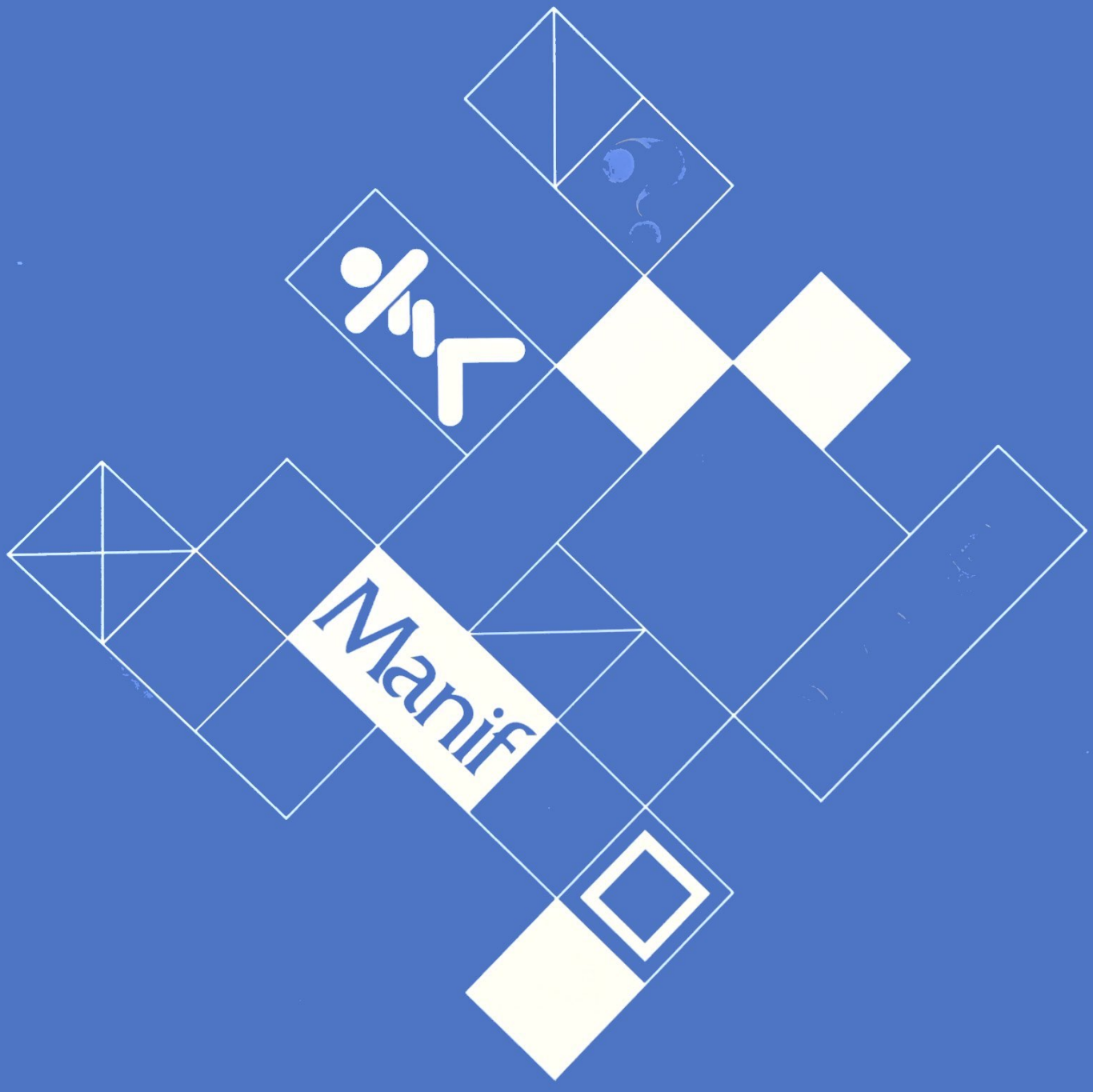
# Reliability: Human Considerations



# Reliability: Human Considerations

A nuclear plant has a meltdown, a light bulb fails on an L1011 aircraft and the flight goes down in the Everglades, a passenger train takes a curve too fast and derails, a valve is installed upside down on an oil rig and millions of gallons of oil go into the sea — these are the kinds of headliners that have their root in human failing and are occurring with an alarming frequency. Closer to home we find that heaters blow up because burner controls were bypassed, boilers fail dramatically because of water deficiencies, machines experience early failure after a human has overhauled them, and the damage that forklift operators inflict on our warehouses often confounds reason. The damage caused by human unreliability defies the imagination; and yet, except for the most catastrophic instances, the genesis of this failure cause is not even investigated.

We certainly can recognize that man (in the generic sense) is his own greatest enemy. But what of man as a human asset? Can one so destructive also be an asset? Perhaps the answer lies in how we define human asset. Certainly we cannot categorically characterize human work that can be more reliably replaced by machines as an asset. No, the human asset lies in man's ability to be creative and innovative. Antithetically, a human liability exists when the capability to be creative and innovative is either withdrawn or suppressed. The tremendous power embodied in man's ability to think and create exists all around us in such marvelous inventions as the aircraft we fly, the space ships that explore our universe, the automobiles we drive, and the telecommunications we enjoy, and in man's ability to be responsible and caring about his own species and other species on earth.

On the shop floor and in the processing plant people are using their creative genius to stabilize and often to improve operations and designs in thousands of small but very important ways. When one shift of operations consistently produces more product or better quality than the other shifts, it is often because the people of that shift have made improvements in the operations. However, in a negative sense creativity is sometimes applied in subtle and concealed ways toward halting or slowing down production, or reducing quality or yields, in plant operations. These deleterious effects also occur by merely withdrawing creativity and innovation in support of the operations.

It is time for us to introduce into our industries the sciences directed at maximizing the human asset and minimizing the human liability. In accomplishing this, our focus must be on asset performance in terms of its ability to generate opportunities and profitability if we are going to stay competitive in world markets.

## Manifestations of Productivity Loss

When a producing facility has difficulty in meeting its production or financial objectives or both of them, we naturally investigate to identify and remedy the issues causing the poor performance. Often we find that equipment failure rates are too high or that process and operational problems are recurring. Perhaps turnarounds are longer than planned, or restarting creates high infant mortality losses. Often times we find ourselves impacted by insufficient storage capacity for raw materials, work in progress or for final product, and we wonder why these conditions were not forecasted and provisions made.

More than likely a combination of productivity issues exists with an often astonishing number of subordinate matters to be resolved. Such issues include lubrication deficiencies, inadequate repair procedures, poorly designed equipment layouts, poorly thought out or deliberately avoided process testing practices, poor

instrumentation design and reliability, inadequately conceived or underutilized operating procedures, poor maintenance and turnaround planning, lack of skills on the job and any number of other combinations or permutations.

A common approach to this myriad of complex problems is to isolate specific issues and deal with each one separately and apart from the other problems. This approach can solve specific problems but often falls short of curing the system problem. If we recognize the influence people have on each other and on the equipment and facilities they operate and likewise the influence that surroundings have on people, we would recognize that solutions must consider all facets of the system.

For example, if the controls on a gas-fired heater are bypassed and the top of the unit is blown off, solutions to this specific problem resulting from investigation of the incident might be to improve burner reliability, add additional fail-safe instrumentation and perhaps discipline persons for the unsafe act of bypassing the controls. A training program might even be recommended and initiated. However, the root cause of this mishap might be the application of indiscriminate pressure on the part of management or supervision to achieve startup. Those applying the pressure might not be cognizant of the effect of their admonishments. In other words, without reviewing the system of influences, the condition of the specific unit will undoubtedly improve; but the root cause problem will remain, waiting to erupt in the future into another productivity loss or, worse, a human or property loss. Not only will these events occur, they will persist until the root of the problem is found and corrected.

### *The Symptoms of a Human Productivity Problem*

I suggest that human unreliability should be a suspect cause of productivity loss in an operating facility that exhibits one or a combination of the following symptoms.

Symptoms of performance problems:

- ☐ Excessive downtime
- ☐ High overtime
- ☐ Poor morale
- ☐ High turnover
- ☐ Protective reports
- ☐ Repeat failure incidences

The approach offered here is to list the problem manifestations. For example:

1. Test results from the laboratory are not timely.
2. Centrifuge has high failure rate.
3. Column reflux rate is difficult for operators to maintain.
4. Control errors are high.
5. Repair downtime is considered excessive.
6. Production commitments are not met.

### *Beginning The Analysis*

What such a list may suggest is a training program for operators and mechanics. At this point in our productivity analysis, I would suggest further examination of the manifestations listed above by defining the conditions surrounding the manifestations and refining the list accordingly.

| Manifestations | Conditions |
|---|---|
| Test results from the laboratory are not timely. | 1. Lab equipment out of date.<br>2. On-line analysis not being considered. |
| Centrifuge has high failure rate. | 1. Root cause failure analysis needed.<br>2. Overhaul working conditions hot and dirty. |
| Column reflux rate is difficult for operators to maintain. | 1. Shift variability apparent. |
| Control room errors are high. | 1. Shift variability.<br>2. Most errors occur on day shift. |
| Repair downtime is considered excessive. | 1. Equipment lubrication haphazard.<br>2. Mechanics excessively idle.<br>3. High repeat failure rates. |
| Production commitments are not met. | 1. Mounting management pressure to stabilize and then maximize operations. |

This list should be divided into two categories. One category would include those items associated with proper execution of tasks needed for productivity. Some writers refer to this category as "discrepancies." For clarity I prefer the word "divergencies." (Divergency suggests a deviation from acceptable task performance, whereas discrepancy suggests a defect in established normalcy.)

The second category would include those manifestations suggestive of a deficiency in knowledge or skill to perform the tasks necessary to regain and maintain the productivity standard.

Our resulting list might look like this:

## Divergencies

First, let's address divergencies. As stated, they are problems of execution. One must accept that if an item is assigned to this category, the people performing the task have the knowledge and necessary skill to perform the task. One must also recognize that the task will generally be acceptably performed when the people performing the task are overtly observed. However, they may not perform the task when they feel they are not being observed.

Divergencies can be categorized into three sets of characteristics: task, situational, and managerial.

### *Task Characteristics*

The first divergency characteristics are those emanating from the task itself. If the task is distasteful or unpleasant in the perception of the task performer, many will become alienated and simply will not perform the task when they are not being watched. Others will perform the task in only the most perfunctory manner, adding nothing of themselves to the task performance. At times this latter alternative will have more dramatic consequences than ignoring the task. Remember, if most subordinates only perform minimally and give only exactly what is asked of them,

| Manifestation | Divergencies | Deficiencies |
|---|---|---|
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productive operations will not long be sustained. Recognize further that distasteful tasks are often ones that lack challenge as well as others that are unpleasant because they are dirty or uncommonly difficult.

Another task characteristic is conflicting task priorities; for example, control room and process design which might require response to conflicting signals or responses that one knows from experience are improper; more specifically, a computer notation might suggest an action the operator knows is intrinsically wrong.

Conflicting work methods might also be presented by the task or its assignment. Experience says one thing — the planning sheet says another. The new method offered by the reliability engineer might be in conflict with informal work group norms.

Finally, but not conclusively, the attempt to scope the task characteristic would include the delay or absence of feedback. The task once completed is often made functional after the performer has left the task or the task is complete, but a signal does not exist that it was done satisfactorily. For example, a heat exchanger is repaired and put back on the line, but no instrumentation exists to signal readily its health as it may be part of a larger system that may mask maladies in the repaired unit.

### *Situational Characteristics*

The second set of divergency characteristics covers situational factors. The atmosphere surrounding a task might be inappropriate or disagreeable. The task might be perceived by the performer as too hot, cold, dirty, chemically active, or dangerous to perform. Again, when many of these people are observed they will perform the task but might not when they are not being watched.

Another situational characteristic is peer pressure. The force that drives people to informal grouping is often times awesomely large. The rejection by such groups often means social isolation, an extremely difficult circumstance for most people to deal with. Characteristically such groups perceive job security as synonomous with low visibility. Therefore, members that attract attention to the group commit a form of treason for which punishment might be harsh and include expulsion. Little wonder that the strength of these groups and their support or alienation of management has a great deal to do with how people perform their tasks.

Situations that demonstrate poor logistics will feed workers' alienation and add to this characteristic. If craft assistance to operations is not timely, if materials are not delivered to work sites on time, if mechanics have to wait for cranes and other heavy equipment, they will reinforce an attitude that If the company doesn't care, why should I?

Plant layouts that are interpreted by operations and manufacturing people as restrictive in operating and maintaining the plant will be paid for by retribution as workers withdraw their creativity or omit needed actions altogether. The lube fitting that requires an eight foot ladder will not be lubricated. Valve handles inappropriately placed will either not be turned or required finesse will be withdrawn.

Situational characteristics, like other characteristics, are many and varied but must also include social considerations. Workers that feel they are deprived of interchanges among their peers and others concerning the football game the night before, the graduation of a child, a daughter's marriage, will build up resentment that will manifest itself in withdrawing of human assets.

### *Managerial Characteristics*

The third set of divergency characteristics is managerial or organizational. One such element is the lack of clear-cut authority that permeates the workplace as managements struggle for appropriate organization forms to fit the immense complexity introduced into business by technology and government intervention. The worker in the field or on the factory floor is generally operating under inbred organizational rules. "I take orders from one man. They better get their act together before I do anything. When you need help or advice it shouldn't be necessary for the foreman to find the answers, he should know them. The plant is not producing and who shows up? — the superintendent. Now how

long is he going to be around and now who's the boss?" These are difficult issues but they must be faced if we are going to reverse the current trend of decreasing productivity.

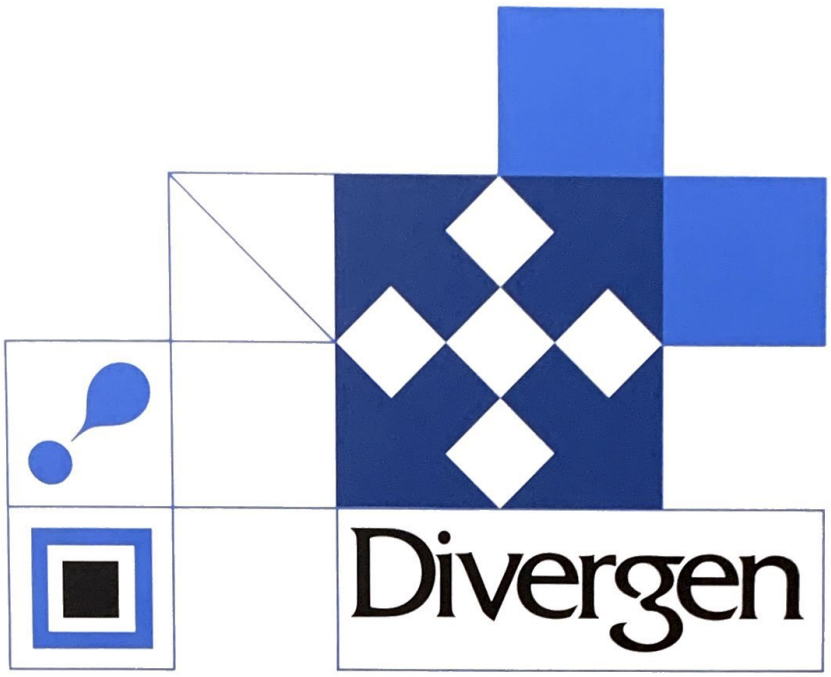
The questions of the quality and quantity of supervision are other managerial issues.

> Joe's approach to supervision is work centered. We exist in this facility because of the work, so it stands to reason that Joe's approach is the one that should bring success.

Studies, however, reveal a paradox. The employee-centered approach to supervision, one that could be viewed as ignoring the work, seems to produce more work in the longer term. Certainly, this opens up some cause for reevaluation of the quality of supervision respecting its ability to discern whether one's approach works and, if not, whether it can indeed be changed.

The question of quantity can only be answered when the role of supervision is determined. Some writers have suggested that first line supervision exists to coordinate factory and plant workers. I do not express a preference for one concept or another but merely point out that it is timely to reconsider role definition in terms of what the behavioral scientists and management researchers are revealing.

Communication to some may be a characteristic that is overworked but this writer believes that it is a recurring problem because satisfactory answers have not evolved. Lately American enterprise is re-evaluating itself because of the stiff competition, particularly as regards product quality, from Japan and some European countries. One point becomes crystal clear; where product quality flourishes, workers are involved. They know what is going on. They are asked to contribute and their ideas are used. The quality circles technique, which originated in the United States but is used more extensively in Japan, is beginning to be reexamined for use in America. It is imperative that, if communication is identified as a divergence, it must be dealt with. Creative minds can build on the font of knowledge available and emerging in this area.




It might be useful to point out that a growing unrest is becoming visible on the continued focus on just the productivity of the individual. Research is revealing that worker groups have much more influence on group members than does supervision. Consequently, it appears timely to reexamine this issue and consider group approaches to productivity.

Recognition is a fundamental human need. When it is not given, anxiety and frustration emerge and the human asset, the human's ability to create and innovate, is expensed. A considerable amount of data exists on forms of recognition. Some of it is conflicting, but all of it is thought provoking. Its

understanding may lead to new approaches in preserving the human asset.

Finally, but again not conclusively, managerial characteristics for poor performance must recognize a lack of performance standards. Standards properly developed and applied motivate people to higher levels of success — the lack of standards, or standards poorly applied, rob people of fulfillment. It is a human requirement to be challenged. Only by being challenged can one be whole. The challenge of a race, a golf game, a university grade, all attest to man's need to be challenged and to match his performance against a standard.

The reader can recognize that placing problem conditions in categories is itself suggestive of a cure for the productivity discontinuity. One also recognizes that none of these problems are solved by training workers. In fact, for purposes of this analysis, training should be considered a strategy of last resort.

## Deficiencies

Another facet of performance problems that emanates from the human being are deficiencies in skill and knowledge to do the necessary tasks. The criterion for identifying a lack of knowledge or skill is whether or not persons could perform the task in question if their lives depended on it. Unlike divergencies, people will not be able to perform assigned tasks when observed because they lack the necessary knowledge and skill. This, of course, presents another paradox, as often times these people are taken to task for their seemingly blatant disregard of responsibilities; where, in fact, the problem lies with us for not providing the necessary strategies to assure people know how to do their jobs. Like divergencies, however, deficiencies also have characteristics which can be categorized into three sets: task, people, and training.

### *Task Characteristics*

The first such set of characteristics centers around the task itself. For example, it may be new or changed. Unless it is necessary for tasks to remain constant and vigilance is used to assure no changes, all tasks will change. This is the result of the human asset at work; that is, people using their creativity to add value to their work or make their jobs easier to perform. A problem often lies in transfers and new hires that may be trained in performance of the task as it was originally conceived.

Sometimes tasks are too complicated for some individuals to perform correctly. Pride often prevents admission that this problem exists. Careful observation should ferret out those individuals without sufficient ability to perform the work as constituted.

Sometimes, people's senses are overloaded. Newspaper reports on the Three Mile Island failure stated that more than one hundred alarms and signals went off, confounding operators and delaying action. This is, of course, an extreme case of sensory overload but it demonstrates what can happen in control rooms when operations are off standard. Most designers unfortunately design individual controls and their associated alarms without regard to the confounding effect of multiple signals.

An insidious danger associated with operational stability is the low frequency of exposure to off-standard conditions. Tasks that are infrequently performed for these conditions should be examined for impact if they are performed badly. If the impact is large, then simulation techniques should be used to maintain proficiency.

### *People Characteristics*

Other deficiency characteristics center around people. People might lack knowledge and skill because they are new or inexperienced to the task at hand. Occasionally they might lack the aptitude and ability to perform the task. If the latter is suspected, I would recommend that a competent psychologist test the individual and make recommendations regarding modified training or alternate work assignments.

Another people characteristic is that some people lack the motivation to learn and apply themselves. Some people have had poor experiences in

school and find classroom instruction alien and frightening. Some people lack the maturity it takes to apply themselves. Again, a competent psychologist trained in instructional techniques would be an asset in handling such situations.

### *Training Characteristics*

Finally, deficiencies have training characteristics. All too often the training content is irrelevant to the need. Often training is pursued because it is an acceptable strategy, but only after all less expensive and more effective strategies have been explored. As previously stated, training should be viewed as a strategy of last resort.

Consider a situation where a class of equipment has been competently maintained over the years and a new addition to the class is introduced. It is appropriate to train in the features that differ from those of the older equipment, but it is inappropriate to train in the common areas.

Another training consideration is appropriate instructional methods. Training people in operation of a petrochemical operation requires a flexibility that would be undesirable in training operators to string up fiber machinery. The latter requires techniques not unlike those employed by military drill sergeants; that is, repetitious discipline until the task can be done safely and efficiently. The former requires training in problem-solving techniques; here gaming techniques might be appropriate.

I have already touched on another training characteristic; that is, inadequate practice and rehearsal. People who perform repetitive jobs will not exhibit this characteristic, but a large problem exists in the process industries that must face off-standard conditions infrequently. If called upon to respond to an emergency situation, the current available evidence reveals that without practice and rehearsal people have a 99% probability of doing the wrong thing in the first minute, and the odds only improve slightly to 90% over the next four minutes. After five minutes, reason begins to take over, and the odds of making a correct decision greatly increases.

Our options for handling emergency conditions are clear. Determine the impact of off-standard conditions and either automate for the first few minutes of a potential catastrophe or train by simulation.

As individuals with different innate characteristics and varying learning experiences, we will all respond somewhat differently to specific training. Some will learn faster, and others, slower. Training, to be effective, should be competency based; that is, there should be recognition that some people will learn at a faster rate than others.

Finally, job training more commonly has a knowledge emphasis rather than a skill emphasis, even though skills are the desired result. Skills can only be learned by doing — by practice and rehearsal. Knowledge is necessary but should not overshadow the need for skills training and practice.

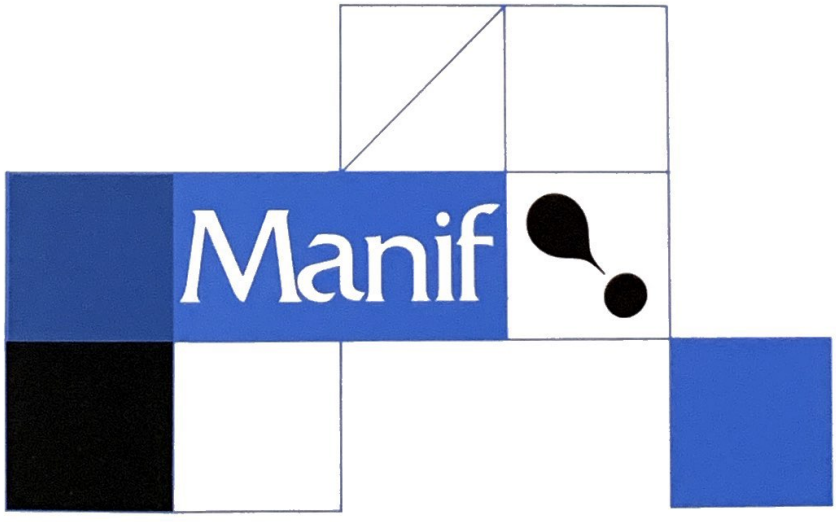
## Conclusion

After reviewing and understanding the characteristics of divergencies and deficiencies, we can review and slot the conditions surrounding our problem manifestations. The slotting techniques often require further analysis of attendant conditions. Now our example analysis might look like this:

## Divergencies

### *Task Characteristics*

1. Mechanics are not allowed to view startups of centrifuges after overhaul.
2. Lubrication points are inaccessible.



### *Situational Characteristics*

1. Negative attitude exists in lab because of lack of modern equipment.
2. Working conditions around centrifuge are excessively dusty and dirty.
3. Peer pressure on "B" and "C" shift limits proper operation of distillation column.
4. Lubricators feel that they are not getting the equipment needed to do a proper job.
5. Poor logistics force idleness on mechanics. Attitude exists that if company does not care about efficiency, why should they.

### *Management Characteristics*

1. New faces in supervision produce uncertainty among hourly workers and first-line supervision.
2. Supervision in lab is not up to date on modern lab and sampling techniques such as on-line sample analysis.
3. Management is not aware of what root cause failure analysis is and how it can help productivity.
4. Performance standards in lab and maintenance are shoddy and, in many instances, nonexistent.

## Deficiencies

### *Task Characteristics*

1. Control room panel board growth is disconnected. New people are confused about operations.
2. Sensory loads in control room are too high during off-standard conditions.

### *People Characteristics*

1. Thirty percent turnover exists in maintenance. Most people are hired from an alien industry.

### *Training Characteristics*

1. Process training is confined to study of piping and instrument drawings.
2. There is almost no practice and rehearsal for off-standard conditions.

As pointed out earlier, most often the identifications of the causes of problem manifestations clearly reveal the solutions.

What I have tried to do in this paper is define the human asset. In doing so, I think the definition offered can significantly influence the way we approach our productivity problems.

Secondly, I have tried to demonstrate that human error is not synonomous with human unreliability but merely a small subset.

If I have accomplished these two objectives, the paper has fulfilled its purpose.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