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Closing the gaps between the types of availability in a cost-effective way makes the plant more successful. It requires a thorough understanding of the top-level factors that determine availability and finding ways to improve in each aspect of those factors.

In Part One of this article, we discussed the three different types of availability—inherent, achievable, and operational (see Fig. 1); their implications for strategic planning; and the methodology for modeling and determining achievable availability. In this installment we will discuss using the availability model to determine plant bottlenecks and increase throughput, the impact of the need for modeling and analysis on the maintenance and engineering organization, and offer suggestions on how to close the natural gaps between the three types of availability.

Identifying and removing process bottlenecks

Availability is a proxy for revenue and throughput. The implication, therefore, is that availability models can be used to find process bottlenecks created by equipment issues. This is in fact the case.

During the design phase the availability model can be used to pinpoint changes in equipment design that will increase plant throughput. The availability model enables the design engineer to make decisions about redundancy levels, plant access, and equipment specifications based on their impact to overall throughput and the cost-benefit ratio (CBR) of the changes.

During the operating life of the plant the reliability engineer and the process engineer can work together using the availability model and Weibull analysis to ferret out process bottlenecks created by poor maintenance strategies, poor initial design, and poor maintenance and operating procedures. By making changes in the availability model the engineers can analyze the CBR of changes in strategy, design, and operating parameters and make those changes which create the lowest life cycle costs for the plant.

Organizational implications

The need to understand and manage the top-level factors that affect availability and to model and understand the achievable availability of a plant has important implications for the shape of the maintenance and engineering organization. The typical organization does not have the necessary resources to accomplish these objectives. Industrial engineering and reliability engineering functions are required.

Fig. 2 illustrates the functional makeup of a typical maintenance organization vs the functional makeup of an availability management-driven organization.

Closing the gaps

Natural gaps exist between inherent availability (A_i) and achievable availability (A_a) and between A_a and operational availability (A_o). Closing these gaps in a cost-effective way makes the plant more successful. Closing the gaps requires a thorough understanding of the top-level factors that determine availability and finding ways to improve in each aspect of those factors. The goal is to select strategies that:

• Minimize the number and length of scheduled outages to drive A_a closer to A_i by making operational and noncapital equipment improvements (see accompanying section "Minimizing Scheduled Outages").

• Minimize the number and length of unscheduled outages to drive A_o closer to A_a by using precision maintenance techniques and making noncapital equipment modifications (see accompanying section "Minimizing Unscheduled Outages").

Further increases in availability may be obtained only by capital investment to increase inherent availability and achievable availability.

Capital improvements for increasing availability

After achievable availability is optimized by improving maintenance operations and making noncapital equipment modifications, the only recourse is to increase availability by capital investment in the plant or by capital investment in the equipment to increase inherent availability:

• Increase achievable availability

1. Modify surroundings: add space around equipment for easier access, improve ingress and egress
2. Modify shops: relocate closer to equipment, improve shop and support equipment (better cranes, better tools, better technology), improve layout
3. Modify stores: relocate closer to equipment, improve storage equipment, improve stores' management software, provide for controlled remote stores

• Increase inherent availability

1. Upgrade equipment: match equipment to production need, improve control system and embed troubleshooting tools
2. Modify equipment: reduce part count, modify guarding, modify lubricant delivery system, add redundancy

Matching availability goals to business need

No business operates in a static environment. Availability goals that are appropriate today may not be appropriate next year, next month, next week, or even tomorrow. Equipment availability is as sensitive to the vagaries of the business climate as any other key performance measure. Business decisions that either enhance or impair availability are made every day at every level of the organization. Availability goals must be reviewed and managed the same as any other business goals because of their sensitivity to available capital and operating funds. Fig. 3 shows typical inputs and outputs of the maintenance process.

The business situation determines whether inputs or outputs are optimized. During times of overcapacity, the business is cost constrained. The input side of the process must be optimized to reduce costs. During times of undercapacity, business is output constrained. The output side of the process must be optimized to increase business output. The important point to remember is that at best, business output will remain constant during periods in which process inputs are being optimized. The longer inputs are constrained, the more negative the effect on the outputs.

Conclusion

Using availability modeling and simulation to engineer availability into a manufacturing facility by laying out equipment and facilities for optimum reliability and maintainability, installing reliable equipment, and engineering maintenance procedures prior to startup will give an organization its best chance of having a reliable plant that is optimally available from day one.

Using availability modeling and simulation to continually monitor operational needs, improve maintenance and operating procedures, and to thoroughly understand the three subtypes of availability and the plant's current status in relationship to achievable availability will help promote long-term success by improving bottom-line results throughout the life of the plant. **MT**

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THREE TYPES OF AVAILABILITY

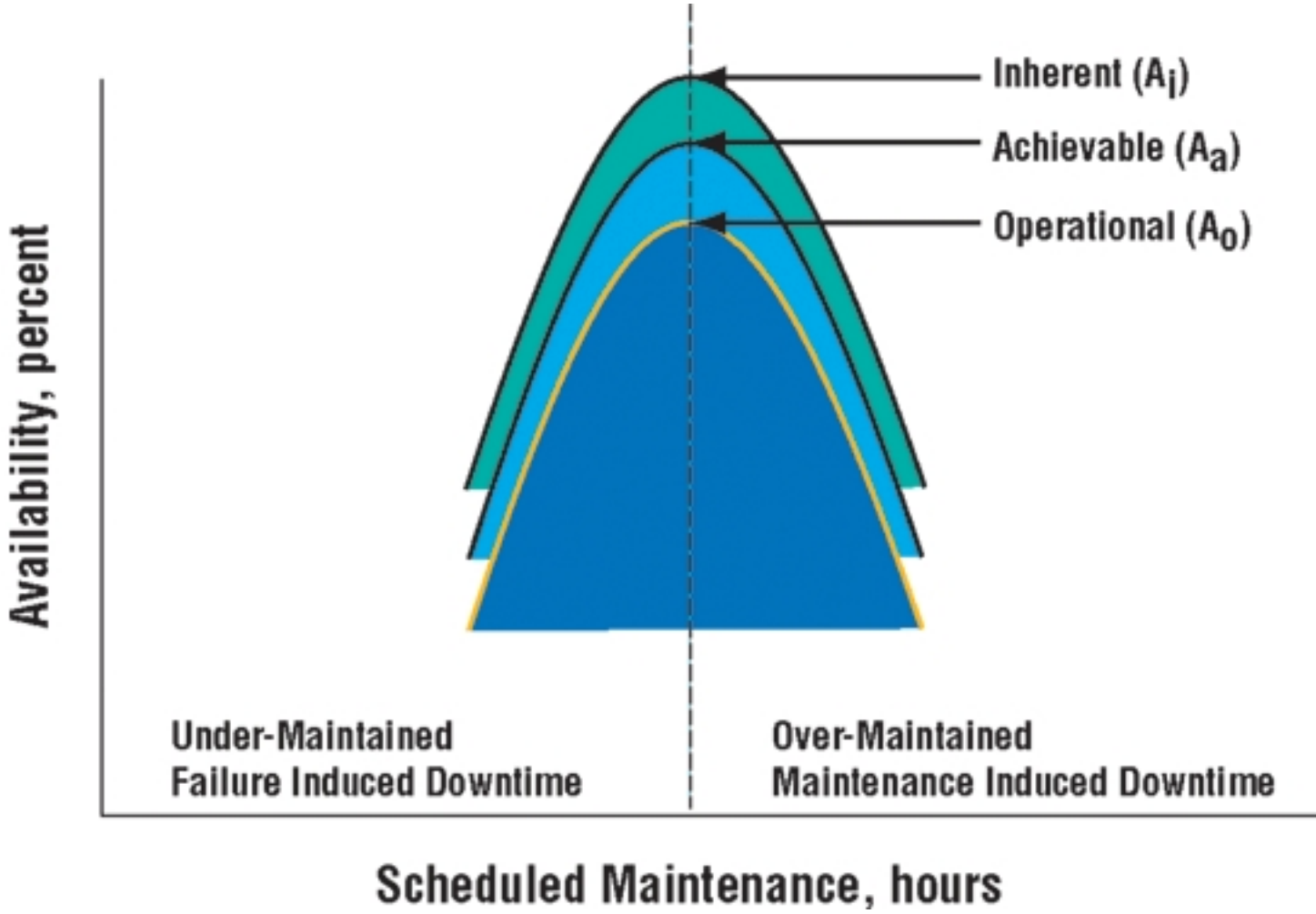

Fig. 1. Inherent availability (A_i) is the expected level of availability for the performance of corrective maintenance only; it is determined purely by the design of the equipment. Achievable availability (A_a) is the expected level of availability for the performance of corrective and preventive maintenance; it is determined by the hard design of the equipment and the facility. Operational availability (A_o) is the actual level of availability realized in the day-to-day operation of the facility. It reflects plant maintenance resource levels and organizational effectiveness.

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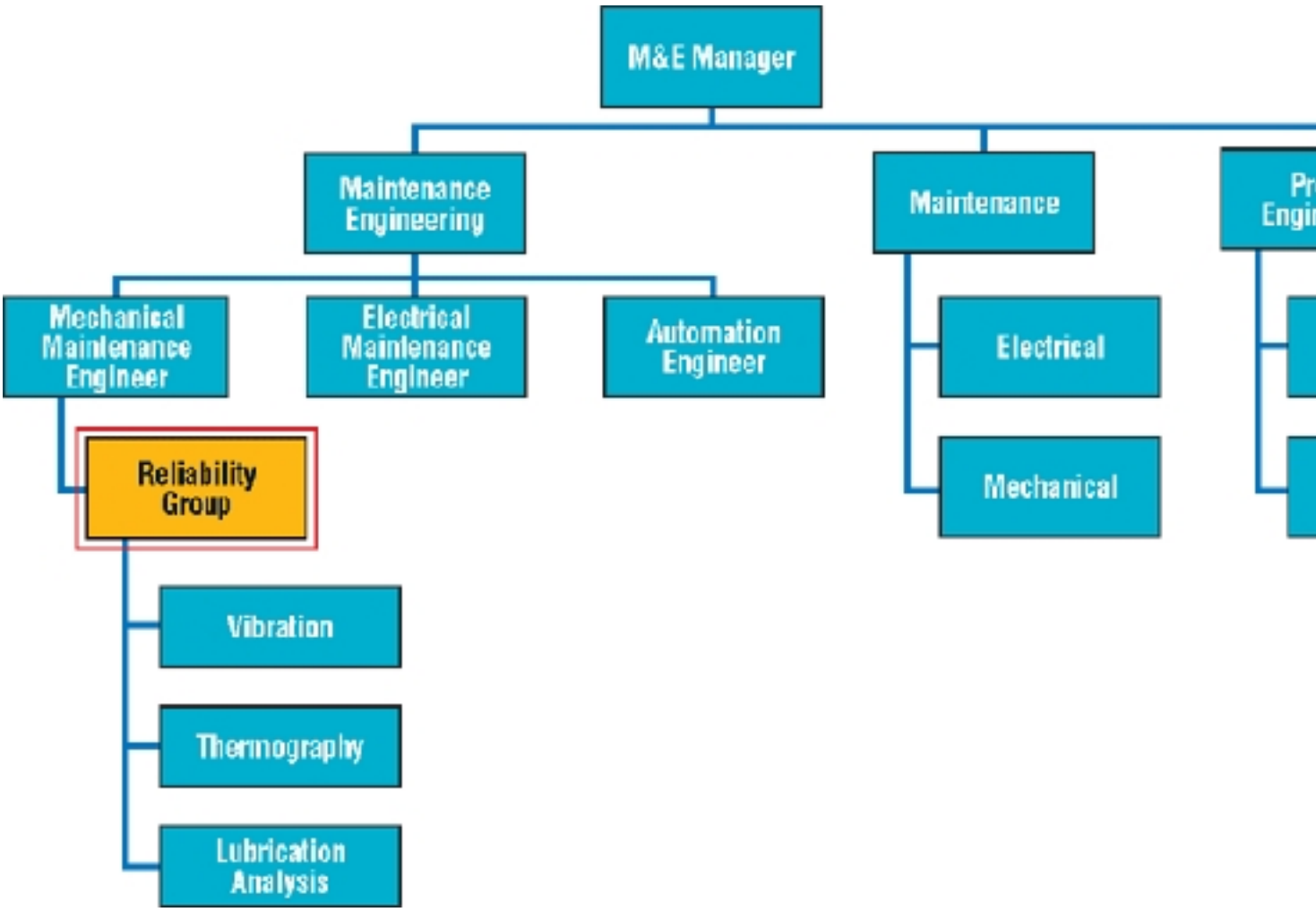
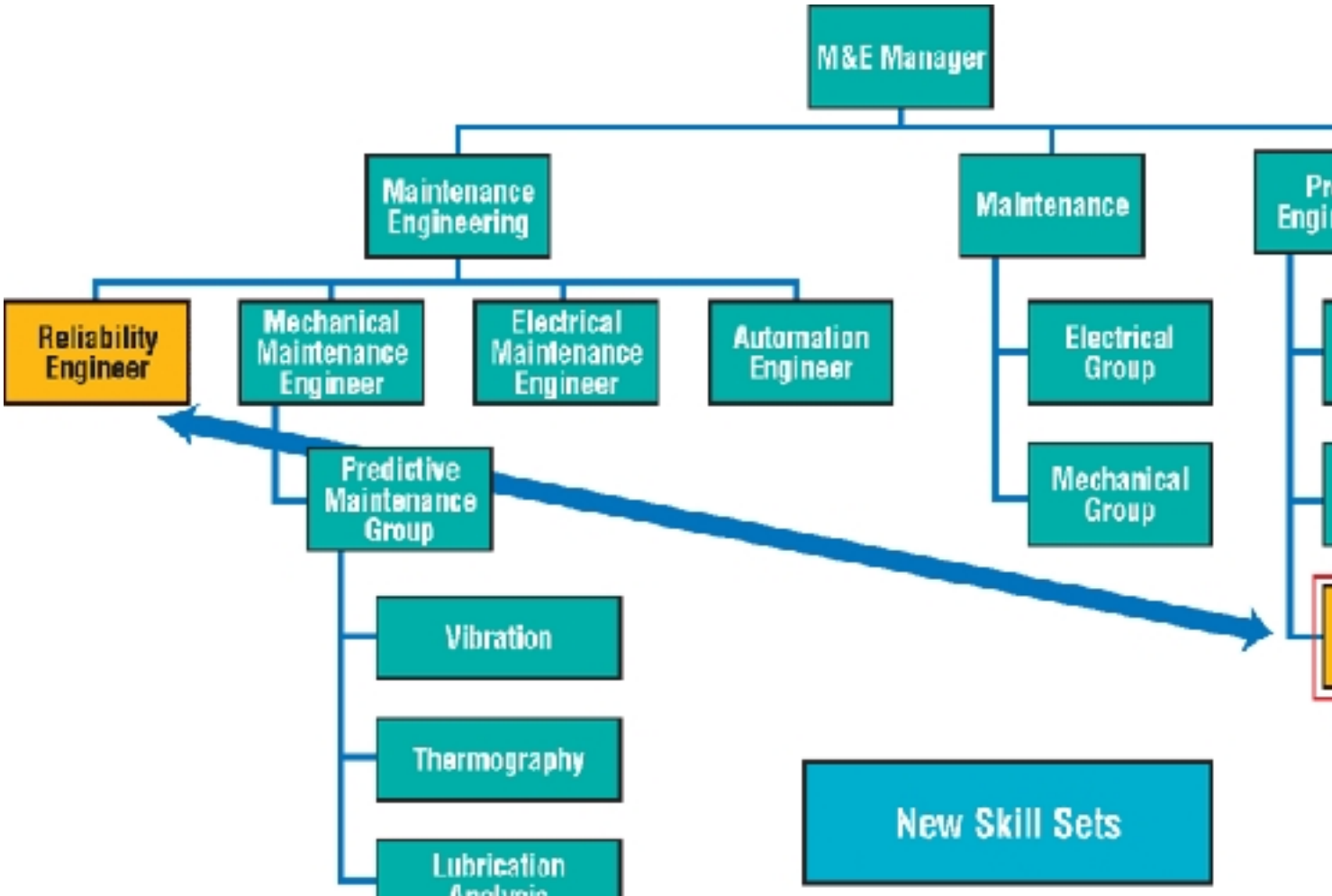
TYPICAL MAINTENANCE ORGANIZATION



NEW MAINTENANCE ORGANIZATION



Analyze failure data to target specific equipment for specific tasks

Analyze equipment using reliability centered maintenance techniques to determine the best PM/Pd

Use predictive maintenance techniques

Perform vibration analysis
" Monitor new installations for minimum vibration
" Monitor existing installations for overall vibration level, signatures, and trends
" Monitor repaired equipment to insure that repairs were done properly

Use thermography

" Monitor electrical equipment
" Monitor like mechanical equipment for temperature differences

Perform lubricant analysis
" Analyze incoming lubricants
" Track trends

Improve outage planning and scheduling

Use project planning techniques
" Gantt charts
" CPM
" Reverse planning

Ensure good planning for every job
" Parts staged
" Good written procedures
" Adequate resources

Improve Equipment

Modify equipment to allow for accomplishing PMs on uptime

Lubrication
Belt checks
Etc.

Modify equipment for easier access

Quick-release guards

Open space around equipment

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THE MAINTENANCE PROCESS

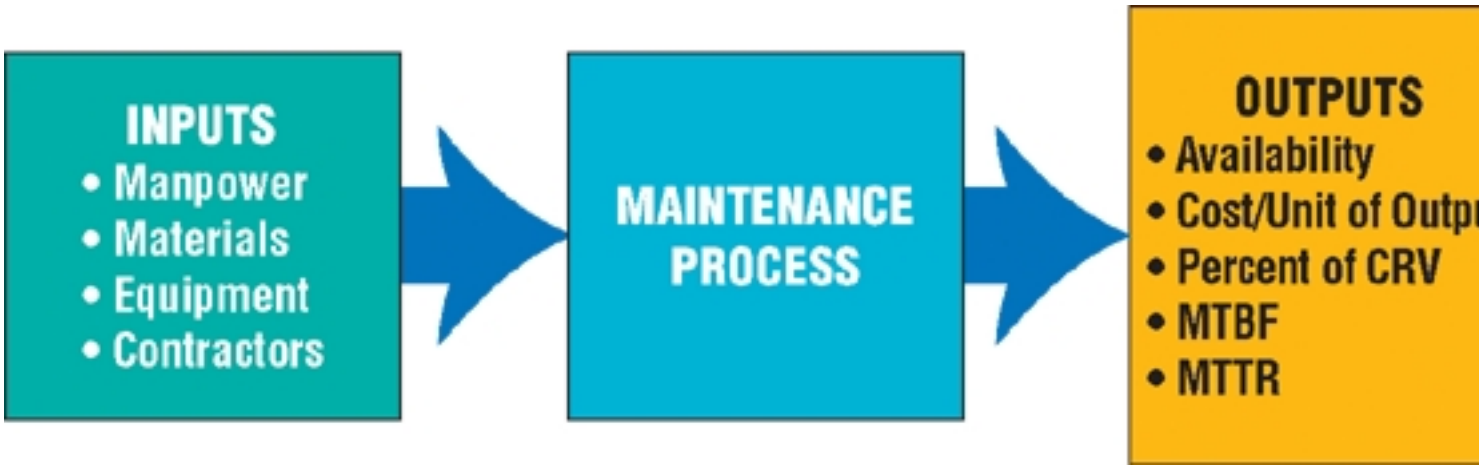

Fig. 3. These are the typical inputs and outputs of the maintenance process. The business situation determines whether inputs or outputs are optimized.

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MINIMIZING UNSCHEDULED OUTAGES

Improve Maintenance Operations

Use predictive maintenance techniques

Vibration analysis
Thermography
Lubricant analysis
Failure trend data

Manage spare parts

Kanban
Poke-a-Yoke
Failure trend analysis
Storage standards

Repair standards for repairables
Remote spares locations
PM procedures for spares

Manage lubricants

Lubricant list
Lubrication routes
Proper storage
Ensure clean lubricant of correct type in correct amount at correct spot

Manage failures

Use canned procedures
Be prepared
Analyze for root cause: physical root and human root
Organizational root

Train

Maintenance personnel
" Precision installation and repair techniques
" Equipment monitoring techniques
" Failure analysis
" Importance of being proactive
" Cost of failures
" Business goals

Front-line supervision and operators
" Proper equipment operation and its relationship to availability
" Their role in achieving availability goals
" What to clean and how to clean it
" Equipment monitoring techniques
" Importance of being proactive
" Cost of failures
" Business goals

Improve Equipment

Quick-release guarding

Open space

Better replacement parts

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