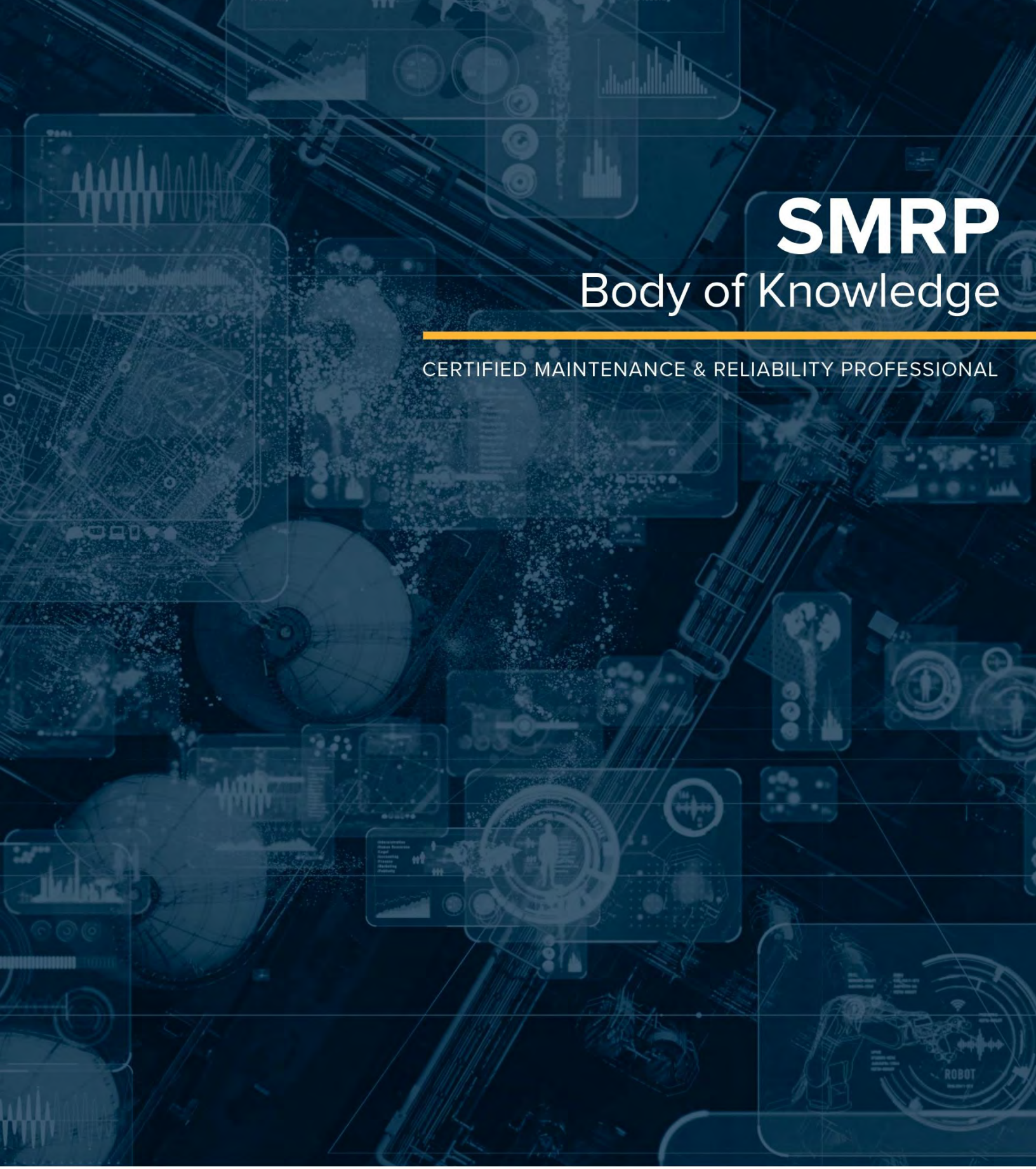

SMRP
Body of Knowledge

CERTIFIED MAINTENANCE & RELIABILITY PROFESSIONAL

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Certified Maintenance & Reliability Professional

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1.0 Business & Management

Translate business goals into maintenance and reliability goals that support an organization's business goals.

1.1 Create Strategic Direction and Plan for M&R Operation

Maintenance and reliability leaders create a vision and a mission as well as a strategic plan, to guide implementation of appropriate maintenance and reliability systems and processes, in order to achieve organizational business goals. The strategic plan provides a clear purpose (a demonstrated business need), defined goals and, in turn, benefits to the organization. Goals should be clear, measurable and established in a top-down (cascading) manner. Maintenance and reliability leaders utilize their knowledge of industry benchmarks to assist in establishing these goals, provide a measurement system, and determine gaps in their maintenance and reliability processes. It is important for operations, maintenance, and other involved disciplines to agree on the goals and the measures used to quantify them. Equally important is an understanding of everyone's role in the strategic plan and the responsibilities they have. Routine review and discussion of progress will provide team commitment and allow for periodic adjustments to the plan that may be required.

1.1.1 Concepts

Understand the organization's business goals
Understand current maintenance and reliability capabilities
Understand "the gap" between current capabilities and stated goals
Understand risk and culture
Establish a vision, mission, and strategic plan
Establish clear and measurable goals
Strategic plan and goals needs to align with and support overall business goals
Strategic plan and goals must be understood and supported by operations, maintenance, and other involved stakeholders

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Develop a business case for change
Develop cascading goals
Benchmarking
Reliability and Maintenance assessments
Leading and lagging KPIs
Gap assessment
Develop roles and responsibilities

1.1.3.1 Definitions

Mission
Vision
Strategic plan

1.2 Administer Strategic Plan

To obtain the support and resources required to implement the strategic plan, a solid business case should be developed that specifies the benefits in financial terms and operational risk mitigation. The business case should include an understanding of the changes that will be required to the organization structure, personnel, roles and responsibilities, tools and training, and priorities.

Support for the resource requirements will be enhanced when management understands the value provided by the plan. Maintenance and reliability leaders should communicate this vision to those with a stake in the process to garner commitment to implementation and execution of the plan. This requires champions positioned to lead the effort and enlist support of customers, stakeholders and staff.

1.2.1 Concepts

1.2.1.1 Understand the Vision, Mission, and Strategic Plan

1.2.1.1.1 Vision

A vision statement describes a future state of a venture in both short and long terms. Intervals of two to five to ten years are common. Vision statements focus on tomorrow and what the venture would like to become. The language often is in present tense as if the vision had been achieved.

1.2.1.1.2 Mission

This is the plan for how you will achieve your vision. Your mission is a call to action. Some reference to a business model would be appropriate. You need not include every detail, which would only handcuff you later. Nonetheless, it is through your mission statement that people will be able to understand how they are going to share your vision with you.

1.2.1.1.3 Strategic Plan

This is a document used to communicate with the organization. You'll need to inform the team with the organization's goals, the actions needed to achieve those goals and all the other critical elements developed during the planning exercise.

Strategic planning is an organizational management activity that is used to set priorities, focus energy and resources, strengthen operations, ensure that employees and other stakeholders are working toward common goals, establish agreement around intended outcomes/results, and assess and adjust the organization's direction in response to a changing environment. It is a disciplined effort that produces fundamental decisions and actions that shape and guide what an organization is, who it serves, what it does, and why it does it, with a focus on the future. Effective strategic planning

articulates not only where an organization is going and the actions needed to make progress, but also how it will know if it is successful.

1.2.1.2. Understand the Business Case and Benefits to Stakeholders

We define a business case as a well-reasoned argument designed to convince an audience of the benefits of an investment, while educating them about the changes, costs, and risks that will be part of the effort. The goal of your business case is to inform key stakeholders about the initiative and convince them to support it in some specific ways.

A complete business case is a package of information, analysis, and recommendations. It includes a plain language statement of the problem to be solved, with key data to illustrate its significance, as well as its severity and complexity. It also identifies customers and other stakeholders and how they are affected by the problem. The case clearly states assumptions, estimates, and other weaknesses in your underlying data. It presents the options available to the decision maker, comparing features, costs and benefits, and stakeholder impacts for each option. The case concludes with a recommended course of action and a justification that presents its strengths and weaknesses.

The business case package includes a variety of presentations, both oral and written, with supporting media such as handouts, slides, or demonstrations. Your business case distills weeks or months of work. You need to be armed with all the data, but you will also need to present your findings and recommendations in a cogent, convincing and interesting way. The best analysis can be entirely misunderstood if the presentation is disorganized, overly technical, or too mired in detail. Decide what the key points are and build your presentation around them. You can always add detail in response to questions.

1.2.1.3 Identify Champion(s) to Lead Implementation of the Strategic Plan

A significant factor in the success of projects is the Champion.

A champion is an individual who identifies with a new development (whether or not he made it) and uses all the weapons at his command against the funded resistance of the organization. He functions as an entrepreneur within the organization. Since he does not have official authority to take unnecessary risks, he puts his job in the organization (and often his standing) on the line.

He has great energy as well as the capacity to invite and withstand disapproval.
The strategic plan needs ownership at the executive level as well as at the staff level. Identify champions of the strategic plan at all levels of the organization and have them help define what's in it for the people they influence. It is important to include all verticals of your organization in this process. Marketing, strategy, planning, and business-development teams should all have buy-in. There are opportunities across the organization for strategic growth. Make sure each team is aligned in the goals and doing its part to execute the plan.

1.3.2.2 Strategic Plan and Goals must be Understood and Supported by Operations, Maintenance and Other Involved Discipline

As mentioned before, everybody must understand what the plan is, the goals, the instruments, and how the follow up process is to be done.

1.2.2 Tools

1.2.2.1 Reporting Tools

Reporting tools are software applications that make data extracted in a query accessible to the user. For example, a "dashboard" is a common reporting tool that makes a variety of information available on a single screen, in the form of charts, graphs, ordered lists, etc.

To do your job well, you need the right information at the right time. Unfortunately, that information lives in an ever-increasing array of disconnected spreadsheets, systems, databases, and applications.

The tool set must include development tools, configuration and administration tools, and report viewing tools.

1.3.2.3 CMMS / EAMS

Computerized Maintenance Management System (CMMS) software makes it easier for maintenance managers to track, manage and report their asset or equipment maintenance needs. To better understand what a CMMS is, we will break the term down into individual components:

Computerized: Computerized refers to the fact that with a CMMS, your maintenance data is stored on a computer.

Maintenance: Maintenance is what users of CMMS software do every day, whether it's responding to an on-demand work order for a broken window or performing routine inspection on a generator. Computer software cannot accomplish the work of a skilled technician. What it can do, however, is ensure tasks are prioritized correctly and that everything is in place (inventory, labor) to ensure success. CMMS solutions give technicians the freedom to focus less on paperwork and more on hands-on maintenance.

Management: Managing maintenance is the most essential role of a CMMS solution. Maintenance management software is designed to give users immediate insight into the state of his or her maintenance needs with comprehensive work order schedules, accurate inventory forecasts, and instant access to hundreds of invaluable reports. CMMS solutions make maintenance management easier by empowering managers with information so that they can make the most informed decisions possible.

Systems: Different CMMS solutions offer diverse types of systems. The best CMMS systems allow users to accomplish existing maintenance practices more effectively while introducing time-saving features that lead to cost reductions and further time savings.

Enterprise Asset Management System (EAMS) is the optimal lifecycle management of the physical assets of an organization. Subjects covered include the design, construction, commissioning, operations, maintenance and decommissioning or replacement of plant, equipment and facilities. To better understand what an EAMS is, we will break the term down into individual components.

Enterprise: Enterprise refers to the scope of the assets in the organization departments, locations, facilities; and potentially supporting business functions, including Finance & GL, Human Resources and Payroll. Various assets are managed by modern enterprises at present. An "Enterprise" often refers to more than one plant, often a group of plants, and often the term covers multiple operations within a single plant.

Assets: The assets may be fixed assets like buildings, plants, machineries or moving assets like vehicles, ships, moving equipment etc.

The lifecycle management of the high-value physical assets requires regressive planning and execution of the work.

Management: Maintenance Management solutions helps companies like yours do the following:

Deploy maintenance resources effectively.

Manage maintenance-related, work-order processes efficiently.

Schedule maintenance based on asset condition rather than on arbitrary dates.

Model scenarios to determine optimum preventive maintenance.

Create customized reports to meet business-specific asset management needs.

Enterprise Asset Management and Maintenance Solutions enables companies to improve performance visibility by analyzing data for key trends and anomalies, forecasting reliability issues, and making forward-looking decisions that deliver improved bottom-line results.

Key functions of EAM software include the following.

Work Orders: Scheduling jobs, assigning personnel, reserving materials, and recording costs.

Preventive Maintenance: Keeping track of preventive maintenance inspections and jobs, including step-by-step instructions or checklists, lists of materials required, and other pertinent details.

Asset Management: Recording data about equipment and property including specifications, warranty information, service contracts, spare parts, purchase date, and expected lifetime.

Inventory Control: Management of spare parts, tools, and other materials including the reservation of materials.

Advanced Reporting and Analytics: Creating customized reports and analyses that can be used to forecast likely problems in time to prevent them. Financial Management and Reporting Tools include Purchase Requisitions (PR), Purchase Orders (PO), and Approvals for Expenditures (AFE)

1.3.2.4 Scorecards

A performance scorecard is a graphical representation of the progress over time of some entity, such as an enterprise, an employee or a business unit, toward some specified goal or goals. Performance scorecards are widely used in many industries throughout both the public and private sectors.

Scorecards can be arranged into many visual configurations, but most will at least place goals alongside a running tally of current totals, to provide an at-a-glance measure of progress.

Though the term "scorecard" is often used synonymously with "dashboard," there is at least one significant difference: Scorecards must exhibit progress against a goal, while dashboards can simply display individual pieces of data without any context.

1.2.2.2 Communication Plan

The communication plan serves as a guide to the communication and sponsorship efforts throughout the duration of the project. It is a living and working document and is updated periodically as audience needs change. It explains how to convey the right message from the right communicator to the right audience; and through the right channel at the right time. It addresses the six basic elements of communications: communicator, message, communication channel, feedback mechanism, receiver/audience, and time frame.

Communication plans should encompass one time and repetitious events to inform and update key audiences and stakeholders on vision, case for change, goals, programs, metrics, and key personnel; along with information on where to get more information as well as key contacts for answering questions and providing ongoing feedback.

A communication plan includes the following:

Who – The target audiences.
What – The key messages to be articulated.
When – The timing. It specifies the appropriate time-of-delivery for each message, including repeating events or updates.
Why – The desired outcomes.
How –The communication vehicle. It is how the message will be delivered.
By Whom – The sender. This is the person who will deliver the information and how he or she is chosen.

1.2.2.3 Project Planning Methodology

Project management is the discipline of initiating, planning, executing, controlling, and closing the work of a team to achieve specific goals and meet specific success criteria. A project is a temporary endeavor designed to produce a unique product, service or result with a defined beginning and end (usually time-constrained and often constrained by funding or deliverable) undertaken to meet unique goals and objectives, typically to bring about beneficial change or added value.

The temporary nature of projects stands in contrast with business as usual (or operations), which are repetitive, permanent, or semi-permanent functional activities to produce products or services. In practice, the management of such distinct production approaches requires the development of distinct technical skills and management strategies.

The primary challenge of project management is to achieve all the project goals within the given constraints. This information is usually described in project documentation, created at the beginning of the development process. The primary constraints are scope, time, quality and budget. The secondary challenge is to optimize the allocation of necessary inputs and apply them to meet pre-defined objectives.

1.2.2.4 Milestone

Milestones are tools used in project management to mark specific points along a project timeline. These points may signal, among other anchors, such anchors as the following: a project start and end date, a need for external review, or input and budget checks. In many instances, milestones do not impact project duration. Instead, they focus on major progress points that must be reached to achieve success.

A good project management plan will include timelines that allow the organization to clearly see the time investment necessary to implement the plan and project.

1.2.3 Processes

1.2.3.1 Present Business Case to Stakeholders

Addressing the individual concerns of stakeholders in the room will go a long way toward winning you allies and gaining buy-in by key stakeholders and formal and informal change agents within the organization. For example, if the finance person frets about keeping expenses under control, discuss expense numbers; if someone is interested in growth in Asia, show how your project helps the company grow in the region.

Research past presentations and outcomes to make sure bases are covered. If other projects had questions or issues, make sure you have answers and address those issues.

Consider allowing decision makers to preview your presentation. Ask for their input in advance and include their recommendations in the final presentation. That increases their investment in your success. Letting key stakeholders see how you listened to their input and included their ideas increases their buy-in into your proposal.

1.2.3.2 Communicate the Plan to Garner **"Buy-In"**

For a plan to be effective, it must enjoy full support from an organization's executive leadership. An information security officer must play the role of a salesman, not only to corporate leadership but also to rank-and-file staff. Top-to-bottom organizational buy-in is essential and will dictate the effectiveness of the plan and its associated policies and procedures.

The need for executive level sponsorship is twofold. First, to assure staff buy-in, corporate leadership needs to visibly and consistently validate the policy and procedures. If the executive level doesn't fully support the program, there will be little reason for the rest of the organization to do so. Second, it is necessary to ensure that funding will be in place to support the program. A significant initial investment of human resources, hardware, and software is necessary for the correct development of the program.

It is vital to communicate with top executives and receive their attention and support. Changes and movements are always involved in these projects and the support and goodwill of all of the organization including top management is necessary.

1.2.3.3 Determine Necessary Organizational Structure and Staffing

The organization may be structured in diverse ways, according to its main objectives. Company structure determines how the business will operate and perform. Organizational structure can allow for the allocation of responsibilities for the company's functions in management and production. Operational standards and routines may be developed based upon the foundation of the organizational structure. Designing an organizational structure helps to determine which staff participate in decision making, which can be helpful in shaping the actions of the company or business.

An organizational structure defines how activities such as task allocation, coordination and supervision are directed toward the achievement of organizational aims. Organizations need to be efficient, flexible, innovative and caring to achieve a sustainable competitive advantage. Organizational structure can also function as a viewing glass or perspective through which individuals perceive their organization and its environment.

1.2.3.4 Determine Roles, Responsibilities and Expectations

The success of a team can be impeded by a lack of clarity regarding the roles, responsibilities, and expectations of the various agencies and individuals who compose its membership. To fully understand the distinction between a role and a responsibility, please keep in mind the following definitions:

> Roles are the positions team members assume or the parts that they play in an operation or process. (For example, a role an individual might assume is that of facilitator, or communications liaison.) Formal roles essentially describe "who" is responsible for "what."
>
> Responsibilities are the specific tasks or duties that members are expected to complete as a function of their roles. They are the specific activities or obligations for which they are held accountable when they assume—or are assigned to—a role on a project or team. (For example, the role of a team facilitator might include responsibilities as follows: that meeting agendas reflect feedback and input from all members; that the

meetings start and end on time; and that all members have opportunities to contribute to discussions.)

Expectations are performance indicators that evaluate how well the responsibilities are being performed. They provide a standard by which people are held accountable for their responsibilities in the organization.

1.2.3.5 Determine Necessary Tools and Training

How should an organization best determine its training needs? Here are eight ideas to consider:

Define your need area or areas. Once you have identified an area in which your organization needs to trained or developed, define the need area with specifics. Can you validate that the need exists? What could excellence in this area do for your organization? How will excellence impact your organization's overall key performance indicators?

Analyze and assess your current state. In addition to traditional analysis, use an assessment. You can find an assessment to measure just about anything, from technical skills to soft skills, from leadership competencies to attitudes, from behavioral tendencies to teaming skills, and everything in between. Look for instruments that are research-backed and reliably measure the specific area or areas you identify. A good assessment should provide comparative norms that you could benchmark your organization against and then measure an individual's progress following training.

Develop your plan. Effective training and development should change behaviors and performance so never enter into it without a plan. Establish goals and objectives that describe where you want to be and when. Determine the resources you will need. Think about what can go wrong during the execution of your plan and develop contingency plans. Focus on measurable outcomes that result from employees successfully applying what they learn.

Engage experts. Face it: If you already had in-house expertise then you would not have gaps in performance, knowledge and behaviors! You need the expertise of outside resources that have a proven track record of helping clients succeed. The good ones will help you design your plan and they may also recommend assessments and tools to benchmark and measure progress. The best ones will help you become self-sufficient.

(Note to self: Beware of those organizations that want to perpetually train you.)

Train your leaders first. Always train your leaders first. Leaders should model the new skills and behaviors themselves. They must know the training well enough to accurately observe performance, reinforce training and coach employees in applying and mastering the training. Effective leaders schedule observation time to follow up training. They have the necessary tools to provide formal and informal feedback to employees. Unless management observation and feedback is intentional, what is learned will not be retained and the organization will have wasted the opportunity and resources spent on a training program.
Train your staff and institutionalize the training. The most effective training programs are those which follow this sage advice: *Never do for the learner what the learner should do for himself.* The learner will only master a skill or behavior through repeated application. Repetition is the heart of learning, so what is learned during the training must be reinforced in the days, weeks, and months following the training.

Catch them doing it right. Leaders should plan on catching their people correctly applying the training and provide immediate feedback to encourage continued use and development. An excellent practice following training is to dedicate a portion of staff meetings for employee discussion and skills reinforcement. Recognize staffers who have done well applying what was learned. Finally, remember that people don't always do what you expect but they do what you inspect.

1.2.3.6 Determine the Detailed Implementation Plan

In this portion of the business plan, you'll clarify objectives, assign tasks with deadlines, and chart your progress in reaching goals and milestones.
Guidelines for the implementation plan include the following:

Objectives: These should be crystal clear and specifically spelled out. You will use them as a building block for the rest of the implementation plan.

Tasks: This part details what must be accomplished to achieve your objectives. Include a task manager for each step, so that roles are clearly defined and there is accountability. As you enumerate tasks and assignments, these descriptions should be plainly and generally stated; don't get into a step-by- step, micromanaged explanation of how the tasks will be carried out.

Emphasize the expected results associated with these tasks.

Time allocation: Each task should be paired with an appropriate timeframe for completion. You should be aggressive but reasonable with your time allocation to ensure not just completion but competent work. For assistance in framing this timescale, use a program such as Microsoft Project, or just create your own Gantt chart.

A Gantt chart is a helpful tool that shows how long it will take to complete different tasks and in what order the tasks should be finished.

Progress: You or a member of your management team needs to oversee monitoring each task's progress and the completion percentage of each objective. When delays occur, try to get to the root of the problem. Did the person responsible drop the ball? Did he or she have too many responsibilities to handle? Did a third party, such as a supplier or the bank, fail to hold up its end of a deal? Adjust your Gantt chart appropriately to account for the delay, and make a note of the previous deadline and the reason it was missed.

The more efficiently you start implementing your business plan, the more likely it is that you will survive this initial period.

1.2.3.7 Determine Available Resources

Having sufficient support for your efforts to become success will make your plan and activities more effective and efficient. Having sufficient resources to carry out the changes you want to make is equally important.

Before you start planning, you need to look at what you already do with regard and what resources you have available. Then you can further expand and improve your current efforts.

Resources include the following:

Human resources: People who are already in the staff or who you'll need to find.

Financial resources: These include incomes and assignations as well as other special sources to be determined by the specialist to find what are we looking.

Materials, instruments and others: This includes whatever will be required to achieve the goals.

1.3 Measure Performance

Measuring the right things, the right way is the key to any successful maintenance and reliability process. With a clear mission, vision and strategic plan, you are ready to match these ideas with leading and lagging key performance indicators (KPIs). These measures will help you know when you have achieved your goals. Each KPI should be the result of multiple dimensions that check for quantity as well as the quality. This approach will magnify any manipulation of data and enable achievement of each goal. Providing written definitions of roles and responsibilities, getting everyone in the organization involved in the process and providing good and bad feedback weekly will ensure continuous improvement.

1.3.1 Concepts

1.3.1.1 Review the Mission, Vision and Strategic Plan

Mission could be defined as the reason why you do something. Vision could be defined as where are you trying to go, or where you would like to see process develop over a period of time. Values keep all the elements together in the organization; they could be defined as how you go about it. Every person in the process should understand the above three elements and include them in their activities, in order to build a strong foundation for the establishment of the goals and objectives that define the strategic direction.

Mission is a statement about your core purpose, why the organization exists. It should be stated in the present tense.

Vision is the statement about the desired stage: Where should we push? What process will achieve a stage? Vision could be stated in the future tense.

Strategic Plan is the organization process that defines the direction and the allocation of resources. The strategic plan makes the decision to pursue the strategy. A strategy describes how the goals are going to be achieved with resources.

1.3.1.2 Establish Written Expectations for Each Process

For the organization to dispose of resources according to requirements, every process should have its expectations described in writing. This methodology will allow for a continuous control of resource allocation and control of the final products.

It could establish the correctives in the proper moment, avoiding an overflow in the use of resources and identifying requirements with regard to quality, quantity and opportunity.

Some authors define steps in the development of these written expectations. They need to be clear for everybody and identify where you need them. Everybody needs to be involved, so meetings are necessary to discuss the steps, understand why they are needed, and to make them unique. Once these phases are complete, write them clearly in a simple language that makes them universal and obtain final agreement.

1.3.1.3. Develop Leading Key Performance Indicators

Leading indicators are oriented toward input. They are hard-to-measure and easy-to-influence. As an example of a leading indicator, a personal goal for many of us could be to lose weight. To achieve this goal, it will be necessary to reduce calories taken and to burn calories. These two indicators are easy-to-influence but difficult-to-measure. Leading indicators are often related to activities undertaken by the work team. In the example above, exercise and eating are activities.

Leading KPIs are process oriented. We can identify some leading indicators as follows: the percentage of work orders over the specific time; or the percentage of available man-hours to total available man hours over the specific time.

1.3.1.4. Develop Lagging Key Performance Indicators

Lagging indicators are typically oriented toward output. They are easy-to-measure but hard-to-influence. Using the weight loss example, standing on the scale and measuring your weight is easy to measure. You immediately get an answer. But weight loss is not an activity.

Lagging KPI are oriented to results. We can identify some lagging indicators as follows: Maintenance Cost, Maintenance Cost over Total Sales, Maintenance Cost over Unit Output, Mean Time Between Failures (MTBF), Failure Frequency, and Unscheduled Maintenance Downtime.

1.3.1.5 Develop Qualitative Performance Measures

Qualitative measures gauge the amount of what is happening. Numbers are building blocks of amounts. Even when you're turning attitudes into numbers, you're doing it to gauge an amount. That technically means that every measure is quantitative.

1.3.1.6 Establish Related KPIs that can be used as Multiple Dimensions

A Key Performance Indicator (KPI) is a quantifiable measurement for gauging business success. A KPI is a collection of calculations associated with a group of measures. These calculations and measurements are used to evaluate business success. Typically, the calculations are a combination of Multidimensional Expressions (MDX) expressions or calculated members. KPIs include additional data and information about how client applications should display the results of the KPI's calculations.

A KPI manages information about a goal set and the actual formula of the performance that is recorded as well as measurements showing trends and the current status of the performance.

The alignment of KPIs with the vision, mission, strategies and objectives of the organization is the key to realizing an impact on the bottom line. The challenge is to develop KPIs that provide a holistic and balanced view of the business. Faced with potentially hundreds (if not thousands) of candidate metrics, how does one select those that are most meaningful? One approach is to think of individual KPIs not just as a singular metric but as a balanced metric of several dimensions. These dimensions include business perspectives (customer, financial, and process and development), measurement families (cost, productivity, and quality) and measurement categories (direct, additive, and composite). By overlaying these various dimensions, one can create a KPI framework that succinctly captures the most critical business drivers.

Robert Kaplan and David Norton introduced the balanced scorecard methodology for performance management in the early 1990s. Since then, the conceptual framework of the scorecard methodology has been enthusiastically embraced by Corporate America. As a performance management tool, the balanced scorecard assists management in aligning, communicating and tracking progress against ongoing business strategies, objectives and targets. The balanced scorecard combines traditional financial

measures with nonfinancial measures to measure the health of the company from four equally important perspectives as follows:

Financial: It measures the economic impact of actions on growth, profitability and risk from the shareholder's perspective (net income, ROI, ROA, and cash flow).

Customer: it measures the ability of an organization to provide quality goods and services that meet customer expectations (customer retention, profitability, satisfaction, and loyalty).

Internal Business Processes: It measures the internal business processes that create customer and shareholder satisfaction (project management, Total Quality Management (TQM), and Six Sigma).

Learning and Growth: It measures the organizational environment that fosters change, innovation, information sharing and growth (staff morale, training, and knowledge sharing).

Although the focus of each perspective is distinctly different, there is a common thread of causality and a universal linkage between the four perspectives. For example, if a company invests in learning and growth to improve employee skills and elevate morale, then those results will be translated into improved internal business processes through best practices and change management programs such as Six Sigma and TQM. Subsequently, these activities will result in superior quality products and services for the customer, which in turn will drive increased sales and an improved financial bottom line.

Another important consideration in the development of KPIs is the selection of the appropriate measurement family. The appropriate KPIs will capture operational performance over time and then be related to internal business and external industry benchmarks. Although the following list reflects common measurement families, different industries will have their own specific business drivers and related measures.

Productivity: This KPI family measures employee output (in terms of units, transactions or dollars) and uptime levels. KPIs can also be selected to show employees use their time. Examples are sales-to-assets ratio, dollar revenue from new customers, and various KPIs related to the sales pipeline.

Quality: These KPIs measure the ability to meet or exceed the requirements and expectations of the customer. Examples are customer complaints, percent returns, and defects per million opportunities (DPMO).

Profitability: These measure the overall effectiveness of the management organization in generating profits. Examples include profit contribution by segment or customer, and margin spreads.

Timeliness: Measures the point in time when management and employee tasks are completed, according to the day, week or month. Examples are on-time delivery and percent of late orders.

Process Efficiency: Measures how effectively the management organization uses quality control, Six Sigma and best practices to streamline operational processes. Examples are yield percentage, process uptime, and capacity utilization.

Cycle Time: Measures the duration of time required by employees to complete tasks in hours, days or months. Examples are processing time, and time to service customer.

Resource Utilization: Measures how effectively the management organization leverages existing business resources such as assets, bricks and mortar and investments. Examples are sales per total assets, sales per channel, and win rate.

Cost Savings: Measures how successfully the management organization achieves economies-of-scale and scope-of-work with its people, staff and practices to control operational and overhead costs. Examples are cost per unit, inventory turns, and cost of goods.

Growth: Measures the ability of the management organization to maintain a competitive economic position in the growth of the economy and industry. Examples are market share, customer acquisition and retention, and account penetration.

Innovation: Measures the capability of the organization to develop new products, processes and services to penetrate new markets and customer segments. Examples are new patents, new product rollouts, and R&D spend).

Technology: Measures how effectively the IT organization develops, implements and maintains information management infrastructure and applications. Example KPIs are IT capital spending, CRM technologies implemented, and Web-enabled access).

The perspectives and measurement families can now be combined to develop a KPI profile matrix as shown in Figure 1). This matrix provides a construct for balancing the number and types of KPIs. For example, performance management implementations typically fall short of balancing financial and non-financial KPIs. The profile matrix helps ensure a proper mix of financial and non-financial measures.

1.3.1.7 Establish a Goal for Each Key Performance Indicator

A key performance indicator (KPI) indicates whether or not you are achieving one of your strategic goals. You need KPI targets to communicate the level of performance you are trying to achieve. To set the targets, follow these four steps:

1. Set a long-term target: Start by defining your long-term target first. This target (which is set for 3-5 years out) typically corresponds with your strategic plan and is a known goal throughout your company. These long-term targets can be:

   Derived from your overall mission.
   Related to your benchmarking.
   Based on your own historical performance.

2. Determine leading and lagging indicators: Lagging indicators show whether or not you accomplished your goals. Leading indicators show what needs to be done to meet your goals.

3. Leading and lagging Indicators must be linked together.

4. Break them down into annually and quarterly targets.

1.3.1.8 Provide Written Definitions of Roles and Responsibilities

A role can be defined as "a prescribed or expected behavior associated with a particular position or status in a group or organization" and a responsibility as "a duty or obligation to satisfactorily perform or complete a task (which can be assigned by someone else, or created by one's own promise or circumstances) that one must fulfill." In order to identify all of the objectives, goals and targets, one must first completely define and determine the following.

Activities performed on a timescale basis.

The correct use without deviation of instruments and tools. In general, all available resources should be identified.

Who will act and when they will be involved in the project. This requires a complete analysis of the team capabilities as well as preparation to assure the correct performance of each person for each situation.

Allocate the resources in a timescale program to avoid deviations. All the resources, people and supplies might not be available in the quantities desired so it is necessary to run the correct planning on resources. Knowing when personnel will be needed on the site and what instruments will be needed in hand allows you to pursue maximum performance during the action window.

1.3.1.9 Develop Training Materials

To reach all our goals in the time and quantities expected and planned, it is necessary to involve all actors, team members, contractors, specialist, accountants, field consultants, operators, maintenance people as well as human resources and top management in the whole project.

It is important to explain in detail each of the project phases, including what is expected and when from all persons, and what is the expectation of their performance.

To accomplish these critical tasks and achieve the goals, it is necessary to study and develop the communication structure and also to design and prepare of all the instruments. Content specialist, if available, could diagram and produce project workbooks. These specialists will collect the information from each team member working in the planning process and work toward a product that should be universal and easy-to-understand, carrying a clear message to everyone.

Once the material is ready, prepare a training calendar and require participation from everyone who is involved in the activity. The assistance will not warranty the results but the teamwork and the power of the information will motivate everybody to support the intentions of the company or organization. Personnel at every corporate levels should be treated with the same respect if you expect the most of them.

1.3.1.10 Develop Incentives for Each Measure

Building an effective incentive plan requires a company to align interdependent elements within the business in a way that communicates a clear behavior standard to its employees. The incentive plan must have a purpose. It must project the potential that can be realized if the purpose is fulfilled and it must identify the people who are able to effect those outcomes.

This interdependent alignment is held together by forming the right measures and metrics in your reward strategies. Those indicators should be measurable even if not be directly reflected in the financial statements. The chosen measures should help track progress towards strategic objectives and reflect improvements in productivity.

The role of indicators is to improve performance and influence behavior. Along with the communication program, indicators help focus on results and encourage ownership culture.

1.3.1.11 Review Measure Effectiveness

Feedback presented in a timely and effective manner is a critical component of a successful performance management program. Such can be included when setting performance goals. Feedback on progress towards goals will improve performance. Employees need to know in a timely manner how they are doing, what is working and what is not.

When: It is necessary to inform in a timely manner. If an improvement needs to be made in their performance, the sooner they find out about it the sooner they can correct the problem. If employees have reached or exceeded a goal, the sooner they receive positive feedback, the more rewarding it is to them.

Direct: Feedback works best when it relates to a specific goal.

How: Feedback should help improve performance. People respond better to positive information so express feedback in a positive manner. That does mean that "making up" the message. If someone or something needs to be disputed, challenged, called into question or otherwise faced or confronted, do not hesitate to do so. However, the actions must be aligned with a common goal that has been agreed upon.

1.3.2 Tools

1.3.2.1 KPIs

KPIs are the key business statistics. They measure a company's performance in critical areas. They show progress (or lack of progress) toward realizing organization objectives or strategic plans. They monitor activities, which, if improperly or poorly performed, could cause severe losses, result in a system failure or yield a defective final product.

Most goals are achieved not just through the efforts of a single person but rather by multiple people in a variety of departments across an organization. Performance management experts agree that cascading and aligning goals across multiple owners creates a "shared accountability" that is vital to a company's success. The company then uses its Key Performance Indicators as the foundation to analyze and track performance and base key strategic decisions regarding staffing and resources.

The achievement of our objectives is measured using qualitative assessments and through the monitoring of quantitative indicators. To provide a full and rounded view of our business, we use non-financial as well as financial measures. Non-financial measures are often leading indicators of future financial performance. Improvements in these measures build our competitive advantage.

Although all our non-financial measures are important, some are more significant than others. These significant measures are designated as Key Performance Indicators (KPIs).

If we can make a list of KPIs then it will be found that most depend on the goals, the activities, and the team. The junction of these three elements define where to measure and what to measure to achieve the goals.

For example, maintenance work needs to support the business aims and operating strategy. Once the link between business goals and the maintenance activities that are needed to achieve them is made clear then everyone can see the benefits that maintenance brings to the business. Interlinked, cascading objectives connect the business together from top to bottom, and KPIs measure and check if they are being achieved.

1.3.2.2 CMMS

A Computerized Maintenance Management System (CMMS) is computer software designed to simplify maintenance management. We'll break the term by each of its components as follows:

Computerized: Maintenance data was historically recorded with a pencil and paper. Because of this, maintenance was largely reactive rather than proactive. That is, maintenance was performed only when something went wrong. Preventive maintenance was less common because it was unrealistic to track which assets needed routine maintenance when all your asset's maintenance records were kept in a filing cabinet. Computerized refers to the fact that with a CMMS, your maintenance data is stored on a computer. When organizations began to migrate from paper and pencil to their computers, suddenly, organizations could track work orders, quickly generate accurate reports, and easily identify assets that require preventive maintenance. These changes led to extended asset lifespans and improved organization. Ultimately computerization reduced costs and increased profits.

Maintenance: This is what it is supposed to done every day. The system idea ensures tasks are prioritized correctly and that the inventory and labor everything else is in place to ensure success. CMMS solutions give technicians the freedom to focus less on paperwork and more on hands-on maintenance.

Management: Maintenance management software gives users immediate insight into the state of his or her maintenance needs. It does so with comprehensive work-order schedules, accurate inventory forecasts, and instant access to hundreds of invaluable reports.

System: The best CMMS system is one that allows users to accomplish the existing maintenance practices more effectively while introducing time-saving features that lead to a reduction of costs and time savings.

Any organization that must perform maintenance on equipment, assets and property can use a CMMS package. Some CMMS products focus on industry sectors such as the maintenance of vehicle fleets or healthcare facilities. Other products aim to be generally applied.

CMMS packages can produce status reports and documents that give details or summaries of maintenance activities. The more sophisticated the package, the more analytic capabilities are available.

CMMS packages can be web-based, meaning they are hosted by the company selling the product on an outside server; or they can be LAN based, meaning that the company buying the software hosts the product on its own server.

1.3.2.3 Business Intelligence Software

Business intelligence (BI) is a technology-driven process for analyzing data and presenting actionable information to help corporate executives, business managers and other end users make more informed business decisions.

A wide variety of tools, applications and methodologies enable organizations to collect data from internal systems and external sources; prepare the data for analysis and develop and run queries against the data; and create reports, dashboards and data visualizations to make the analytical results available to corporate decision makers as well as operational workers.

BI software offers maintenance and repair professionals the following benefits:

- Accelerate and improve decision making.
- Optimize internal business processes.
- Increase operational efficiency.

Drive new revenues.
Gain competitive advantages over business rivals.
Help companies identify market trends and spot business problems that need to be addressed.

BI software comprises a set of strategies, processes, applications, data, technologies and technical architectures. Enterprises use these features to support the collection, data analysis, presentation and dissemination of business information. The software provides historical, current and predictive views of business operations.

Common functions include the following:
Reporting
Online analytical processing
Data and text mining
Complex event processing
Business performance management
Benchmarking
Predictive Analytics and many others

BI software can handle copious amounts of structured and sometimes unstructured data, which helps identify, develop and otherwise create new strategic business opportunities. BI software aims to allow for the easy interpretation of these big data. Identifying new opportunities and implementing an effective strategy based on insights can provide businesses with a competitive market advantage and long-term stability.

1.3.2.4 Scorecards

The Balanced Scorecard (BSC) is a strategic planning and management system that organizations use to accomplish the following:
Communicate what they are trying to accomplish
Align day-to-day work with strategy
Prioritize projects, products, and services
Measure and monitor progress towards strategic targets

The BI system connects the dots between big picture strategy elements and operational elements. Big picture elements include mission (our purpose), vision (what we aspire for), core values (what we believe in) and strategic focus areas (themes, results and/or goals). The more operational elements

include objectives (continuous improvement activities), measures (or key performance indicators, or KPIs, which track strategic performance), targets (our desired level of performance), and initiatives (projects that help you reach your targets).

The Balanced Scorecard suggests that we view the organization from four perspectives and develop objectives, measures (KPIs), targets, and initiatives (actions) relative to each of these four points of view.

Financial: The financial perspective is often called stewardship or other more appropriate names in the public sector. Its view is towards organizational financial performance and the use of financial resources.

Customer/Stakeholder: This perspective on organizational performance is from the points of view of the customer or other key stakeholders whom the organization serves.

Internal Process: Organizational performance can also be viewed through the lenses of quality and efficiency as they relate to our product and services as well as other key processes within the business.

Organizational capacity (originally called learning and growth): Finally, organizational performance can be viewed through the lenses of human capital, infrastructure, technology, culture and other capacities that are key to breakthrough performance.

1.3.2.5 Audits

An audit is a systematic evidence gathering process. Non-financial audits of systems and processes involve periodic verifications to verify that a documented Quality Health Safety and Environmental (QHSE) management system or industrial process is being effectively implemented. Audits help validate compliance with regulatory requirements and industry standards. They can also be used as an information tool to drive better business decisions.

An audit is a systematic and independent examination of books, accounts, statutory records, documents and vouchers of an organization to ascertain how far the financial statements as well as non-financial disclosures present a true and fair view of the concern. It also attempts to ensure that the books of accounts are properly maintained by the concern as required by law.

Any subject matter may be audited. Audits provide third-party assurance to various stakeholders that the subject matter is free
from material misstatement. The term is most frequently applied to audits of the financial information relating to a legal person. Other areas which are commonly audited include secretarial & compliance audit, internal controls, quality management, project management, water management, and energy conservation.

From an audit, stakeholders may effectively evaluate and improve the effectiveness of risk management, control, and the governance process over the subject matter.

1.3.2.6 Communications Plan

Communication is the process of transmitting ideas and information. For an organization, that means conveying the true nature of your organization, the issues it deals with, and its accomplishments in the community.

Communication can take many forms, including the following.

- Word of mouth
- News stories in both print and broadcast media
- Press releases and press conferences
- Posters, brochures, and fliers
- Outreach and presentations to other health and community service providers and to community groups and organizations
- Special events and open houses held by the organization

To communicate effectively, it helps to plan what you want from your communication, and what you need to do to get it.

In developing a communication plan, consider answering these items.

- Why do you want to communicate (purpose)?
- Who is your audience?
- What do you want to communicate (message)?
- What communication channels will you use?
- How will you distribute your message?

The answers to these questions constitute your action plan, that is, what you need to do to communicate successfully with your audience. The remainder of your communication plan, involves two more steps.

Implement: Design your message and distribute it to your intended audience.

Evaluate: Review your efforts, and adjust your plan accordingly.

1.2.3.7 Incentives

An incentive motivates an individual to perform an action. It is not necessary to provide incentives for what one is supposed to do or for what one is contracted to do. Nonetheless it will be helpful to motivate the team to move to an alternative or an updated process in the startup phase. One could establish recognition of the indicated goals. One could reward milestones with respect to specific KPI that have been established to measure the project development.

A few words of recognition could help achieve the desired results. It is necessary to do a complete study to avoid over-dimensioning the goals in such a manner that the incentive becomes a countermeasure instead of an incentive. Define the levels, quantities, amounts or any other kind of measure that people could monetarize themselves to perform their activities. Offer the option to receive something else from what are they doing every day. Incentives aim to provide value for money and contribute to organizational success.

1.3.3 Processes

1.3.3.1 Train Stakeholders on Definitions, Expectations and Goals

Key Performance Indicators define the factors that the institution needs to benchmark and monitor. Assessment techniques provide the mechanism for measuring and evaluating the defined factors to evaluate progress or impact. KPIs specify what is measured and assessment techniques detail how and when it will be measured. KPI is a measure that defines and evaluate the success of an organization.

Typically, it is expressed in terms of making progress towards its long-term organizational goals. A KPI incorporates information on the sources,

calculations and definitions for each measure and it sets out the timetable for submission of monthly data.

After the definition, analysis and plan creation is done, a training system needs to be established. Training needs to reach every team-member, that is, every constituent of the program stakeholders. The idea is to correct distribute or divulge the information keeping in mind the following aspects.

Definitions: All the new and existing components, elements, acronyms, and any other nomenclature or vocabulary should be communicated.

Expectations: Everyone must be instructed on what the company wants from them in terms of an assessment performance.

Goals: As the program is defined and refined, everybody must understand what the company is looking for. Everybody needs to be in line with the rhythm needed to achieve the aims of the company. Those goals will depend on what everyone in the company and top management agree that they are willing to conquer.

Management must be convinced that the necessary time and resources are available to achieve this important activity and that the activity will be positively reflected in our work if performed properly.

1.3.3.2 Track Performance

One approach is to keep a notebook or diary and take notes all day about assignments received, goals set, guidelines provided as well as intermediate and final deadlines established, tasks to complete and concrete actions taken. Regardless of the kind of registry, it must be used to capture key components such as the following.

Expectations: This component includes any goals and requirements spelled out; instructions given, and assigned to-do lists. Also includes are standard operating procedures, rules or guidelines reviewed, deadlines set and timelines established.

Concrete Actions: This component is a record of your actual work. It includes each to-do item that is completed, each goal that is achieved, each requirement that is fulfilled, and each deadline that is met.

Measurements: This component shows tracks how concrete actions match up against the expectations. Have requirements been met or exceeded? What instructions, standard operating procedures and rules were followed? Were goals met on time?

All the recorded dates constitute a basis for the construction of periodical report. The performance analysis introduced can be used to check if changes were introduced and what corrective actions were taken to return the goal path. This journal will be a source of useful information for evaluating cost, evaluating the people and doing what management is supposed to do: Administrate the operation.

1.3.3.3 Periodically Present Results to Leadership

Making presentations to C-suite executives can be a nerve-wracking proposition for even seasoned leaders. Top executives aren't shy about showing their impatience with reports that don't quickly address their key concerns or that fail to draw a connection between workforce data, operational situation or financial results.

To be useful to leadership, your executive presentations should have these characteristics.

Keep it simple, tight and short. Focus on the metrics that matter most to your executives.

It is best to show just a few slides with your key messages or metrics.

If you have been given 15 minutes to present, that means no more than 15 minutes, which usually means a maximum of seven slides.

The first sentences in the presentation state why we are here and what decision will ultimately be needed from executive-level management.

Executives want context. Is a certain metric good or bad relative to the industry.

There are several important considerations to keep in mind when presenting to senior executives. They can be impatient because their schedules are jam-packed and they have to make lots of high-stakes decisions, often with little time to weigh options. The considerations are:

Summarize up front: You should lead with the information your audience really cares about: high-level findings, conclusions, recommendations, a call to action. State those points clearly and succinctly right at the start, and then move on to supporting data, subtleties, and material that's peripherally relevant.
Set expectations: Let the audience know you'll spend the first few minutes presenting your summary and the rest of the time will be reserved for discussion.

Create summary slides: When making your slide deck, place a brief overview of key points at the front. The rest of your slides should serve as an appendix. Follow the 10 percent rule.

Give them what they asked for: This time-pressed group of senior managers invited you to speak because they felt you could supply a missing piece of information. So, answer that specific request directly and quickly.

Rehearse: Before presenting, run your talk and your slides by a colleague who will serve as an honest coach. Try to find someone who's had success getting ideas adopted at the executive level. Ask for pointed feedback.

This is not a lot of work but it is a necessary and sensible advice on how to convey information to company leaders.

1.3.3.4 Revise Plan Periodically

When a plan is generated and established it is necessary to update it periodically. You will need to review the field reports, the KPI information and, in general, the feedback received from the field actors who handle the process day by day.

The latest version of the plan needs to be released where there are changes and improvements. Periodic release of a new plan allows new results to be retrieved while also removing any obstacles from the path as identified from daily performance.

Once the plan is ready or a revised version released, a communication plan is important to allow access to everyone. Access to the updated information should be available without losses or deviations due to following outdated procedures or operations that have been discarded or replaced.

1.3.3.5 Communicate Plan

The distribution of the responsibilities and opportunities must be established without exceptions. The communications plan must define the following.

Who: Who must perform or indicate an activity or instruction to accomplish each of the phases involved in the project in reference?

What: This statement defines in detail what must be executed. The details on the specification would not constitute a limit to the ideas, improvements, or other expectations. This statement could constitute a warranty of what is expected in which case that warranty must be indicated.

When: The opportunity to take a measurement, make a decision or perform some other action is usually determinant to reaching the goals. These opportunities must be indicated in the plan and identified. In this manner, everybody in the corporate community could identify opportunity and could coach, support or guide the activity.

Where: The place and circumstance associated with when the action must be taken is also important to note so everybody and everything must follow it.

How: In a symphony, all the notes and chords must sound in time, and all the instruments must be tuned and performed properly to avoid distortion. In our case, this analogy could represent deviations in costs or loss of interest. So, similar to conducting a symphony, it is important to define what is expected from everybody, what instruments they require, and the intensity of the action expected.

1.3.3.6 Measure Performance Weekly

As we mentioned in previous points, continuous evaluation of the process performance is necessary. Electronic devices and data collection systems will be helpful to develop a way to retrieve information from many devices and use a computer to produce a report on a weekly basis.

These could be a brief period if the process is slow, but the information management systems today could handle short periods and weekly reporting does not present any problem. Be sure to have a report or reports available to all team members, or to a specific group with the information of the activities they performed.

1.3.3.7 Provide Weekly Feedback

Once the information is in hand it is possible to give feedback to all the team members. Both positive and negative feedback is necessary to communicate.

Following the formulas for negative feedback, one should specifically mention those that could be affecting the job, and run through a detailed analysis to determine the cause of the faults or shortcomings. Avoid public analysis and judgment of the person or persons who are affecting the performance. The public approach is known to have consequences on behavior and could create an adversary for the project.

In case of good news, report it and identify key person or persons that helped achieve the result. Also commend any team with outstanding performance that will allows the company to achieve certain objectives. If it is considered in the incentives and recognition plan, use this weekly moment to give them the incentives. This practice will capitalize on incentives and have an overall beneficial effect on the project.

1.3.3.8 Communicate Exemplary Performance

An excellent instrument of promotion to help achieve the goals is to publicize those important developments and outstanding performance of a team member or group of team members.

For publicity, use all the media available within the program or in the broader corporation to let the people be recognized by others. Allow them to be featured in computer dashboards all around the corporation. Write an article for periodical newsletters or magazine published by the organization. Write a letter of recognition, or give an award of something material or metallic that has been included in the recognition program of the corporation.

This could not be for everybody but it is a global achievement and with relevant results for the corporation. It is necessary to recognize attitudes and performance that are over-and-above the expected behavior. It is important that the recognition is supported by real results.

1.4 Organizational Changes

An organization's resistance to change needs to be countered by leadership to influence and sustain the change. Changes include the way that maintenance is identified, planned, executed, tracked and analyzed. Developing a change management plan is important because it affects the people who do the work. People have a different ability to change depending on the implementation and their role as well as their diverse backgrounds and personality. How each progresses through the change process needs to be kept in mind when developing a change management plan.

1.4.1 Concepts

Organizational change is complex and often misunderstood. It can either propel the maintenance, reliability or asset management program forward or prevent it from being successful. To ensure the organization progresses through the change curve successfully, a change management plan is required.

The change curve describes the four stages of change: shock; denial, anger and fear; acceptance, and commitment. Most people go through these four stages as they adjust to the change. A change plan identifies the requirements and ongoing activities required to assist the organization and its people through the curve. There are models to assist with the change management plan and activities for the organization; these typically embrace the mission, vision and strategic plan of the organization as well as current and future business processes and roles and responsibilities.

The change management plan will address, the expected changes, leaders, and sponsors, stakeholders, goals and objective of the change and a tactical plan to implement the change which may include communication, training, re-organization, etc. Success in organizational change can be attributed to the workability of the change management plan and activities. Change management does not have to be done perfectly but a little work goes a long way.

1.4.1.1 Review and Understand the Mission, Vision and Strategic Plan

As described above (in Section 1.0 on Business Management) the organization needs to understand current and future states before change can occur. Before planning for organizational change, the mission, vision and strategic plan must be reviewed and understood.

1.4.1.2 Develop Future Business Process Documentation

The future state of the organization must be established for the staff to understand the proposed changes and how such changes will affect them. This future state includes new business processes and organizational structures as well as new roles and responsibilities. Each of the processes, structures, and roles should include written expectations, benefits, and proposed performance measures.

1.4.1.3 Establish Leadership and Sponsors

Change must be led from the top. Organizational change will only be successful when fully supported at the highest levels of the organization. The leadership may come from a plant manager if the change only affects a single site, or a CEO if the change affects the entire organization. Sponsors must be established to provide support to the individuals managing and implementing the change.

1.4.1.4 Determine Stakeholders

Organizational change affects almost everyone in the organization in one way or another. Therefore, it is vital to understand the impact of the change on each stakeholder, how the stakeholder will react to that change, and how to assist that stakeholder along the change curve.

1.4.1.5 Develop a Change Management Plan

The change management plan will provide the strategic and tactical activities to assist the organization through the change and successfully realize the future state. The change management plan will include the inputs from the organizational strategy, stakeholders, and objectives to determine the specific activities and milestones of the organizational change.

1.4.2 Tools

Many tools will be involved in the organizational change activities. Each tools will be consistent with all other tools, regardless of the change management model.

1.4.2.1 Change Model

A change model is a tool that will provide guidance on how organizational change should be prepared, implemented, and sustained. Each model includes a set of tools and various approaches to assist the staff through the change curve. Multiple models are available, and each has its own advantages and disadvantages. Some of the most common are models by Prosci, ADKAR, Kotter, Lewin, and Beckhard and Harris.

1.4.2.2 Change Plan

The change plan provides the expectations, activities, and resources to implement the change. The change plan will typically include the following.

The reasons for the change;
Type and scope of change;
Stakeholder analysis, support and management activities;
Change management team;
Leadership and sponsor support;
A communication plan;
A method to track the adoption of the change; and
How barriers to adoption will be addressed.

1.4.2.3 Performance Objectives

Performance objectives (KPIs) are necessary to understand the adoption of the organizational change and the support of individuals and business units in the change. Performance objectives should be written according to the SMART framework. Also, when selecting the performance objectives, the objectives should be balanced to ensure inadvertent behavior is not triggered by focusing on a single objective. Also the performance objectives should be a mix of leading and lagging indicators to ensure the organization change is occurring as planned.

1.4.2.4 Scorecards

Scorecards visually display the performance objectives for an organization. The performance objectives are usually displayed to reflect four key areas of business: Financial, Customer, Internal Business Process, and Learning & Growth. A scorecard that includes these four areas is known as a balanced scorecard.

1.4.2.5 Audits

Audits are systematic and independent examination of a process, record, documents, etc. An audit is used to understand how well the selected change management model has been followed and how well the change has been adopted. This tool allows organizations to learn from the change management process and improve it for future changes.

1.4.2.6 Stakeholders Analysis

Stakeholder Analysis is a tool used to identify the stakeholders of the change, their current position on the change and what must be done to bring the stakeholders along with the change. This tool ensures that the stakeholders do not become blockers of the change.

1.4.2.7 Incentives

Incentives are ways to motivate people to adopt the change. Incentives can come in many forms, such as monetary, recognition, celebrations, etc. Typically, incentives are used to reward those who achieved a specific milestone or performance objective related to the change.

1.4.2.8 Communication Plan

Communication plans are tools that identify what information must be communicated, to whom, when it must be communicated and how it will be communicated. A communication plan plays a critical role in the building awareness and desire in the stakeholders; and in bringing the majority of the staff through the change curve. Further information on communication can be found above in Section 1.5 on Communicate with Stakeholders.

1.4.2.9 Vision and Strategy

The Vision not only defines your organization's purpose (that is, the purpose of the change) but also focuses on its goals and aspirations. These statements are designed to be uplifting and inspiring, to create awareness and desire for the change.

1.4.3 Processes

There are many change models available, but they all follow the same process with the same steps. Listed below are the key activities and generic processes for change management.

1.4.3.1 Create Urgency

For the early adopters to embrace the change and bring the majority along the change curve, there needs to be an urgent need for change. This urgent need for change can come from internal or external threats to the organization or internal or external opportunities to be capitalized on.

1.4.3.2 Train on Goals

The stakeholders need to fully understand the change. They need to see how it will affect their role or function and understand the goals associated the change. Without this guiding direction, the stakeholders will worry about the change and not readily adopt or support the change.

1.4.3.3 Create the Vision

The sponsor, stakeholders and change manager need to create a compelling vision to effectively communicate the need for the change. This vision will provide the staff with clarity on why the change is needed. It will not only create awareness of the change but also will focus the team on the end goal.

1.4.3.4 Communicate the Vision

Communicating the vision must be done frequently across multiple media. The communication plan will prescribe exactly what is required, but the change and need for it should be communicated often by all levels of the organization.

1.4.3.5 Remove Obstacles

Obstacles will arise quickly at all levels of the organization. Team members, team leaders, and managers must be empowered to work through and remove the obstacles preventing the change. If the local team is unable to resolve the situation then managers and senior leaders must be prepared to step in and remove the obstacle quickly. If the obstacles linger too long then the change is at risk of stalling and failing.

1.4.3.6 Create Short-term Wins

Having staff adopt the change and move along the change curve quickly requires a sense of accomplishment and success. To keep staff motivated and focused, use a series of short-term goals that lead up to the overall goals of the change. Once the team achieves the short-term goals, celebrate. Reward and recognize the team for their success. Everyone wants to be on a winning team, so create winning teams to bring more people along the change curve.

1.4.3.7 Embed the Change

As the change progresses, there will be less focus on it. To sustain the change after the initial excitement and launch, embed the new ways of working into the daily routines of the staff. Implement routine checks and balances, rewrite the existing processes and procedures to incorporate the changes. The new behaviors have to be embedded into the staff's daily routines. Otherwise the change may go backwards and fail.

1.4.3.8 Conduct Audits of the Process

A way to ensure the changes have been embedded is to routinely audit and check that the new processes are being followed. This audit can be conducted routinely by the team leader and line manager as part of their standard work (which helps to embed the change). Also, audits can be conducted by other members of the team to ensure compliance with the process. These audits should not be punitive. Rather they can act as an opportunity to identify gaps in the change management process; and they can improve the coaching and training process.

1.4.3.9 Communicate Results to Leadership Periodically

To maintain full support to see the change through to full adoption, the senior leadership team must be kept in the loop. Regular communication must include actual versus planned objectives, what barriers need to be overcome, and plans to close the gaps between actual and planned objectives.

1.4.3.10 Reinforce Good Behaviors

Similar to the step "Create short term wins," the goal here is to reinforce the good behaviors through incentives and recognition.

1.4.3.11 Track Performance

The performance objectives must be tracked, reviewed routinely and be relevant to the organization objectives. Any gaps from actual to planned must be addressed and actions put into place to close the gaps.

1.4.3.12 Revise Plan Periodically

No change is truly ever complete. Once the change is embedded, the processes must be checked to ensure the change continues. Any gaps between actual and expected results should be reviewed, and a plan must be implemented to close those gaps. This activity may be built into the routine planning activities of the organization.

1.5 Communication with Stakeholders

Maintenance and Reliability leaders should be capable of creating and executing a comprehensive communication plan to achieve organizational business goals. The plan includes appropriate communication with all stakeholders and recognizes the audiences for the various intended messages. To ensure the engagement of the stakeholders, an effective communication plan provides methods of sharing information, receiving feedback and providing input to decision-making processes. Multiple communication approaches and methods should be used and the advantages and limitations of each should be understood.

1.5.1 Concepts

Why communicate? Simply put, communication is expression. We each have a unique way of thinking hence also a unique way of perceiving things. In the field of maintenance and reliability, it is important to communicate inputs and experience as well as individual ideas that could help solve crucial real-world problems.

Communication processes include how do people send and receive communications and how communications are affected by noise, environment, filtering, and experience.

People communicate through different mediums such as speaking, writing, visual signs etc. Focus is the key element in any source of communication; otherwise it is considered noise. When we talk, focus on the communicator or the speaker's voice; otherwise this voice could be lost in the noise from the environment, such as traffic, other voices, music etc.

In the field of M & R, communicate effectively so the subject is understood completely and no confusion remains. Ineffective communication or miscommunication leads to unnecessary or futile activities that add to the expense of the organization. For example. a supervisor is directed to replace motor X located in area Z. Upon arriving at the place, he finds two identical motors located in the area with no tagging. What will he do? There is a 50 percent probability that he will replace the properly functioning motor which would not only add to the expense of the organization but would also put the process at risk.

Such examples can be found in several organizations, proving that effective communication is necessary for an efficient M & R program.

1.5.1.1 Communication Tools

Communication can be done with the following tools. However, the best means would be a combination of visual, written, and audio. Each of these has pros and cons.

For visual communications, pros include the following.

- Effective in delivering
- Less time consuming than written directions
- Concise and space saving

For visual communications, cons include the following.

- Limited space
- There may be a problem of standardization across multiple disciplines
- Cost consuming

For written communications, pros include the following.

- Efficient way of explaining
- Readily available information in case someone forgets
- Traceable to the source and the actual words communicated

For written communications, cons include the following.

- Time consuming effort required to read
- Unnecessary detailing is also one of the drawbacks of written communication
- Lack of face to face interface so that the reader won't know effectively which point is emphasized

For audio or oral communications, pros include the following.
- Simple and Quick
- Quick response

For audio or oral communications, cons include the following.
- Easily forgettable
- Buffer can cause miscommunication
- Relatively harder to understand than pictorial views
- Can be easily changed

1.5.1.2 Communication Plan

Even though this Body of Knowledge is targeted towards M&R, communication is universal in applies to all disciplines and even our daily life. One cannot stress enough the importance of proper communication.

An effective communication plan contains three elements: Sender, Receiver and Message. Keep in mind is that any message should contain enough detail so the receiver interprets the message according to the satisfaction of sender. However, it should not be overly detailed with the result that the receiver spends excessive time understanding it.

1.5.2 Tools

1.5.2.1 Visual

Visual communication involves the use of pictorials and symbols to communicate. A common example would be the use of flowcharts, standardized signs etc. Another method is the use of videos and other digital media to communicate with the receiver.

1.5.2.2 Written

Written communication is by far one of the most common means of communicating. It is descriptive in nature and involves the use of written words. Common examples include emails, books, memos etc. These are explanatory in nature and provide a means of traceability.

1.5.2.3 Verbal and Audio

The easiest to use and most frequently used communications are verbal. They involves the use of words as a mean of sharing thoughts, ideas, and general speaking. Common examples would be face-to-face conversation as well as phone conversations.

1.5.2.4 Hybrid

A mixture of above-mentioned tools of communication is called hybrid. Such can be used to obtain the benefits of all the tools and communicate most effectively.

1.5.3 Processes

Identify stakeholders
Identify message for stakeholders
Identify support for message
Identify methods to reach stakeholders effectively
Perform communications
Evaluate effectiveness

One of the most important tasks for anyone in the M&R is to identify key personnel who can affect or are affected by their activities. These stakeholders have to be satisfied or at least kept well informed of the actions that can affect them. They include personnel from operations, maintenance, safety etc. and usually involve senior-to-middle management as they are most likely to either cause disruption or support your actions.

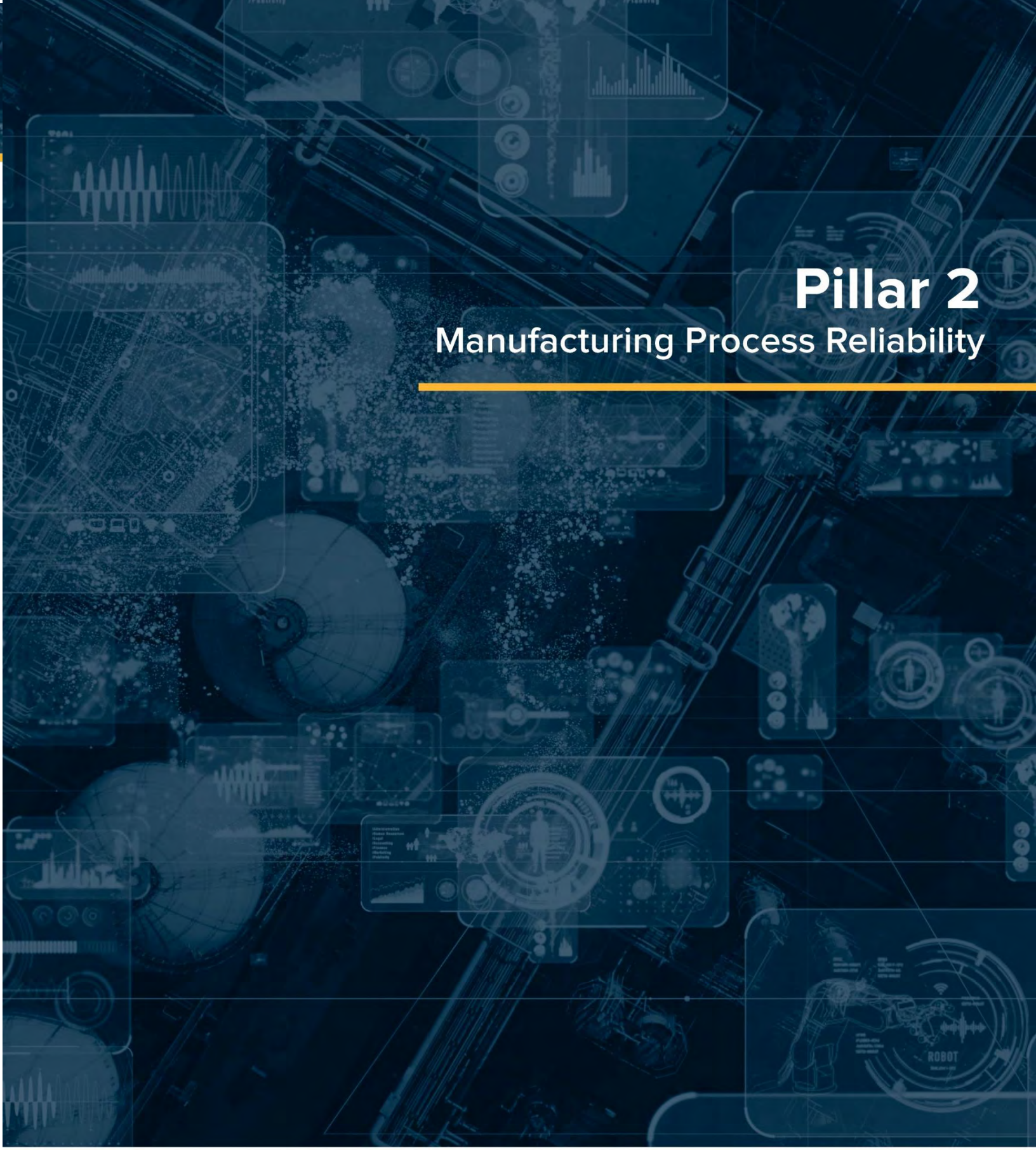
Once the stakeholders are identified, they should be provided with a concise message that is easily understandable. The message should contain enough logic and detail so there is no chance of misunderstanding.

Memos and internal emails are an effective means of communication. Once the email or memo has been read, it may be a good idea to follow up by phone or in-person to confirm that the message has been received and understood clearly. The effectiveness of a communication can be measured by how many times the message was delivered, what the response was to the message and what actions were taken on it.

Pillar 1 Metrics Appendix

To access and download the SMRP Best Practices 6th Edition, please go to www.smrp.org.

Metric 1.1 Ratio of Replacement Asset Value (RAV) to Craft-Wage Headcount
Metric 1.3 Maintenance Unit Cost
Metric 1.4 Stocked Maintenance, Repair And Operating Materials (Mro) Inventory Value As A Percent Of Replacement Asset Value (Rav)
Metric 1.5 Total Maintenance Cost As A Percent Of Replacement Asset Value (Rav)



Pillar 2

Manufacturing Process Reliability

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Certified Maintenance & Reliability Professional

2.0 Manufacturing Process Reliability

2.1 Operating Procedures

This subject area relates maintenance and reliability activities to the manufacturing or production process of the organization, to ensure that maintenance and reliability activities improve the manufacturing or production process.

This subject requires an understanding of applicable processes: document process flow, process parameters, quality specifications, process risk and operating procedures.

A complete understanding of processes that influence the performance and safety across all disciplines and at all levels of the organization can provide tremendous benefit. The ability to react appropriately to changing conditions in the process allows for real-time process control and optimization. This ability to react to change applies not only to one's direct function but also to its effects on the total process.

Process understanding includes how to start up, operate, shut down, analyze and troubleshoot; and it also includes methods for communicating and documenting continuous improvement activities in operations, maintenance, quality and safety. Clearly defined the standard operating procedures and flow diagrams of processes are helpful tools in communicating and documenting the desired process performance.

2.1.1 Concepts

2.1.1.1 Plan and Evaluate the Process

When developing or revising a new process, care should be taken to develop a list of things that could go wrong. When evaluating a current process, analysis of the process is limited to the current condition, initial design attributes, and flaws.

Periodic evaluation of all processes is a best practice. Several factors can change the effectiveness of a process over time.

Each process evaluation must include perceptions (favorable and unfavorable) and interviews from each department or group that supports or interacts with the process. The perceptions voiced via the interviews point to deficiencies in the process. Documenting process deficiencies will ensure a clear understanding of opportunities for improvement.

A documented risk identification procedure should be developed and implemented and then used to assess process-related risk. In turn, this procedure will lead to the development of necessary control measures and modification of the process with risk mitigation measures.

2.1.1.2 Adopt a Process Monitoring Practice

Regardless of which process-monitoring program is adopted, the best way to ensure its success is to elicit participation from each department or group involved in or affected by its execution. If process-monitoring programs are already in place then evaluate the effectiveness of those programs. If the programs are not meeting organizational goals or objectives, make adjustments to improve.

Historical process information, including successes and failures should be taken into account in the development of a manufacturing process. Process selection and development requires careful consideration. Avoid developing processes that will require immediate or frequent changes. Constantly changing processes is detrimental to the overall success of the program.

2.1.1.3 Maintain Consistent Data Collection

Consistently accurate and timely data collection is the most difficult challenge facing reliability programs. Incorrect or missing data can cause poor decision making that leads to errant program direction. Data collection must be based on documented data standards. These data standards should follow industry standards where applicable in order enable benchmarking across industry. Accuracy should be emphasized over quantity. Data control should be ingrained in the culture at facilities with any kind of reliability program and it should be supported at all levels of an organization. Data accuracy should never be the responsibility of one person. Everyone that interacts with the process should provide clear, complete, and accurate data in the proper format.

2.1.1.4 Data Analysis

Analysis of the collected data is necessary to maintain effective processes. Raw data collection is of no use without analysis to discover opportunities for improvement. Several methods for analyzing data are available in the industrial sphere. Determine which method of data analysis would best promote the organizational goals.

2.1.2 Tools

2.1.2.1 Process Flow Chart

Much can be accomplished by a "Process Flow Chart," simply defined as a visual representation of the steps in a process. Synonyms are "Process Mapping" and "Flow Diagrams."

The construction of a process flow chart should be one of the first activities of process improvement. Process flow charting offers several benefits for the organization. It helps end-users understand the process. It helps identify waste in the operation as well as bottlenecks. Since process flow charting is a group effort, it promotes teamwork and communication while keeping contributors on the same page.

Constructing a process flow chart based upon the steps of a process is an easy and efficient way to understand the process. The chart should be used early on in any process improvement activity. Benefits are identifying wasted steps and highlighting bottlenecks. It also has uses for training. When constructing process flow charts all departments affected by the process should contribute to ensure all steps are covered accurately.

2.1.2.2 Statistical Process Control (SPC)

Statistical Process Control (SPC) is used primarily as a quality control tool. SPC uses statistical methods to understand process parameters. Software programs provide effective process data-point measuring and monitoring as well as data interpretation and, ultimately, process control. A process that is in control will yield the greatest benefit by eliminating errors, minimizing waste, and increasing throughput and predicted consistency of the process.

2.1.2.3 Understanding Process Parameters (Variables)

A process variable should be measured and monitored constantly to determine if the process is operating within the control band defined by the OEM. Process variables can be temperature, pressure, flow, pH, density, turbidity, chemical composition, and so on. Processes are optimized by operating process variables at a set-point and regulating the proper functioning of process elements and operations.

Process parameters are an essential part of process management, and extremely important in controlling a process. Therefore, process parameters need to be continuously and accurately measured and monitored throughout a process run.

Process parameters maintain the process efficiency and may be controlled with a help of technological sensors mounted at critical areas of a process, along with implementation of special methods and equipment to adjust them.

If a parameter deviates from its set-point (goes beyond the acceptable level of variance), the root cause can be due to an automated process controller failure or possibly an equipment failure. To restore the process to a controlled state, operator intervention is recommended. The operator should evaluate the process, determine what caused the process to deviate outside of the control band. He should then then take appropriate action to override failed automated controls and stabilize the process to prevent further upset; and also he should notify appropriate personnel.

2.1.2.4 Understanding Risk

The understanding of risk requires the classification of processes and their scope. The subject matter expert (SME) team should be able to identify credible risks; and subsequently the current risk controls. They would also be able to determine level of risk; and therefore the tolerability of risk.

Risks are categorized according to their dominant, controlling areas, which are those areas that would be most affected if it materializes. Knowing these six areas will influence the means to mitigate known risks.

The six controlling risk categories are Safety, Environmental, Financial, Operations, Property, and Reputation.

Known process risks can be approached in several ways: budget for risk if there is no feasible mitigation strategy available; cease activity which incurs the risk; treat the risk with inspections, modified operating procedures, or spare parts accessibility; or transfer the risk by means to a third party, for example, an insurance policy.

2.1.3 Processes

2.1.3.1 Quality Management System

Each empowered team must define its manufacturing process and requirements for specific production outputs. Manufacturing processes should be as simple as possible. Critically evaluate processes at set intervals. Remove unnecessary process hurdles, consolidate process steps if possible, and minimize the number of process touchpoints. Focus on what the process is trying to achieve with the overall corporate end-goal in mind.

To get buy-in from every stakeholder affected by the manufacturing process, document the entire process and have each person review, approve and understand each step. This approach will establish expectations. It will be easier to refer to an archived meeting-training document rather than to remember verbal details from a meeting-training session.

Ensuring that the manufacturing process is understood by all operators and supervisors is the key to achieving high-quality results. Once the manufacturing process is documented and expectations are set, and all stakeholders agree upon and understand its content; then one can write a clear and detailed, standard operating procedures for the process. Formulate operator and maintenance training that clearly and completely defines how to operate and maintain the process equipment; and how to keep it operating at peak performance.

Hold manufacturing process owners accountable through goals and periodic, consistent review of KPI's. The owner of the manufacturing process will be highly motivated to ensure success if they are being graded and ultimately compensated based on the success of their work.

Develop an in-house work management process self-assessment tool or adopt an existing tool; and use it to periodically evaluate applicable quality standards, to look for changes and to identify opportunities for improvement.

Understanding and acting appropriately on trends allows organizations to stay ahead of below-the-surface issues with the manufacturing process. This focus on trends allows the manufacturing process to be optimized and provides input for continuous improvement, leading to actionable tasks.

2.1.3.2 ISO 9000

ISO 9000 provides a structured approach to product quality by focusing on detailed process documentation by maintaining appropriate records. ISO 9000 is the foundation for making high-quality become second nature. The three fundamental aspects for establishing a high-quality culture are implementing verifiable quality controls, documenting the various operational processes and procedures, and ensuring that the appropriate quality emphasis is established and followed by everyone in the organization.

ISO 9000 series of standards enables product and service suppliers to assure prospective and current customers that an operational quality system has been established. This concept of a two-party contractual relationship is inherent in the ISO 9000 standards. The series offers the most fundamental and basic aspects of quality by demonstrating that the organization is doing what it says it is doing with regard to satisfy customer needs.

The ISO 9000 standard stipulates that management will be committed, involved, focused and responsible for implementation and continued support. Facility organizational processes will be documented and periodically checked for applicability. They will be updated, made visible, traceable, consistent, and repeatable. Owners of the processes will gain authorization to make decisions, become organized, competent, knowledgeable, and responsible.

ISO 9000 registration ensures that organizations understand what their processes are. The processes are documented, implemented, understood, and adhered to by everyone affected by them in the organization. The documents supporting the processes are reviewed and maintained for the purposes of providing highly detailed information to an internal or external auditing agency.

2.1.3.3 Risk Register

A Risk Register records and manages risk within the organization. It will comprise a list of risks defined in terms of likelihood, consequences, and detectability. The risk register is a ranking mechanism that ranks risks from highest to lowest; and therefore prioritizes how, when, where, who and why resources will be expended to address risk. The risk register aids in the development of a risk mitigation strategy. Overall, maintaining, updating and auditing the risk register is of paramount importance in achieving corporate goals.

2.2 Process Improvement Techniques

This subject area relates the activities of maintenance and reliability to the manufacturing or production process, to ensure that maintenance and reliability activities improve the manufacturing or production process.

Apply process improvement techniques: Identify production losses, establish a process for continuous improvement process, etc.

The implementation of process improvement techniques is an important cornerstone of reliability efforts. These techniques should incorporate best practices at all levels of business performance, including cost, risk and benefit analysis.

The key to establishing and sustaining improvement techniques is to involve the people who are responsible for the work and who own, operate, and maintain the process or manufacturing equipment. This heightens the sense of continuous improvement and nurtures a culture of empowerment, discipline, and accountability.

The establishment of these techniques must align with the business plan and goals and include sustained workforce excellence, quantitative organizational performance assessments and ultimately, customer satisfaction. To establish comprehensive process improvement techniques, organizations have adopted various tools, ranging from International Standards Organization (ISO) standards to a Total Productive Maintenance (TPM) operational approach.

A crucial step in any process improvement is to identify key performance indicators (KPIs) that align with the goals of the organization. The type of metrics, the process for implementing the metrics and the quality of the metrics are just a few of the considerations that must be considered during the development stage. Good metrics are designed around the objectives of the business goals. They have three attributes: their data is consistent, easy to understand, and quick to collect. The metrics specify accomplishments and drive continuous improvement while identifying the progress of the criteria accomplishments. Without metrics, it is difficult to measure any process.

2.2.1 Concepts

2.2.1.1 Zero Defects

Ideally, one strives for zero defects in process, production and maintenance as manifested by gains in process efficiency. A competent workforce needs to be in place to support this ideal. Sufficient training-and-resource allocation should be provided to support the zero-defect initiative, offering incentives and job satisfaction to the employees. These efforts will provide workers with the ability to consistently perform at a high level while promoting an environment of excellence.

2.2.2 Tools

2.2.2.1 Total Quality Management (TQM)

Total Quality Management is a corporate effort to project and establish an environment in which an organization continually improves its ability to deliver high-quality products and services with hopes of making itself the provider of choice to the consumer. It is a management approach to long-term success through customer satisfaction not only by meeting customer expectations but also by exceeding them.

The complete satisfaction of the customer is the focus TQM. To implement TQM, management should involve all levels of the organization and must first clarify the corporate vision, the mission, and company values. Each employee needs to understand the direction of the organization (its vision), the organizational goals (its mission) and the operational principles (values) that will steer the focus and actions of the company.

Next, identify critical success factors. Critical success factors provide the focus necessary to meet the objectives. They measure for how well the organization is meeting its objectives. An organization needs to develop metrics to monitor critical success factors.

Critical success factors should be identified to measure the effectiveness of the organizational objectives. These factors help organizations monitor the progress of company defined goals and communicate the progress to employees.

An organization needs to identify the key customer group. Knowing the demands of the customer is important to steer product and service development toward customer demand.
Employees are a key customer group as well as suppliers, vendors and volunteers; as well as, of course, the end customer.

Request customer feedback to make it easy for customers to communicate positive and negative comments. There are many customer satisfaction survey tools available such as focus groups and online survey tools that can be used to determine the level of satisfaction provided.

Conduct the survey on each customer group to establish a baseline of the customer's perception of current practice. This baseline is the starting point and the point of reference to measure progress against. Develop an improvement plan. After a period, perform the same survey again on the same customer group to see if scores have improved and if expectations have changed over time. Also, revisit critical success factors to ensure there is consistent progress being made towards goals.

2.2.2.2 Root Cause Failure Analysis (RCFA)

Systemic- and human-interaction Root Cause Failure Analysis (RCFA) is a method for identifying the root cause of a failure. There are several ways to conduct a Root Cause Failure Analysis. Methods include Five Whys Analysis, Fishbone Diagram, and Fault Tree. The principle behind RCFA is that if the root cause is accurately and completely identified and eliminated (either by re-engineering, procedural operating process modifications, or administrative controls) then that failure does not occur.

2.2.2.3 Failure Modes and Effects Analysis (FMEA)

Failure Modes and Effects Analysis (FMEA) is sometimes referred to as Failure Modes and Effects Criticality Analysis (FMECA). It is an economical and methodical procedure intended to identify all possible ways a process might fail, or the failure modes of that process. The effects are the consequences of those failures. Criticality is assigned to assets within processes to denote their importance. FMEA is done to prioritize the significance of processes if the consequences of downstream failures are intolerable. If this analysis is done during the design phase then errors can be designed out of processes, thus eliminating failures caused by that fault.

2.2.2.4 Pareto Principle

The Pareto Principle is otherwise known as the 80-20 rule. This principle when applied to maintenance and reliability states that 80 percent of asset failures will originate from 20 percent of the assets in an organization.

2.2.2.5 Total Productive Maintenance (TPM)

Total Productive Maintenance promotes cooperation between maintenance and operations and fosters equipment co-ownership. All operations team members learn how to perform basic care of operating equipment such as cleaning, and inspections. This co-ownership encourages a vested interest in the proper maintenance of equipment which should lead to efficient and reliable operation and processes. TPM hopes to attain no breakdowns and no accidents. It is most concerned about reducing overall operations and maintenance (O&M) costs by striving for zero process defects in a team environment.

Total Productive Maintenance is a system of sustaining and improving the integrity of production and quality systems through the assets, processes, and employees. TPM requires full support of the entire top-to-bottom workforce. TPM requires a paradigm shift from the typical perception that maintenance is the sole owner of asset efficiency, and places that ownership across the entire facility. Proper equipment maintenance supports optimum process and operations. And proper startup and operating procedures in turn supports optimal equipment condition and minimal reactive or unplanned maintenance. This symbiotic relationship needs to be understood by engineering, operations, maintenance, environmental, purchasing, stores, accounting, safety, and human resources to be fully effective. To raise this awareness, it is imperative that every member from top management to hourly employees understands and are actively involved.

2.2.2.6 Key Performance Indicators (KPIs)

Key Performance Indicators are specific process variables that when measured and controlled allows the process to perform at a high level. It is an historical as well as a forward-looking performance measurement. All KPIs should be meaningful to an organization's shareholders, measurable by the correct personnel, and manageable by those what are measuring the data.

2.2.2.7 Balanced Score Card

The Balanced Score Card is a conglomeration of several KPI's used in unison to provide a complete picture of how the process is being managed. It is used to articulate a successful process strategy in actionable terms and provides a roadmap for continual improvement.

2.2.3 Processes

2.1.3.1 Six Sigma

Six Sigma provides a set of techniques and tools for process improvement by identifying errors early on and removing them from the process. The sigma rating indicates its yield of defect-free products. Six sigma equates to 3.4 product defects per one million production runs.

2.1.3.2 Lean

When applied to manufacturing, "Lean" is a systematic method for identifying and eliminating waste from a manufacturing process (or muda, from the Japanese word meaning "futility; uselessness; wastefulness"). Waste is found through overburden, or muri, from a Japanese word meaning "unreasonableness; impossible; beyond one's power; too difficult"; from unevenness in scheduled workloads, or mura, meaning "unevenness; irregularity; lack of uniformity; nonuniformity; inequality." The term "Lean" as applied to Work Management means that level-loading a schedule is cost effective.

Value-stream maps are used to document the steps needed for delivering a product or service. They map the steps from the start of production to delivery. These diagrams layer the process with a timeline that measures value-added activities and non-value-added activities. They will help determine which activities should be kept and which ones should be removed from the process.

2.1.3.3 Five S

Five S eliminates waste by sorting, straightening, shining it (keeping it clean), standardizing and sustaining all that has preceded it. Some may incorporate a sixth "S" and that would be safety. Making safety first is of foremost importance in everything we do

2.1.3.4 DMAIC

DMAIC stands for "Define, Measure, Analyze, Improve, and Control" as applied to a known operations process. This process is a data-driven improvement process and is a subcomponent of Six Sigma. It can, however, be implemented as a standalone quality improvement process.

2.3 Change Management

Change Management helps to manage the effects of changes in processes and equipment; it may establish change protocol, update documentation and procedures, etc. In parallel with Process Improvement Techniques, this subject area also relates the activities of maintenance and reliability to the manufacturing or production process of the organization, to ensure that maintenance and reliability activities improve the manufacturing or production process.

The success of a maintenance and reliability program can be greatly hampered when changes made to the process (or changes to the equipment governed by the process) are not properly managed. Change can occur intentionally, such as a process modification or improvement; or unintentionally, such as component wear or general equipment degradation over time. The effects of these changes must be analyzed and managed to ensure the desired level of reliability is maintained.

A formal change management process is needed to identify any significant changes to the process, equipment capability, or inventory items. A basic component of an effective change management program is the requirement that all intentional changes to the process (including temporary changes and engineered experiments) must be submitted and approved before the change can occur. After a proper application has been submitted, it is reviewed by all affected parties within the organization, including management, engineering, maintenance, safety, production, environmental, and possibly others. The review ensures that the effects of the change are properly evaluated, and that all stakeholders are properly prepared.

The change management process also makes certain that all affected documents are updated, including the following: (a) Drawings such as plant layouts, P&ID's, PFD's, etc.; (b) Maintenance documents such as MEL's, PM's, FMEA's, parts lists and others; and (c) a variety of others including production control documents, safety documents, asset lists and other documents.

Upon approval of the requested change, the change can then be implemented. The management-of-change process must include devices to monitor the progress of the implementation. This includes making certain that documentation is created, collected and stored in an appropriate manner. Upon completion of the change, devices must be in place to verify that the change achieved its desired effect and that all subsequent changes to methods and documentation have been properly addressed.

2.3.1 Concepts

Unplanned adverse effects need to minimized, including effects on the system integrity, security, stability, or reliability, consequent to the altered or new business process. At the same time, maximize the productivity and efficiency of staff planning, coordination, and implementation of the changes. Asset management demands a high level of technical completeness, accuracy of modifications and testing of the system before implementation. Management requires a line-of-site approval of this change and should be engaged with the process. All this is necessary for a stable production environment given the inevitable change that progress brings.

2.3.2 Tools

2.3.2.1 Management of Change (MOC)

Management of Change (MOC) is a tool that ensures safety, health, and environmental risks are identified and controlled whenever a facility changes a plant asset layout and configuration, documentation, personnel and operations.

MOC has inherent operational benefits. It minimizes unplanned adverse impacts on system integrity, security, stability, and reliability of the altered process. It maximizes the productivity and efficiency of staff planning/scheduling, coordinating and implementation of proposed changes. MOC provides a stable manufacturing environment. MOC ensures the proper level of technical completeness, accuracy of modifications, and testing of systems before implementation. MOC also provides line-of-site management approval, involvement, and responsibility.

2.3.2.2 Process Safety Management (PSM)

Process Safety Management (PSM) is a system of best practices to sustain safety in an environment where many hazardous chemicals are present in large quantities. PSM is a systematic analytical tool for preventing the release of these chemicals. Hazardous chemicals consist of toxic, reactive, explosive and flammable liquids and gases.

The goal of PSM is to decrease the number and severity of accidents relating to hazardous chemical releases. PSM and MOC share several attributes. Together with MOC, operational risk is managed.

2.3.2.3 Manufacturing change request (MCR)

Manufacturing change request (MCR) is a request originating from the manufacturing team members identifying a specific problem and a subsequent proposed modification to the manufacturing process or equipment to rectify the deficiency.

2.3.2.4 Manufacturing change order (MCO)

Manufacturing change order (MCO) is a manager-approved change order describing the modifications to the manufacturing process or equipment

2.3.3 Processes

The processes in change management can be summarized as follows:

Compile safety information on the products, equipment, materials, or processes that are changing and write policies and procedures to use the new information. Be sure to include information on how to investigate accidents, audit compliance with safety procedures and plan for emergency responses.

Establish a way to gather employee input on the changes, such as interviews, group discussions or surveys. Include their comments and suggestions in the draft policy and procedures.

A proper MOC system requires that any changes be evaluated before implementation. The level of evaluation will depend on the magnitude of change and how critical it is to the safety of the manufacturing process.

Write instructions for all employees on every process which involved the changes. The procedures must be clear. They must include steps for performing every operation, cover safety information, state what to do in the case of an emergency and be readily available to the employees performing the procedures.

Changes being made must be thoroughly evaluated for how they affect employee safety and health.
There might be a domino effect, where one change leads to more changes, and one will need to determine if the changes being considered prompt additional changes to operating procedures or require modifications to existing maintenance procedures.

Train employees on the changes. Emphasize safety and health hazards and what to do in the case of an emergency. The training must take place before an employee can operate the equipment or perform jobs related to the changes.

Establish written procedures for what you will do the next time you have a change in safety management.

Keep MOC documentation and use it as a source document to review events leading to corrective maintenance, root cause failure analysis, and process anomalies.

Adhere to OSHA's documented 14 elements of Process Safety Management (PSM).

Cultivate a working relationship between engineering and the production floor.

Train relevant personnel on the MOC process.

Nurture an environment that facilitates easy communication for the manufacturing change process such as a change review board.

2.4 Maintain Processes

This subject area relates the activities of maintenance and reliability to the manufacturing or production process of the organization, to ensure that maintenance and reliability activities improve the manufacturing or production process.

Maintain processes in accordance with applicable standards and regulations. Understand industry standards, understand regulatory requirements, ensure compliance, etc.

Standards and specifications are used as a way of translating the efforts of the reliability program into improved performance.
One approach is benchmarking, which uses a comparative analysis between internal results and the results of others, particularly if the performance of others is seen as a world class. Gaps in performance of the reliability program must be identified, quantified, interpreted, and communicated to other functions, *e.g.*, financial, operational, and other service departments. Action plans to close the gaps are created, reviewed, and improved on a continual basis as part of a "living program" approach to reliability. Measurements and action plans are posted in designated areas of the company for all employees to review.

Regulations specify legal requirements that are mandatory. They include such topics as environmental effects, worker safety, product safety, and consumer or public interest. A regulation usually consists of either a federal, state or local government technical specification or requirement; on occasion, the use of a particular private sector standard may be permitted as a means of compliance. Although regulations may seem a bit confusing and intimidating, a proper understanding of them and how they affect a business model may actually save companies money and increase productivity. The integration of regulatory requirements with operational best practices in a continuous improvement culture is the best way to ensure that compliance is achieved, and that risk and liabilities are managed.

2.4.1 Concepts

Operating at a world class level signifies achieving the highest level of operational excellence among your peer group. Operational excellence in maintenance and reliability programs means your manufacturing process is poised for growth and profitability. Being world-class is being among the best, the top quartile in terms of performance, in every aspect that performance is measured. Emphasis is placed on the human side of things and being the driver for world-class performance. Organizations operating at world class level not only train managers but also create leaders for optimum organizational effectiveness. These organizations are viewed as model corporate citizens, while demonstrating environmental stewardship and social responsibility, and striving to achieve zero incidents. Achieving unified, success-oriented goals is the main focus.

2.4.2 Tools

2.4.2.1 Code of Federal Regulations

The Code of Federal Regulations (CFR), Occupational Safety and Health Administration (OSHA), and the U.S. Department of Labor are good resources for references on federal regulations. On the state level, consult the local Chamber of Commerce since not all states have the same level of EH&S involvement. Measurements of various types may be used, including employee engagement, training, involvement of safety committees and injury rates.

2.4.2.2 Benchmarking

Benchmarking is comparative analysis. It compares companies on a level playing field with peers within the same business group, internal processes, and performance metrics. A specific indicator such as unit cost, process cycle time, or productivity must be selected to benchmark against. Benchmarking reveals where a company's processes and performance metrics rank amongst the peer group. Benchmarking reveals the top performers in the group. Gap analysis will indicate differences in processes and procedures, and actions plans can be in place to close the gaps based on this data.

2.4.2.3 Gap Analysis

Gap Analysis is a method of assessing the differences in performance between current condition and want-to-be condition. Want-to-be condition should be modeled after a business entity in the same industry which is world-class by its peers. Gap Analysis identifies the areas where moving from a current condition to an ideal want-to-be condition is beneficial. It improves processes, increases organizational abilities and competencies by reducing time needed to execute corporate plans. Besides improving overall performance to the desired level, which is the ultimate goal, gap analysis also identifies by how much the need to increase performance exceeds the ability to do so.

2.4.3 Processes

2.4.3.1 Environmental, Health & Safety (EHS)

The goals of Environmental, Health and Safety are achieved through great leadership. Leaders must lead by example to drive employee engagement. An integrated systems approach such as an Integrated Resource Plan should be used by integrating safety processes into all M&R functions and structures.

This approach will result in safety becoming embedded in how a Maintenance Repairs and Operations (MRO) unit maintains all of its manufacturing or process activities. Leading and lagging indicators monitor and drive continual improvements, while striving to achieve zero safety incidents daily. Subject matter experts (internal or external) can be selected to lead teams in a category for improvement. World-class M&R organizations extend their safety efforts beyond the workplace and into the community.

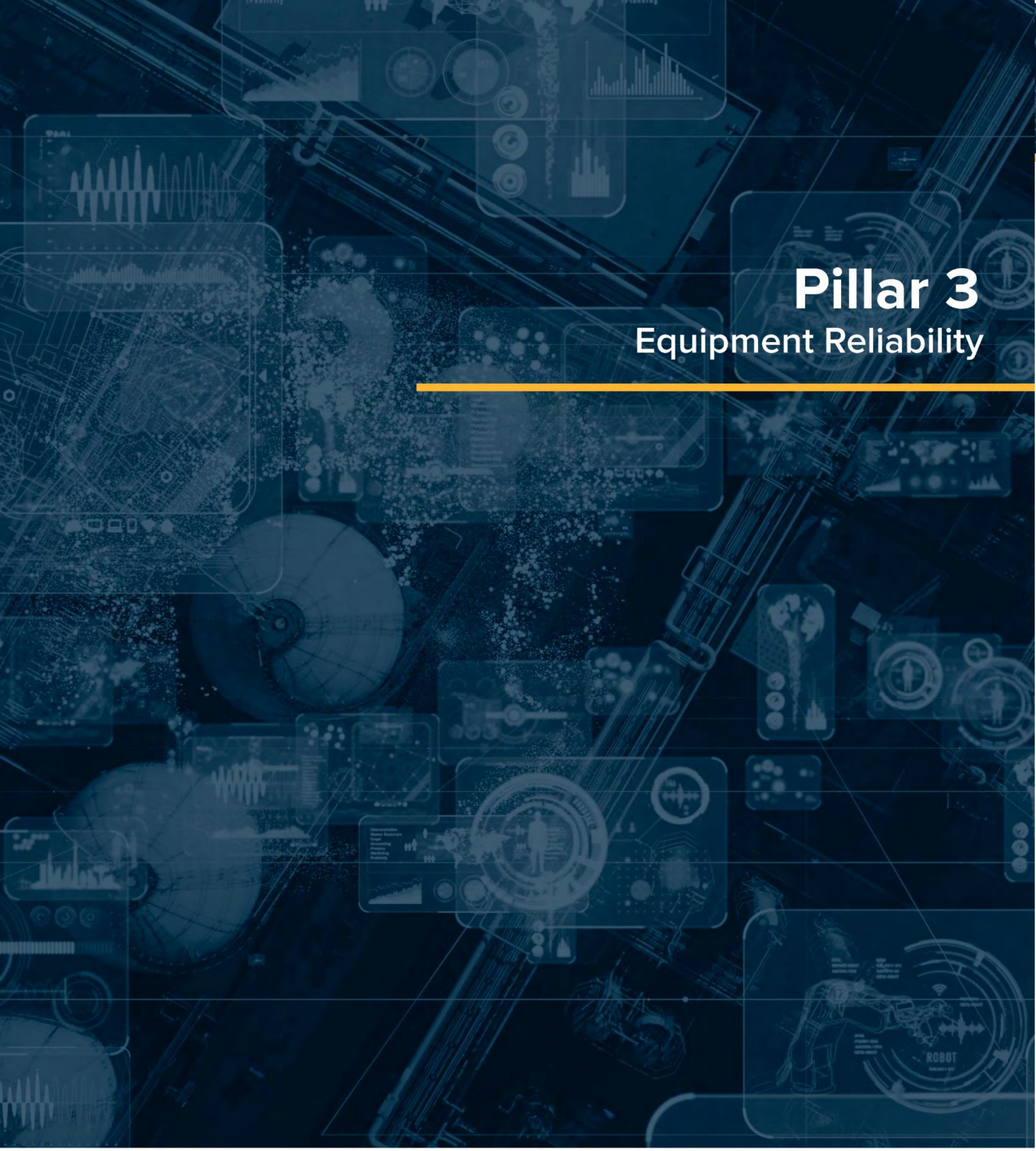
2.4.3.2 SMART Goals

Once it is determined that closing the gap is possible, a plan should be developed listing specific goals. These are the goals that will be achieved the target when accomplished. Specific, Measurable, Achievable, Realistic, and Timely goals methodology (also known as SMART Goals) can help determine which goals to pursue.

Pillar 2 Metrics Appendix

To access and download the SMRP Best Practices 6th Edition, please go to www.smrp.org.

Metric 2.1.1 Overall Equipment Effectiveness (OEE)
Metric 2.1.2 Total Effective Equipment Performance (TEEP)
Metric 2.2 Availability
Metric 2.3 Uptime
Metric 2.4 Idle Time
Metric 2.5 Utilization Time



Pillar 3
Equipment Reliability

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3.0 EQUIPMENT RELIABILITY

This subject area describes two kinds of activities. They concern the equipment and processes for which the maintenance and reliability professional is accountable. The first kind is used assess the current capabilities of the equipment and processes in terms of reliability, availability, maintainability, and criticality. The second kind is used to select and apply the most appropriate maintenance practices, so the equipment and processes continue to deliver their intended capabilities in the safest and most cost-effective manner.

3.1 Determine Equipment Reliability Expectations

Business-plan goals and stakeholder expectations are the foundation that form the requirements for equipment reliability and availability. Knowledge of the plant processes and business objectives as well as regulatory and code requirements and inherent design capabilities enable the development of meaningful and measurable equipment reliability and availability expectations.

3.1.1 Concepts

Equipment reliability expectations are derived from the business objectives, asset strategies and plant processes. The configuration of various equipment make up the systems, which in turn provide the plant throughput and performance in support of the manufacturing process as defined in Pillar 2.0.

An asset management plan is needed to determine equipment reliability expectations based on the corporate strategy. Pillar 2 on manufacturing process reliability needs to be applied to the equipment configuration, according to the criticality of each individual equipment. Criticality is based on reliability expectations in terms of Operational Severity, Safety, Environmental, Single Point Failure, Financial Impact, Cost of Equipment, Reliability, Maintainability, Spares Availability with Lead time, Cost of Decommissioning, and Regulatory Severity.

3.1.1.1 Business Requirements and Expectations

Define long-term and short-term reliability goals.

3.1.1.2 Facility Processes

Identify and confirm the process requirements and the related expectations on equipment reliability.

3.1.1.3 Systems and Equipment Used Within the Processes

Identify the relationships and configurations of equipment and systems; their maintenance, operation, inspection and repair history; and criticality assessment of systems and equipment.

3.1.1.4 Regulatory and Code Requirements

Identify external requirements (Federal and State), industry standards and recommended practices as well as internal policies and standards.

3.1.1.5 Equipment Availability Required to Meet Business Expectations

To determine equipment requirements necessary to meet business expectations, execute the following processes.

Reliability, availability maintainability and safety (RAMS) assessment. This process is further defined as follows.

Reliability: Look within the CMMS at the volume of preventive and corrective tasks performed on the equipment and evaluate whether or not the preventive maintenance is sufficient enough by looking at the corrective maintenance and how the equipment is failing.

Availability: Compare the time that equipment is prepared to operate versus the time it is out-of-service when called to operate.

Maintainability: Can the equipment be easily repaired and supported? In other words, can the equipment be repaired cost-effectively? Viewing and understanding the contents of historical Corrective Work Orders will yield this information

Safety: Evaluate equipment posing safety risks to personnel operating the equipment at the time of equipment failure. Is there a personal injury risk from being in close proximity at the time of failure? Is there a threat of fire or sudden energy release upon failure? During Maintenance, is there a safety risk to the craftworker during repair or replacement? Consider the degree of Lock-out/Tag-out (LOTO), hoisting or rigging requirements, fall protection, confined spare entry, and hot work such as cutting, grinding and welding.

Equipment uptime and downtime evaluation: This requirement includes tracking and reviewing MTBF along with MTTR. This functionality is found on modern CMMS programs

Equipment failure assessment: Mining the CMMS database will provide a repair profile. Note how, when and why equipment failed over many years, as a means to nominate equipment as candidates for RCFA.

Production utilization: Planning and scheduling evaluations are best determined by customer demand versus equipment capability over time per expectation.

Assessment of maintenance and turnaround plans: This assessment applies to mandatory or discretionary plans. Turnarounds are continually being planned so new plans commence the day old plans end. Maximal time is allocated for scoping work prior to the onset of the turnaround. Recurring maintenance plans are memorialized within the CMMS and updated as the equipment maintenance requirements change per equipment condition assessment.

3.1.2 Tools

These tools are needed to support the concepts and related processes effectively and thereby achieve the equipment reliability expectations.

3.1.2.1 Process Reliability Modeling

These tools ensure overall visibility and management of equipment reliability in the operating context in which they are configured.

Process simulation and RAMS modeling and analysis
Operating parameter monitoring
Budget monitoring and actual cost tracking
Management of changes
Technical incident reporting, investigation and corrective action process management.

3.1.2.2 Facility Level Availability Simulation

Facility-level equipment configurations need to be reflected and managed in reliability tools. This arrangement will drive sustainment and improvement. A list of tools typically used for this purpose is as follows.

Asset register (for maintenance significant items)
Criticality analysis
Failure Mode and Effect Analysis (FMEA) analysis software for equipment level functions and effects
Reliability Centered Maintenance (RCM) analysis
Failure Recording and Corrective Action System (FRACAS)
Root Cause Failure Analysis (RCFA)
Physical/technical root cause performance-monitoring software
Condition monitoring equipment and software
Mechanical integrity and RBI software
Safety Integrity Level (SIL)
Computerized Maintenance Management Systems (CMMS)
Lifecycle assessment

3.1.2.3 Schedule of Outages Required by Regulation or Code

Mandatory regulatory reports need to be identified, produced and provided to regulatory bodies in accordance with applicable regulations, to show compliance with maintenance tasks performed under system outage conditions.

3.1.3 Processes

The following equipment-reliability processes are needed to achieve the outcomes defined below under the "Concepts" heading.

Understand the process reliability requirements described in Pillar 2
Develop facilities technical information
Develop, maintain and manage change to the asset register
Define and implement strategies for assets, reliability and maintenance.
Evaluate, assess and rank the criticality of assets
Develop a maintenance and reliability program
Assess asset failure, condition and performance
Review process reliability requirements and adjust strategies accordingly
Manage corrective actions
Manage change to assets, strategies, programs and plans
Develop and report the adequate key performance indications (KPIs) in line with business needs and expectations

3.2 Evaluate Equipment Reliability And Identify Improvement Opportunities

The evaluation of equipment reliability begins with the selection of where, how, and when to measure equipment performance. Consistent and accurate data collection methods are essential. Analysis of performance data must also consider load, speed, environment, and other factors that may influence performance.

Once sufficient equipment data has been gathered, it can be compared with the established expectations of reliability and availability. Gaps identified in this comparison are candidates for further investigation.

Any equipment that is not meeting performance expectations may be analyzed by a variety of methods (*e.g.,* root cause analysis, Weibull analysis). Nominal design parameters and best demonstrated performance levels should also be compared with the process requirements; that way, it can be determined if the requirements have changed over time to the point that they exceed the inherent design capacity of the equipment. This comprehensive analysis results in clearly defined improvement opportunities for achieving equipment performance that meets expectations.

3.2.1 Concepts

The concepts for this section are as follows.

Current condition, capabilities and limitations of equipment and production processes.
Expected failure modes for equipment in the current operating context
Current maintenance & reliability strategies
Programs in place to mitigate risk of failure
Current workflow processes
Maintenance efficiency and reliability effectiveness measurement
Performance measures, including leading, process, and lagging
Measured comparison of current performance through benchmarking
Required steps to address identified gaps leading to improved reliability

3.2.2 Tools

There are many tools to enable processes and procedures. These include tools that are fully described in the Sections on "Equipment Reliability Best Practices Metrics" of the current edition of "SMRP Best Practices."

Total downtime – Section 3.2
Scheduled downtime – Section 3.3
Unscheduled downtime – Section 3.4
MTBF (Mean Time between Failures) – Section 3.5.1
MTTR (Mean Time to Repair) – Section 3.5.2
MTBM (Mean Time between Maintenance) – Section 3.5.3
MDT (Mean Down Time) – Section 3.5.4
MTTF (Mean Time to Failure) – Section 3.5.5

Additional tools include work-order management workflow metrics (e.g. proactive versus reactive) as follows:

Availability metrics
Quality metrics
Speed/run rate metrics
Cost metrics
EH&S performance metrics
Energy efficiency metrics
Criticality analysis
Root cause analysis
Interval analysis (Weibull)
Asset health assessment tools

3.2.3 Processes

Processes required to achieve the outcomes defined under the "Concepts" heading are as follows:

Prioritize equipment assets and processes to assure that maintenance and reliability resources are appropriately allocated.
Assess current condition and capabilities of equipment assets and production processes.
Review equipment operating and maintenance history and failure identification.
For existing equipment and processes, review results of performance assessment to identify opportunities for improvement and potential performance shortfalls.
Develop detailed path forward / action plan to address identified reliability gaps.

3.3 Establish A Strategic Plan To Assure Reliability Of Existing Equipment

Properly developed maintenance and reliability plans consist of optimal tasks to safely meet reliability and availability requirements at the lowest sustainable cost. The achievement of this goal requires the identification of appropriate analysis techniques; the development of maintenance strategy and tactics; and a thorough understanding of the scope and applications of maintenance activity types (*e.g.,* condition-based, restorative and replacement, failure-finding, autonomous, *etc.*).

The use of one or more processes focused on the development of reliability-based maintenance plans is recommended. Selection may be based on the criticality and failure consequences of the asset, system, or process to ensure alignment with the strategic plan. It is important to perform periodic reviews of these plans and equipment reliability performance, and to adjust as business needs, performance, or requirements change.

3.3.1 Concepts

3.3.1.1 Risk Identification

Risks related to equipment failures need to be identified. Also equipment criticality and gaps in equipment reliability need to be identified.

3.3.1.2 Risk Mitigation

It is necessary to establish maintenance strategies, tactics, plans and activities to mitigate risk of failure. Also spare part criticality analysis and stocking strategies in support of maintenance strategies need to be established.

Technologies are available that might improve equipment process reliability and the effectiveness of existing maintenance strategies and plans. These technologies need to be applied and integrated with the work management process.

3.3.2 Tools

Tools to enable the processes and procedures are as follows:

Criticality assessment tools
Reliability-centered maintenance analysis
Failure modes effects and criticality analysis (FMECA) targets the effects of failure on the function of the equipment
Precision maintenance
Autonomous maintenance
Restoration and replacement activities
Spare part management (in support of restore and replace activities)
Condition-based maintenance activities
Failure-finding tasks
Risk-assessment tools
Root cause failure analysis (RCFA)

3.3.3 Processes

The processes needed to achieve the outcomes defined under the concepts heading are as follows.

Criticality applies not only to the equipment criticality but also on the class, selection and application of appropriate maintenance strategies.

Additional analysis to identify appropriate maintenance strategies is required for equipment or processes where maintenance costs are high or reliability is low.

3.4 Establish A Strategic Plan To Assure Reliability Of New Equipment

The plan will include reliability specifications and acceptance criteria as well as requirements for complete documentation, etc.

The strategy for equipment reliability defines the performance, availability, and maintainability requirements to achieve the business mission. These requirements are translated into reliability specifications and acceptance criteria for procuring equipment, including documentation requirements. They also provide specific guidance for use in the maintenance planning process. A documented equipment reliability strategy that is fully integrated into the equipment selection, procurement, and commissioning processes is the essential first step in assuring reliability over the life of the equipment. The strategy for new equipment should be congruent with the strategic plan.

3.4.1 Concepts

The concepts for this section are as follows:

Understand applicable Maintenance and Reliability (M&R) "best practices" for initial design criteria.
Procurement of equipment that yields the lowest overall life-cycle cost while meeting business needs.
Consider maintenance strategies and spare parts support in the analyses of the Life Cycle Cost and Total Cost of Ownership.
Acceptance tests should determine or prove that reliability criteria have been met.
Commissioning tests should determine or prove that reliability criteria have been met.
For capital equipment purchases and installations where no maintenance history exists, apply M&R "best practices" to assure maximum reliability.
For capital equipment purchases and installations where like equipment exists, apply existing M&R "best practices" to assure maximum reliability.
Equipment criticality post-design

3.4.2 Tools

Tools to enable the processes and procedures are as follows:

Life-cycle cost analysis
Criticality assessment tools
Value stream analysis
Reliability-centered maintenance analysis

Failure modes and effects criticality analysis
Failure mode mapping
Purchasing specifications
Reliability requirements
Standardization
Performance requirements
Ergonomic requirements
Qualification of vendors
Performance specifications and validation testing
Precision installation practices and specifications
Detailed commissioning and operating procedures
Proper application of engineered maintenance strategies
Spare part strategies and activities
M&R "best practices"
Condition monitoring strategies
Preventive maintenance strategies
Autonomous maintenance strategies

3.4.3 Processes

Processes to achieve the outcomes defined under the "Concepts" heading are as follows:

Design for reliability
Design for maintainability
Based upon equipment class, criticality and existing condition, select and apply appropriate M&R strategies prioritized by equipment criticality
For equipment or processes where maintenance costs are high or reliability is low, perform additional analysis to identify appropriate maintenance and supporting spare part strategies

3.5 Justify the Costs of Selected Plans for Implementation

It may be necessary to conduct a cost-benefit analysis, communicate the benefits, and obtain approval, etc.

Cost justification is based upon identified and quantified benefits or values, costs or resources, and possibly risks associated with a proposed equipment reliability plan. These are used to produce an information package for decision-making and performance measurement. The information package is presented as a business case in a format suitable for enterprise budget reporting and analysis. The package is a useful tool for obtaining management approval for financial and labor resources necessary to implement strategic and tactical plans and achieve specified reliability requirements.

3.5.1 Concepts

The concepts which apply to this section are as follows:

Dollar value of overall equipment effectiveness (OEE)
Effects of not meeting business needs
How the equipment or process selection impacts energy efficiency
Calculation of life-cycle cost, year-to-date cost and replacement cost.
Understand the full life-cycle cost portion of the equipment due to reliability
Calculation of direct maintenance cost and production process loss due to unreliability
Hurdle rate to approve the funding for the product (capital) project. "Hurdle rate" is the minimum rate of return on a project or investment. It is the weighted average cost of capital, or expected internal rate of return; or the percentage or investment set by the organization, typically based on "investment to profit return on the product,"
Safety or environmental impact resulting from equipment failure
Resources required to implement versus not implementing

3.5.2 Tools

Tools used to enable the processes and procedures are as follows.

Interval analysis, such as Weibull or Crow AMSAA

Equipment Reliability Best Practices Metrics:
Total downtime
Scheduled downtime
Unscheduled downtime
MTBF (mean time between failures)
MTTR (mean time to repair)
MTBM (mean time between maintenance)
MDT (mean downtime)

Maintenance Cost Metrics and Production Loss Metrics:
- Material cost
- Labor cost
- Service cost
- Rework cost
- Wrench time cost

Workflow Metrics (e.g., percent planned versus unplanned)

Overall Equipment Effectiveness Metrics:
- Availability metrics
- Quality metrics
- Speed/Run rate metrics
- EH&S performance metrics
- Energy efficiency metrics

3.5.3 Processes

Processes to achieve the outcomes necessary to justify the costs of selected plans are as follows:

- Identify high-cost equipment units, using use Pareto charts that include cost of lost production plus maintenance costs
- Calculate financial metrics to justify the selected maintenance plans (*e.g.*, DCF and NPV)
- Establish equipment maintenance plan resources budget
- Determine and steer towards the financial metrics that are required to manage maintenance plans
- Develop business plan
- Prioritize costs as required to meet business plan
- Determine cost difference of scheduled versus unscheduled repair work to enable "what if" assessments to justify costs of the maintenance plan.

3.6 Implement Selected Plans to Assure Equipment Reliability

Implementing an equipment reliability strategy may include monitoring equipment condition, measuring equipment performance, analyzing data, communicating results and recommendations, and taking appropriate action to achieve specified reliability requirements. Properly applied technologies and procedures are keys to implementation. The organization should be structured to support and enable the implementation of a reliability strategy.

3.6.1 Concepts

To implement plans for reliability assurance, it is necessary to align and proactively manage the things that impede reliability (such as equipment degradation and failure) and develop a plans to mitigate those effects. Key concepts that impact implementation are as follows:

Design for reliability
Procurement and storage of spare parts
Operating within the equipment capability
Precision maintenance and repair
Equipment condition and performance monitoring
Failure identification and prediction or estimation
Failure mode and related failure prevention strategies and tactics
Required standard maintenance procedures
Preventive and corrective work initiation.
Maintenance work-management processes (see Pillar 5)
Failure investigation and root cause failure analysis (RCFA) including physical and technical root cause
Resource requirements for implementation
Organizational change issues
Skill sets, including technical skills and soft skills (presentation and communication)
Business and management issues due to the impact of outages

3.6.2 Tools

Toolsets to execute and support concepts vary depending on the type, complexity and configuration of the equipment as well is the operating context. They need to be used and managed effectively to cover the reliability assurance part of the lifecycle. Required tools are as follows:

Process control monitoring systems
Equipment condition monitoring systems
Predictive Maintenance (PdM) tools and software/hardware systems
Computerized maintenance management system (CMMS)
Work management practices and procedures
Job descriptions
Skills training
Communication plan
Key performance indicators (KPIs)

3.6.3 Processes

The following processes should be executed to support the concepts.

Maintenance management program using the following software tools.
CMMS/EAM
Technology specific database
Machine Learning
Asset/predictive analytics

Failure prediction and analysis process
Implementation communication strategy
Acquire skills through training or hiring process
Develop standard maintenance procedures
Recommend business processes to address shortcomings
Develop plan for continual improvement

3.7 Review Reliability Of Equipment And Adjust Reliability Strategy

Assess key performance indicators, analyze deviations, identify relevant best practices, and implement continual improvement, etc.

Every reliability program should be assessed against established reliability goals and process expectations.

Carefully selected maintenance and reliability key performance indicators (KPIs) provide insight into the effectiveness of the reliability strategy as it is applied. Analysis and comparison of KPI trends (along with research into the cause of deviations from expected performance) lead to tactical implementation adjustments, which in turn impact the KPI results.

Relevant industry best practices and related metrics also drive continual improvement of the maintenance and reliability processes. These best practices support business objectives when integrated appropriately at the strategic and tactical levels. Some examples of industry best practices are as follows.

Review and evaluate maintenance-plan data
Target failure modes by equipment class
Develop and recommend corrective-action processes

3.7.1 Concepts

Concepts for assessment are as follows:

Current-state benchmarking against external- and internal-standards and best practices
Overall design capabilities of the plant
Selected KPIs and methods of calculation
Target setting for KPIs to enable performance management
Continual improvement process using plan, do, check and act (PDCA) and using targets to drive the correct behavior and performance.

3.7.2 Tools

Tools for assessment are as follows:

Auditing of process and data management
Dashboards to produce KPIs and related performance indicators and analysis measures
CMMS, LPA and downtime systems
Statistical data analysis
Strategic and tactical Plan

3.7.3 Processes

Processes to support the concepts of assessment are as follows.

Identify and assess gaps between actual performance and improvement targets
Review the observed failure modes versus targeted failure modes by equipment class
Failure investigation and defect elimination
Implement corrective actions required close performance gaps
Apply a continuous defect-elimination strategy
Track strategic and tactical actions to completion

Pillar 3 Metrics Appendix

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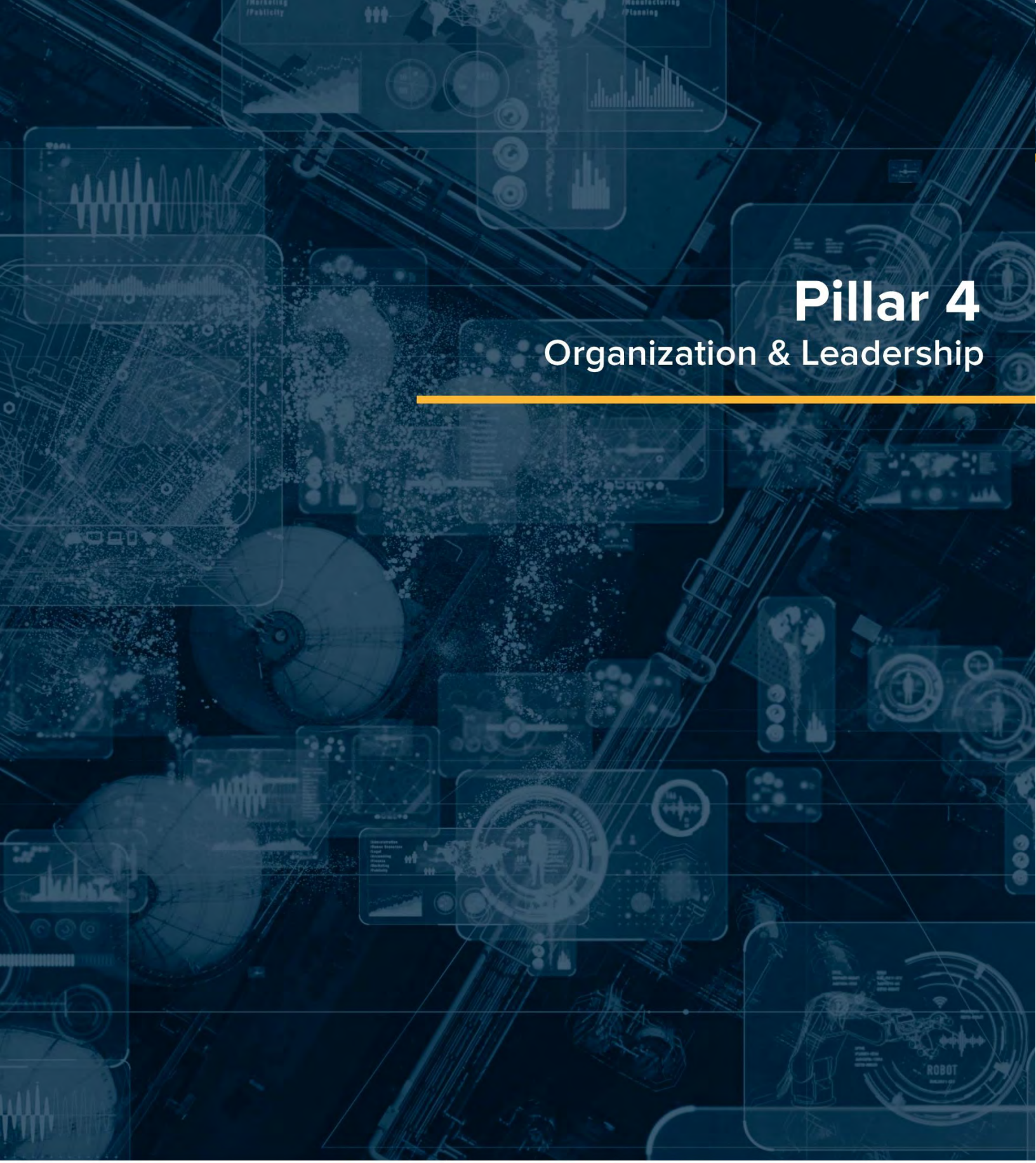
Metric 3.1 Systems Covered by Criticality Analysis
Metric 3.2 Total Downtime
Metric 3.3 Scheduled Downtime
Metric 3.4 Unscheduled Downtime
Metric 3.5.1 Mean Time Between Failures (MTBF)
Metric 3.5.2 Mean Time to Repair or Replace (MTTR)
Metric 3.5.3 Mean Time Between Maintenance (MTBM)
Metric 3.5.4 Mean Downtime (MDT)
Metric 3.5.5 Mean Time To Failure (MTTF)



Pillar 4
Organization & Leadership

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4.0 Leadership and Organization

This subject area describes processes for assuring that the maintenance and reliability staff is well qualified and assigned to achieve the maintenance and reliability organization goals.

4.1 Determine Organizational Requirements

4.1.1 Concepts

The organizational requirements need to align with the Maintenance & Reliability strategic plan. Analyze the overall capability of the organization in terms of the business conditions in which the organization operates and the capability and skills of personnel as well as industrial trends, issues and opportunities that might affect the organization's programs. Develop strategic and tactical plans for hiring qualified personnel, creating an employee training curriculum, and maintaining the necessary skill levels by communicating to all levels of the organization. Establishing and communicating these requirements early in the planning stages and throughout the process will assist in maintaining alignment to the organizational strategic plan.

4.1.1.1 Develop the Maintenance and Reliability Goals

As described in the first Pillar (1.0 Business and Management) the first step in developing the organizational requirements is to determine what you within the organization are trying to accomplish in the scope of maintenance and reliability. Therefore, short-term and long-term goals need to be developed and agreed upon by all stakeholders.

4.1.1.2 Develop an Organizational Strategic Asset Management Plan

Develop a strategic asset management plan designed to accomplish the maintenance and reliability goals. This plan may include key performance indicator (KPI) development. It may also include maintenance & reliability business processes such as work management, reliability engineering, predictive and proactive maintenance, precision maintenance, and materials management processes. Engineering and capital improvement processes can be included. The plan may also include operations excellence processes promulgated through highly scrutinized standard operating procedures (SOPs); computerized maintenance management System (CMMS); and enterprise asset management (EAM) usage, regarding work management.

All these processes are designed to help an organization attain its strategic goals. The overall Maintenance & Reliability (M&R) organizational reporting strategy should be designed to operate alongside the operations and production organization; or as an independent organization to the operations and production organization, or as a combination of the two concepts. The reporting strategy is not that important. The important concept is that the M&R organization strategy is designed to accomplish the M&R goals.

4.1.1.3 Develop the Organizational Requirements

Certain Maintenance & Reliability organizational requirements are necessary to support the organization's goals and strategic plan. These requirements include positions that support maintenance and reliability business processes. Positions include planners, schedulers, reliability engineers and maintenance engineers. Positions in support of the material management organization (MRO) processes may include buyers, procurement specialists, and storeroom personnel.

One method used in organizational requirements is a responsible, accountable, consulted and informed (RACI) model. A RACI matrix is the simplest, most effective means for defining and documenting project roles and responsibilities. Knowing exactly who is responsible, who is accountable, who needs to be consulted, and who must be kept informed at every step will significantly improve chances of project success.

There are a number of alternatives to the RACI model that could be applied to a specific industry or process application.

4.1.2 Tools

The MRO process is a crucial part of the M&R function. An effective tool to remind the MRO staff why they do what they do is a "mission statement".

4.1.2.1 Attributes of a Mission Statement

One sentence in length
Not wordy but short and succinct
Can be easily memorized
Not just words or a slogan but a concept that provides a purpose
Published for internal customers to see and acknowledge (intranet)

4.1.2.2 Creation and Development of a Material Management Organization (MRO) Information Site

The MRO information site should contain the mission statement and information about activities in support of the mission statement. Contents include organizational charts, facility description, storeroom layout, storeroom usage guidelines, work management process, tips on how to use the CMMS/EAM modules, tips on safe work practices, tips on best maintenance practices, and links to internet maintenance publications of interest. It can also include the predictive-, preventive- and proactive-maintenance program, maintenance accomplishments, training schedules, outage schedules, preferred vendors, and storeroom statistics with key performance indicators (KPIs).

All members of the MRO staff should contribute to the MRO site in one form or another. Such participation promotes ownership and proactively engages the internal customers they serve. This site should be updated with the most recent MRO information on a quarterly basis if not monthly basis. There should also be a means of soliciting feedback or constructive criticism.

4.1.3 Processes

4.1.3.1 Initial Reliability Processes

From the beginning of the planning cycle, effective reliability leaders intensively focus on understanding the organization's overall strategic plan. An effective reliability leader facilitates the formation of a reliability plan by actively sharing information, increasing overall understanding of how the reliability department contributes to and supports the overall strategic plan. The leader elicits support for the reliability-department plans with as much real information and detail as required to obtain support at the strategic level.

Leaders facilitate the efficiency of the reliability department and build a collaborative work environment with an organized plan that clearly communicates work structure to the work groups with whom the department collaborates as detailed below in Section 4.3.

Leaders develop SMART incremental goals as follows:

"S" for specific, significant, stretching.
"M" for measurable, meaningful, motivational.
"A" for agreed upon, attainable, achievable, acceptable, action-oriented,
"R" for relevant, and
"T" for time-based.

The identification of SMART tactical targets allows results to be measured and communicated with stakeholders. Finally, modifications might be considered if the results are not meeting SMART targets.

In addition to the aligned and positive reliability department deliverables; the leader evaluates, negotiates for, and facilitates the procurement of the resources that the reliability department requires to meet its promises, as detailed in section 4.2.

4.1.3.2 Ongoing Reliability Processes for Leaders

Effective reliability leaders facilitate the creation and maintenance of KPIs, which focus the individuals and workgroups within the department.

Leaders create a clear communication methodology, which supports and rewards incremental progress toward agreed-upon reliability goals. This methodology supports and encourages improvements and progress, and it plainly reinforces workgroup goals.

Leaders evaluate on-going intellectual resources within the department, including resources that meet reliability goals to develop personnel as outlined in Section 4.4 below. Leaders facilitate a plainly understood process for requesting and using additional education. They monitor the needs of all staff and motivate them to keep abreast of developments and innovations, which will energize the organization in a positive direction.

Leaders facilitate the process for evaluating and encouraging the continual improvement. Continual improvement in communication, a team-oriented collaborative work environment, and work performance will contribute toward continually improving reliability as outlined in Section 4.5 below.

Leaders continually monitor progress toward goal improvements. They develop effective modifications to the reliability plan or reliability actions as required to assure delivery of agreed-upon results. In addition, the leader monitors and improves upon the strategic plan, making sure to align on-going reliability efforts with overall organizational goals.

4.1.3.3 The Final Steps of the PDCA Cycle are CHECK and ACT

The PDCA cycle is an iterative model for continuous improvement of the quality of processes and products. It consists of a logical sequence of four repetitive steps for continuous improvement and learning.

PLAN is to plan ahead for change.
DO is to execute the plan, taking small steps in controlled circumstances.
CHECK is to study the results.
ACT is to take action to standardize or improve the process.

Effective reliability leaders proactively monitor, tabulate, communicate, and cycle results of the reliability department findings. Such reporting is detail enough to foster understanding by workgroups and stakeholders.

Leaders fairly and honestly evaluate the reliability results against the tactical and strategic plan. Leaders actively celebrate the successes with all the active contributors; where results fall short, they proactively communicate corrective information with adjustments and decisions.

4.1.3.4 DMAIC

DMAIC is a data-driven, quality strategy for improving processes. Although DMAIC is considered a Six Sigma initiative, it generally can be implemented as a standalone quality improvement procedure or it can complement other process improvement initiatives, such as lean.

"DMAIC" stands for Define, Measure, Analyze, Improve, and Control. It represents the five phases that make up the process as follows.

Define the problem, the improvement activity, opportunities for improvements, the project goals, and customer requirements (including internal and external customers).
Measure process performance.

Analyze the process to determine root causes of variation, and poor performance (defects).
Improve process performance by addressing and eliminating the root causes.
Control the improved process and future process performance.

4.1.3.5 Launching the Project

In launching the project, the maintenance leader will need to adequately engage a process of communication. Using available communication means, typically email, the maintenance leader must communicate the intentions of the project to staff members in operations as well as the information technology (IT) department.

The maintenance leader holds meetings with operations staff and invites various representatives from operations to attend meetings. The maintenance manager will mention the creation of the website and state the purpose of having it. The maintenance leader will facilitate the development of a mission statement by the team with a deadline for submittal.

The maintenance leader will also coordinate the creation of the MRO site with the IT department and ensure technical aspects of the project are addressed. A representative from the IT department will provide the maintenance leader with a target date for the website to become active and available to the end-users as well as a service level agreement on the upkeep of the website.

Also, the maintenance leader will communicate the launching of this website to all collaborative stakeholders. Through effective communication, the maintenance leader establishes open lines of dialog between maintenance and operations to solidify the notion that both have an equal interest in the success of the organization as a whole.

4.2 Analyzing Organizational Capability

This includes inventorying staff skills and determine performance gaps.

4.2.1 Concepts

Assessment of organizational capability begins with a performance analysis. The organization needs to measure actual performance against desired performance by assessing personnel to identify any performance and knowledge gaps.

4.2.1.1 Supporting the Organizational Strategic Plan

The organization's resources and capabilities must be measured against current requirements, the strategic plan and competitive advantages in its target market. The resources must include the tangible, intangible and human aspects of the organization. Tangible resources include financial and physical elements. Intangible resources include the technology, reputation and culture of the organization. Human resources include skillsets, capacity, and employee motivation. The following factors must work together to fully create the organizational capability.

- Capabilities versus requirement gap analysis
- Organizational capability
- Tangible and intangible resources
- Human resources
- Strategic plan implementation

For the MRO staff to be empowered to achieve the organizational goals and support the strategic plans, all resources must be organized and work together with the same target goals. Competencies are demanded by the strategic plan, which needs to define the human skills, the number of each skill required, and motivations for each role in the plan. An employee skill assessment and competency matrix should be conducted to find training and gap opportunities. Documentation and review will ensure the staff is aligned to the organizational goals and strategic plan.

4.2.2 Tools

4.2.2.1 Personnel Assessment and Gap Assessment. Knowledge Assessment. SMRP Training Matrix.

Companies can benchmark with similar companies to better their strategic plans and improve execution. Many opportunities for benchmarking exist within the maintenance and reliability industry. Companies are willing to share their own experiences with one another. Benchmarking has the advantage of allowing both organizations to look at themselves in depth and improve their processes.

Gap assessment requires comparison of desired performance to actual performance. This process yields valuable indicators relating to training needs, budgetary planning, and performance to plan.

Knowledge assessment evaluates personnel or personnel groups with respect to the knowledge and skillsets that are required for the assigned workgroup.

Training matrices or training charts are methods for tracking personnel skills and skillset knowledge. Training charts provide the documentation points from the knowledge assessments. The charts can be used to track: training requirements, support gap assessment analysis, and (CMMS) work order skill level requirements.

4.2.2.2 Competency Model

Another tool to support personnel assessment is to build a competency model. This matrix model will allow the organization to determine the skillset, knowledge content, attitude and values necessary to implement the strategic plan. It builds upon the knowledge assessment and training matrix to capture all assessments on one chart. This matrix model supports the gap analysis, which determines budgeting for training needs, hiring decisions, promotions and compensation. Implementation of the strategic plan requires that resources be identified, selected and committed to continuous improvement.

4.2.3 Processes

The completion of models and matrices requires that project meetings be scheduled with stakeholders and sponsors for the purpose of creating plans and setting objectives. This process identifies the work activities necessary to accomplish objectives and create work plans. Assigning activities and delegating priorities and deadlines to project team members helps to ensures that personnel requirements are met. Design a reporting hierarchy of relationships, clarifying roles, responsibilities and communication channels; and ensuring all personnel know their roles and responsibilities. Classify and group the necessary work activities into manageable units and then execute the plans. Measure progress against stated goals making every effort to stay on schedule.

4.3 Develop the Organization Structure

This includes establishing reporting channels, determining roles and responsibilities, managing reorganization, etc.

4.3.1 Concepts

Organizational structure refers to the division of labor as well as the patterns of coordination, communication, workflow and formal power. This structure directs organizational activities. An organizational structure reflects the organization's culture and power relationships.

A number of organizational structures could be applied to a company or division and will work if people are willing to work together. No matter the structure, structures will not work if people are unwilling to work together. It's critical to make it easy for employees to work together, maximizing their alignment to the strategy and goals of the company and minimizing the potential for conflict among elements of the organization.

The organizational structure defines roles, responsibilities, relationships, governance, and other organizational characteristics. When effectively communicated, the structure facilitates work by the people and teams to which the various functions are assigned. Organizational structure starts at the strategic level and moves down through various levels, whether corporate or plant and facility, helping the organization better organize for its success.

4.3.1.1 Value of Employees

Successful businesses rely heavily on their employees. It's important to build an organization around its people to support the overall strategy. This approach ensures goals and objectives are attainable since the capabilities of the team are kept in mind during planning.

Employees must keep them motivated, so they remain productive and inclined to exceed expectation. One way of keeping employees productive is to provide professional and personal growth opportunities within their job-related discipline. Having a technically competent workforce with a cutting-edge skillset is a prerequisite for attaining high-aiming corporate goals. The most significant organization structural corporate goal for any business is to align the abilities of its employees with its business strategy.

Employees need to be involved in the corporate mission statement creation process. Likewise, they need to share in the company's values. Empowered employees will strive to take the company to its future visionary state by working within the stated business strategy and applying their skills. Motivated and educated people in the organization hugely influence organizational success by executing the business strategy.

4.3.1.2 Organization Challenges

Consideration should also be given to attracting and developing key talent; developing a leadership culture; making continuous, relevant training a mainstream activity; succession planning; managing diversity; and adapting the best organizational structure for supporting a highly-efficient maintenance and reliability culture.

Several critical issues must be addressed to make it easier for people to work together. At the highest level, the organizational structure must be aligned to the following:

The business strategy.
The production process, or in some cases, the supply chain.
The skills of the staff running each element in the structure.
Focus.

The best organizational structure depends on the firm's external environment, size, technology, and strategy. The concept of single point of accountability (SPA) for a given business requirement relates to organizing along functional lines and assigning a single point of accountability for various requirements. It aligns the various areas with the overall strategy and attributes responsibility for that area to a sole person. It includes the use of cross-functional teams and partnership agreements as needed, along with superordinate goals, to ensure SPAs work together to meet the overall business goals; in this manner, a "silo mentality" can be avoided.

There is substantial task-interdependence between production and maintenance, manufacturing and marketing, manufacturing and procurement, and other functions. Determine which parties should be responsible for each group of areas and move forward from there. For example, production is accountable for output, quality and on-time delivery; it may also be accountable for maintenance downtime and repair costs, since it has direct influence on these; and finally, it may also be accountable for maintenance schedule compliance, since the production schedule will include the maintenance schedule.

"Span of control" refers to the number of people directly reporting to the next level in the organizational hierarchy. The span of control could be relatively narrow, for novel or complex tasks; or it could be relatively wide, for routine tasks. The best-performing manufacturing operations today rely on self-directed work teams; so direct supervision (formal hierarchy) is just a backup coordinating mechanism. The best span of control depends on nature of the task. The degree of interdependence among employees within the department or team can have an influence on span of control.

Emphasize team-based and team-rewarded activities as appropriate. It's a maxim that people act in their own self-interest. Incentives and structures must be set up to align and incentivize self-interests with the company's interests as well as optimization of the business as a whole. "Rewarding results" works significantly better than "paying for performance." In other words, structure the organization and reward people based on the success of the entire organization and not necessarily on the success of any one individual. Profit sharing encourages good work when it is provided as an incentive.

Consider the short-term and long-term effects of any re-organization. Any re-organization of a particular area must have a positive effect on that area as well as a positive or neutral effect on the balance of the organization. If the short-term impact is so disruptive that it puts the organization at risk of failure, then it should be reviewed and modified to minimize that risk. Evolution is generally a better approach than revolution. Similarly, any re-organization in one area have a positive effect for that area and hopefully a positive or neutral effect on other areas. Most important, it must not have a negative effect on the balance of the organization to the overall detriment of the organization.

Consideration should also be given to attracting and developing key talent, developing a leadership culture, making continuous relevant training a mainstream activity, succession planning, managing diversity, and adopting the best organizational structure for supporting a highly efficient maintenance and reliability culture.

The aging of the workforce shines light on succession planning. Succession planning continually remains at the forefront of human resource activities since the pool of qualified candidates is shrinking for demographically driven reasons. Succession planning identifies and prepares suitable, qualified employees. Retain the already qualified, long-time employees as mentors to aid in the development and execution of succession planning.

No organizational structure is perfect and compromises must be made to optimize the overall organization. Most organizational structures will work if people are willing to work together toward a common purpose. The organizational structure needs to make it easy for them to work toward a common purpose. In general, any re-organization should be evolutionary and not revolutionary, and it should be tempered to minimize its disruption of the organization and its effect on business.

4.3.1.3 Global Competition and Organizational Change

Global competition is bringing about continuous change. The geographical locations of the business units, management teams and interfaces may change. It is difficult to manage and support the efforts of people who are spread across different plants, office buildings, states or even countries. Travel times and differing time zones create difficulties in scheduling and planning. Much time is lost in traveling. Different processes at different locations adds complexity to the managerial job. When you are faced with the task of automating teams across several different locations, working to uncover the similarities between the teams may decrease the complexity of your tasks.

Demographics keep business leaders awake

The impending loss of skills in an aging workforce is a challenge. Generally, the two levels of action or effort are strategic and tactical.

Strategic actions

Annual strategic planning processes look ahead five, ten and 15 years. Typical work sessions include market- and competitive-analyses, exploring what the future holds for the company. How will markets and customers change? What capabilities will new technologies bring? Given those scenarios, how will the company hold market share and grow the business? Optimally, the review extends to skill requirements. What skills will be needed to meet future challenges? What changes, if any, will need to be made to existing skillset mixes?

How does the company acquire and retain critical skill sets? Laying these requirements over the retirement schedules gives a full picture of priorities. The requirements all focus on the same priorities. The plan to meet the priorities includes the integration of mentoring, development programs, succession planning, and hiring efforts.

Tactical actions

Tactical action is required where serious skill loss will occur in five years or less. Plant maintenance typically has the highest anxiety about skill loss. Maintenance personnel is the most senior and highest skilled in plant operations. They play a critical role in sustaining equipment reliability, production capacity and therefore revenue

A Knowledge Gap

Demographic analysis tells leadership what percentage of the workforce will be eligible for retirement and in what time frames; however, the demographics doesn't describe the exact effects of retirements on operations. Coupling those effects with the duration and cost of traditional apprenticeship programs, decision makers are left in a quandary. What will be the need for each craft, for examples, instrument, electrician, mechanic, pipefitter, etc.? How many should the company begin developing? When and how will they be developed?

One problem with answering these questions is the lack of quantifiable data. The key is to identify the specific equipment affected by retirements and the corresponding specific skillsets that will need replacement. Just saying, "We need five more mechanics" does not cut it. Rather, one must be able to say, "We need three people who can overhaul back-pressure regulators and two who can troubleshoot and overhaul our engines." This focuses replacement on specific efforts rather than shot-gunning for a general skill set. A matrix analysis of individuals, equipment and skills provides the necessary specificity and quantification.

Organizations are being flattened by the removal of middle management positions. The overall size of the maintenance and reliability departments is being reduced. Organizations are restructuring to provide critical maintenance and reliability functions for effective use of its employees.

Three types of organizational structures could be used to set up an M&R organization: centralized, de-centralized and hybrid. The hybrid organization takes the best of both worlds. It lays out the foundation for a fairly flat command and control system with uncomplicated lines of communication. One such hybrid organizational structure five departments (maintenance, engineering, inventory, procurement and operations) reporting to a plant manager, who has instant decision-making authority. This structure depends on maturity of the M&R process that is in place.

Examples of mature processes include a good work/maintenance management system, disciplined planning and scheduling (including adequate planners) and excellent condition monitoring to better determine the work to be done, parts needed, etc.

If the maintenance processes are immature yet maintenance functions are decentralized into area teams, the result may be similar to "putting firefighters close to the fires" without stopping the cause of fires or having the ability to efficiently put them out. In that case, a more centralized maintenance function likely is needed to focus first on getting needed processes in place. Once these processes are reasonably mature, creating area teams for maintenance execution with the support of centralized functions is likely best.

Examples of centralized support functions include the following:

- Maintenance planning and scheduling
- Machinery repair
- Predictive maintenance
- Technical support
- Contractor management
- Human resources

For centralized maintenance planning and scheduling, all planners report to one supervisor, regardless of assignment to specific areas.

4.3.2 Tools

4.3.2.1 Employee Planning

Enhancing both career and succession planning shows employees that the organization is committed to their long-term success and values them as employees. It also demonstrates a desire for strategic investment in career development programs. The casual worker program is a tool deployed by the organization to capture the knowledge and work ethic of retiring, experienced employees, and transferring those admirable attributes to new employees. The casual worker program offers limited benefits with no pension and is way to supplement retirement income. The program serves as means of preserving highly valued corporate culture, while supporting new hire and existing employees. Career development coaching for the new employee along with the job satisfaction for the casual worker program participant makes this program a win-win proposition.

Leadership management should not only coordinate the skilled-attribute experience of the retiree but also develop a "flight plan" or growth plan for

the new employee, to ensure employee development and continued growth for the company.

Determining the training needs of the employees in conjunction with the corporate strategic plan is an important criterion that needs to be developed in the corporate training structure.

4.3.2.2 Outsourcing and Other Options

Outsource work allows the organization to find specific skills needed to support projects and operations. Outsourcing can be used briefly, such as on a special one-time project, as a supplement to its own workforce. Some companies choose to have dedicated permanent contractors support their internal workforce.

The outsourcing of operations or maintenance is one way to reduce labor costs while still addressing operations and or maintenance needs.

The practice of mentoring engineering college interns is growing in popularity. This practice is not only a low-cost alternative for temporary workforce enhancement but also interns are eager to learn. Internship provides practical, hands-on education in return for work accomplished in line with strategic goals. Organizations evaluate intern performance to select the best candidates to fill vacant positions or soon-to-be-vacant positions from retiring employees.

Intra-company networking is another option that supports diversity. It brings employees from different parts of the company together in an informal atmosphere. They get to know each other and can cross-share various interests and aspects of their company. Otherwise departing employees may acquire a new interest within the same organization and seek employment in a new discipline. In this manner, the skillset remains within the overall organization to the benefit of both the employee and the organization. Corporations commonly post projects intracompany, allowing employees to apply for positions on the projects. This method allows for the creation of cross-functional development teams and supports a multi-platform cross organizational corporate structure. Corporations benefit from this concept by better deployment of its employees to needed tasks.

4.3.3 Processes

4.3.3.1 Organizational Planning

Organizing is a process much like planning. This process consists of determining what work is to be accomplished, assigning this identified work to individuals, and arranging those individuals in a decision-making framework. All of these steps are done with the corporate-defined strategic goal in mind. A properly coordinated, structured approach to building the organizational planning process will yield a well-tuned organization.

The benefit of organizing is a clear-line-of-sight, upward-reporting protocol, and unambiguous team-member responsibilities. If the organizing process is not coordinated, the results will be less than optimal and even wasteful.

Along with organizing, short-term and long-term objectives are key and they must be defined. Specific activities must be completed to attain these objectives and achieve the goals of the organization. These activities need to be planned. Managers must examine plans initially and continue to examine them even as the plans change and new goals are developed. Managers are responsible to list and analyze all the tasks that need to be accomplished in order to reach organizational goals and objectives. Managers negotiate with employees and assign the defined work activities to teams and specific individuals. They give each individual or team the authority to carry out the assigned tasks. A manager should take into account both the vertical (decision-making) and horizontal (coordinating) relationships of the organization.

Using the organizational chart, managers can diagram these relationships, establish channels of communication and set expectations amongst peers, subordinates and supervisors.

4.4 Develop Personnel

This includes training, hiring needed expertise, delineating career paths, etc.

4.4.1 Concepts

No matter their industry or field of expertise, everyone needs an organization that operates successfully and smoothly. The goal is to operate problem free and avoid the development of situations. Aging equipment, human errors and conflicting approaches to life seem to make problems inevitable. To prepare for this environment, you need a team of problem solvers. These are people who can see beyond today and act on what they see.

4.4.1.1 Align Personal Goals with Career Paths

The *development* of personnel plays a crucial role in improving organizational performance, aligning staff with the strategic plan, and establishing career paths for individual employees. The objective is not only to *train* your staff but also to *develop* them.

In the past decade, organizations have confused training and development. Training tends to homogenize the workforce by conforming to a norm and adapting to the status quo; on the other hand, development emphasizes the unique character of individuals. Development distinguishes between differences in ability. It recognizes qualities of work behavior and tends to shatter the status quo.

Unfortunately, maintenance managers have viewed these very different ideas as synonyms. Training directly grows the knowledge base of all team members and is relatively easy to implement. On the other hand, employers may find the development opportunities expensive; consequently, they may forego development and spend their budget only on training. Typically, employers forego development not because of expense but because they lack the skilled professionals within their organizations to develop their team. Notwithstanding the usual drawbacks, training and development both offer crucial advantages to the organization and its team members. Considering these advantages, the time and money spent on training and development is a valuable investment.

4.4.1.2 Develop Continuous, Job-Specific Strategic Training Programs

All team members have weaknesses in their job skills. A development program allows managers to strengthen needed skills. Addressing the needs of individuals instead of general training for the entire crew allows for better management of limited training dollars. A development program carries all team members to a higher level, so they all have comparable skills and knowledge. Weak links within the organization can be strengthened by training those who otherwise would rely heavily on others, so they can complete basic work tasks.

Training and development creates an overall knowledgeable staff with team members who can cover for each other, work as a team member, or work independently without assistance and supervision from others.

A properly developed team member performs better at his or her job than one who is not. Developed team members are more aware of safety practices and proper procedures for basic tasks. Development builds confidence by strengthening their understanding of the industry and job responsibilities. This confidence may push them to perform even better and think of new ideas that help them excel even more. Continuous development also keeps your team on the forefront of industry developments. Team members who are competent and on top of changing industry standards help your organization maintain a competitive advantage and remain a leader in their industry.

4.4.1.3 Cross-Functional Training

A structured training and development program ensures that your team has consistent experience and background knowledge. Such consistency is particularly relevant to basic policies and procedures. All team members need to be aware of the expectations and procedures within the organization, including safety, discrimination, and administrative tasks. Putting all team members through regular training in these areas ensures that all staff members have exposure to such information.

Team members with access to training and development programs have an advantage because it shows the team members that they are valued. The development creates a supportive workplace. Team members may gain access to ideas that they wouldn't otherwise have known about or sought out themselves.
Team members who feel appreciated and challenged through training opportunities may feel more satisfaction toward their jobs, and such job satisfaction will increase retention.

Development programs offer the best way to build an organization of problem solvers. Your development program needs to focus on building a team that not only can maintain the equipment but also knows how to detect and identify issues. Any issue on the plant floor is an opportunity to improve performance and efficiency. A staff that communicates issues and solutions instead of hiding them is evidence that the company culture promotes continual improvement. This culture will be beneficial to the bottom-line in the short term and in the long term.

Investment in skills development will enhance organizational output and employee morale. A trained staff that can address any situation is proof that your team is a well-rounded and improved operation.

Classroom training followed with practical experience could put an end to money being wasted on maintenance courses that team members quickly forget. Organizations can spend tens of thousands of dollars on maintenance training yet most of the knowledge is never used in the plant. In fact, it is common for trainees to forget most of the lessons learned just weeks after the event. One way to help put an end to this phenomenon could be to give classroom training in conjunction with practical experience.

It is a good idea to do due diligence on all training that is provided in your plant. There is no justification for providing training that does not deliver on better reliability in the plant. There needs to be a plan with a result in mind before any training takes place. Training for the sake of training is not a good business decision. If the plan does not include development once the training is complete, then save your money. There should be audits of the development plan to ensure the plan is being executed.

4.4.1.4 Hire Well

The first step in training your team is to hire the right people. Hiring needs to be determined in maintenance and reliability by qualified maintenance and reliability leaders. At no time should you allow human resources (HR) to influence hiring of unqualified personnel. Hiring warm bodies is not the goal and not considered hiring well. Filling positions for the sake of filling them does not strengthen your team or improve your proactive strategy.
Hiring of unskilled handymen for journey-level positions diminishes the pool of qualified craftspeople. It is not safe for the unqualified candidate or the organization. Your search needs to focus on people eager to learn and continually improve. Improving team performance requires team members who are engaged. If your team is striving to learn more about their industry and organization, they will perform better in their job and see it as their career. Development is vital to any employer's ability to retain their team members, build loyalty, and harness the full value of their team.

Help your team members understand how their contributions help the overall function. Not everyone can see how they fit in the big picture. When an employee has a job with a limited scope, he or she can feel like his or her efforts are not important. Through development, the employer can help the team members understand how they fit into the organization's goals, mission, and structure. This will lead to more highly motivated team members who understand how they contribute to the overall success of the organization.

4.4.1.5 Engaging the Team

Engaging the team in the improvement process capitalizes on "intellect," one of the eight "wastes" of Lean manufacturing. Some employees may know more about how to improve the process than others. Companies could hire outside consultants to point out opportunities, but none of these consultants have the insights of the persons doing the job. The goal is to develop your employees to see the opportunities and give them a process to bring these ideas to the proper people. Most of the time, all employees need are tools, education, or organization to reach their full potential. Enabling your teams to help get things right will improve output and quality. If people are happier in their work then the chances for success increase dramatically.

Training for the sake of training, merely to tick a block on a checklist, serves no real purpose. Evaluating each member of your team and their skills is necessary to build a development plan for the individual. People join companies not just for a job but for a career. To increase performance and retention, you must provide them with opportunities for advancement. These opportunities must be real. Theoretical prospects will lead to disenfranchisement. Helping the team realize their goals will motivate them to perform at a higher level. Education will open their eyes to the business and can result in leadership skills for the future.

It is important to send the right message to your team. Investments in the team let the team know they are valued. These investments tell them they are a long-term solution to the company's success and that the organization values continual progress. This investment creates loyalty and enthusiasm and strengthens retention. The reason most training fails to achieve the desired results is that it alone cannot achieve the results. Training without development is the reason development fails. Before sending your team off to training, you need a development plan designed for everyone and focused on the objectives.

4.4.2 Tools

4.4.2.1 Personnel Assessments

Annual employee performance reviews are the primary mechanism used to assess job performance. During this time, the technician and their immediate supervisor look back over the accomplishments and shortcomings of the previous year. Goals are reviewed and progress in attaining these goals are also taken into consideration. Merit raises are given as a reward for work well done. Training needs are identified at this time and also at other times during the year. Goals for the coming year are established or reiterated and both the employee and supervisor agree in writing.

4.4.2.2 Start with the End in Mind

To transfer the skills desired and addressed by the training sessions, several things are imperative before starting the development. Number one is to make sure the development is needed. A real skills assessment is required to determine the needs of each employee. Next provide context to the team members. Finally, focus the training and development on the relevant skills that you need the team to have.

4.4.2.3 Assessment

Ensure that the opportunity you seek or what you are trying to solve can be answered by development. If the employee is not performing to the expected level, identify if you have provided the necessary development to do their job. Does the employee have the aptitude for the position? Is the job is a good fit? If this answer is, no then developing them is not the answer. People are either willing but not able, not willing but able, or willing and able. Until you understand where the employee sits, sending them to development should wait.

4.4.2.4 Context

Make sure they know why they need a new skill, enhancement of their current skills, or other benefits that the development offers. The employee needs to see the connection between their job and the development. When they understand this connection, they will be motivated to find the relevant information in development.

4.4.2.5 Focus

A one-size-fits-all training program designed to provide generic information is not what skilled professionals need. Customized approaches designed to meet specific objectives with follow up development will offer the greatest return on investment. Design your approach so it is measurable and focused on specific outcomes. Tying the development objectives directly to the employee's job and skills objectives will drive the employee to attain the promised objectives. Keep the message clear and show the employee how the development will enrich his or her job.

4.4.3 Process

4.4.3.1 Expectations

Management should always communicate to trainees the following:

Development results are expected from the training.
Support for the implementation of the course will be provided.
There will be audits on the results.

The focus of a maintenance department's development usually concentrates on lowering maintenance costs and improving equipment reliability. A good example of this would be alignment development. Mechanics usually perform an alignment after installing a new motor, gearbox or pump, for example. The usual form of this training focuses on how to use the alignment tool. This approach achieves teaching the team how to use the tool, which is a necessary part of the tasks. A better approach should include a practical application of how to align these types of equipment. A comprehensive training plan has both a classroom and a practical aspect. A plant standard for alignment along with actual alignment specification for each piece of aligned equipment would ensure value in the training and enhancement to the plant's bottom-line.

4.4.3.2 Approach

Most training classes teach theory about what to do and sometimes include hands-on classroom application. Some organizations do a good job at training a few technicians in a classroom followed by practical application in the plant. However, most train several people, only to never reinforce the training with practical application in the facility. The best approach is to include implementation of the theory taught in the class. The practical application should include safety, getting the right tools, scheduling the time on the equipment with operations, and what to do if the alignment standard cannot be achieved.

4.4.3.3 Resources

Maintenance consultant companies have structured training classes based on the above principles. Training courses in the essential care of equipment customarily lasted for two or three days. In the new training approach, the courses lasted for three weeks. But despite taking much longer, results showed that there are major benefits to practicing the standards that have just been taught. Including a practical aspect to training helps the team members understand the need for the standards and training and helps them remember what was taught. Also, the participants get more motivated and participate in the training, because they can see how it applies directly to their daily work.

A lot of planning is required to make this approach work. Scheduling the equipment, personnel and other resources in a good plan will enhance the results of the training. Maintenance leaders must put together a plan that includes the following:

Working hours
Development time
Development of condition-based routes
Time from supervisors and planners
Personnel for entering data into the computerized maintenance system, etc.

A base line is established during the preparation period. Usually, it is easiest to take a few pictures in the plant. Issues such as lubrication, alignment, corrosion, balancing, and filtration can then be brought up during the course and visual examples displayed.

Spending money on developing your maintenance team's skills will not only increase plant output but also improve employee morale. When you have a properly developed staff with the necessary skills to perform their job, you will see a step change in your plant's reliability.

4.5 Lead and Manage People

This includes developing leadership skills, assessing performance, promoting a cooperative work environment, facilitating communication, etc.

4.5.1 Concepts

One of a manager's most important and most difficult responsibilities is to lead and manage people. As leaders we have to motivate, inspire, and encourage our team while as managers we have to hire, fire, discipline, evaluate and develop our staff. Employees are the face to the customer and the heart of an organization. Without a capable and committed workforce, neither the organization nor the manager will be successful. Managers must treat employees with dignity and respect and help them understand the importance of a reliability-focused maintenance program. Managers must ensure that their workforce is working under safe conditions and feels empowered to speak up when a job is unsafe or not being done correctly. Managers need certain skills and know how to successfully lead a proactive reliability-focused, asset-management program.

4.5.1.1 Leadership Responsibilities

A reliability leader sets the vision and strategy for the organization and makes sure the workforce understands its role in its execution. Leaders must communicate the strategy and vision often through multiple methods as discussed in 4.5.2.3. Most workforces are diverse. Some employees may not read their emails often; others may embrace social media. Showing up for toolbox talks, placing important messages on bulletin boards or using Twitter can be effective methods of communication. The message must be consistent.

A reliability leader cannot manage from behind a desk. Time must be set aside to periodically visit employees in the field. Strong management engagement ensures employees are well informed, responsible, effective, safe and productive. Leaders have to be flexible and adaptable. In today's environment, budgets are constantly being adjusted and employees are more transient.

Leaders have to constantly evaluate the vision and strategy to ensure it aligns with the overall needs of the organization and its customers and explain any changes to the workforce in a timely manner.

Effective leaders set the example for both moral and performance standards for their staff and the organization to emulate. Effective leaders have the responsibility of creating a positive and effective work culture. Working together the team produces more value than the sum of the individual efforts. A leader can be defined as someone who consistently inspires ordinary people to perform at extraordinary levels. This along with genuine "do-the-right-thing" behavior are the impetus for inspiration.

Leaders empower employees at the lowest level possible. Employees who feel empowered to make decisions based on fundamentals, training and experience will take ownership for results. Such empowerment reduces the number of decisions that a reliability leader has to make and frees him or her to focus on high-level objectives of the organization.

4.5.1.2 Maintenance and Reliability Leaders

Maintenance and reliability leaders are ultimately responsible for knowing and applying reliability best practices to ensure assets are available to support the mission when required.

Leaders educate and reinforce the M&R best practices horizontally and vertically throughout the organizational team. They ensure the workforce has the proper training and tools to perform their job safely and effectively. They leverage the following tools in their organizations.

- Conduct root cause failure analysis (RCFA)
- Plan and schedule work
- Develop KPIs and metrics
- Encourage employees to become certified (CMRP or CMRT)
- Focus on quality of proactive work
- Review CMMS data for accuracy and clarity
- Encourages employees to achieve higher levels of education
- Utilizes predictive maintenance (PdM) methods as much as possible

4.5.2 Tools

4.5.2.1 Precursor Tools

Leaders orchestrate with and within various resources and frameworks to achieve the desired results. These resources and frameworks can be established by successful completion of the following.

Identifying the organization's goals (4.1).
Analyzing needs and gaps (4.2).
Training and hiring for needed expertise (4.4).

Asset-management assessments are valuable to identify gaps in maintenance organizations. Whether performed internally or by a third party, they should focus on the five pillars. Once the gaps are identified a plan is developed to close each gap. Managers should be careful about attempting to close every gap in the first year if there are significant areas for improvement. Just like maintenance work orders, each task should be prioritized and scheduled to ensure efficiency and effectiveness.

Good job descriptions ensure employees are hired and trained properly. Job descriptions should identify specific tasks that the technician, maintenance and reliability engineer or supervisor will be performing, along with the appropriate physical requirements and knowledge parameters. Nothing hurts an organization more than hiring the wrong people. Job descriptions should be evaluated periodically to ensure they are up to date. For example, many modern machines require the use of computers or human-machine interfaces to troubleshoot and maintain them. Job descriptions should require technicians to be able to use a personal computer for troubleshooting.

4.5.2.2 Operational Framework Tools

The above section 4.3 above on the developed organization structure provides the rules and framework by which information, decisions, and workflow are acted upon according to the below section 4.5.3 on processes.

Effective management systems identify the processes and procedures needed execute the work in an efficient manner. They should be detailed enough for employees to complete their task yet vague enough to permit employees to think and apply logic to complete the task without stopping work for an interpretation. They aren't tangible like wrenches, vehicles and computers but without these processes and procedures the organization cannot be as efficient as it needs to be.

ISO 55000 establishes the basic policies, processes and procedures to ensure an effective asset management program.

One of the most important tools available to a maintenance manager and the workforce is a computerized maintenance management system (CMMS). CMMS should be fully understood, used and applied. Many organizations typically use only the bare minimal capabilities of the CMMS; for example, they may use CMMS only to process and track work orders. Organizations should evaluate every capability of these systems and consider how each affects others. Perform return on investment (ROI) calculations to determine whether or not additional modules or capabilities should be implemented. The data in the CMMS ideally must be used by leaders to make informed decisions about PM optimization, bad actors and how to invest in future capital improvement projects.

Other tools available to managers include the industrial internet of things (IIoT), on-line condition-based monitoring and data analytics. As more and more sensors are deployed during the fourth industrial revolution, these sensors can be used to assess the condition of equipment. Data analytics software allows for the evaluation of data not only from sensors but also from the CMMS. It can eliminate non-value added maintenance processes as well as indicate where maintenance crews should be focusing their time. Organizations who fail to recognize that this is where the world is going will be phased out.

4.5.2.3 Communication, Responsibility, and Accountability

Communication is the lifeblood of any organization. Most failures can be traced back to poor communication practices. Many communication tools are used throughout industry with one of the more common ones being the RASCI model, a formalized way to record who is Responsible, Accountable, Supportive, Consulted, and Informed during a process or project. The RASCI tool and many like it are used to identify the various parties with whom to communicated, to clarify their roles and resolve any overlaps and gaps in the communication plan.

In addition to the aforementioned, formal, communication methods, informal communication is equally powerful. Routine sharing of information is a pathway for learning as well as teaching within an organization. Frequent informal meetings to share or seek information is a great way to ensure communication is occurring.

Whether using formal or informal communication methods, clarity in the message is key. Clarity is achieved by understanding of the intent of the communication. Whether information is being shared or sought, clarity is an output of planning the communication.

4.5.3 Processes

4.5.3.1 Set, Communicate, and Maintain the Course

Effective leaders evaluate and develop ideas and methods from all stakeholders to accomplish the goals. In the end, the leader approves and then communicates the plan.

Leaders must do the following:

Share broad swatches and details of the plan,
Address any questions and reservations early on,
Delegate earned responsibility,
Develop reporting feedback channels,
Enforce accountability, and
Endure understanding of the "why."

The "why" is the reason for the idea and defines how each team member contributes. Team members who understand why their contributions matter will be more likely to buy in to the process. In most organizations the "why" is never discussed. Without a well-defined and simple "why," team members are unable to figure out the "what" and the "best how" to achieve the most efficient solution.

Leaders establish formal, time-based, open channels, which are for reporting and sharing information and results from each functional departmental section. Effective, open, and structured meetings can be used to share updates, celebrate victories, and solicit ideas from peers for improvement.

Leaders create the mechanism for how and when course modifications are developed, evaluated, justified, approved and communicated. Leaders create the environment where crucial information is transparently shared within the maintenance and reliability department as well as throughout other departments of the organization, wherever it can benefit or be followed up on for the betterment of the organization.

Individual development is enhanced by establishing formal, timely, regularly scheduled, individual *one-on-one* meetings with direct reports. These meetings can be used to openly discuss, set, and steer individual performance, training (see Section 4.4.3 above) and careers.

The organization's most valuable resource is its organized, productive, motivated and team-oriented employees. Encourage honest, performance-improvement discussions with opening questions such as "What is the most important thing we should talk about today?" Encourage responsibility in individual associates with self-reporting of their goals and accomplishments. Provide encouragement and resources for continual learning and self-improvement, which could be mandated if necessary. Effective leaders mentor and motivate any staff members with direct reports, encouraging one-on-one meetings and striving for the same continual self-improvement.

4.5.3.2 Develop Workflow Procedures

Leaders develop procedures and processes that strive for safe, repeatable results given similar inputs, regardless of the associates within the work process. In other words, results should be meet the objectives of the requestor, regardless of the individual, shift, or time interval, which may have changed since this type of work was last accomplished. Leaders use, enhance and reinforce the assigned duties, roles, and responsibilities that are delineated in Section 4.3 on organizational structure. In this manner, all members knows their roles and the roles of their teammates.

Leaders develop and publish methodologies for how work is reported and categorized by priority. They develop the process for how requested work is evaluated, how costs and benefits are determined and approved, and what levels of approval are required for work types and cost/benefit values of requests. This process is designed to obtain a "decision consistency" that is based on organizational value, regardless of requestor or their "passion" for the request.

For consistency of output, leaders encourage staff to follow the existing processes used for work/task planning, scheduling, and execution. Leaders develop and encourage open communication to solicit ideas for improvement of existing processes.

4.5.3.3 Develop Information Storage Procedures

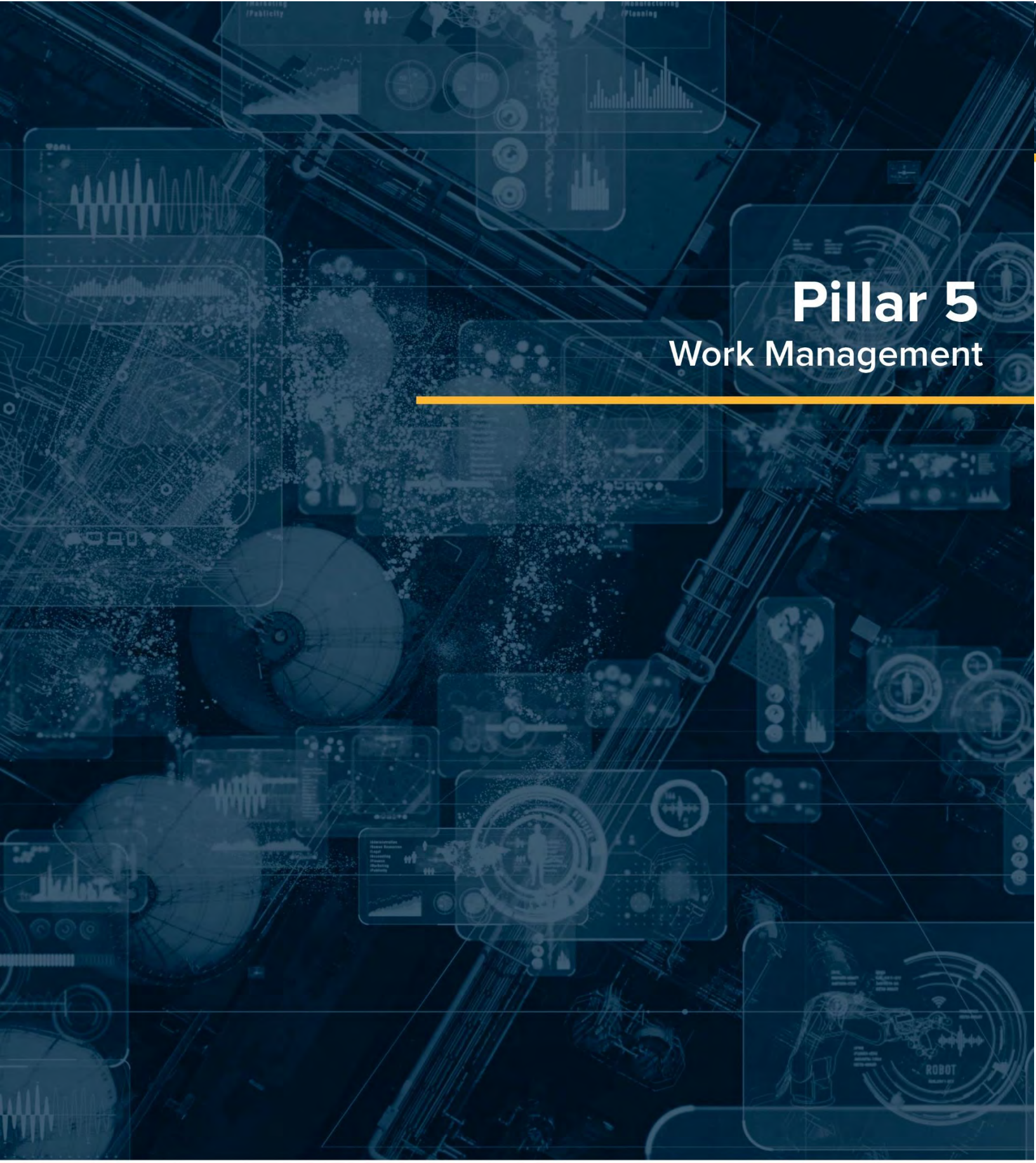
Leaders develop procedures to strive for repeatability of the descriptions and recordings of problems, including how problems are categorized and the resolution of the problem. This process allows problems to be analyzed over time for trends, root causes and solutions. It also allows for long-term, consistent storage of thinking processes, potential repairs, and astute resolutions. Leaders develop processes for what and how to record asset information and for who executes the recordings of work.

Leaders will capture and document the changes in process and will determine and publicize the one "evolved" process that works the best and will stick with it. The process which works the best is the one that yields the best results in attainment of stated goals.

Pillar 4 Metrics Appendix

To access and download the SMRP Best Practices 6th Edition, please go to www.smrp.org.

Metric 4.1 Rework
Metric 4.2.1 Maintenance Training Cost
Metric 4.2.2 Maintenance Training Hours
Metric 4.2.3 Maintenance Training Return on Investment (ROI)



Pillar 5
Work Management

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Certified Maintenance & Reliability Professional

5.0 Work Management

5.1 Identify, Validate and Approve Work Intake

Establish work identification processes, select and approve viable work, etc.

The persons who identify maintenance requirements need to know types of actions that can be taken and when they should be taken from a technical standpoint. Capabilities to assess the business justification for the maintenance plan and develop data support systems are also important. The ability to manage the work, maintain the appropriate backlog, and minimize overdue work are also necessary. The maintenance professional needs to understand the inputs to the work identification phase of a planned work process. Planning, scheduling, reliability, and supply chain management all depend upon the early identification of work to be successful.

5.1.1 Concepts

5.1.1.1 Work Identification

Work Identification should follow a systematic process that allows anyone to identify work, typically of a materiel deficiency, corrective nature.

5.1.1.2 Work Request Prioritization

Work Request Prioritization will be assigned to the Work Order after the weekly planning and scheduling meeting. The prioritization is either Urgent or Routine. All Emergency work will be updated after the emergency work is complete.

5.1.1.3 Work Request Submission Process

Work Request Submission Process will be simple and will not require craft-workers to log into CMMS.

5.1.1.4 Work Request Approval

Work Request Approval will be reflected in the Work Order status. If work request is not approved, the originator of request will be informed as to why.

5.1.1.5 Work Request Categorization

Work Request Categorization will be described as either corrective or preventive; or else as an upgrade or modification

5.1.2 Tools

5.1.2.1 EAMS and CMMS

Work identification tools include an Enterprise Asset Management System (EAMS) or a Computerized Maintenance Management System (CMMS). The system contains past, present, and future data on assets, labor, planned spare parts used, and in which capacity where the parts used as well as any special tooling or required craft-worker qualifications.

5.1.2.2 Work Request

This document is used for consistent data collection for the work requested.

5.1.2.3 Work Order

One or more work requests combined in one approved document which specifies the activities, resources, deliverables, scope, proposed delivery date and cost budget required to complete the job.

5.1.3 Processes

An effective procedure ensures that maintenance resources are requested accurately and consistently with all necessary elements provided to the maintenance groups. Each organization must define their individual work identification process. All incoming work requests are submitted in the same manner within an organization no matter what entity generates the work request. They are prioritized based on a defined set of requirements. Requests need to include basic data points that allow next level reviews. The organization needs to determine data points (e.g., asset impacted, reason for work, submitter, cost estimate, schedule requirements).

For Corrective & Reactive Maintenance, a scoping document can capture information, such as any parts needed and in what quantity, tools, location, SWP/LOTO requirements, hot work, Confined Space; and answer if the needed work requires lifting, transporting a heavy load, fall protection, other PPE, or interaction with another work group.

5.1.3.1 Work Request Standardization

Establish a standard document for all incoming work requests. Set minimum data points to be included thereby enforcing business rules. Train end-users that required fields need to be populated before saving the document.

5.1.3.2 Personnel Assignment

Assign personnel to review submitted work request to ensure information is accurate and complete.

5.1.3.3 Authorized Personnel

Designate/identify personnel authorized to approve work request. The approval process determines what work will be completed and removes duplicate requests. Develop a system that prevents duplicate work requests from being entered into the CMMS by different originators. Establish follow-up steps to be taken for all submitted, approved or denied requests.

5.1.3.4 Work Categorization

Develop and apply a process that categorizes planned and unplanned work:

Proactive Work (such as root cause failure analysis)
Preventive Maintenance
Corrective Work (identified by anyone)
Reactive Work (anything breaking into a schedule, regardless of the reason, including breakdowns and unplanned maintenance.
Fast track any safety- or compliance-related tasks
Plant or equipment upgrades

5.1.3.5 Work Request Validation Criteria

Establish criteria that constitute validation of work requests.

5.1.3.6 Work Request Escalation

Develop procedure to determine if the work request will be formally turned into a work order for further scoping/planning/scheduling/execution.

5.1.3.7 Work Group Communications

Develop communication process to update the requesting business unit of on the status of the Work order. Approved or rejected work will be driven by Work Order status.

5.2 Prioritize Work

5.2.1 Concepts

5.2.1.1 Prioritization Process

Prioritization process is employed for new and backlog work. If the CMMS has this functionality, consider assigning a work priority ranking such as emergency (1), urgent (2) or routine (3). Consider whether or not the asset is critical, or whether or not the system where asset lives is critical.

5.2.1.2 Asset Criticality

Criticality assessment of the assets and the work required will assist in ranking scheduled work in order of importance.

5.2.1.3 RIME

Ranking index for maintenance expenditures (RIME)

5.2.2 Tools

5.2.2.1 Asset Criticality Evaluation Process

Equipment/system criticality determines the relative criticality based on organizationally accepted criticality criteria. A numerical score will be assigned to each equipment record.

5.2.2.2 Production

Production needs will it meet expected quota.

5.2.2.3 Compliance

Safety and regulatory compliance as well as environmental work will have higher priority than routine corrective maintenance work.

5.2.2.4 RIME

Ranking Index Maintenance Expenditures (RIME)

5.2.2.5 Prioritization Model

The Intercept Ranking Asset prioritization worksheet is used to evaluate assets on operational, safety, environmental, single-point failure, maintainability, reliability, spares lead time, regulatory severities. An FMEA analysis of the most critical equipment is carried out per results of prioritization worksheet. ISO 14224-2006 and other similar standards can be used.

5.2.3 Processes

5.2.3.1 Perform Criticality Assessment

Develop and perform a criticality assessment for key systems or equipment and establish a system to communicate results to be used in the planning and scheduling process.

5.2.3.2 Identified-Work Prioritization Process

Develop and implement a formal prioritization process for identified work using system and/or equipment criticality and/or other inputs such as environmental health and safety (EHS) impact and quality.

5.2.3.3 RIME Work Ranking

Ranking Index for Maintenance Expenditures (RIME) is a method of ranking based on work classification, asset criticality, and creation date of work-order.

5.2.3.4 Identify Prioritization System

Identify the priority system that meets the plant-specific requirements and establishes asset criticality relative to operations.

5.2.3.5 Document Prioritization System

Thoroughly document the prioritization system, communicate its intended use to the appropriate personnel and implement the system.

5.2.3.6 Personnel Training

Train all applicable personnel and expect use of prioritization of work in all conditions.

5.2.3.7 Prioritization System Audit

Audit the prioritization process to ensure compliance to the established system.

5.2.3.8 Outliers

Determine process to review outliers that don't fit in scope of reviews.

5.3 Plan Work

Develop job package including scope, procedures, references, materials, tools, testing, *etc*.

The work planning function uses knowledge and information about equipment, job tasks, tools and materials, craft-worker skills and credentials, and work environments to produce a worker information package (or a job plan). The package contains detailed information about work scope and procedures, specifications and regulations, and required tools and materials. It is produced and communicated prior to commencing work. The planning function also includes securing of permits and clearances, assuring availability of tools and materials, and estimating time and material costs. Work planning leads to increased efficiency and effectiveness of the maintenance workforce by increasing wrench time, thus producing business value by lowering costs. Note that not all work should be planned; planning must add value to be effective. An example of non-planning is the predetermined run-to-failure of the assets.

5.3.1 Concepts

5.3.1.1 Planner

Role of a planner determines what work will be planned and how it will get done.

5.3.1.2 Formal Work Planning Process

Work Planning Process reviews all orders not in the backlog. Work is tentatively planned in increasing detail as the date approaches as to when it will get done.

5.3.1.3 Work Type

Determine type of practice to apply: Planned, predictive, or run-to-failure practices.

5.3.1.4 Estimating

Job estimating includes but is not limited to the following:

SWP/LOTO/Hot Work/Confined Space
Spare parts kitting preparation
Wrench time
Clean up / return to service
Equipment operational check prior to return to service.

5.3.1.5 Material Requirement

Resource & Material requirements should be an output of scoping document.

5.3.1.6 Contractor Requirement

Contractor & Interface requirements should be aligned with Procurement Planning.

5.3.1.7 Work Content

Job package content will consist of reference to safety, tooling, plant conditions, any specialized labor qualifications needed to do the work, and required spare parts.

5.3.1.8 Work Sequencing

Work sequencing (routes) is determined proactively, mapping out the most efficient route to do the work.

5.3.1.9 Lead Times

Lead times assist in scheduling work with parts requirements whose current balance is insufficient to perform scheduled work. Work Order status will reflect this information.

5.3.1.10 Level Loading

Labor Loading or work center capacity needs to be tracked. A certain percentage of contingency must be managed to anticipate priority 1 or 2 corrective work, so there is less chance of becoming a schedule breaker when the plan is executed using available capacity.

5.3.1.11 Look-Ahead Scheduling versus Backlog

Ready backlog versus not-ready backlog will compare work orders falling within the scheduling horizon compared to those outside the scheduling horizon.

5.3.1.12 Compliance Permits

Environmental, Health and Safety Requirements (EHSR) (for example, permits) have a much more rigid scheduling approach since their execution is time sensitive.

5.3.2 Tools

5.3.2.1 CMMS

Computerized Maintenance Management System (CMMS) is the tool for Work Order management throughout its life cycle.

5.3.2.2 Estimating Guides

Industry Estimating guides for much larger and complex jobs help identify the critical path.

5.3.2.3 Safety

Permits (lock-out, tag-out, confined space entry, hot work) are essential in bolstering safety as well as compliance with and adherence to regulatory mandates.

5.3.2.4 Planning & Scheduling Software

Planning and scheduling software assists in the efficient execution of both planned and unplanned work.

5.3.2.5 Technical Documentation

Technical reference manuals (machinist handbook, ANSI/ISO/ASME, OEM/vendor specifications, industry standards etc.) can supplement known techniques and craft knowledge.

5.3.2.6 Job Plan Library

The job plan library is a generic collection of job plans for performing work in several disciplines. The generic plans can be copied and customized to fit the particular task at hand.

5.3.3 Processes

5.3.3.1 Work Identification

Create a process to identify what work requires planning on a daily basis using the work prioritization process (See Section 5.2 above.)

5.3.3.2 Work Scoping Document

A procedure is used to assess job prior to execution and to fully Identify and document a job plan package containing all necessary requirements for the execution of the work order. Requirements would include such things as safety precautions, needed permits, job scope, required tools, drawings, reference information, parts, labor requirements, and detailed quantifiable work instructions to perform the task. Purposes of the job plan are to avoid delays, unique and common; directly improve wrench time by skilled technicians; and foster consistent standard work. A job plan package should be fully documented and published with all required parts assembled into "Kits" where possible; and staging parts day ahead of scheduled work before releasing the work order to the scheduling function.

5.3.3.3 Dynamic Job Plan Library

Create a common reoccurring job plan library to store all fully documented job plans for future use.

5.3.3.4 Planner's Role

Planner role is to improve work force productivity and work quality by planning and coordinating labor, parts, and equipment access.

5.3.3.5 Parts Usage

Develop and implement a process of retrieving (via store-room disbursement or order issuance and receipt) all necessary parts required per the job plan. All parts are then combined, kitted, and staged in a central location clearly identified with the work order number for easy retrieval.

5.3.3.6 Planning & Scheduling

A process is established whereby job plans are reviewed for completeness and all parts have been verified to be on hand prior to releasing a work order from planning to the scheduling function. Planner accuracy is a concern here. Did the planner over- or under-estimate the job plan? Was the estimate within plus or minus 15 percent of the for the planned estimate versus actual cost (including parts and labor). If not then the planner should update the job plan before adding it to the job plan reference library for later use.

5.4 Schedule Work

Develop scheduling process, produce work schedules, balance resources, monitor backlog, manage break-in work, coordinate equipment access, etc.

Implementing a scheduling process that incorporates the planning process will enable effective execution of work. Consider the needs of plant groups as well as the needs of the business in the scheduling process. Understand how to balance all factors and create a logical and achievable schedule. Systems connected to and supporting the scheduling process need to be well understood. The scheduling function starts after planning of work is completed. The purpose of scheduling is to ensure that resources are available at the specified time. All activities need to be scheduled in order to optimize the resources including labor and material. Work is scheduled after confirmation that all prerequisite work has been completed. Coordination and communication requires periodic meetings to review planned work, production requirements, material availability and backlog activities. The maintenance professional needs to understand the critical success factors for proper work scheduling. Effective implementation and execution of scheduling requires that the process meets expectations according to pre-determined key performance indicators and that the work meets or exceeds performance thresholds.

5.4.1 Concepts

5.4.1.1 Work Scheduling

Work scheduling relates to who will do the work and when the planned activities are to be carried out, depending on commitments of relevant disciplines

5.4.1.2 Backlog Management

Backlog management maintains the backlog which is the repository of all known work and should constitute the list of identified requirements for use of maintenance resources.

5.4.1.3 Materials Management

Materials management supports the Work Management Process with needed spare parts in the right quantity as needed to perform work per the schedule.

5.4.1.4 Preventive Maintenance

Use pre-determined maintenance practices: planned, predictive, and run-to-failure.

5.4.1.5 Shutdown, turnaround and outage (STO) plan

Shutdown/turnaround/outage plan for equipment will be denoted on the Work Order

5.4.1.6 Work Center Skillset

Mechanic skillsets/training completed to perform work and training record updated.

5.4.2 Tools

5.4.2.1 Schedules

Daily, weekly, monthly schedules
Daily morning meetings: Plan, Do and Review
Weekly planning and scheduling meetings
Roles & Responsibilities Matrix (RACI Method)

5.4.2.2 Leveling Workload

Workload balancing and level-loading hours for each work center are developed for 30-day periods, scheduling critical equipment and routine PM first, followed by routine CM work.

5.4.2.3 Metrics

Performance metrics from the previous week are reviewed during the current planning and scheduling meeting.

5.4.2.4 Planning & Scheduling Software

Planning Software (for example, CMMS software and Planning & Scheduling Software) assists in the efficient execution of both planned and unplanned work.

5.4.2.5 Industry Estimating

Industry estimating guides for much larger and complex jobs helps identify the critical path.

5.4.2.6 Safety Work Permits

Applicable permits (such as lock-out, tag-out, confined space entry, hot work) are essential for the successful execution of work.

5.4.2.7 Technical References

Technical reference manuals (machinist handbook, ANSI/ISO/ASME, OEM/vendor specifications, Industry standards etc.) can supplement known techniques and craft knowledge

5.4.2.8 Job Plan Library

Job plan library is a generic collection of job plans for performing work in several disciplines These plans can be copied and customized to fit the particular task at hand.

5.4.2.9 Equipment Availability

Equipment availability is based on plant operational schedules for major equipment and should be known years in advance.

5.4.3 Processes

5.4.3.1 Job Assessment

Assess job prior to execution to fully identify and document a job plan package, with all necessary requirements for the execution of the work order.

5.4.3.2 Planning Requirements Review

Review planning requirements to verify that the job includes safety precautions, permitting, job scope, required tools, drawings, reference information, parts, labor requirements, and technician skillsets required as well as detailed quantifiable work instructions to perform the task.

5.4.3.3 Work load & Work center matching

Balance equipment availability with resources required to accomplish the work.

5.4.3.4 Equipment Operating Profile

Knowledge of equipment shutdown requirements and start-up times to be incorporated in the schedule.

5.4.3.5 Parts availability

Ensure that the Bill of Material is available for parts and consumable materials

5.4.3.6 Operations work schedule versus outage window

Operations work schedule: Operations should be present and see the work and approve it during the weekly scheduling meeting.
Maintenance Work Schedule: There should be a scheduling horizon of up to seven weeks ahead. This schedule should be reviewed during weekly P&S meeting. Work order statuses should be updated I accordance with the outcome of the meeting.

5.4.3.7 Backlog Management Report

Backlog management report

5.5 Execute Work

Manage labor, material, and services; control productivity; and ensure EHS compliance

The methods and best practices for effective use of maintenance resources need to be clearly understood. The skills of the maintenance workforce must be evergreen so they can satisfy the collective needs of the maintenance plan. The systems needed to properly support the management of critical resources; they should readily available and well understood. The criteria for the appropriate use of the various methods of making spare parts available to the maintenance function, along with the benefits and the risks associated with each, need to be known. Methods for sound cost management of the maintenance function and how the value of the work performed impacts the business financial metrics needs to be thoroughly understood. Health, Safety and Environmental guidelines are used to develop and implement efficient, comprehensive and proactive programs to ensure a safe and environmentally compliant work environment.

5.5.1 Concepts

5.5.1.1 Process for Managing Resources

Develop processes for managing labor, materials, and services. This will be accomplished through a formalized Work Management Process

5.5.1.2 Process for Controlling Productivity

Develop processes for controlling productivity. This will be accomplished through a formalized Work Management Process.

5.5.1.3 Process for ensuring EHS Compliance

Develop processes to ensure EHS compliance by using business-level management of governance, risk management, and compliance software to report across the enterprise.

5.5.1.4 Skillset Tracking

Develop skillset tracking in relation to craft's proficiency level.

5.5.2 Tools

5.5.2.1 Work Order Templates

Work Order template is resident within the CMMS

5.5.2.2 Work Package

Work Package

5.5.2.3 Quality Management

QA/QC plans for testing

5.5.2.4 Safety Work Permit & Lockout/Tag out

A Lock out/Tag out Program is essential for the successful execution of work, if applicable.

5.5.2.5 Bill of Material

Bill of Materials (BOM) provides line of sight to coded spare parts usage in either a preventive or corrective capacity on equipment (assets) listed in the CMMS asset registry.

5.5.2.6 Equipment Pictures

Pictures of equipment in digital format are used with Work Orders to diagnose problems and supplement Work Order narratives.

5.5.2.7 Skills Assessment & Training

Skills assessment & training

5.5.2.8 EHS Considerations
EHS procedures, including Process Hazards Analysis

5.5.2.9 EAMS/CMMS
EAMS/CMMS are system-wide software tools supporting all aspects of asset management.

5.6 Document Work
Create post-work documentation, record failures, events, etc.

Maintenance professionals must demonstrate their ability to create, update and manage tasks that need to be done, including safety precautions as well as estimates of the time, tools and materials. Instructions should be provided on how to capture the as-found condition of the equipment, which components failed, and steps taken to return the equipment service. Accurate, detailed documentation will provide information on resource utilization (*e.g.,* skillsets, tools, special equipment, delays, *etc.*) as well as actual cost of maintenance. This documentation will support budget and planning efforts and enhance the ability to document and categorize trends.

Effective, accurate documentation can be a tool for analyzing and comparing maintenance activities (including failure history, repair cost, and production downtime) so maintenance can be improved. A maintenance professional should use a Computerized Maintenance Management System (CMMS) as the management tool to capture information, using failure codes after the maintenance tasks are completed. Proper recording of information after the completion of work is essential for measuring and communicating maintenance performance, and to suppose analysis of equipment failure.

5.6.1 Concepts

5.6.1.1 Work Order Systems
The work order system is the main output of a CMMS and the main input for the work management system.

5.6.1.2 Failure Reporting
Failure reporting is essential for proper failure modes & effects analysis.

5.6.1.3 Cost Planning
Planned versus actual cost, materials, labor, services help improve the estimating process with feedback from actuals.

5.6.1.4 Equipment Condition Status
As-found and as-left conditions are used to document condition and later for troubleshooting recurring instrumentation problems.

5.6.1.5 Measuring Points
Measuring points have a wide application within the CMMS. Notably they are used to trigger meter-based preventive maintenance.

5.6.2 Tools

5.6.2.1 CMMS/EAMS
CMMS and enterprise asset management (EAM) software assist in all aspects of asset management.

5.6.2.2 Work Orders
Work orders are the primary means to document all stages of work management.

5.6.2.3 Inventory/Stores
Inventory contains coded and non-coded material used in support of maintenance

5.6.2.4 Bill of Material
Bill of material (BOM) provides line-of-sight to coded spare parts usage in either a preventive or corrective capacity on equipment (assets) listed in the asset registry.

5.6.2.5 Equipment Spare Parts
Equipment Spare Parts are the coded spare parts aligned with preventive and corrective maintenance.

5.6.2.6 Failure Reporting
Failure reporting is essential for proper failure modes & effects analysis. Develop a set of damage, cause, and remedy codes for each equipment type.

5.6.2.7 Document Control

Document management provides a chronological series of changes that extends past one aspect of asset management and ensures tools such as job plans and task lists remain relevant when executed against equipment.

5.6.2.8 Configuration Management

Configuration management

5.6.3 Processes

5.6.3.1 Post Work Documentation

Post-work documentation includes reason for repair, the corrective actions taken, and failures noted in process or equipment. Detailed documentation by the mechanic is critical for warranty claims, training development, review of equipment performance (retrofit changes), replacement justification, documented repairs for OSHA, etc.

5.6.3.2 Work Management

Work management organizes work in an order according to due dates and priority.

5.6.3.3 Maintain History

The history is used for life-cycle-costing, return-on-investment calculations, pareto analysis, project management office (PMO) process, and also verifying the lock-out and tag-out (LOTO) process, noting any discrepancies. Replacement asset value (RAV) is used for repair or replace decision making. The percent RAV (%RAV) calculation use a value of about 20 percent as the threshold amount to replace.

5.7 Analyze Work and Follow-Up

Compare actual work with plan, identify variances, etc.

The maintenance professional should be able to analyze work, comparing the actual work with the plan set forth for the identified maintenance tasks. Documentation of work allows for adjustments to improve the accuracy of the job plan in such areas as the estimated job duration, materials and tools required, etc. After completion, the work order should be analyzed and compared with the equipment history and to benchmark data. Maintenance costs should be reviewed, and improvements made to the work process.

The results could be used as inputs to programs such as Failure Mode Effect Analysis (FMEA), Reliability Centered Maintenance (RCM), and Root Cause Failure Analysis (RCFA), which will assist in changing maintenance job plans and improving reliability.

5.7.1 Concepts

5.7.1.1 Work Analysis
Develop work analysis to categorize work orders by work type

5.7.1.2 Follow-Up Review
Develop work follow-up process to be reviewed by the facility work management team.

5.7.1.3 Analyze Performance
Analyze performance using agreed-upon key performance indicators measuring the effectiveness of the work management process.

5.7.1.4 Gap Analysis
Develop plan to close gaps which may require training for both the planner/scheduler and crafts performing the work.

5.7.2 Tools

5.7.2.1 Work Order
A work order is the primary means to document all stages of work management.

5.7.2.2 Equipment History
The equipment history is used to help determine dominant failure modes and equipment condition.

5.7.2.3 Benchmarked Data
Benchmarked data is used to identify gaps in the process.

5.7.2.4 Maintenance Cost Data
Maintenance cost data is used to determine %RAV, repair or replace decisions.

5.7.2.5 Failure Mode Effects Analysis (FMEA)
Failure modes effects analysis is a systematic means to address risk by prioritizing risks, addressing risks on critical equipment.

5.7.2.6 Reliability Centered Maintenance (RCM)
Reliability centered maintenance (RCM) is a tool to streamline maintenance.

5.7.2.7 Root Cause Failure Analysis (RCFA)
Root cause failure analysis (RCFA) is based on the theory of if you remove the cause of a certain failure, you eliminate that particular failure. RCFA should be performed after significant failure on critical equipment.

5.7.2.8 Mean Time to Repair (MTTR)
Mean time to repair (MTTR) can be considered a performance indicator highlighting repair efficiency. This technique can shed light on inefficient wrench time or incorrect spare parts procurement.

5.7.2.9 Mean Time Between Failure (MTBF)
Mean time between failure (MTBF) is a direct comparison to the failure rate. MTBF can also be considered a performance indicator suggesting a link between equipment achieving its inherent design reliability and the correct timing and type of preventive maintenance.

5.7.3 Processes

5.7.3.1 Comparison of Work Order and History
Compare work order and history.

5.7.3.2 Comparison of Benchmark and Cost Data to Work Order
Compare benchmark and cost data to work order.

5.7.3.3 Analyze Data to Identify Variances
Analyze data to identify variances.

5.7.3.4 Change Job Plans To Eliminate Variances
Change job plans to eliminate variances, including the Bill of Materials (BOM)

5.7.3.5 Preventive Maintenance Optimization
Preventive maintenance optimization.

5.7.3.6 Review History and Resource Requirements

Review history and resource requirements. Historical system review determines historical resource requirements (labor, materials, contractors, *etc*.) when a job plan doesn't exist for the task; or a review of the job plan can identify required resources.

5.7.3.7 Long-lead Maintenance Requirements

Identify long-lead maintenance requirements, such as parts, permits, contractors *etc*.

5.8 Measure Work Management Performance

Establish performance indicators, report schedule compliance and rework, *etc*.

An understanding of maintenance performance metrics and their application needs to be demonstrated. The ability to identify and use complementary metrics, to give a well-rounded assessment of performance and to support the needs of the business, should be evident. It is important to identify and measure performance to determine the current state of the maintenance function, to recognize the gaps against expectations or established benchmark information, and to develop a process affecting the necessary changes.

The key principle of performance management is to ensure measurements are made of things that should be managed. Appropriate and achievable metrics should be selected across all work management functions to support the needs of the business and lead the workforce to higher levels of performance. Performance measures may include metrics for measuring the effectiveness of planning, scheduling and execution along with reliability and production measures. Some of the metrics that can be used are percentage of planned work, schedule compliance, percentage of rework, etc.

5.8.1 Concept

5.8.1.1 Performance Measurement and Management

5.8.1.2 Quality Management

5.8.1.3 Leading vs. Lagging metrics or indicators

5.8.1.4 Work Management Process Effectiveness

5.8.2 Tools

5.8.2.1 Work Management Metrics

5.8.2.2 CMMS

5.8.2.3 Dashboards

5.8.2.4 Reports

KPI Scorecard

5.8.2.5 Status Review Meetings

5.8.2.6 Work Management Process (WMP) Gap Analysis

Work management process gap analysis (WMP GA) is a perpetuity tool to determine how well the operations and maintenance (O&M) staff is adhering to the work management process.

5.8.3 Processes

5.8.3.1 Performance Measurement and Management

5.8.3.2 Established Biannual/Annual Work Management Process Assessment

5.8.3.3 Communications with Leadership on Revised Priorities

5.8.3.4 Continuous Improvement

An ongoing evaluation program that includes constantly looking for the "little things" that can make a company more competitive. It's a measure of all work that increases or improves the current operating perimeters. (Metrics)

5.9 Plan and Execute Projects

Define scope, estimate project and life cycle cost, apply critical path methods, track progress, coordinate staffing, *etc*.

The maintenance professional understands all of the steps required to plan and implement a capital project. Project management is defined in the PM BOK 6th Edition as the discipline of initiating, planning, executing, monitoring and controlling, and closing the work of a team to achieve specific goals and meet specific success criteria.

Each step needs to be known and understood. The ability to use inputs, tools and techniques, and outputs critical to the success of the project-planning process needs to be evident. The project scope, time-to-execute and cost should be defined, considering the materials, plant configuration, spare parts (new and obsolete), manpower and financial requirements. An analysis of the various activities required for project execution must be made to identify a proper project team and define the responsibilities for each individual team member. The execution of the project should enable completion of the project on time and without rework or faults. Project execution should be continuously monitored and reported. Any deviations to the plan must be communicated to make adjustments to the project design, scope and resources. A maintenance professional should be able to use life-cycle cost analysis (total cost for design, procurement, delivery, warehousing, installation, start-up, commissioning, operation, maintenance and decommissioning) for capital projects to achieve the most effective approach for least cost of ownership of an asset.

5.9.1 Concepts

5.9.1.1 Project Phases and Life Cycles

5.9.1.2 Project Team

5.9.1.3 Life-cycle Costs

Total cost for design, procurement, delivery, warehousing, installation, start-up, commissioning, operation, maintenance and decommissioning

5.9.1.4 Contract Management

5.9.2 Tools

5.9.2.1 Estimating Job Packaged and Costs

5.9.2.2 PERT Diagrams and Critical Path Methodology, CPM

5.9.2.3 Risk Analysis

5.9.2.4 Metrics for Project Management

5.9.2.5 Project Management Tools (*e.g.* Primavera or MS project)

5.9.3 Processes

5.9.3.1 Project Justification from Business Unit Requesting Project
Project justification from business unit requesting project.

5.9.3.2 Determine Requirements: Scope, Stakeholders, Communication Plan, Testing
Determine requirements: Scope, stakeholders, communication plan, testing.

5.9.3.3 Project Scheduling And Estimation Of Labor And Material
Project scheduling and estimation of labor and material.

5.9.3.4 Develop Operational and Control Procedures
Develop operational and control procedures.

5.9.3.5 Work Supervision

5.9.3.6 Contractor Selection and Management
Contractor selection and management, and project procurement management takes into account contractor selection, bid process, *etc*.

5.9.3.7 Manage System Information and Documentation

5.9.3.8 Manage Reports and Metrics

5.9.3.9 Risk Management

5.9.3.10 Commissioning

5.9.3.11 Project Closeout Process

5.10 Use Information Technologies effectively

Leverage capabilities of data historian, process control systems, condition monitoring software, EAM/CMMS, *etc*.

5.10.1 Concept

5.10.1.1 Develop an Information Management Process

Develop an information management process.

5.10.1.2 Apply Technology for Documentation Transfer and Record Keeping

Apply technology for document transfer and record keeping of critical process and operational variables.

5.10.1.3 Apply Basic Functions of a CMMS or EAM

Apply basic functions of a CMMS or EAM.

5.10.1.4 Apply Preventive and Predictive Maintenance Information Technology Tools

Apply preventive and predictive maintenance information technology tools.

5.10.1.5 Integrate Process/Equipment Monitoring Capabilities

Integrate process or equipment monitoring capabilities, using SCADA System and CMMS or EAM.

5.10.2 Tools

5.10.2.1 CMMS/EAM

5.10.2.2 Document Control Software/Document Management Software

5.10.2.3 CAD Software

5.10.2.4 Project Management Software

5.10.2.5 HMI Software

5.10.2.6 Document Management Software

5.10.2.7 SCADA
Supervisory Control and Data Acquisition (SCADA)

5.10.3 Processes

5.10.3.1 Select Appropriate Level of Data

5.10.3.2 Equipment History/Bill of Material (BOM)
Equipment History is used to help determine dominant failure modes and equipment condition.

Bill of Materials (BOM) provides line of sight to coded spare parts usage in either a preventive or corrective capacity on equipment (assets) listed in the CMMS asset registry.

5.10.3.3 Work Order Control System

5.10.3.4 Planning & Scheduling Work

5.10.3.5 Equipment History Records

5.10.3.6 Process Safety Management Records

5.10.3.7 Interface to Other Systems
Interface to other systems like accounting, personnel, sourcing

5.10.3.8 Reporting Capabilities
Converting data to information

5.10.3.9 Calibration Records

5.10.3.10 Process and Operational Variable Records and Historian

5.10.3.11 Detective Maintenance for Instrumentation, PLC and SCADA Systems

5.10.3.12 Work Management Metric

5.11 Manage resources and materials

Control materials inventory, manage spares and equipment, establish MRO procurement process, manage contractors, etc.

The effective management of inventory (spare parts, tools, etc.) for maintenance activities is critical to the work management process. When the procurement process is performed by another organization, the maintenance professional needs to support that process, ensuring that what is purchased meets the overall business needs of the organization (i.e. cost versus reliability). When the inventory management system that is used to manage spare parts and materials is not a function of the CMMS, the maintenance professional should ensure that the methods and software fully support the goals of the maintenance function. The process should provide a framework of what to buy, when to buy, who to buy from, what to keep in stock and what inventory should be eliminated. This framework will provide effective control of storerooms and inventory related costs while maintaining an expected level of service. The process depends on accurate documentation of equipment components and parts in the CMMS along with recording information after completion of maintenance activities. This documentation will enable setting up stocking parameters and prioritizing inventory to support work planning and scheduling processes. Also, in addition to materials and spares, contract resources should be documented so they can be requested, planned and scheduled for work.

A maintenance professional should develop measurements to gauge performance (e.g. stock outs, excess inventory, obsolete inventory, etc.) for inventory and resources. Proper management of spares, tools and resources will facilitate continuous improvement of cost, workforce productivity and process availability.

5.11.1 Concepts

5.11.1.1 Materials/Resource Demand Forecasting

5.11.1.2 Bills of Materials

5.11.1.3 Equipment Spare Parts/Where Used/Quantities

5.11.1.4 Critical Equipment

Equipment that has been evaluated and classified as critical due to its potential impact on safety, environment, quality, production and cost. (Metric)

5.11.1.5 Critical Spare Parts

5.11.1.6 Inventory management

5.11.1.7 Life Cycle Assessment
Life-cycle costing, materials and resource management strategies, and mean time to repair.

5.11.1.8 Storeroom / Inventory Management

5.11.1.9 Spare Parts Management Models

5.11.1.10 Perishables or Shelf Life (Cure Dates)

5.11.1.11 Procurement Process

5.11.1.12 Inventory Process

5.11.2 Tools

5.11.2.1 CMMS
A Computerized Maintenance Management System (CMMS) is computer software designed to simplify maintenance management.

5.11.2.2 Inventory turns

5.11.2.3 Automatic Replenishment

5.11.2.4 ABC Analysis

5.11.2.5 Spare Parts Criticality Analysis

5.11.2.6 Demand Forecast Analysis

5.11.2.7 Material Requirements Planning

5.11.2.8 Lead time

5.11.2.9 Cycle Count

5.11.2.10 Economic Order Quantity

5.11.2.11 Standardization

5.11.2.12 Parts Kitting

5.11.2.13 Storeroom Key Performance Indicators

5.11.2.14 Supplier Selection Criteria

5.11.2.15 Manufacturing Resource Planning (MRP)

5.11.3 Processes

5.11.3.1 Inventory Control
Inventory Control is management of spare parts, tools, and other materials including the reservation of materials.

5.11.3.2 Life Cycle Costing

5.11.3.3 Spare Parts Kitting For Planned Jobs

5.11.3.4 Spare Parts Justification

5.11.3.5 Analyze Cost

5.11.3.6 Optimize Stock Availability and Cost

5.11.3.7 Spare Parts Quality Assurance

5.11.3.8 Inventory Valuation

5.11.3.9 Inventory Carrying Costs

Pillar 5 Metrics Appendix

To access and download the SMRP Best Practices 6th Edition, please go to www.smrp.org.

Metric 5.1.1 Corrective Maintenance Cost
Metric 5.1.2 Corrective Maintenance Hours
Metric 5.1.3 Preventive Maintenance (PM)
Metric 5.1.4 Preventive Maintenance (PM) Hours
Metric 5.1.5 Condition Based Maintenance Cost
Metric 5.1.6 Condition Based Maintenance Hours
Metric 5.1.9 Maintenance Shutdown Cost
Metric 5.3.1 Planned Work
Metric 5.3.2 Unplanned Work
Metric 5.3.3 Actual Cost to Planning Estimate
Metric 5.3.4 Actual Hours to Planning Estimate
Metric 5.3.5 Planning Variance Index
Metric 5.3.6 Planner Productivity
Metric 5.4.1 Reactive Work
Metric 5.4.2 Proactive Work
Metric 5.4.3 Schedule Compliance – Hours
Metric 5.4.4 Schedule Compliance – Work Orders
Metric 5.4.6 Work Order Aging
Metric 5.4.7 Work Order Cycle Time
Metric 5.4.8 Planned Backlog
Metric 5.4.9 Ready Backlog
Metric 5.4.10 Preventive Maintenance (PM) & Predictive Maintenance (PdM) Work Order Compliance
Metric 5.4.11 Preventive Maintenance (PM) & Predictive Maintenance (PdM) Work Orders Overdue
Metric 5.4.12 Preventive Maintenance (PM) & Predictive Maintenance (PdM) Yield
Metric 5.4.13 Preventive Maintenance (PM) & Predictive Maintenance (PdM) Effectiveness
Metric 5.4.14 Preventive Maintenance (PM) & Predictive Maintenance (PdM) Compliance
Metric 5.5.1 Craft Worker to Supervisor Ratio
Metric 5.5.2 Craft Worker to Planner Ratio
Metric 5.5.3 Direct to Indirect Maintenance Personnel Ratio
Metric 5.5.4 Indirect Maintenance Personnel Cost

Metric 5.5.5 Internal Maintenance Employee Cost
Metric 5.5.6 Craft Worker on Shift Ratio
Metric 5.5.7 Overtime Maintenance Cost
Metric 5.5.8 Overtime Maintenance Hours
Metric 5.5.31 Stores Inventory Turns
Metric 5.5.32 Vendor Managed Inventory
Metric 5.5.33 Stock Outs
Metric 5.5.34 Inactive Stock
Metric 5.5.35 Storeroom Transactions
Metric 5.5.36 Storeroom Records
Metric 5.5.38 Maintenance Material Cost
Metric 5.5.71 Contractor Cost
Metric 5.5.72 Contractor Hours
Metric 5.6.1 Wrench Time
Metric 5.7.1 Continuous Improvement Hours