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*The checklist is actually a shortcut to problem solution, serving to ensure that no necessary steps have been overlooked. As such it can be useful in a wide variety of business situations —*

## **CHECKLISTS IN PROBLEM SOLVING**

*by John J. Mariotti*

*General Motors Institute*

**I**N DEVELOPING structured approaches to problem solution, problems can be broken down into sub-problems, which in turn can be solved by taking a series of identifiable steps. The steps appear in checklists which have proved useful in specific cases. The lists may represent a consensus of planners on the important steps in solving particular types of problems. They assure the user that most relevant factors have been considered and all necessary actions have been tak-

en. Checklists usually state what the planner should do—they do not specify how he should do it or why. The lists do not necessarily indicate relationships or priorities among steps, nor do they deal with specific analytic methods or basic concepts.<sup>1</sup>

Checklists can be found every-

where. They are widely used in textbooks, in reference works, and in professional, trade, and governmental publications. We see checklists used by lawyers, doctors, and engineers. Example 1 on page 29 is a checklist used by the author in the study of office methods. Figure 1, page 30, is a chart of the paper flow for a tool checkout procedure while Example 2, page 31, is the checklist used by the analyst in developing the chart. Rarely is a problem of any size solved without

<sup>1</sup> Eagle, Alan, "A Spectrum of Analytical Approaches and Their Fields of Application to Planning," Stanford Research Institute, Stanford, California, 1965.

the aid of one or more checklists. Most of us have been pressed into grocery shopping by our wives, who may have lightened our burden by presenting us with a checklist.

### **Nature of a checklist**

What is a checklist? It has been described as an analytical framework,<sup>2</sup> an attempt to ensure that everything will be taken into account that should be taken into account before reaching a decision.

Can one ensure that all the factors which could influence a problem are included in a checklist? While the total number of factors that could influence a problem is probably finite, they are unlistable and unmanageable. However, even though the checklist cannot be a complete mapping of the factors, it serves an excellent purpose—it provokes thought and saves time by giving one a basis for analyzing one's own situation. Checklists are easily understood and can be used by relatively inexperienced people.

### **Dangers**

An inherent danger is that they have an aura of directness and completeness. One is tempted to place too much faith in their completeness. However, let us consider a specific problem such as developing a checklist for use in buying groceries. What is the purpose of the list? Are there musts? Are there wants? Who will fill it out? (Housewife, husband, children, maid—all this affects language used and format.) How often? Under what conditions? Can one checklist fit all anticipated uses? Can one checklist facilitate use by both the housewife (planner) and the husband (buyer)? What other ways are there? Are they better? Is there a standard checklist available? It is apparent that we are developing a checklist which can be used as an aid in the design of checklists.

In the typical home situation, the

## EXAMPLE I

### Office Methods Analysis Checklist

1. Volume.
  - a. The number of logical records in the file. All information concerning its history.
  - b. The number of documents processed in a significant operation.
    - (1) The average number over a given period of time sufficiently long to include at least one full cycle where applicable.
    - (2) The peak number during a cycle and when it occurs.
    - (3) The peak number during a cycle normal period.
  - c. Messages, triggers, and other data media (same information required as in 1b).
2. Estimated time required to perform the operation.
  - a. Set-up time.
  - b. Elapsed time average.
  - c. Elapsed time maximum.
  - d. Elapsed time minimum.
3. Skill or job code required to perform an operation (typist, hourly clerk).
4. Handling urgency.
  - a. Dispatch required in performing operation (posting must be done by 4:00 p.m.).
  - b. Priority or ordering of eligibles for the operation.
5. Retention in file—the duration a document or record is held in a file, a file being any significant accumulation of the documents or records even if only for a portion of the day.
6. Sequence—internal ordering of a file (alphabetic by vendor name, chronological, part number).
7. Media—form the record takes (telephone message, paper form or tag, magnetic tape, punch card).
8. Method of entering information (tools and equipment):
  - a. Keyboard (typewriter).
  - b. Handwritten.
  - c. Voice (telephone).
9. Form number and names.
10. Number of copies involved in operation.
11. Approximate number of digits or characters added or referenced in an operation detailed by components such as—Description—13 characters, Quantity—8 characters.
12. Reliability.
  - a. Likelihood of errors and their nature.
  - b. Checks and audits designated to eliminate errors.
13. Brief explanation of reason for performing operation.
14. General comments.
  - a. Exceptions—description of and frequency.
  - b. Complaints of individuals performing operation.
  - c. When form comes into a department from many departments, show all sources.

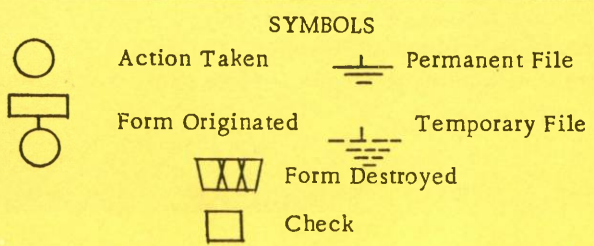
<sup>2</sup> *Ibid.*

FIGURE 1

ROUTINE SEQUENCE CHART

TITLE Tool Check-Out Procedure OBSERVER Jones DATE \_\_\_\_\_  
 (Three-Slip Method)

STEP NO.	PLACES OF PERFORMANCE									EXPLANATION	
	OPER-ATOR	FORE-MAN	TOOL CRIB ATT.	TOOL CRIB RECORD SECT.							
1		S <sub>1</sub> S <sub>2</sub>									When operator needs tool from Tool Crib.
2	S <sub>3</sub>										Checks slip for accuracy and completeness and if O. K. approves.
3		S <sub>2</sub> S <sub>3</sub> S <sub>1</sub>									
4		S <sub>2</sub> S <sub>3</sub> S <sub>3</sub>									Crib attendant checks slip authorization. If O. K. fills order.
5		T	S <sub>1</sub> S <sub>2</sub>								S <sub>1</sub> filed on board, S <sub>2</sub> filed in Tool Rack.
6	S <sub>3</sub> T										S <sub>3</sub> filed in worker's Tool Box.
7			S <sub>1</sub> S <sub>2</sub>								When need for tool is finished Time Lapse-Why Several Days.
8		S <sub>1</sub> S <sub>3</sub>									
9		S <sub>3</sub>		T					S <sub>2</sub>		Place tool back in Tool Rack.
10											Record use of tool on Tool Record card.
11									S <sub>2</sub>		
12											
13											
14											
15											



**LEGEND**

S.	TOOL SLIP	
T.	TOOL	

EXAMPLE 2

ROUTINE SEQUENCE CHART

COMPLETENESS AND ACCURACY

CHECK SHEET

	CHECK EACH POINT CAREFULLY	NO	YES	IF NO	
				STEP NO.	REMARKS
1	Is each copy of each form originated?				
2	Does each place of performance occupy one and only one column?				
3	Does each copy of each form have a definite purpose or use?				
4	Does each copy of each form end in a permanent file or destroy?				
5	Does each copy of each form have a separate line indicating its flow?				
6	Is each flow line identified?				
7	Do the number of lines entering each place of action equal the number of lines leaving each place of action?				
8	Do the number of lines entering each "check" equal the number of lines leaving each "check"?				
9	Do the number of lines entering each temporary file equal the number of lines leaving each temporary file?				
10	Does each step have only one action?				
11	Does the chart read chronologically from top to bottom?				
12	Is the chart properly identified?				
13	Are all explanations complete?				
14	Is each symbol recorded in the legend?				

### EXAMPLE 3

#### Grocery List—Ungrouped

Bread	Root beer
White, 2 loaves	Coca-Cola
Rye, 1 loaf	Biscuits
Cottage cheese, small curd	Soda crackers
Milk	Graham crackers
Lunch meat	Cakes
Ham	Ice cream
Bologna	Chicken
Hot dogs	Breasts & thighs
Soup	Steak
Vegetable	Paper towels
Chicken gumbo	Shampoo
Chicken noodle	Toothpaste
Tomato	Butter
Tide	Eggs
Light bulbs	Pickles, dill
Lettuce	Relish
Oranges	Olives
Apples	Tuna fish, 4 cans
Cucumbers	Frozen orange juice
Frozen corn	Frozen lemon juice
Peas	Hot dog buns
French fries	
Tomatoes	
Sanka	
Instant coffee	
Regular grind	

*A woman may organize a shopping list to be used by her husband so that items are arranged by classes as they are grouped in the store; all bread and pastry items are listed together, for example, and all frozen foods.*

housewife creates a list for each major shopping expedition. The list may appear as in Example 3, above, with the items arranged in the order in which she considered them.

#### **The grouped list**

With more care and some concern for her husband, the buyer in this example, the wife may group the items to facilitate finding them in the supermarket. In Example 4, page 33, Grocery List—Grouped, the items are arranged by classes such as dairy, bread and pastries, frozen foods, etc. Notice that we have some overlap in the groups, since vegetables can be fresh, frozen, or canned. This overlap is an ever present problem in the development of checklists.

To facilitate maximum use of the list by the buyer, the groups should be arranged to match the layout of the store. The actual layout of the

supermarket supplies the rationale for the arrangement of the groups in Example 5, page 34: Grocery List—Grouped by Layout.

In order to make this a good working tool, we should list most of the foods which our housewife might buy. This list should be open-ended, and after each category, some space should be left to allow the housewife (planner) to add different items, as shown in the following list:



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## EXAMPLE 4

### Grocery List—Grouped

White bread	Lettuce
Rye bread	Oranges
Buns (hot dog)	Apples
Lunch meat	Cucumbers
Ham	Tomatoes
Bologna	Instant coffee
Hot dogs	Regular grind
Light bulbs (4 40W)	Sanka
Tide	Root beer
Facial tissues	Coca-Cola
Paper towels	Chicken, roasting
Soda crackers	breasts, thighs
Graham crackers	Steak
Frozen cake	Soups
Ice cream	Vegetable
Shampoo	Chicken gumbo
Toothpaste	Chicken noodle
Tuna fish (3)	Tomato
Salmon	Frozen
Dill pickles	Orange juice
Relish	Lemon juice
Olives	Corn
Cottage cheese	Peas
creamed, small curd	French fries
Milk (4 half-gallons)	
Butter	
Eggs	

*Order picking in warehouses is a similar situation. What manufacturing plant situations require the periodic use of a checklist?*

*They are very common for periodic inspections for items such as safety, fire prevention, and housekeeping and for preventive maintenance of fork trucks, conveyors, machines, etc.*

#### Breads (fresh)

White  
Rye  
Raisin  
Potato  
Buns

#### Breads (frozen)

Buns  
Loaves

#### Dairy

Cottage cheese  
Milk  
Butter  
Margarine  
Eggs  
Cheese

Order picking in warehouses is a similar situation. What manufacturing plant situations require the periodic use of a checklist? The use of checklists is very common for periodic inspections for items such

as safety, fire prevention, and housekeeping and for preventive maintenance of fork trucks, conveyors, machines, etc. A checklist can be used to compare the problem situation against a standard. In inspecting materials handling equipment, a checklist can be used to record the degree of wear and tear from a standard or from the previous inspection tour. Many large organizations which purchase fork lift trucks and other materials handling equipment also rely on checklists to guide those who specify and purchase the equipment; see Example 6, page 35, for a typical list.

In the design of manufacturing systems, the checklist is considered a must. Example 7 on page 36, a final assembly checklist, shows some of the automobile components for which assembly space must be allowed, while Example 8, page

### EXAMPLE 5

#### Grocery List—Grouped by Layout

White bread	Frozen vegetables
Rye bread	
Buns (hot dog)	
Cottage cheese	Frozen juices
Creamed, small curd	
Milk	
Butter	Bacon
Eggs	
Fish	Cake
Pickles	Pie
	Ice cream
Household items	
Drugs	
Crackers	Soaps
Soft drinks	Paper
Luncheon meats	Pretzels
Coffee	
Canned meats & fish	Breakfast food
Canned vegetables	Canned fruits
Meats	
Vegetables	Fruit

36, illustrates some of the functions for which space must be allowed.

The aid to planning which is given by checklists is most important. The act of recording the elements or factors of future actions can save much effort. An engineer who is attempting to solve a material handling problem can certainly use many checklists, possibly at least one for each phase of the steps used in his problem solving approach:

1. *Define the problem.* The checklist for this step could consist of the Kepner-Tregoe list,<sup>3</sup> which includes questions used to identify

<sup>3</sup> Kepner, Charles H., and Benjamin B. Tregoe, *The Rational Manager*, McGraw-Hill Book Company, New York, 1965.

what the problem is and what the problem is not.

2. *Gather and treat the data.* The checklist for this step could include the types of data required such as truck arrivals, wait times, unload times, nature of the cargo unloading method, where to get the data, and how to arrange and compress the data.

3. *Develop criteria for evaluation.* The checklist for this step could include investment cost, operating cost, space, project life, time to install, and availability of emergency substitutes.

4. *Develop alternatives.* The checklist for this step could include material type (packaged, liquid, gas, bulk), material characteristics (volume, size, weight, shape, fragil-

ity), move type (fixed path, variable path, continuous, intermittent, occasional), move characteristics (distance, source and destination, quantity per move, rate of movements, nature of the route, alternate routes, flow patterns, horizontal, inclines, elevate, lower).

5. *Evaluate alternatives.* The checklist for this step could include techniques such as paired comparison, ranking, game theory, dominance, decision trees, rating, average score, musts and wants, and simulation.

6. *Implement the best alternative.* The checklist for this step could include Gantt charts, Critical Path Planning, PERT, purchase notices, check design, check fabrication, tryout, deliver, install, production tryout, etc.

7. *Follow-up.* The checklist for this step could include investment cost, down time (frequency, duration, severity), safety, and deviation from original estimates.

#### Specific checklists

Specific types of checklists have been proposed to facilitate thinking creatively about problems. Some of these are:

1. *Osborn's Checklist.*<sup>4</sup> It proposes a list of words such as magnify, substitute, rearrange, etc. Each is considered in turn on a specific problem.

2. *Attribute Listing.*<sup>5</sup> All the attributes or characteristics of a thing are listed, and we examine each in its turn. In checking a fork lift truck application, a person might list lifting speed, turning radius, reliability, etc.

3. *Area Thinking.*<sup>6</sup> The three or four major areas of consideration in a problem are used as starting points and the general approach of the solution is toward the detail. This is somewhat the opposite approach from attribute listing.

<sup>4</sup> Osborn, Alex F., *Applied Imagination*, Scribner, New York, 1953.

<sup>5</sup> Simberg, A. L., *Creativity at Work*, Industrial Education Institute, Boston, Massachusetts, 1964.

<sup>6</sup> *Ibid.*



E.4 SAFETY STANDARDS FOR POWERED INDUSTRIAL TRUCKS

PARKING BRAKES

Parking brakes on all rider type trucks shall be manually or spring applied through a direct mechanical system and shall be capable of holding a fully loaded truck on a 15% grade. Parking brakes shall be an independent system.

SERVICE BRAKES

Service brakes on all rider type trucks capable of speeds in excess of five miles per hour shall be hydraulic wheel brakes, and shall be capable of holding a fully loaded truck on a 15% grade. Spring applied hydraulic brakes are not acceptable.

Brakes shall be capable of sliding tires in either direction when the truck is carrying a capacity load. The brake system shall be capable of withstanding a 250 pound pedal pressure without component failure.

Electric powered rider type trucks should be equipped with a Deadman Brake. When the operator leaves the truck, all power shall be cut off and the direction control shall return to neutral.

Gasoline powered trucks should be equipped with a Deadman Brake.

On gasoline powered trucks equipped with automatic transmissions, when the operator leaves the truck the direction control shall return to neutral.

WALKIE TYPE TRUCKS

Electric motorized hand trucks shall be equipped with a Deadman Brake in the control handle which applies the brakes and cuts electrical power when the handle is in the near-vertical or near-horizontal position. The brakes shall be capable of holding a fully loaded truck on a 15% grade.

STABILITY

Tests representing minimum stability requirements for fork trucks having basic capacities up to and including 20000 lbs. at 24 inch load center, equipped with either cushion, pneumatic, or solid tires, shall be in accordance with American Standards Association Standard B56.1-1959 or the latest revision thereof.

SAFETY GUARDS

Motorized hand trucks shall have guards affixed to the ends of the operating handle. All operating controls shall be confined within the guards.

OVERHEAD GUARDS

Wherever truck operation exposes operator to danger from falling objects, the truck shall be equipped with an overhead guard. It shall be of ample strength to support a uniformly distributed static test load in accordance with Table 1, but it is not intended to withstand the impact of a capacity load falling from any height.

TABLE 1

Truck Capacity Rating (in pounds)	Static Test Load As A Percent of Truck Capacity Rating
Thru 5000	200% of truck rating
Over 5000, thru 10000	10000 plus 100% of increment rating over 5000
Over 10000, thru 20000	15000 plus 50% of increment rating over 10000

The guard shall be capable of withstanding the impact of a 100 lb. solid hardwood cube (or equivalent) dropped a distance of 5 feet, 10 times, without fracture or without permanent deflection.

LOAD BACK REST

Fork trucks shall be equipped with vertical load back rest or rack which shall have height, width and strength sufficient to prevent the load or any part of it, from falling toward the mast when the mast is in a position of maximum backward tilt, and shall have no opening greater than the smallest parcel carried.

HORN

Rider type trucks shall be equipped with a warning horn of the automotive type.

BACK-UP WARNING LIGHT

When requested by the purchaser, rider type trucks used in areas of pedestrian traffic should be equipped with a red flashing back-up light which will flash a minimum of 60 times per minute when truck is placed in reverse drive.

FORKS

All forks shall be SAE 8640 fully forged steel. Each fork shall be capable of carrying three times the rated load of the fork truck without exceeding the elastic limit of the steel.

## EXAMPLE 7

### Plant Layout Productive Area Checklist Automotive Assembly Plants

#### Productive Area

##### Passenger

- 1) Frame, Spring, and Axle
  - a) Control arm sub-assembly
  - b) Power steering sub-assembly
  - c) Rear axle schedule and sub-assembly
- 2) Front End
  - a) Fender sub-assembly
  - b) Hood sub-assembly
  - c) Radiator sub-assembly
  - d) Air condition sub-assembly
  - e) Painted metal bank

##### Truck

- 1) Frame, Spring, and Axle
  - a) Rear axle schedule
  - b) Front axle schedule
- 2) Front End
  - a) Fender sub-assembly
  - b) Hood sub-assembly
  - c) Radiator sub-assembly
  - d) Painted metal bank

## EXAMPLE 8

### Plant Layout Non-Productive Area Checklist Automotive Assembly Plants

#### Non-Productive Area

##### Material Handling

- 1) Standard parts area
- 2) As required area
- 3) Obsolete material storage area
- 4) Truck receiving
  - a) Aisle behind leveler
  - b) Marshalling area
  - c) Wells per day
  - d) Design length of well
- 5) Storage area
  - a) Optimum size
  - b) Maximum size
  - c) Recommended aisle width
- 6) Railroad receiving
  - a) Unloading and marshalling area
  - b) Dock aisle

##### Miscellaneous

- 1) Truck receiving area
  - a) Quality control and receiving inspection
  - b) Inspection hold area
  - c) Shipping hold area
  - d) Offices and toilet
- 2) Maintenance
  - a) General maintenance area
  - b) General stores
  - c) Maintenance stores

4. *Word Stimulation.*<sup>7</sup> Lists of appropriate words are scanned for ideas and suggestions toward a solution.

Example 9 on page 37 shows the use of a standardized checklist in a problem solving situation. The progressive die operation is studied by examining each motion of the press operator in sequence. The motion is compared with the items in the list, and, if any apply, the motion and the ineffective items are recorded in conjunction with the observed or possible cause. The analyst summarizes his conclusions and develops a set of recommendations (suggestions).

#### ***Points of departure***

For those of us who wish to use standard checklists, a word of caution is in order. Use them only as points of departure. No matter how good they are, they can rarely apply to one's situation without some modification, whether by simplification, changing of items, or changing of emphasis.

In conclusion, if the question is asked, "Does the use of checklists yield good results?", the author must answer "Yes" and add that checklists are indispensable for efficient problem solving.

<sup>7</sup> *Ibid.*

# INEFFECTIVE WORKER MOVEMENT ANALYSIS

Date 7/10/70

Analysis By RS

- Long Tugging
- Fumbling Holding
- Waiting Blind
- Extra Effort Prying
- Positioning Eye-directed
- Hazardous Complicated
- Awkward Loss of control
- Changes of Control

Name of Operation BLANK RADIATOR TANK

Part No. 23945137

Operation #10 No.....

Department Name #5 PRESS DEPARTMENT

No.....

INEFFECTIVE WORKER MOVEMENT	OBSERVED OR POSSIBLE CAUSES
1. Long reach to cargotainer, left side	Cargotainer too low and too far away
2. Awkward place to die sta. #1	Design of part and design of die
3. Waiting with right hand	No activity available during place act
4. Awkward get of foot trip	Foot switch location and die extension
5. Waiting both hands	No activity available during process
6. Tugging to remove part	Part sticking in die station #3
7. Long and Awkward	Cargotainer low and too far away for place act.
8. Waiting (left hand)	No activity available during dispose and transfer
9. Change of Control	Reorientation required for die station #2
10. Tugging part	Part sticking in die station #3

*summary of ineffective movement and causes*

1. Location of cargotainers causing ineffective movements throughout.
2. Apparent unbalance of manual activity.
3. Die stations not releasing parts freely.
4. Hazardous situation can be eliminated immediately.

*suggestions for further study or improvement possibilities*

1. A cursory examination of die details to possibly improve nesting and freedom for removal.
2. Investigate material handling for possible change of container and elimination stacking.
3. Redesign work content for improved balance.