

SMART Maintenance

Systematic Management of Assets
Using Reliability Tools

Agenda

- Introductions
- Goals and Expectations
- Interface with Existing Programs
- The New Maintenance Paradigm
- Experience and Examples

Project Goals and Expectations

- Maximize Availability of Equipment
- Enhance Plant Performance
- Reduce Maintenance Expense
- Optimize Sparing
- Reduce Risk
- Comply With Regulations

Interface With Existing Life Extension Program

- Existing Life Extension Program
 - ◆ Addresses Major Equipment/Problems/Issues
 - ◆ Manages Degradation
- Comprehensive Program Assured by
 - ◆ Rigorous Maintenance Program
 - ◆ Addressing Reliability/Availability of Equipment
 - ◆ Responding to Failures
 - Individual Relatively Low Consequence
 - Total Efficiency of Program Threatens Plant Life

Why Do We Need SMART Maintenance?

- To Manage the Degradation of Plant Equipment
 - ◆ Wear and Tear
 - ◆ Long-term Aging (creep, fatigue, corrosion, erosion, etc.)
- To Avoid Obsolescence
- To Apply Improved Technology
- To Reduce Costs
- To Improve Safety and Decrease Risk

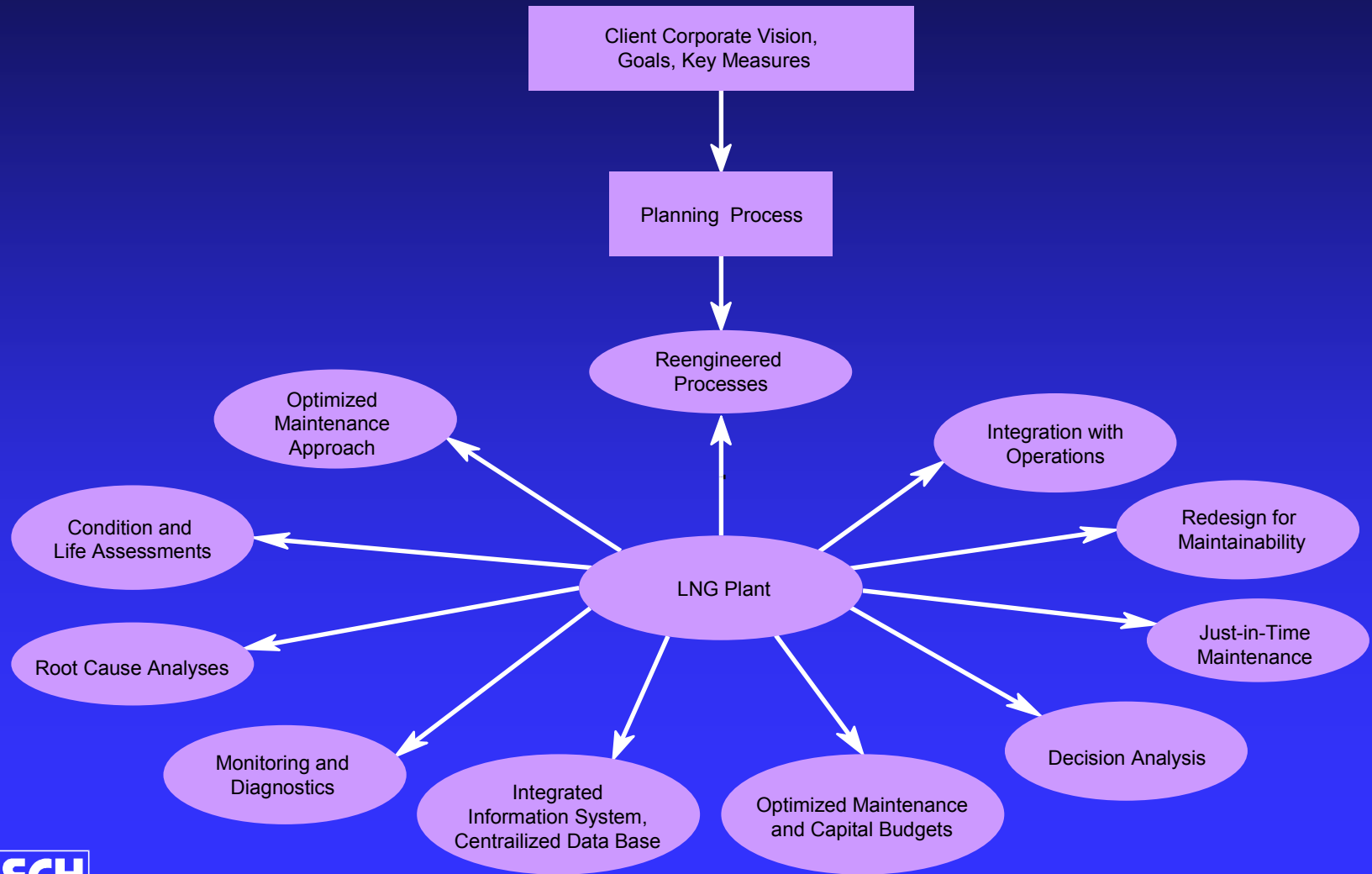
SMART: Performance-Based Maintenance

- Maintenance Based on Criticality and Condition of Equipment
 - ◆ Corrective Maintenance: Failure Based
 - ◆ Preventive Maintenance: Time Based
 - ◆ Predictive Maintenance: Condition Based
 - ◆ Reliability-Centered Maintenance: Reliability Based
 - ◆ Risk-Based Maintenance: Risk Based
 - ◆ Proactive Maintenance: Life Based

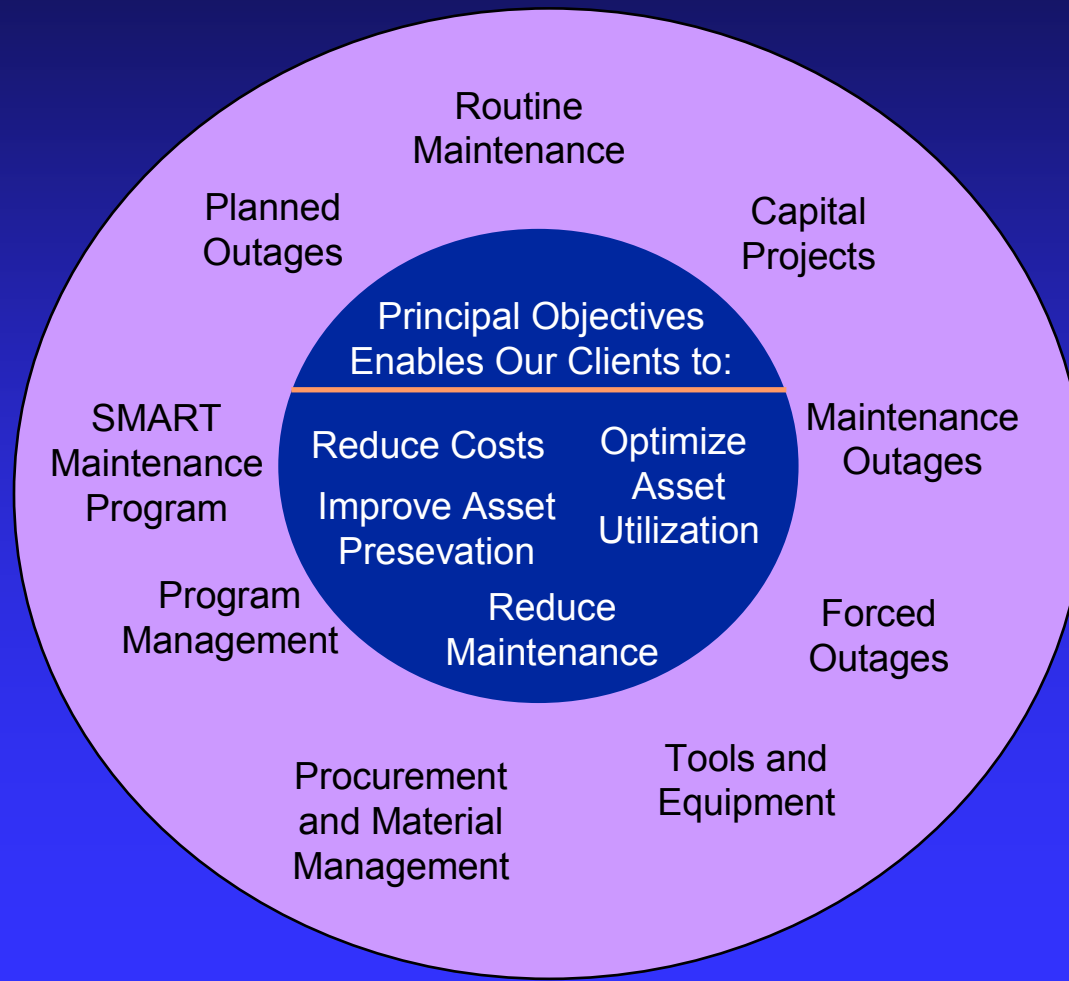
SMART: Performance-Based Maintenance

- Maintenance Performed Only As Needed
- Procedures and Practices are Standardized
- On-Line Maintenance Where Possible

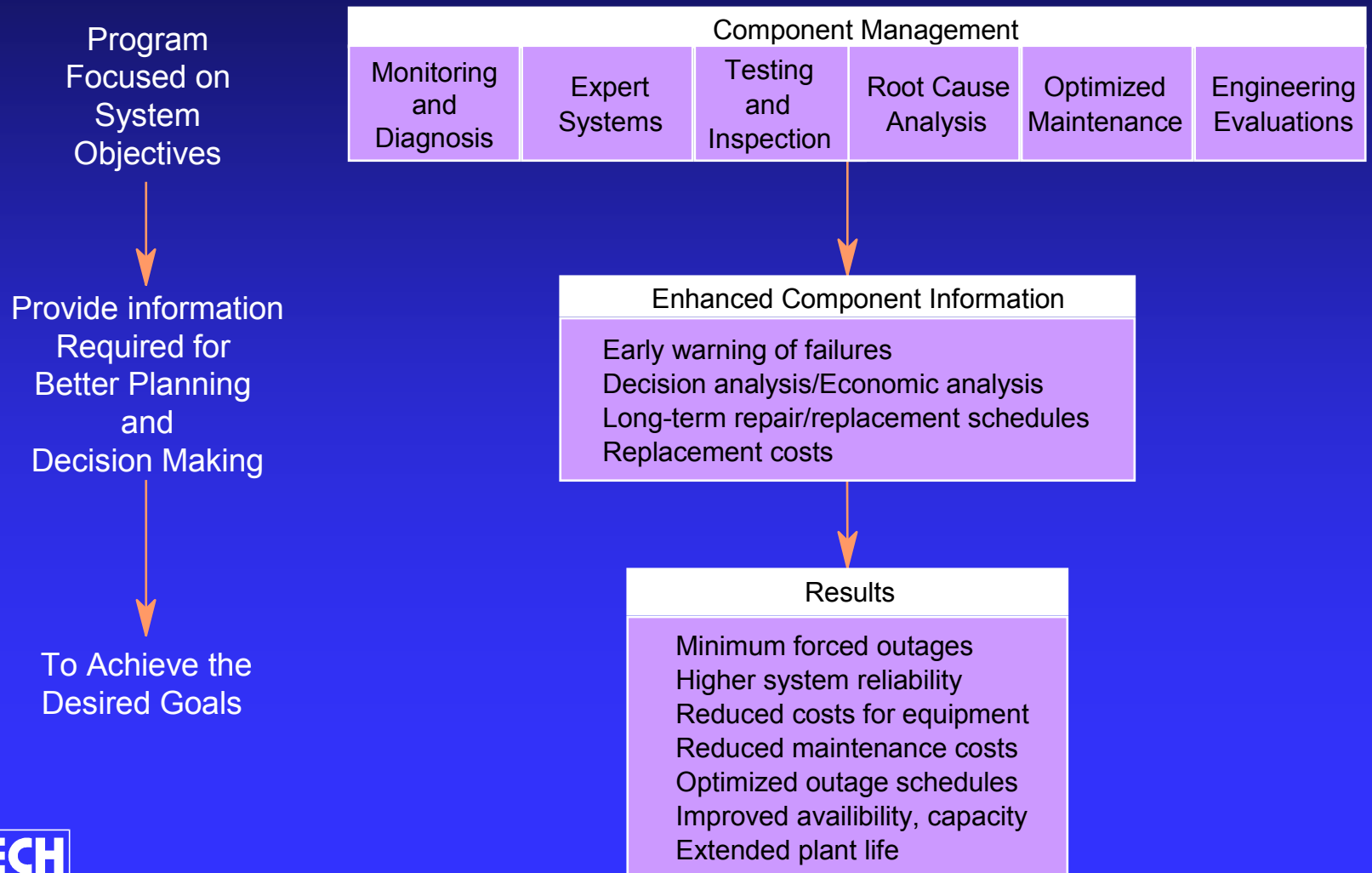
SMART Maintenance Program



SMART Maintenance Program



SMART Maintenance Program



SMART Maintenance Features

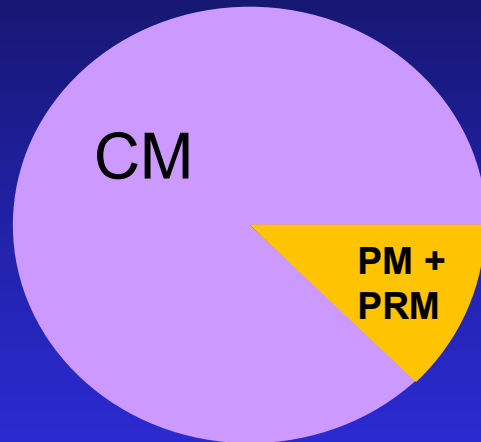
- Integrated With Corporate and Plant Goals
- Coordinated Activity Focused on Reducing Costs
- Reengineered Processes
 - ◆ Utilizes Integrated Information Systems
 - ◆ Increases Responsibilities and Optimizes Staff Levels
- Eliminates Traditional Barriers Between Engineering, Maintenance, and Operations

SMART Maintenance Features

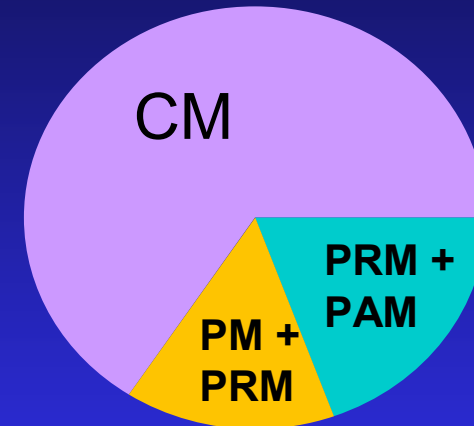
- Decision Analysis Systems Optimize:
 - ◆ Modifications and Replacements of High Maintenance Cost and Unreliable Equipment
 - ◆ Allocation of Capital and O&M Funds
- Component Life Cycle Management
 - ◆ Anticipate Failures and Minimize Forced Outages
 - ◆ Optimize Repairs/Replacements of Critical Equipment
 - ◆ Optimize Spare Parts Inventory
 - ◆ Improve Outage Planning, Intervals, and Execution
 - ◆ Develop Long-Term, Least-Cost Agreements With Key Suppliers

Optimized Maintenance Approach

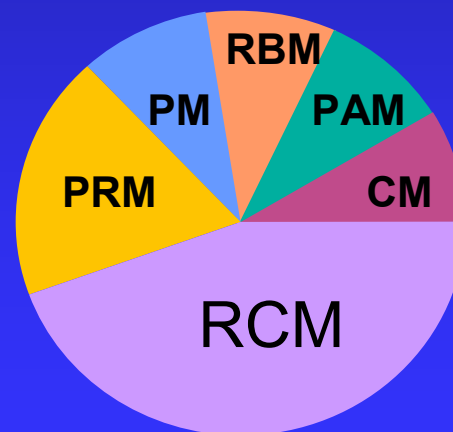
Past



Present



Future



CM = Corrective
PAM = Proactive
PM = Preventive
RCM = Reliability Centered
PRM = Predictive
RBM = Risk-Based

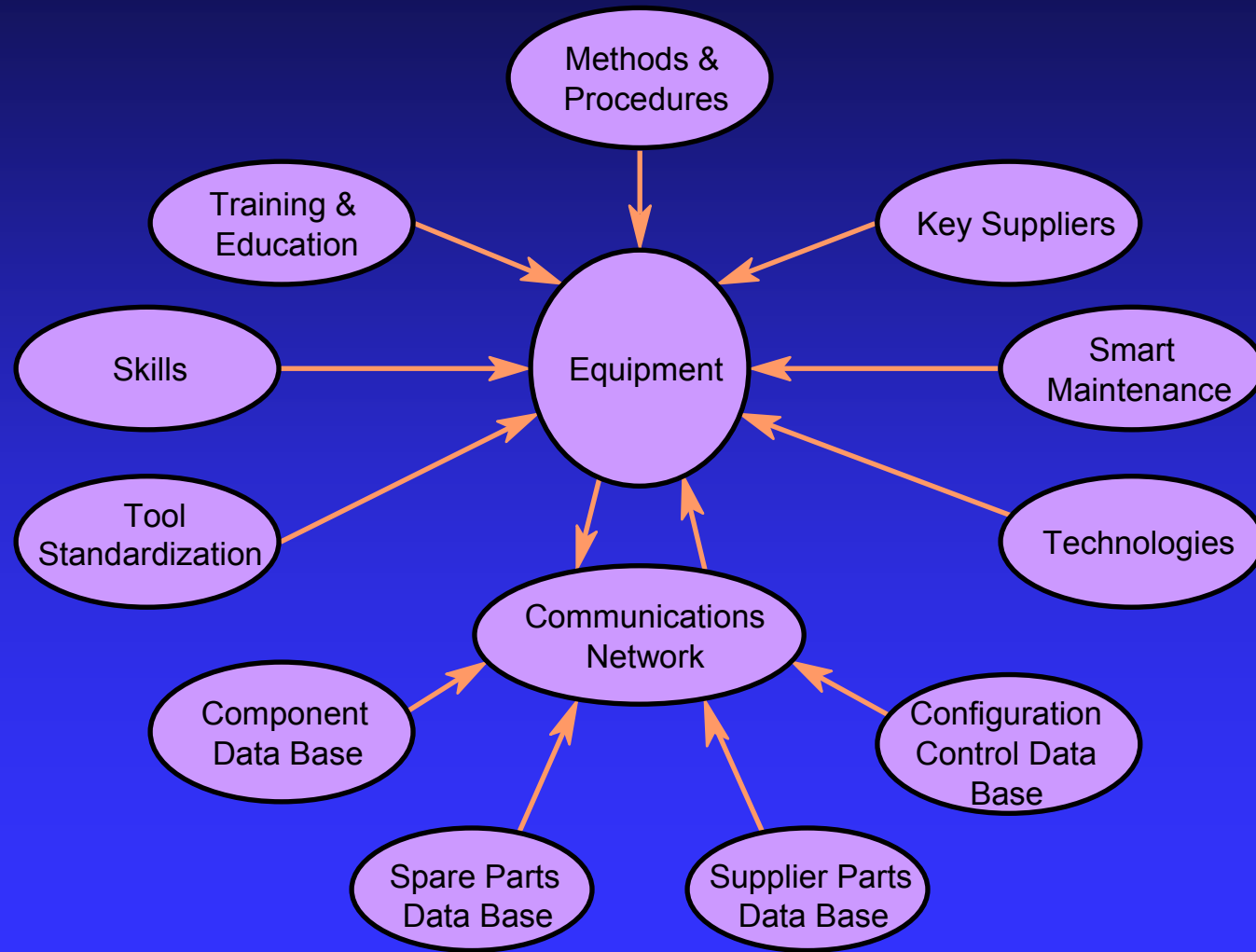
The SMART Program

- Provides for Root Cause Analysis on:
 - ◆ Individual Component Basis
 - ◆ Equipment Family Basis
 - ◆ System or Functional Group Basis
- Enhance Maintenance Staff to Service Auxiliaries
 - ◆ Training
 - ◆ Multi-Skilling

The SMART Program

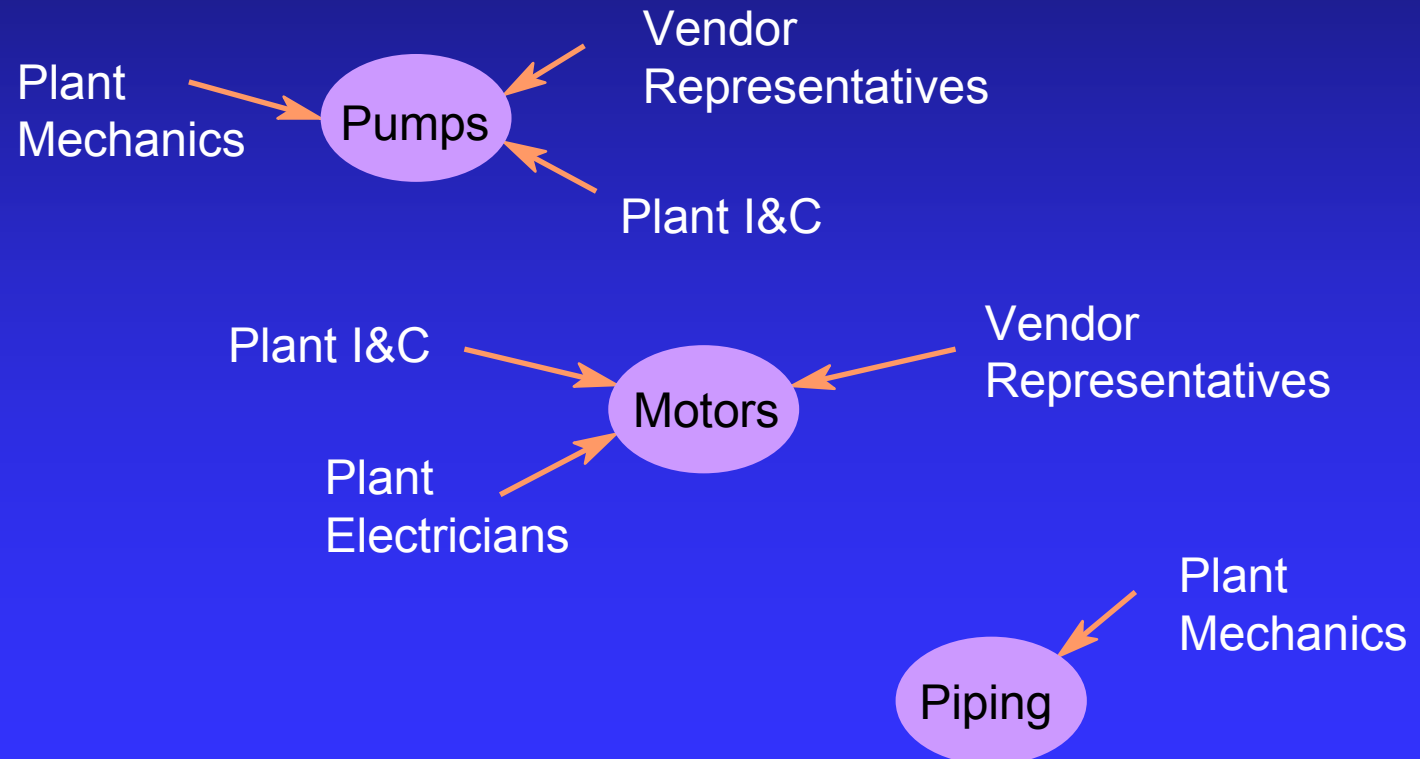
- Optimizes the Use of Key Suppliers
 - ◆ Integrated Approach on an Equipment Family Basis
 - ◆ Developing Standardized Methods of Maintenance/Repair
 - ◆ Optimized Spare Parts Inventory
 - ◆ Assist in Training
 - ◆ Standardize Needed Tools
 - ◆ Integrated Communications Network

Program Elements



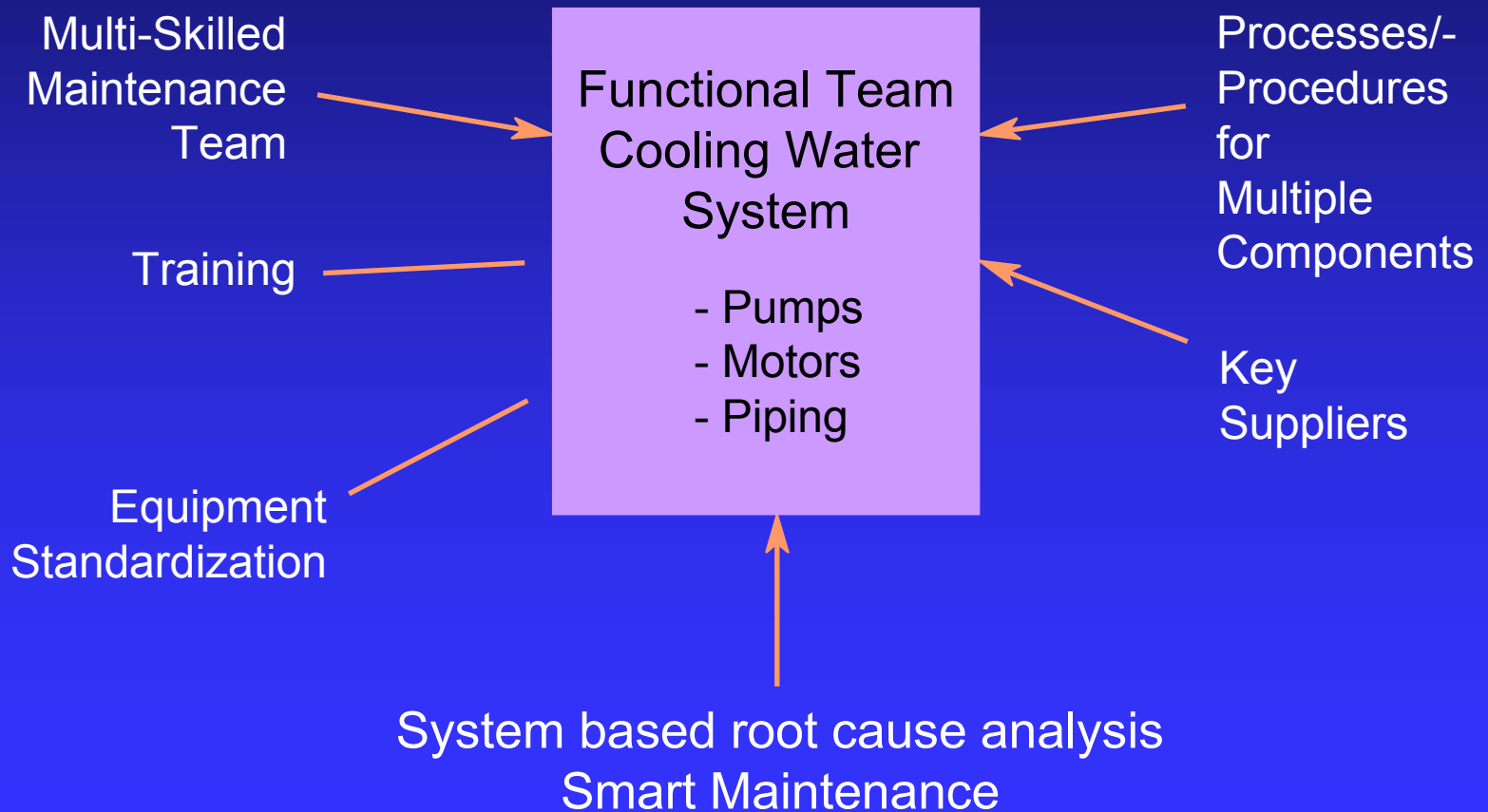
Maintenance Paradigm

BEFORE



Maintenance Paradigm

NOW



Equipment Groups

Motors

Circuit
Breakers

Pumps

Valves

Heat
Exchangers

I & C
Components

Piping

Tanks

Vessels

Outage Management Process: Planning

- Work Identification
 - ◆ SMART Maintenance Program
 - ◆ Cost Estimates
 - ◆ Schedule
 - ◆ Estimated Resource Requirements
- Outage Evaluation
 - ◆ Lessons Learned
 - ◆ Future Work
 - ◆ Maintenance Effectiveness
 - ◆ Key Measurement Indicators

Outage Management Process: Planning

- Outage Planning
 - ◆ Develop Preliminary Outage Schedule
 - ◆ Finalize Overall Scope
 - ◆ Finalize Budget
 - ◆ Determine Resource Availability
- Work Authorization
 - ◆ Work Orders Issued at Least 90 Days Prior to Outage Start

Outage Management Process: Work Execution

- Key People Mobilized Prior to Scheduled Outage Start
 - ◆ Review Plan
 - ◆ Achieve Buy-In
 - ◆ Outage Alignment Session

Outage Management Process: Work Execution

- Outage Execution Plan, Written Documentation
 - ◆ Manpower/Staffing Plan
 - ◆ Logistics Plan
 - ◆ Contracting Plan
 - ◆ Procurement Plan
 - ◆ Work Scope
 - ◆ Change Management

Outage Management Process: Work Execution

- Outage Execution Plan, Written Documentation
 - ◆ Quality Plan
 - ◆ Material/Staging Plan
 - ◆ Contingency Plan
 - ◆ Tools and Equipment Plan
 - ◆ Safety Plan
 - ◆ Environmental Plan
 - ◆ Performance Plan

Forced Outage Response Process: Key Elements

- Emergency Communication System
 - ◆ Availability Rosters
 - ◆ Pagers/Mobile Phones
 - ◆ Reporting Structures
 - ◆ Key Contact List of Regional and Site Management to Client Management
 - ◆ Emergency Mobilization Process (standardized)

Forced Outage Response Process: Key Elements

- Emergency Staffing Capabilities
 - ◆ Technical Expertise for Condition Assessment, and Perform Root Cause Analysis to Scope Repair Needs/Options
 - ◆ In-Place Base Crews - Resource Flexibility
 - ◆ Quick Hire Procedures
- Contingency Plans/Training
 - ◆ Plan to Anticipate and Respond to Most Probable Repair Scenarios (e.g., heater tube failures, pump failures, fires, etc.)

Reliability Tools

- RAM Simulation Technology
 - ◆ Unit Availability Modeling
 - ◆ Availability Improvement Cost Optimization
 - ◆ Unit Spares Analysis
 - ◆ Equipment Overhaul Replacement Decision Analysis
- BALIFE - Bayesian Life Prediction

RAM Simulation

- Applicable to Any Complex, Multi-State Process System (commercial or military)
- For Modeling Business Risk, not HSE Risk
- Models Effect of Component Behavior on System Performance

RAM Simulation

- Evaluates:
 - ◆ System Capability at All Levels of Demand
 - ◆ Component and Subsystem Sensitivity
 - ◆ Data Uncertainty
 - ◆ Time Variant Behavior
 - ◆ Impact of Reliability (and/or maintainability growth on anticipated performance)
 - ◆ Effects of Component and System Data Changes on Unit Performance

RAM Applications

- Expected Design Performance
- Design Cost Trade-off Studies
- Warranty Evaluation
- Maintenance Resource Optimization
- Spare Part Level Determination
- System Improvement Cost Optimization

Cost Optimization

- Optimally Determines Which RAM or Efficiency Improvement Options Should Be Selected and Their Order of Implementation
- Addresses Non-Linear and Inter-Dependent Relationships Between Alternatives
- Iterative Process, Using Integer and Dynamic Programming Algorithms
- Uses RAM Model(s), and Economic Screening, RAM Forecasting, and Option Data

Cost Optimization Benefits

- Cost-Effective Means for Selecting Competing Projects When Capital Budgets Are Tight
- Fast, Efficient Process for Accommodating Changes in Capital Budgets and in Implementation or Benefit Costs
- Objective, Reproducible Methodology for Supporting Improvement Selection Decisions
- Substantial Savings in Implementation Costs While Maintaining Production Goals

Spare Parts Analysis

- Optimizes Spare Parts Investment
- Evaluates Worth of Stocking Spares Relative to Improvement in Unit Performance
- Uses a UNIRAM System Model and Spares Costs Data File
- Application
 - ◆ Optimal Inventory List Determination for a Given Budget
 - ◆ Optimal Spares Capital Budget Determination
 - ◆ “Sanity Check” of Existing Spares Investment

Overhaul Analysis

- Too Frequent
- Accomplished at the Wrong Times
- Induce Additional Failures
- Are the Wrong Decisions Realized?

Overhaul Forecasting

- Forecasts Failure Rate Variation of Major Equipment
- Assesses Effectiveness of Prior Overhauls
- Evaluates Alternative Action Options:
 - ◆ Do Nothing (corrective maintenance only)
 - ◆ Overhaul Equipment
 - ◆ Replace Equipment

Overhaul Analysis Benefits

- Total Number of Overhauls Reduced
- More Effective Utilization of Overhaul Resources
- Substantial Cost Savings
- Permits Improved Overhaul Planning
- Reduces Overhaul Induced Failures

Experience

- Client A
 - ◆ Generation Reliability Improvement Program
- Client B
 - ◆ Gas Processing and Subsea Pipeline Reliability

Assessment Highlights: Client A

- Developed System-Wide Reliability Improvement Program
- Performed Condition Assessments on Six Gas-Fired Units
- Produced 20-Year Recommended Plan for Each Unit
 - ◆ Repairs/Replacements, Testing and Inspection, Design Modifications, Engineering Evaluations, etc.
 - ◆ Prioritized Capital and O&M Budgets

Assessment Highlights: Client A

- Identified Many Immediate Problems
 - ◆ Saved Numerous Forced Outages and Many Million Dollars
- Produced System-Wide Plan
 - ◆ Optimized Recommendations Across System
 - ◆ Optimized Capital and O&M Budgets
 - ◆ Implementation Plan
- Chosen to Assist in Program Implementation

Assessment Highlights: Client B

- Developed Natural Gas Reliability Model
 - ◆ On-Shore
 - ◆ Sub-Sea
- Researched Industry Data
- Populated Database
- Feedback to Conceptual Design and Procurement Process

APTECH's SMART Maintenance Program

- Phase I - Program Development
- Phase II - Modeling and Data Collection
- Phase III - Model Execution
- Phase IV - Implementation
- Phase V - Program Monitoring
- Phase VI - Program Transition

Phase I - Program Development

- Site Visit/Needs Assessment
 - ◆ Review Plant Goals and Objectives
 - ◆ Define Intolerable Consequences/Risks
 - ◆ Coordinate Program Objectives and Mission With Above
 - ◆ Develop Detailed Work Plan for SMART Maintenance Program
 - ◆ Form SMART Maintenance Program
 - ◆ Form SMART Maintenance Team of Stakeholders
 - ◆ Technology Transfer

Phase II - Modeling and Data Collection

- Develop Facility-Specific Reliability Model
- Collect Train Reliability Data
 - ◆ Records; Drawings
 - ◆ APTECH Data; Industry Data
 - ◆ Equipment Vendors
 - ◆ Maintenance Management System
 - ◆ Incident Reports; Operation Logs
- Define Future Data Needs/Collection Systems
- Technology Transfer

Phase III - Model Execution

- Input Data to Reliability Models, etc.
- Run Reliability Models
- Establish System/Component Reliability Requirements
- Feedback to Phase II
- Reevaluate Goals/Objectives
- Technology Transfer

Phase IV - Implementation

- From System/Component Reliability Requirements Develop SMART Maintenance Program
- Develop Maintenance and Capital Projects Cost Data
- Optimize Implementation Based on Balance of Cost and Reliability
- Establish Equipment Sparing Levels
- Technology Transfer

Phase V - Program Monitoring

- Benchmark Program Against Goals
- From Phase IV, Develop Inventory Reduction Program
- Develop Continuous Reliability Improvement Program
- Technology Transfer

Phase VI - Program Transition

- Hand Over Program to Plant Staff
- Continuous Monitoring Benchmarking (audits/evaluations)
- Ongoing Technology Updates

BENEFITS

- Reduced Costs
- Optimized Reliability
- Preserves Your Valuable Production Assets
- Operational Flexibility to Make the Most Efficient Use of Your Assets
- World Class Maintenance Program
- Enhanced Safety