at Boeing, Washington State University, and every professionally successful engineering team, relies on applying complex principles of thermodynamics, heat transfer, materials behavior, etc. to make judgments of the viability of proposed designs without having to spend years tinkering with them.

4. Here is my list. It is obviously not unique.
   1. *engineers*-designing the tunnels, stations, and vehicles
   2. *heavy equipment operators*-excavation
   3. *elected officials*-securing public financing
   4. *transportation planners*-identifying routes and station locations
   5. *welders*-manufacturing the vehicles
   6. *lawyers*-securing legal right-of-way
   7. *real estate brokers*-purchasing properties needed for station access
   8. *artists*-designing murals for stations
   9. *public relations*-informing public of plans and progress
   10. *carpenters*-building wooden forms for concrete structures

5. Here is my list. It is obviously not unique.
   1. *engineers*-preliminary design of the structural, mechanical, and electrical systems
   2. *financial analysts*-estimate costs of land acquisition, construction, and operation
   3. *elected officials*-assess public willingness to share costs
   4. *architects*-specify the exterior and interior shapes, sizes, and materials
   5. *marketing specialists*-explore feasibility of selling naming rights, luxury box seats, seat licenses
   6. *lawyers*- draft leasing and concession agreements
   7. *real estate brokers*- examine ownership status of properties needed for arena construction
   8. *public relations*-informing public of plans and progress

6. Here is my perspective. Your approach may be equally valid.

a) this is the only one that has polar symmetry

b) this is the only one whose perimeter is composed solely of straight lines

c) this is the only one that does not possess an axis of symmetry

d) this is the only one whose perimeter consists of a combination of straight lines and curved segments

e) this is the only one whose only axis of symmetry is vertical

7. Here is one way to envision the correspondence between each step in the model and the elements of the ABET definition.

Design Process Model	ABET Definition of Design
1. Recognizing the need	...to meet desired needs
2. Defining the problem	...establishment of objectives and criteria, ...formulation of design problem statements and specifications ...include...constraints
3. Planning the project	...construction, testing, ...feasibility considerations
4. Gathering information	n.a.
5. Conceptualizing alternative approaches	...synthesis, ...creativity
6. Evaluating the alternatives	...analysis, construction, testing, and evaluation
7. Selecting the preferred design	n.a.
8. Communicating the design	...detailed system descriptions
9. Implementing the preferred design	...construction, testing

8. Step 1 in Walton's model combines Steps 1 and 2 in our model. Steps 2 and 3 in Walton's model correspond to Step 5 in the 9-step model. His Step 4 corresponds to our Step 6 and his Step 5 refers to our Step 7. Walton's Step 6 is the same as our Step 9.

Steps 3, 4 and 8 in the 9-step model to not have any explicit counterpart in Walton's version.

9. Step 1 in Meredith's model combines Steps 1 and 2 in our model. Steps 2 and 3 in Meredith's model correspond to Step 3 in the 9-step model. His Step 4 corresponds to our Step 6 and his Step 5 refers to a combination of our Steps 5 and 6. Meredith's Step 6 is the same as our Step 7.

Steps 4, 8 and 9 in the 9-step model to not have any explicit counterpart in Meredith's version.

10. Step 1 in Middendorf's model combines Steps 1 and 2 in our model. Steps 2 and 4 in Middendorf's model correspond to Step 6 in the 9-step model. His Step 3 corresponds to our Step 5 and his Step 5 refers to a combination of our Steps 8 and 9.

Steps 3, 4 and 7 in the 9-step model to not have any explicit counterpart in Middendorf's version.

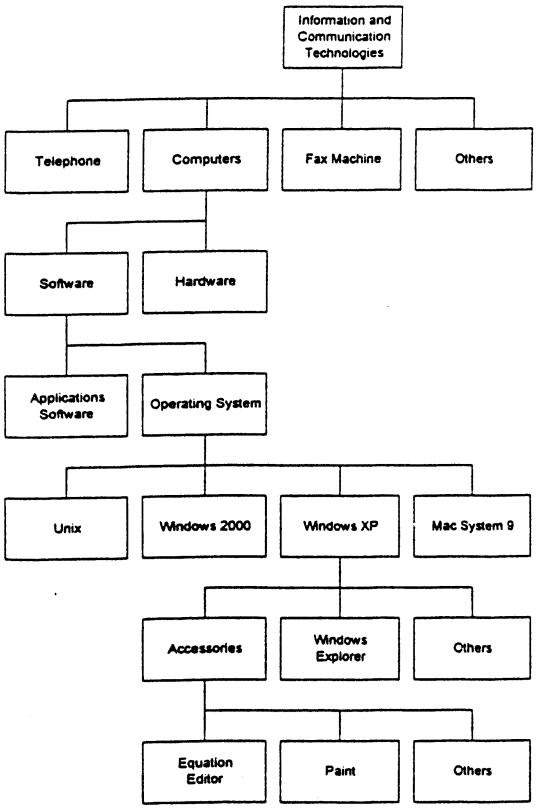
11. Step 1 in Simon's model combines Steps 1 and 2 in our model. Step 2 in Simon's model corresponds to Step 4 in the 9-step model. Without additional clarification about Simon's terminology, it is hard to know what he meant by the next two steps. However, his Step 3 appears to correspond to our Step 6 (analysis) and his Step 5 could refer to our Step 5. The optimization step in Simon's model does not have an explicit counterpart in the 9-step version. Simon's Step 7 combines our Steps 8 and 9.

Steps 3 and 7 in the 9-step model do not have any explicit counterpart in Simon's version.

12. There are many plausible ways to think about the system structure for personal computer operating systems. The important aspects are to think of:

1. a progression of increasing larger systems of which personal computer operating systems are a part ;
2. a progression of subsystems into which personal computer operating systems can be decomposed.

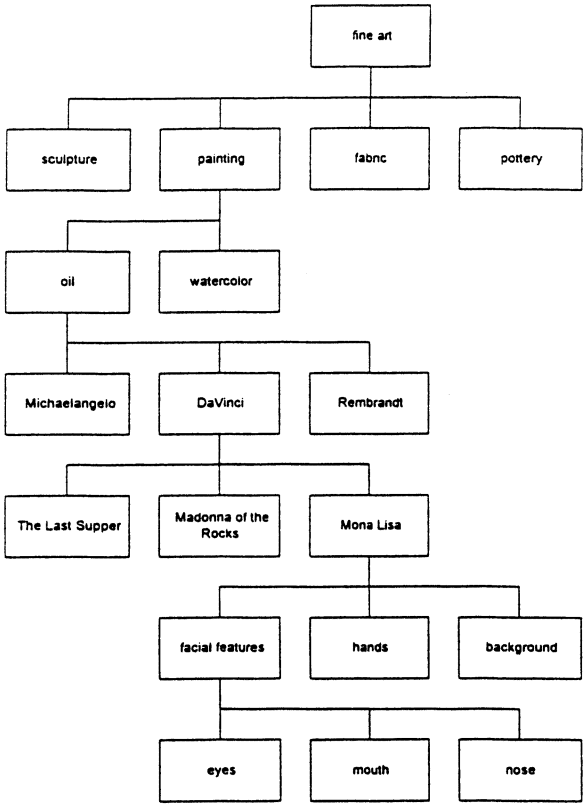
My seven-level system diagram is:



13. There are many plausible ways to think about the system structure for the Mona Lisa. The important aspects are to think of:

1. a progression of increasing larger systems of which the Mona Lisa is a part;
2. a progression of subsystems into which the Mona Lisa can be decomposed.

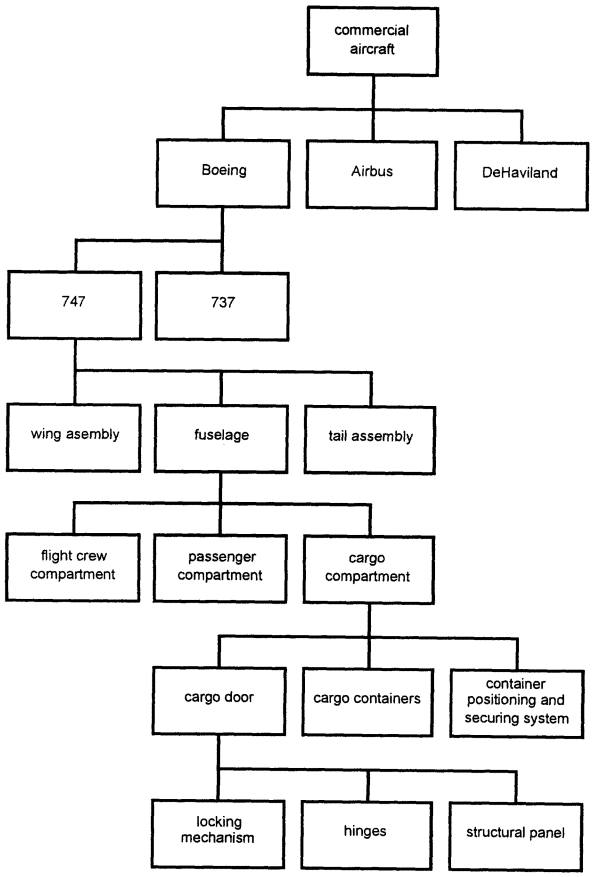
My seven-level system diagram is:



14. There are many plausible ways to think about the system structure for the cargo door of a commercial airliner. The important aspects are to think of:

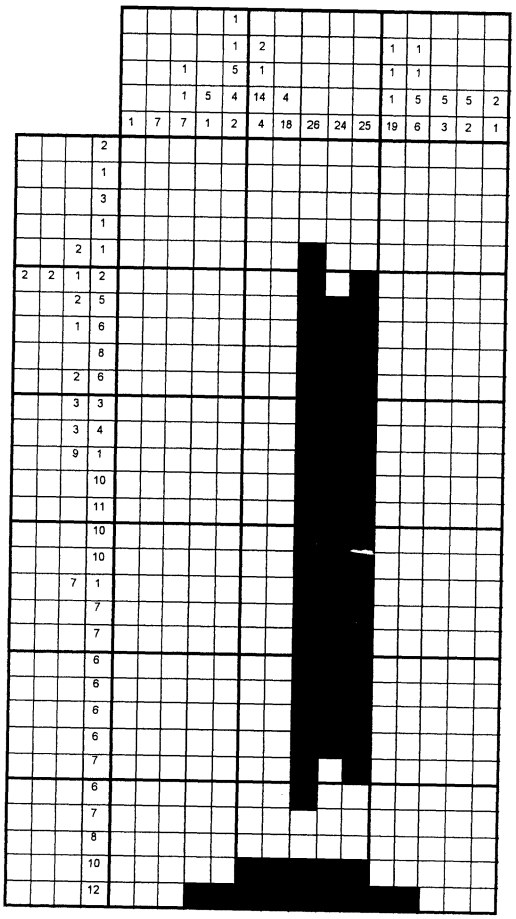
1. a progression of increasing larger systems of which the cargo door of a commercial airliner is a part;
2. a progression of subsystems into which the the cargo door of a commercial airliner. can be decomposed.

My seven-level system diagram is:



15. Controlled convergence refers to the process of steadily reducing the number of design concepts being considered through a process of consolidation and elimination. This convergence to a single concept or a small number of options occurs in several cycles during which each reduction in the number of viable options is followed by a temporary small increase in options as new concepts or refinements of current concepts are introduced. A schematic representation of this "controlled convergence" process is shown in Fig. 1-17.

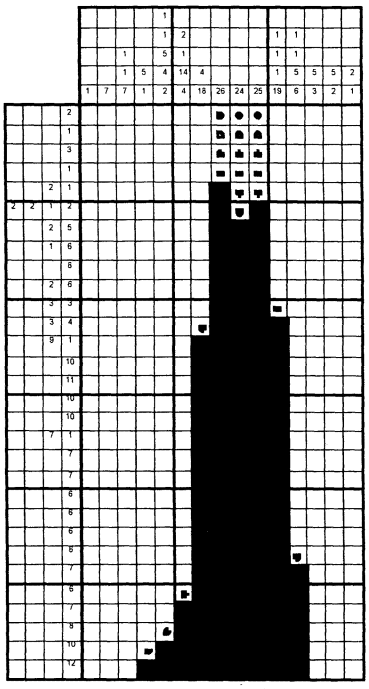
16. After examining the numerical clues in the margins, I decided to focus my initial attention on the three columns that contained solitary, long strings (26, 24, 25 boxes in length). These strings represented the largest subsystems and I was able to fill in a substantial part of each column immediately. Next I addressed those rows that had sufficiently long solitary strings that could be filled in independently of the three columns partially filled in during the previous step. These actions brought to mind the notion of focusing early design efforts on the largest subsystems. No sense getting bogged down in details until the main features of the largest subsystems have been established. See the partially completed diagram below for the results of these first two steps.



I next turned my attention to the interaction between the two main subsystems (the three columns and two rows already partially completed) and that allowed me to complete those columns. In doing so, I placed small circles in the cells near the top of those columns to mark locations not to be filled in. This process reminded me that it is not unusual for design decisions to be made by a process of elimination.

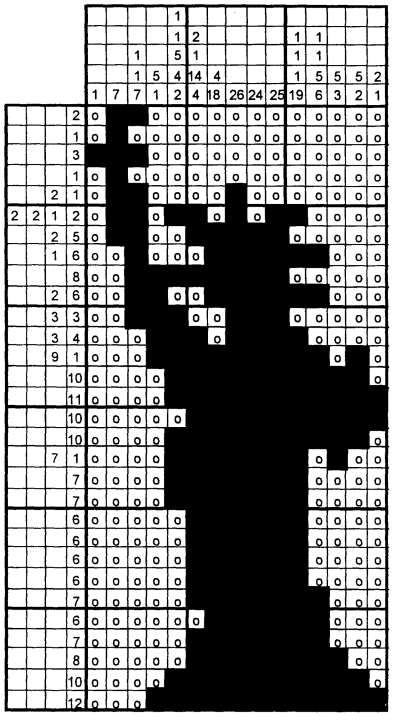
Then it was a matter of extending short branches off the existing rows and columns, beginning with starting to build up from the bottom row the six columns adjacent to the three long columns already completed.

The partially filled in grid after this second phase is displayed below.



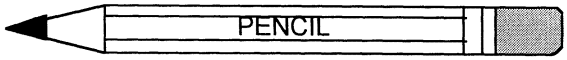
I could then extend additional rows, using the presence of the small circles to dictate the extensions in some cases. From this point on it was a matter of moving back and forth between the rows and columns, filling in the details in a process analogous to the detail component design stage.

The completed puzzle, depicting the Statue of Liberty, is shown below.



17. Here are four (out of many) inexpensive writing instruments together with their advantages and disadvantages. Obviously there are are many other possibilities.

advantages	disadvantages
• readily available in any desired color	• cannot be purchased individually
• draws thick lines	• cannot draw thin lines
• permanent	• not easily erased
• uses all material	



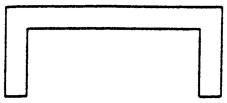
advantages	disadvantages
• easily produce thin lines	• smudges
• erases easily	• requires pencil sharpener
• built-in eraser	• point breaks easily

advantages	disadvantages
• easily produce thick lines	• cannot draw thin lines
• erases easily	• breaks easily
• uses all material	• produces dust
	• requires blackboard

advantages	disadvantages
• permanent mark	• hard to erase
• retractable point	• uneven ink flow
• built-in pocket clip	• ink clogs

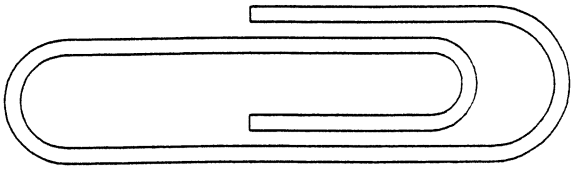
18. There are many possibilities. The four products I selected are: a staple, two styles of paper clips, and a binder clip. They are depicted below along with a list of advantages and disadvantages for each one. These lists are clearly not unique. You may have thought of many reasonable items that are not on my lists.

Option 1: staple



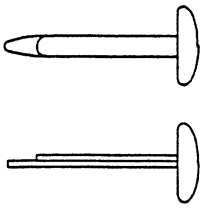
advantages	disadvantages
• durable connection	• requires special tool (stapler)to install
• compact connection	• requires special tool (staple remover) to remove
• conducive to automated installation	• leaves two small holes in paper
• requires no special preparation of paper	• not reusable

Option 2: paper clip type 1



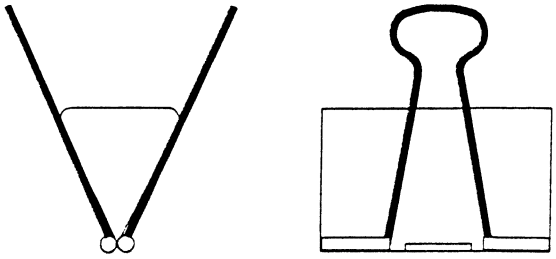
advantages	disadvantages
• easy to use	• easily dislodged
• easy to remove	• can only accommodate limited number of sheets
• does not require special tools	
• requires no special preparation of paper	
• reusable	

Option 3: paper clip type 2



advantages	disadvantages
• easy to use	• requires pre-punched paper
• easy to remove	• tips of prongs easily snagged by other objects
• does not require special tools	
• reusable	
• can handle a wide range in the number of sheets	

Option 4: binder clip



advantages	disadvantages
• easy to use	• bulky
• easy to remove	• expensive
• does not require special tools	
• reusable	
• requires no special preparation of paper	
• can handle a wide range in the number of sheets	

19. Here is my list of five ladder types:

• step ladder - This is a self supporting ladder, allowing it to be used in open areas away from walls. Versions for use around the house may have as few as one or two steps.

• extension ladder - The high end of this ladder requires a wall or other structure to rest against. The ability to adjust the length of this ladder makes it a popular configuration for outdoor projects such as house painting.

• escape ladder - This specialized ladder has a set of hooks at its top so that the ladder can be hung from a wall or window sill, permitting occupants to escape from a fire.

• articulated ladder - This ladder has several elements whose position relative to adjacent elements can be adjusted. One possible arrangement is in the form of a step ladder with unequal legs, allowing the ladder to be set up on a stair case.

• collapsible ladder - Primary advantage of this ladder is compact storage.

20. Design a balloon that can carry 1200 ml of H_2 to an altitude of one mile.

21. Design a 10 volt DC circuit so that the current flowing through the circuit 0.1 sec. after activation is 0.227 microamps. The governing equation is

$$i = \frac{V}{R} e^{-\frac{t}{RC}}$$

For a given V, t, and i, this reduces to an equation involving two unknowns, R and C. There are an infinite number of

solutions, each one obtained by specifying a value of one of these unknowns and solving for the other.

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22. Generally, I would prefer a piece of cake to the other options at a party or as dessert for a sit-down meal. An ice-cream cone or candy bar is more likely to be an on-the-go snack, with ice cream being the preferred choice during a hot summer day.

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23. My notion of a cappucino is a thick layer of milk foam sitting on top of espresso. It is made by spooning the foam on top of the liquid espresso. Consuming all the foam likewise usually requires a spoon. This presents a technical feasibility issue not normally encountered with consumption of beverages.

Another feasibility issue is the size of the market. How many people are both cappucino drinkers and bike riders? And of those, how many wish to combine those activities?
