Lessons Learned by the Army Materiel Command

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During the last five years, the U.S. Army and its contractors have experienced cost and schedule problems of significant proportions. In a number of instances, these problems surfaced only during production start-up or well into production.

About two years ago, Gen. Richard H. Thompson, the commander of the U.S. Army Materiel Command (AMC), assigned me the task of ferreting out root causes by spending time with contractors and their subcontractors. As one might expect, the underlying causes turned out to be rather complex. They were found at all levels of an enterprise. The material presented in this article is a collection of issues, the sum total of which, fortunately, does not exist in any one company. The findings are divided into four parts: Management, Engineering, Manufacturing, and Subcontractors and Parts Suppliers.

One of the key issues encountered in the management of some companies, especially in the electronics sector, is that production is viewed as an extension of the engineering laboratory. Consequently, the managers do not plan for or provide adequate resources for production.

Most strategic plans encompass marketing and engineering but do not include planning for future factory needs. Thus, the factory is asked to produce today’s product with equipment representing yesterday’s technology. The results are major inefficiencies. Machinery used to produce today’s weapons cannot adequately hold the required tolerances. Resultant rework and reject rates are too high, causing unacceptably high costs.

Worse yet, the problem will be even greater when the next generation of weapons comes along.

Successive generations of weapons differ in technology by 10 to 15 years. Major changes in manufacturing processes and capital equipment are necessary to meet the demands of new systems, but single year procurement policy discourages major capital investments. Thus, the contractors do not make the investments that would achieve substantial improvements in producibility.

Another problem encountered is the lack of organizational and physical separation of laboratory activities and production. These two functions have totally separate objectives; i.e., production facilities should not be used for laboratory work. In the laboratory, the objective is to solve design problems. In manufacturing, the objectives are to produce an item on time, within cost, and to acceptable quality standards.

Too often, one encounters situations where the experience gained on one program is not transferred to the next program and that is within the same company. The Army has to pay for the learning process again and again.

Companies spend good money for the development of procedures. Then top management assumes that they are being followed. The loop is not closed because there is no audit function, or it is not effective where it does exist.

Engineering

In engineering operations, systems architectures are not developed in sufficient detail, and interfaces between line replaceable units (LRUs) are inadequately defined.

Insufficient emphasis is given to the budgeting of tolerances of the functional parameters. Adherence to this concept is an absolute necessity to assure interchangeability of all replaceable parts and subassemblies. How can one adequately specify LRU test equipment or prepare a complete interface specification without properly budgeted tolerances?

Designing for producibility has been consistently neglected, addressed too late, or ignored completely. At least 60 percent of avoidable manufacturing costs are created during the design phase.

Nor has much thought been given to the methods of inspection and testing and how they need to be accommodated in the equipment design. An example is the early identification of test points so that they can be incorporated in the design of the device.

The issues discussed above are the most significant causes for engineering changes during production start-up. Having passed the final engineering test merely attests to the fact that the specified performance requirements can be met. One must recognize that every part used in production, from system to system, is slightly different even though within specified tolerances. The stack-up of the tolerances in each system is different and can be such that a performance function can indeed fall outside the specified limits. This is a statistical fact. Tolerance budgeting is extremely important to achieve interchangeability.

Recently, I had the opportunity to visit a company that produces cameras. Before they enter the market with a new design, they make a pilot run of 5,000 cameras to assure design maturity. Then they still expect 5 percent to be returned during the first year of full production. Now, we all know that, except in the case of conventional ammunition, we will never have production rates and runs of comparable size. What can we and should we do to achieve greater design maturity earlier to achieve better producibility and get better yield during production?
We must build the requirements into our development contracts and convince our contractors to:

- Develop and maintain throughout the design: system architectures for hardware and software, flow charts, block diagrams, timing charts, power distribution diagrams, inspection and test plans (in-process), tolerance budgeting, interface specifications, specifications for in-process test equipment, and system modeling and optimization routines.

- Operate a producibility engineering program that focuses on both the producibility of the design and the factory that is needed to make the product. These are two separate issues. To achieve the objectives of these issues, the contractor has to have qualified manufacturing engineers on the design team. Moreover, it does not stop there. Quality engineers must be included as well as procurement people. The latter are needed so that, up front, the vendor base can also be given time to prepare itself for the upcoming production requirements. The objective is to achieve design-to-unit production cost.

- Identify all critical manufacturing processes at all levels, make sure they are fully understood and demonstrated during engineering development, and make sure that methods are devised to prevent them from going out of control. Included must be a requirement for full documentation.

This appears to be a long and costly shopping list. But the costs of these efforts are small compared to those that will arise from not making the up-front investments. They will pay huge dividends during production.

Manufacturing

As pointed out earlier in this article, in many instances manufacturing has suffered from the lack of attention by senior management.

In general, production control and material management are a part of the manufacturing operation. The people in these organizations are responsible for translating the contractual delivery schedule and the bill of materials into detailed shop schedules and material requirements. They have to start by breaking down a deliverable item into the sequences of operations for the manufacture, inspection and testing of every part, subassembly and the end item. From that breakdown, they must establish the cycle time (setback chart) that starts with the release by engineering and extends through final acceptance test. Included must be allowances for the preparation of requisitions, obtaining vendor quotes and negotiations of price and delivery, receiving, incoming inspection, stocking, material draw, kitting and queuing times at every operation. However, the cycle time is meaningless unless the standard times used for the manufacturing operations are realistic and scrap and rework are taken into consideration.

This information now needs to be translated into a line-of-balance chart or its equivalent. It is imperative that this effort be carried down to the lowest subassembly. Now one knows when every part is needed at every step in the process. The chart also provides the tool for controlling the manufacturing operations, namely when material should be ordered and should be available to start the fabrication process.

Too often, schedulers are not sensitive to the fact that the delivery information provided by purchasing may be an average time true for the class of parts, but does not apply to the specific part used in the system; e.g., a specialty item that is an exception to the rule. Changing economic conditions can also have a significant effect on deliveries.

Consistent tracking of schedules during the entire purchasing cycle is imperative. In many instances, expediting is started only during the last 30 or 60 days preceding the start of final assembly. The lack of understanding of the importance of proper scheduling and expediting is an underlying cause of the contractor's inability to reach rate and maintain production schedule.

There is a decided lack of communication between management and the worker, especially between the foreman and his crew. Span of control may be an issue. In many instances, though, the worker is not told what is expected of him both in terms of rate and quality. He is not given the opportunity to make suggestions for improving the process he is using or the operation that he is performing.

Processes are not properly documented and controlled. The consequence is that when the process is lost, a major effort is required to reconstitute it. That, of course, puts the project schedule in jeopardy.

Material Review Board (MRB) actions yield a wealth of data that are either ignored, not understood or not used. For example, in the case of an in-house fabricated part, disposition is to either scrap, rework, or accept as is. The probable causes for scrap or rework are sloppy workmanship, poor tooling, worn-out machinery or an engineering requirement beyond the capability of the existing process or available equipment. Where too many parts of a given part number fall into the "accept as is" category, a drawing change is the solution. Properly understood and administered, the data coming out of the MRB can be very useful in eliminating unnecessary delays and costs.

On each project, the contractor has developed standard repair procedures that are completely valid across many or all contracts. A considerable amount of paper-
work can be eliminated by an ear-
ly-on review of all previously
used and potentially applicable
repair procedures and their ap-
proval for use on the project in
question.

The name of the game in pro-
duction is to eliminate excep-
tions. Scrap, engineering changes,
MRB actions and rework are all
exceptions and, therefore, an un-
necessary expense. They don't go
away by themselves. Like every-
thing else, they have to be man-
aged.

Parts Procurement

This activity is divided into two
parts, material and parts procure-
ment, and subcontracting. The
least-addressed and least-worked
issue is anticipatory expediting.
Too often, expediting is not start-
ed until the day the part is due on
the receiving dock, or worse, at
the assembly line. Sole-source
parts, those parts for which there
is only one supplier because of
the propriety nature of his prod-
uct, automatically should be con-
sidered high risk because of total
dependence on one source. Usual-
ly, the number of parts falling into
this category is small and, there-
fore, requires a relatively small
effort.

The blind use of certificates of
compliance without incoming
sample inspection and testing can
be a real trap.

Reference has been made to
the loss of a process. When this prob-
lem occurs and there are an insuf-
cient number of alternate qualifi-
ced sources with adequate capac-
ity available, the highest
level of management must give
full attention. The resources need-
ed to bring the process back on
track usually are beyond the lim-
its of authority of the immediate
management in whose area the
problem occurred. Speedy solu-
tions may require technical assist-
ance not available in the division
and/or capital expenditures be-
ond the limits of authority of the
division general manager.

Subcontracting

Many subcontractors are rela-
tively small companies, possibly
companies that are in receipt of
the largest production order they
have received since they have
been in business. They have thin
financing, limited technical re-
sources and little experience in
setting up and operating a manu-
facturing facility. Often when
they get in trouble, they don't
know it until they are knee deep
in it. The prime contractor has to
be on the alert for the possible
development of such an issue and
has to be prepared to jump into
the breech. In the past, the prime
has relied too heavily on the gov-
ernment. When the prime con-
tactor enters into a contract with
the government he assumes re-
sponsibility for managing his
subs.

Not infrequently, the engineers
of the prime contractor, in prepar-
ing the performance specification
for a subcontract, tighten the re-
quirements excessively when pass-
ing them down. Now, if the
tolerance budgeting had been
done properly, this problem
would not arise.

During the last several years,
some of our contractors have gone
offshore to obtain parts and other
specialty items. This tactic to
reduce cost contains another risk
element that we have not had to
deal with in the past. The falling
dollar can create a loss for the
offshore supplier, which can easi-
ly outweigh the expected savings
resulting from going offshore.
There are techniques to prevent
this reversal, but their use de-
pends on the degree of sophistica-
tion of the offshore supplier in
dealing in transactions involving
currency exchange rates.

Conclusion

What has the AMC done to
overcome the problems we've en-
countered? We have:

1. Created a Directorate for
Production to give production
appropriate recognition and
attention.
2. Created the position of as-
sistant deputy for production
with the express assignment to
work the most serious produc-
tion issues.
3. Established the requirement
that every major program have
a complete acquisition plan
prior to the start of the project.
The plan includes the require-
ments for producibility engi-
neering and planning (PEP)
and a design-to-unit produc-
tion cost during the develop-
ment cycle.
4. Redefined PEP to include
design for producibility, the
development of new manufac-
turing processes and work to
reduce high risks in manufac-
turing.
5. Vigorously supported con-
tinuation of the Atlanta con-
ferences.
6. Held a series of meetings
with top-level corporate exec-
utives.
7. Held a one-day seminar on
parts management.
8. Established PRIDE (Produc-
tion Review Integrated Data-
base).

The list is not intended to be
all-inclusive but is an example of
the actions AMC has undertaken
to overcome the problems dis-
cussed in this article.

The author is the assistant deputy
for production at the U. S. Army
Materiel Command, where he pro-
vides technical advice on produc-
tion to the commander and depu-
ty commanders and initiates
corrective actions on major pro-
duction deficiencies. He has been
on a number of national commit-
tees and has been a guest lecturer
at several institutions of higher
learning. He spent over 30 years
with Westinghouse and E-Sys-
tems, where he held management
positions in engineering and
manufacturing. He holds a B.S.
and M.S. in mechanical engineer-
ing. He is a director of CASA-SME
and chairman of Autofact '87. He
is a recipient of the Army's Deco-
ration for Meritorious Civilian
Service.
I've been the commander of the U. S. Army Materiel Command (AMC) for almost three years now. During that time, I've spent close to 60 percent of my time on the road visiting AMC installations and activities and the commands and units that use the materiel that we in AMC develop, buy, field, and support. I also speak frequently to industry groups and, whenever possible, visit with management and tour plants and other facilities. In 1986, I was able to make 21 industry visits that gave me an across-the-board look at how the U. S. defense industry operates.

While I see some good, tight operations, and I am able to observe quality planning and procedures that give us quality products, I often see the opposite as well. Then the result is real frustration—frustration because costs and schedules get out of control. As a customer, I want what I ordered, in the quantity and quality I contracted for, and when I expect it. When I'm a satisfied customer, we all benefit. I don't like the idea that the taxpayer, the Congress, and, especially, the soldier might think that we don't know how to manage and fulfill our mission.

Because the percentage of AMC's contractors is of such great importance, we've made a number of substantive moves to focus more fully on all aspects of production. As an example, I created the position of assistant deputy for production, which is now held by Fred Michel. He spends over 90 percent of his time away from AMC headquarters, working directly with management on engineering, production and supply, and parts problems. He has put the observations he has made through his extensive time with industry into this report. He has presented his views to AMC's program, project, and product managers and to other AMC and Army audiences, but I feel that his insights and perspective will be of great value to members of the American Defense Preparedness Association as well.

I want to stress that our comments, although generally negative, are presented in a most positive spirit. Improvements you make in your ability to fulfill your contractual obligations to us are good for all of us. In addition, we are well aware in the Army Materiel Command that we have much to improve in our own operations. In fact, in my view, our list of negatives surpasses yours, and we are vigorously working to do better.

What I hope to stimulate is a healthy dialogue much like the exchange we experienced at the Atlanta Conferences. The more we talk frankly and constructively, the better we will meet America's materiel defense needs. I welcome any comments and suggestions you might have.

As a final and related note, I want to take this opportunity to ask for your support for a new organization focusing on finding solutions to our country's productivity and competition problems. The National Center for Manufacturing Sciences (NCMS) is a private, not-for-profit consortium of small and large manufacturers from a variety of U.S. industries. Their goals are to advance the state of manufacturing science and foster the development of manufacturing processes, tools, and techniques.

I'm encouraged by this initiative. I think that by combining their talents and experience, the consortium's members will make significant contributions to American industry's search for ways to improve our productivity rates and competitiveness in world markets. I know, too, that this group's efforts will benefit the Army Materiel Command as we work to support our American soldiers.—Gen. Richard H. Thompson

You may obtain information on the National Center for Manufacturing Sciences by writing:

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