IPAMC – DataTrak Systems Inc

Continuous Maintenance Improvement Roadmap
November 2017

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Agenda

1. ***Introduction and definition of Best Practices***
2. The Maintenance Cube of Excellence
3. Maintenance Assessment
4. Best Practices for Maintenance Strategy
5. Using KPI's to drive Best Practices
6. Work Orders , Planning, Scheduling and Control Best Practices
7. Equipment Management and Work Tactics
8. Continuous Maintenance Improvement Best Practices

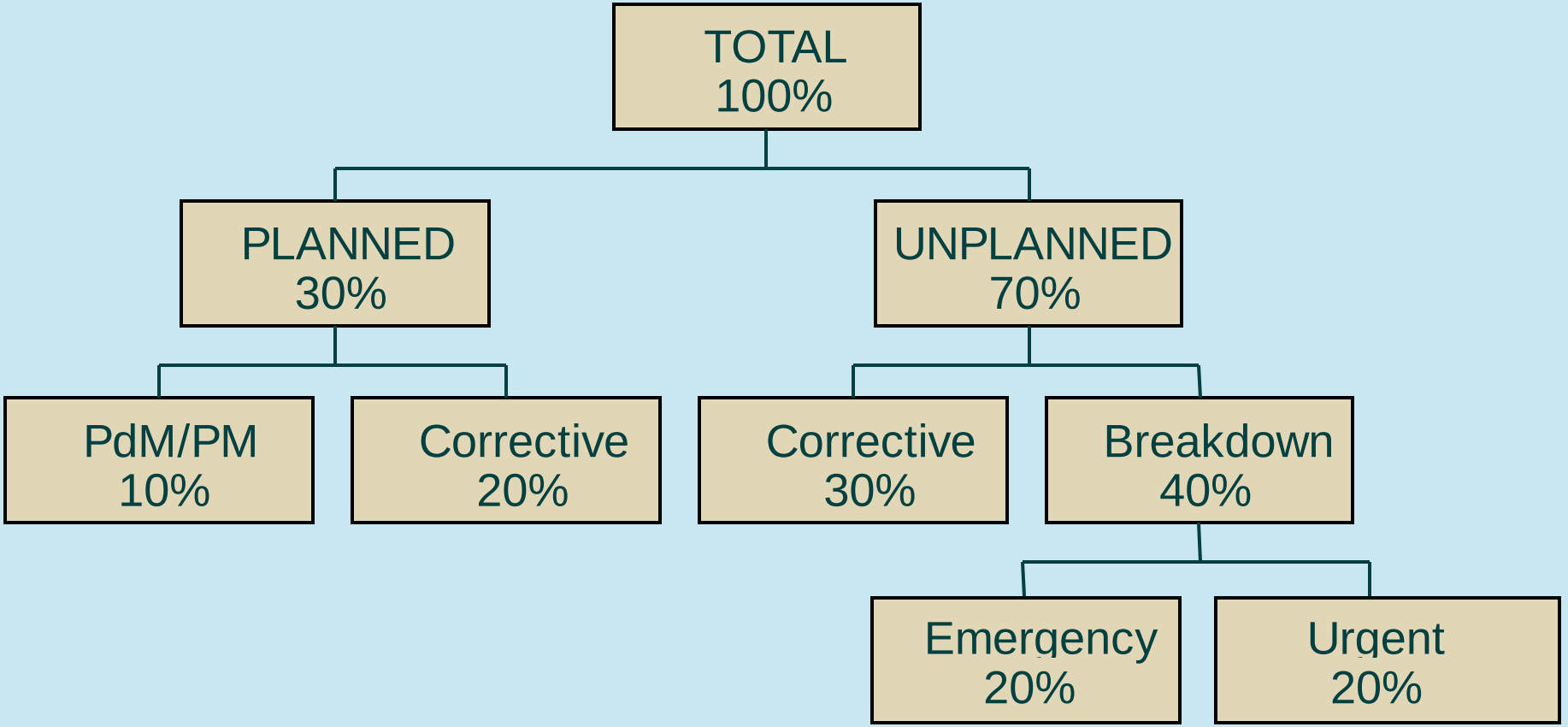
What can be achieved through a focus on Best Practices

- Cost reduction per unit output
- Increased output from increased availability of physical assets
- Risk reduction through improved safety and environmental compliance
- Increased ROI through longer asset life
- Higher levels of output & lower costs
- Fewer breakdowns and outages
- Lower capital expenditures
- Happier Customers
- Happier Owners, Happier Employees
- Less work for maintenance
- Others?

Prioritise them!

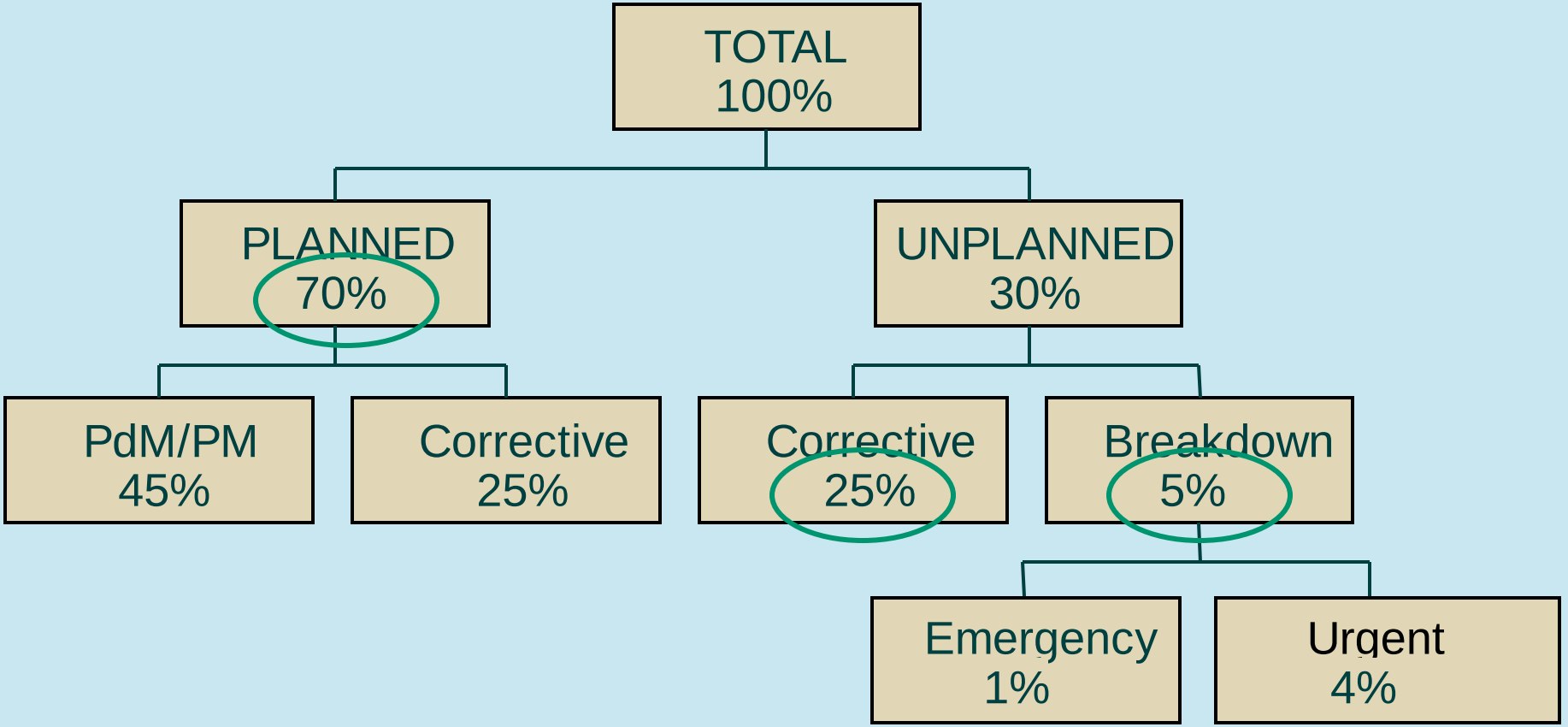
Case Study

Do we need Best Practices?
Typical Maintenance Work Processes



Case Study

Benchmark Maintenance Work Processes



Case Study

Valuing the Selection of Best Maintenance Tactics - 1

Example:

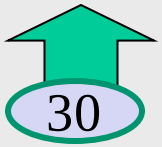
1. Assume the distribution of Maintenance is 30% Planned and PM, 30% Unplanned Corrective and 40% Breakdown.
2. Assume that the ratio of effort and cost is 1 to 3 to 10
3. Then for a $100k spend, the cost distribution is:

Tactic	% of Total	Cost Ratio	% x Cost = Units of work	Cost $
Planned and PM's	**30%**	**1**	**30**	**$5,760**
Unplanned Corrective	**30%**	**3**	**90**	**$17,280**
Breakdowns	**40%**	**10**	**400**	**$76,800**
Total	**100%**		**520**	**$100,000**

That represents 520 units of work @ $192 per unit.

Case Study

Putting a value on Best Selection of Maintenance Tactics - 2 - By increasing the Planned/PM from 30% to 70%

Tactic	% of Total	Cost Ratio	Activity Units	Cost $
Planned and PM's	**70%** 	**1**	**70**	**$13,440**
Unplanned Corrective	**25%** 	**3**	**75**	**$14,400**
Breakdowns	**5%** 	**10**	**50**	**$9,600**
Total	**100%**		**175**	**$37,440**

Total cost reduction = $100,000 - $37,440 = $62,560 = 63%

Best Practices will vary…

- …according to the business you are in
- …according to your business objectives
- …according to your culture

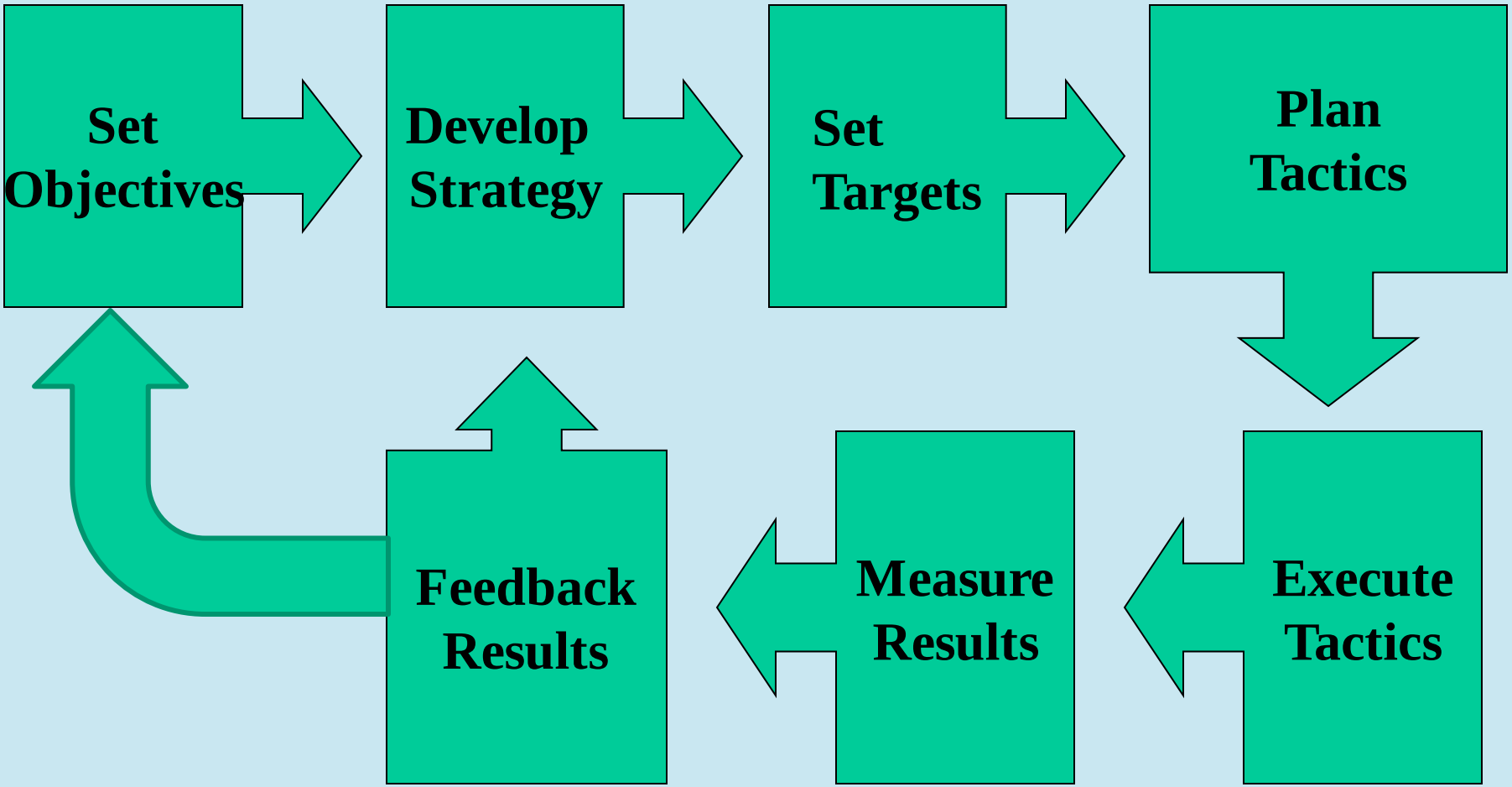
- There is no set of absolutes.
- They are always changing.

Maybe "Continuous Maintenance Improvement" is a better expression??

General Roadmap for Best Practices

- **Know where you are in statistical terms,**
- **Understand your Organisation's Operating and Maintenance Strategies,**
- **Investigate and select your "Best Practice" targets**
- **Investigate and select your "Best Practice" tools**
- **Establish numeric targets**
- **Identify gaps in performance between actual and target**
- **Set up a Performance Management system**
- **Create case for change and train train train**
- **Execute to desired performance**
- **Establish a long-term, continuous improvement feedback loop**
- **Do root cause analysis on shortfalls.**

Among all the details, the basics are simple….



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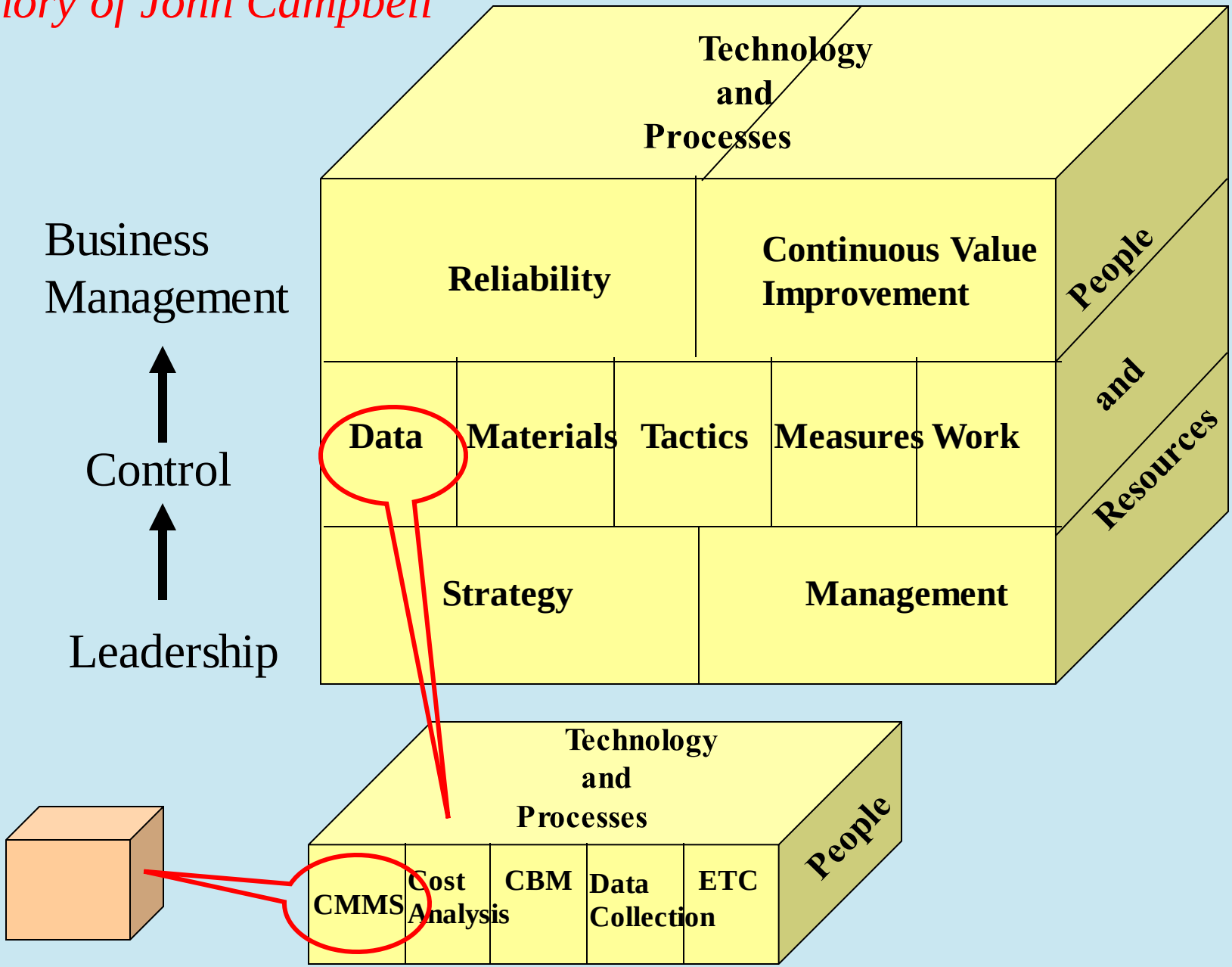
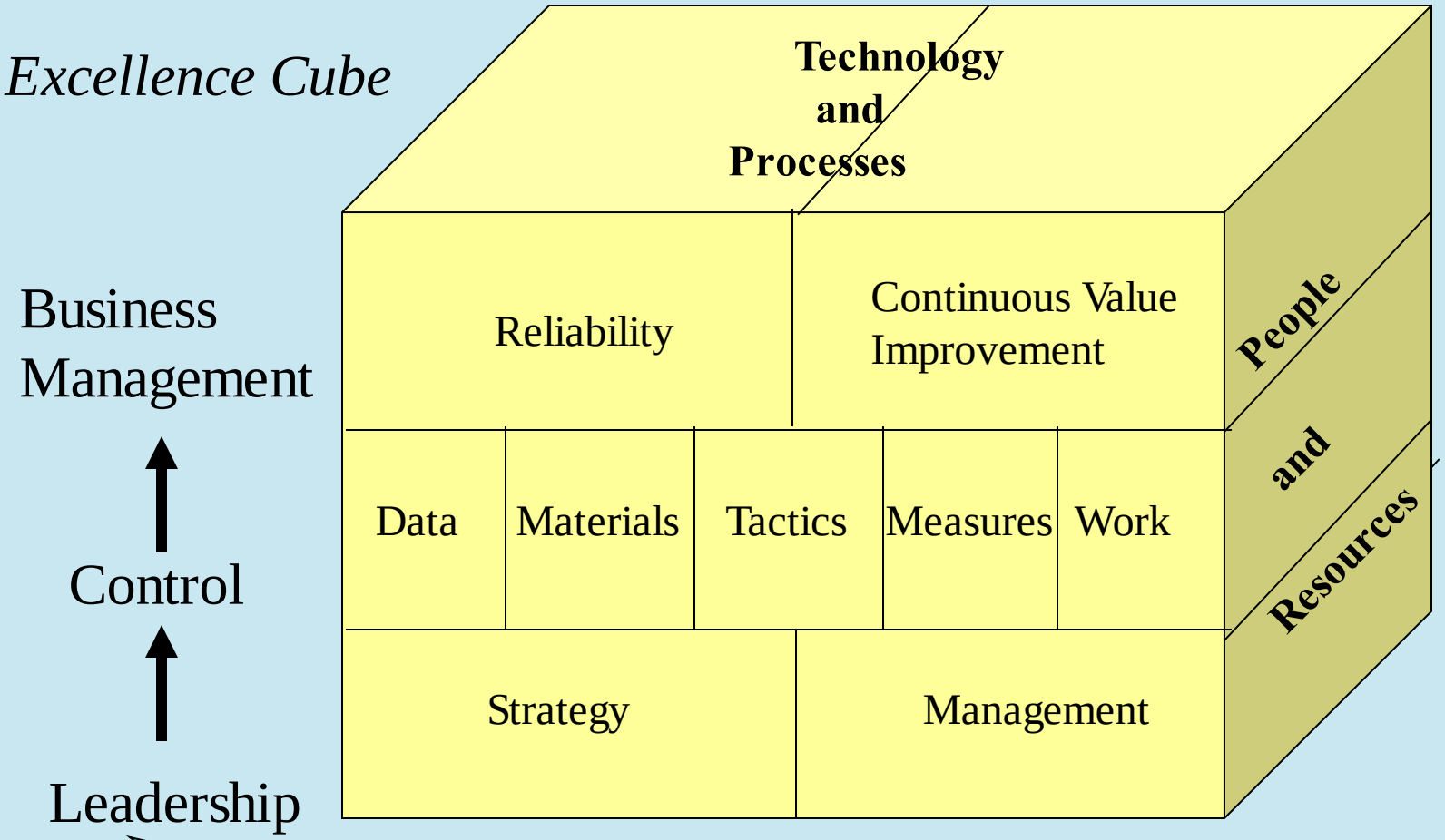
The Excellence Cube - A framework for a Best Practices Roadmap

In memory of John Campbell



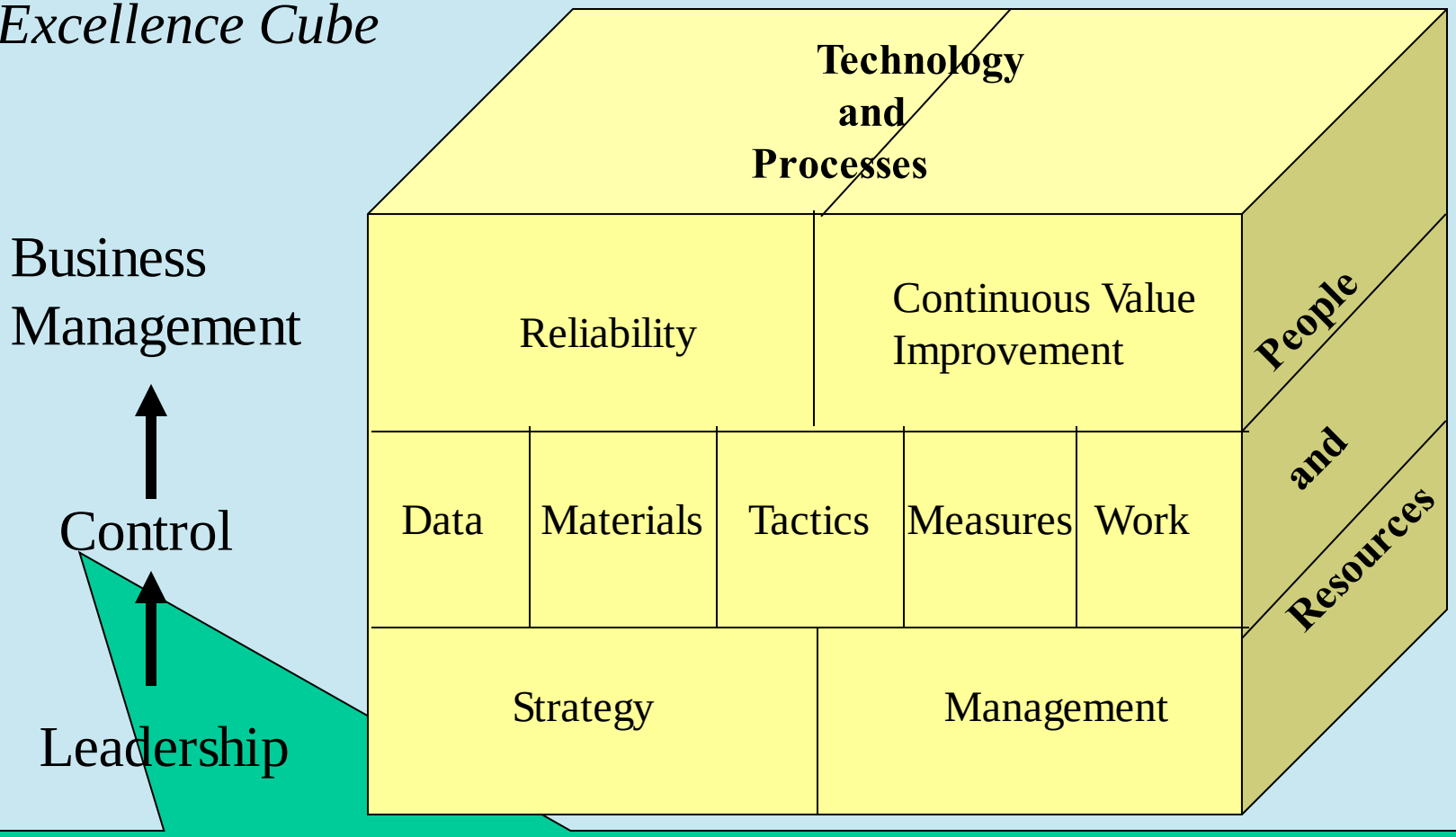
The Excellence Cube



Develop asset strategy --> maintenance vision --- integrate into the business plan.

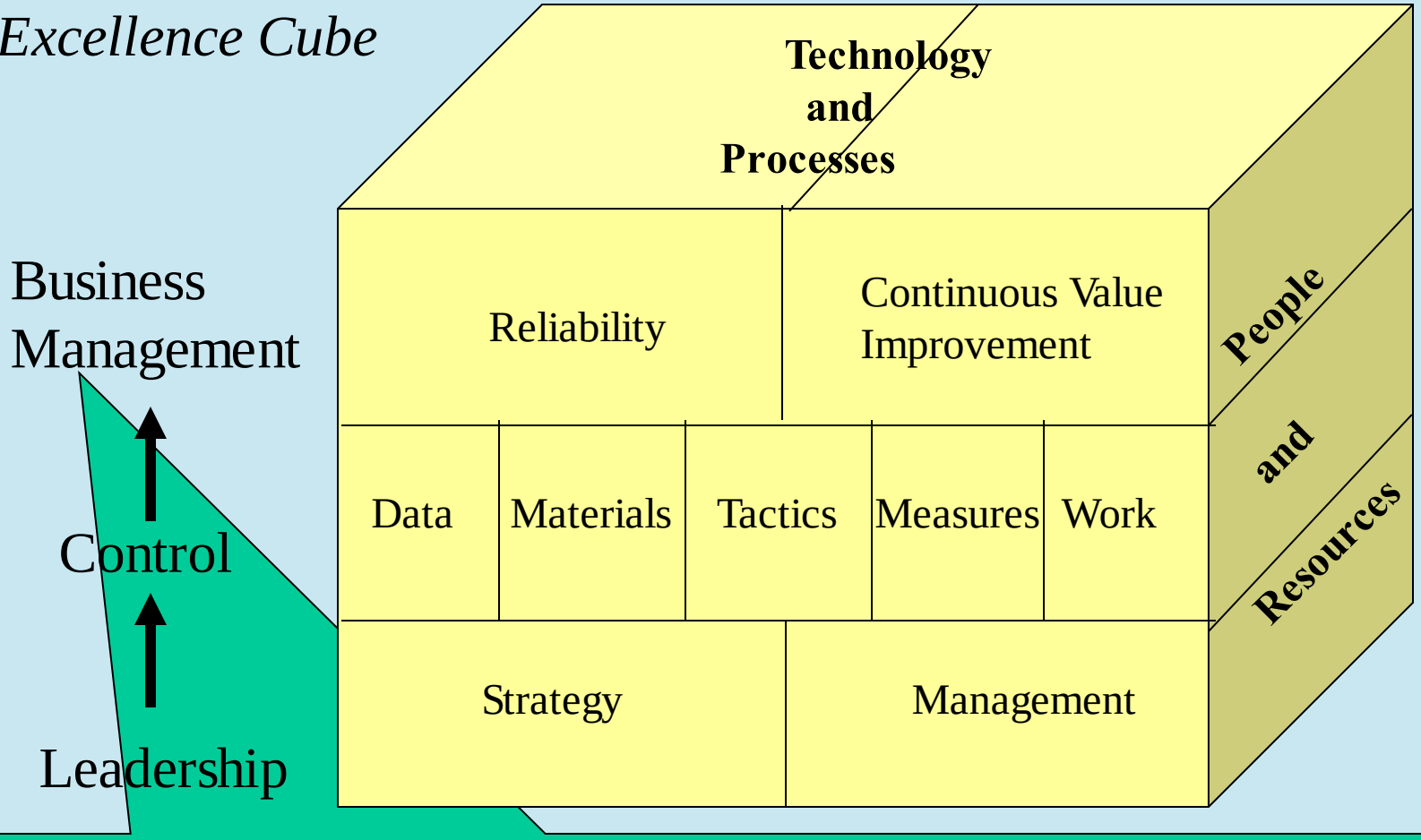
Management structure, organization and change.

The Excellence Cube



- Asset life-cycle productivity, including:
  - –work identification and planning - work scheduling and coordination
  - –purchasing and inventory -selection of maintenance tactics
  - –technical and information support - performance measurement

The Excellence Cube



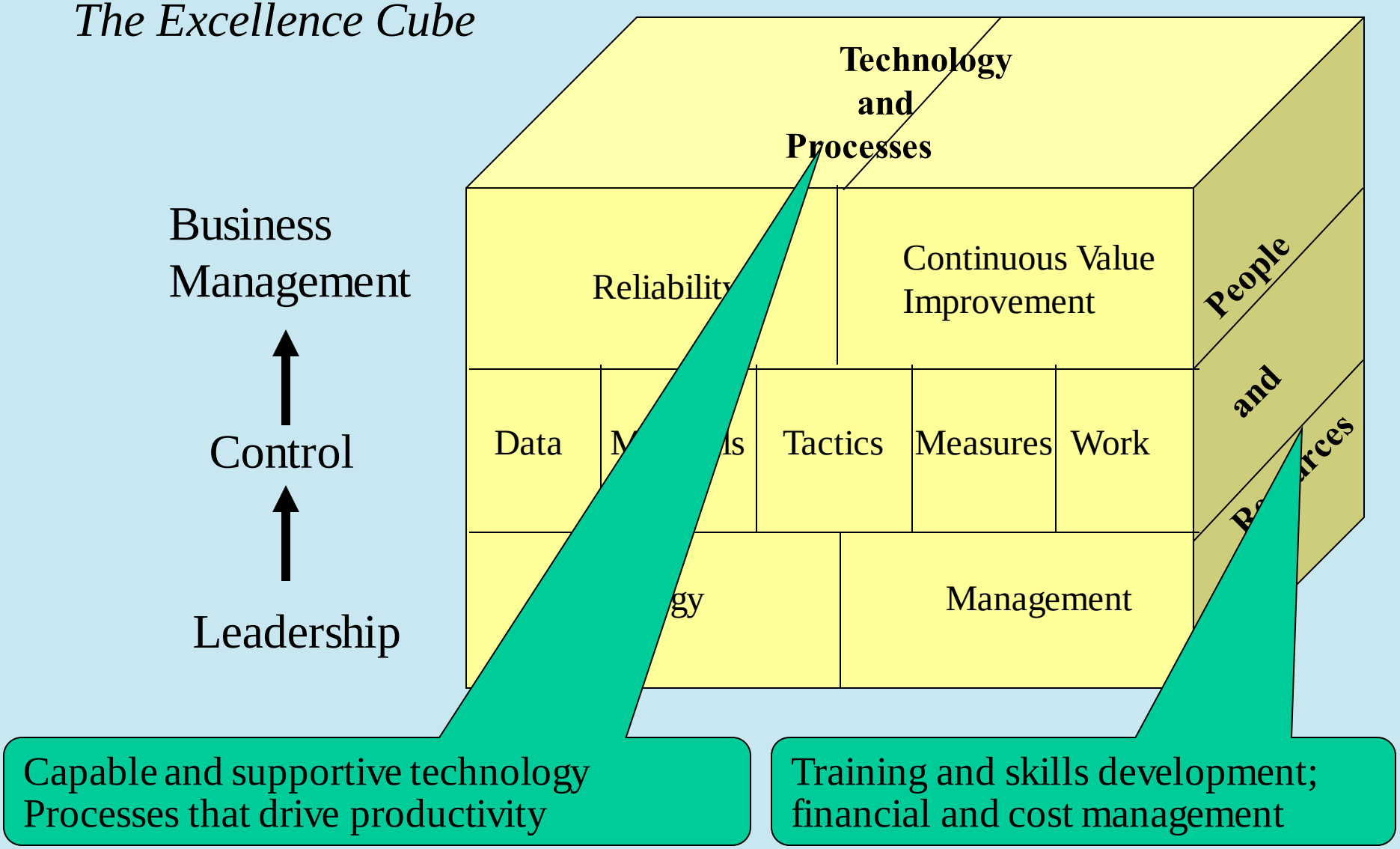
- Performance Improvement via failure management.

- Improved productivity via proactive and planned maintenance.

-Integration of all resources - maintenance, materials, operations, technical, and admin.

-Measurement and increase in the value of Maintenance

The Excellence Cube



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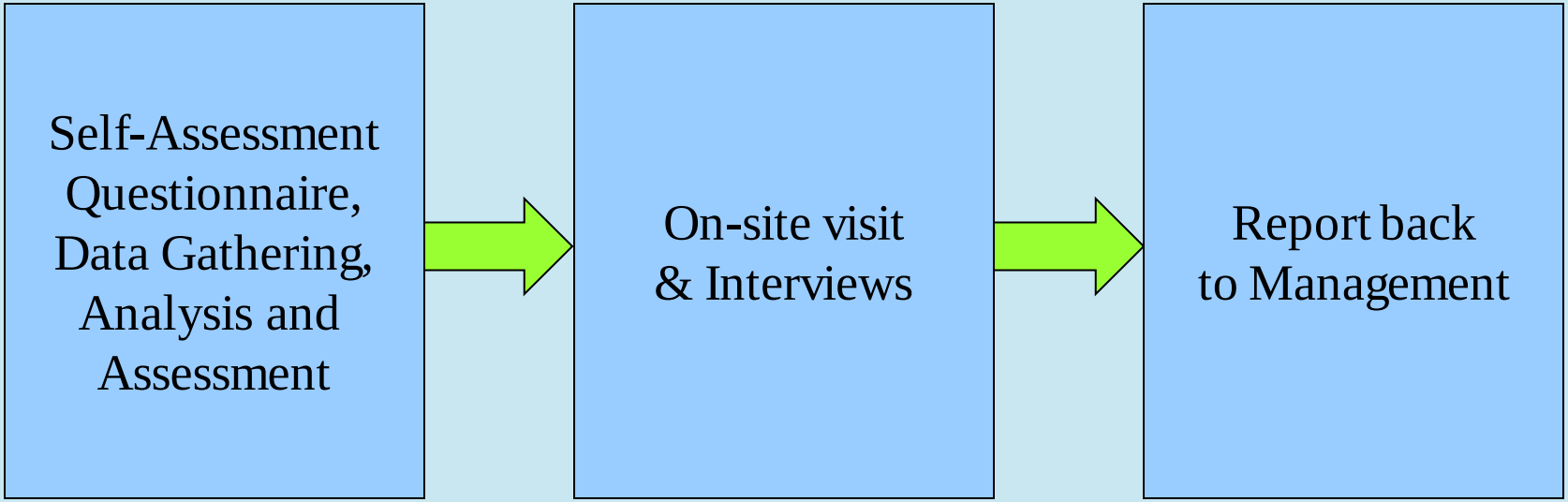
Maintenance Cube of Excellence acts as the basis for Maintenance Assessment – Objectives:

- 1. To provide a high level, objective review of the Maintenance function.
- 2. To identify strengths and weaknesses
- 3. To provide recommendations and benefits, and to propose priorities.
- 4. To provide real value in terms of needs, priorities, directions and next steps
- 5. To create a road map for change

Maintenance Organization doing formal Assessments typically…

1	want to move towards World Class Maintenance
2	want to improve their Maintenance operations and are looking for the best place to start.
3	think they need to change strategies
4	get reasonable value from their Maintenance IT Systems, but want to increase the ROI
5	recognise they need help straightening out an internal problem
6	have an appetite for change?
7	Know they can get their boss to approve the process?
8	…and agree to the changes recommended?
	Do you (tick, X or ? For your organization……...)

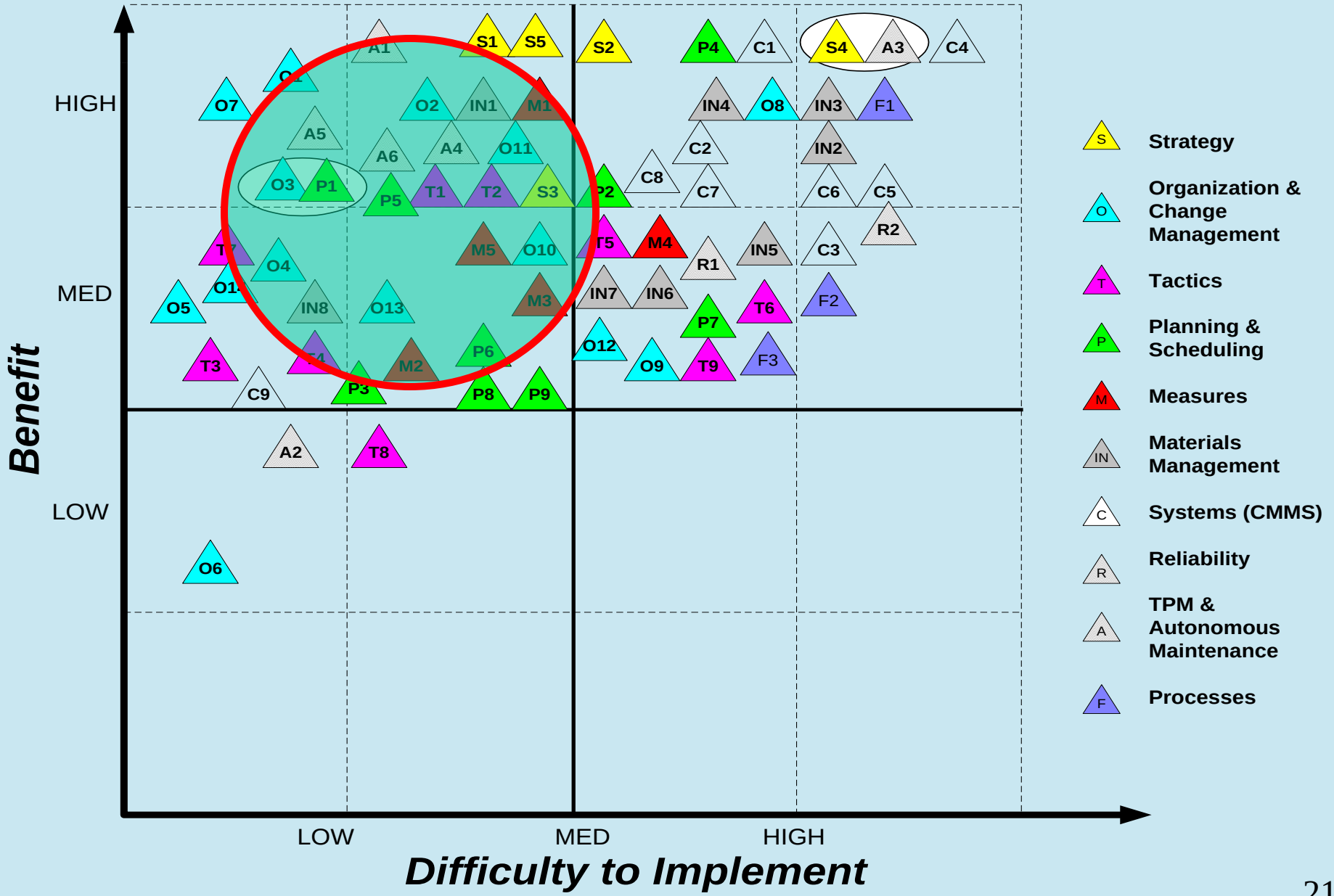
Assessments have a common Methodology:



Sample Teams

1. Internal -- Maintenance Engineer, Maintenance Manager, Maintenance Supervisor, Selected Trades PLUS a facilitator (usually external)
2. External – Experienced consultant or consulting team

So where do we start???



Best Practices - Where do you stand?

Where do you stand – 1

Adapted from JC Campbell: Uptime

	Strategy	Organization Management	Planning & Scheduling	Maintenance Tactics	Performance Measures	Information Technology	Reliability Engineering	Process Analysis
Excellence	Set corporate mtc. strategy / asset strategy	Multi-skilled independent trades	Long term & major projec planning & engineering	All tactics based on analysis	OEE; bench marking, full cost database	Fully integrated, common database	Full value, risk analysis RCM and root cause analysis	Regular Re-view of Pro-cess Cost, Time Quality
Competence	Long term improvement plan	Some multi-skilling	Good job planning, scheduling & eng'g suppo	Some CBM, some PM, few surprises	MTBF/MTTR availability, separate mtc. costs	Fully functional; linked to financials & materials	Some FMECA used	Some review of Admin, Eng and Trades procedures
Under-standing	Annual improvement plan	Decentralize, mixed trade teams	Planning group established; ad hoc engineering	Time and use based inspections. Some NDT	Downtime by cause; Mtc. costs available	Fully functional; stand alone	Good failure database; well used.	Some review of Trades Processes and Tactics
Awareness	PM improvement program	Partly centralized for some trades	Troubleshoo ing support; inspection scheduling	Time based inspections	Some downtime records; mtc. costs not segregated	Basic mtc. scheduling, some parts records	Collect data but make little use of it	One time review of Maintenance Process
Innocence	Mostly reactive breakdown mtc.	Highly centralized.	No planning, little scheduling & no engineering	Shutdown inspections only	No systematic approach; mtc. cost unavailable.	Manual or ad-hoc specialty systems	No failure records.	Never reviewed

Where do you stand -2?

	Strategy	Organization Management	Planning & Scheduling	Maintenance Tactics	Performance Measures	Information Technology	Reliability Engineering	Process Analysis
Excellence	Set corporate mtc. strategy / asset strategy	Multi-skilled independent trades	Long term &	All tactics	OEE; bench marking, full cost database	Fully integrated, common database	Full value,	Regular Review of Process Cost, Time Quality
Competence	Lo	S	Good job planning, scheduling & eng'g suppo	Some CBM, some PM, few surprises	MT	Full	Some FMECA used	Some review o
Under-standing	Annual improvement plan	Decentralize, mixed trade teams	Planning group established; ad hoc engineering	Time and use based inspections. Some NDT	Downtime by cause; Mtc. costs available	Fully	Good failure database; well used.	Some review of Trades Processes and Tactics
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Organization's Mission
Organization's Objectives
Department Objectives
Operations Objectives
Maintenance Objectives
Maintenance Strategy
Maintenance Policies
Maintenance Tactics
Maintenance Budgets
Job Plan
Work Orders
Activities, Tasks
KPI's, Results

What's behind Maintenance Strategy?

- The core requirement of maintenance is to increase the stakeholders' value – USUALLY Profitability

The 5 key maintenance drivers to perform this are

- 1. Reliability (does the asset generate output as required)
- 2. Availability (is the asset ready for use when required)
- 3. Maintainability (can the asset be effectively maintained)
- 4. Productive value (can the value of the asset be maintained as it is used and minimise the future capital cost)
- 5. Maintenance Output Value - Can we measure it?

Strategy Best Practices

1. Understand your Corporate Mission and Strategy
2. Understand your Operations environments
3. Understand the issues related to the different Mtce strategies
4. Apply RCM thinking (concentrate on critical equipment and critical problems)
5. Select the best strategy per Production line and per equipment
6. Implement via the EAM Maintenance Plan
7. Measure the results and feed them back to the strategy review

When to Change

Typically reviewed each year at Budget time to ensure it still matches the business environment

Updated whenever there is a significant change in:

- the business environment (market demand)
- operations and its demands on Maintenance
- the way Maintenance must be done in the near future

(Remember Volvo!)

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Best Practices for KPI's - 1

1. Understand the Corporate Strategy and Maintenance Objectives
2. Understand how measures in Maintenance, Production and Stores drive behaviour
3. Propose a set of measures and test them to make sure.
   - they drive behaviour.
   - they can be understood by the users and the technicians
   - the data is readily available, consistent and measurable
   - they have the impact and meaning required to achieve the desired results
4. For the overall maintenance function, select about 5 (and certainly less than 10) KPI's from among the major maintenance KPI groups:
   - Overall Maintenance Results - Maintenance Productivity
   - Maintenance Operations - Maintenance Work Efficiency
   - Maintenance Costs - Maintenance Quality

Best Practices for KPI's - 2

5. Select specific KPI's at a lower organizational level such as
   - Plants, production lines, equipment trains, key equipments, key components
6. Define the KPI measurement and calculation process
   - Set up the measuring process and document
   - Define the purpose of the measurement and what is expected to be done with the result
   - Define who is responsible for data collection, analysis and reporting
   - Establish how and how often the readings are to be taken, plus any specific conditions (time of day, in relation to equipment run time, from where is the reading to be taken)
   - Define how is the data to be interpreted, analysed and displayed

Best Practices for KPI's - 3

- Explain details to Inspectors and Maintenance crews and train them
- Automate the data collection process wherever feasible; where not, then make it part of the regular work routine via an inspection sheet or work order
- Make sure the measures are reliable, consistent and easily accessible
- Publish and discuss the results:
  - Encourage feedback
  - Focus on the implications of the trends
  - … and the remedial action
- Use the Results as the basis for setting next year's targets

Remember – the key result of KPI's is the change in behaviour that they prompt

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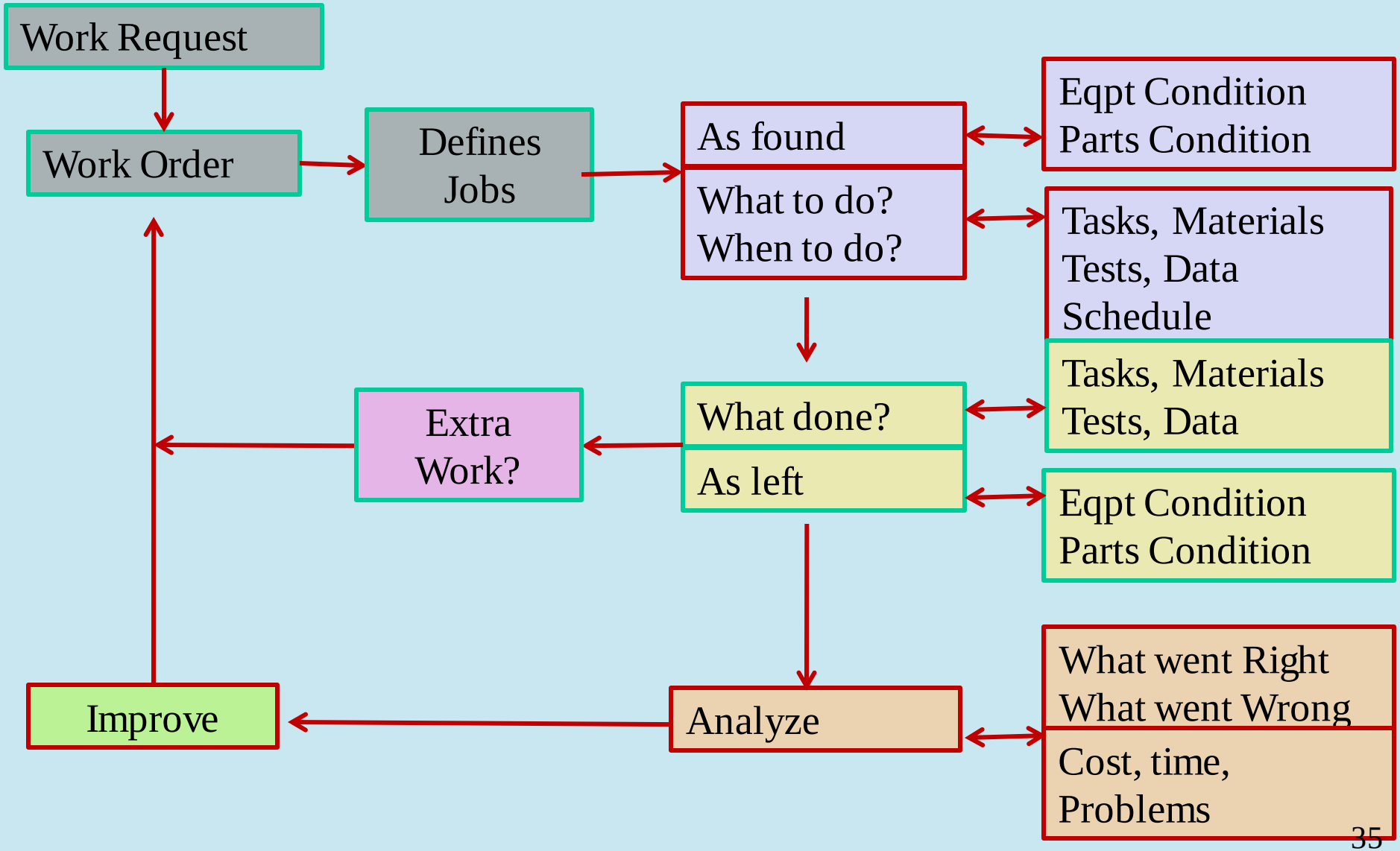
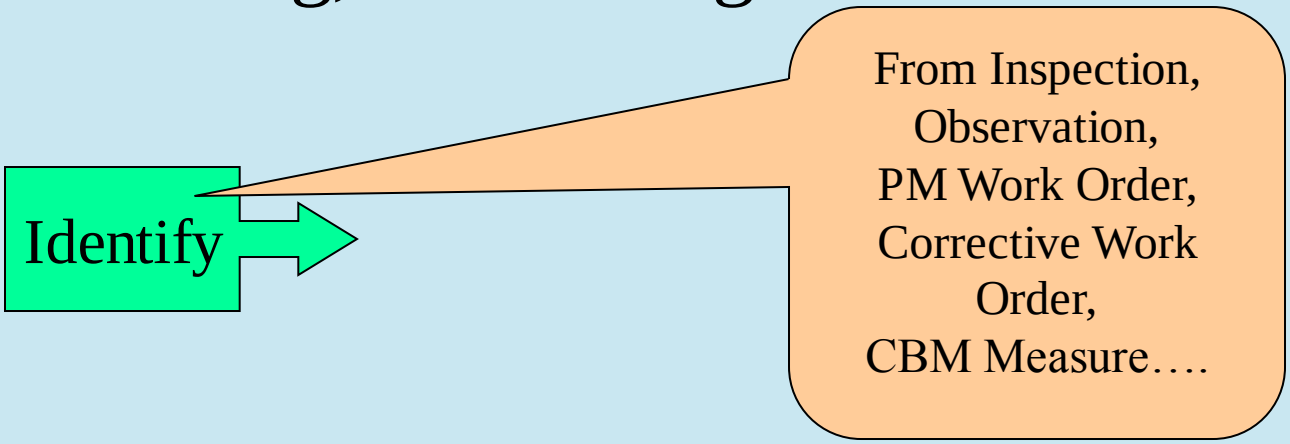
The Work Order Cycle

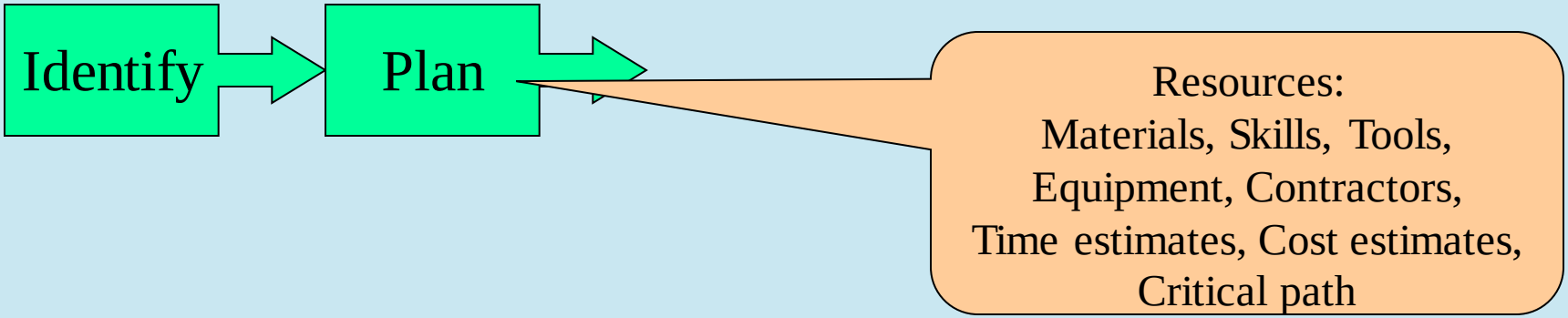


Planning, Scheduling & Control - Step 1



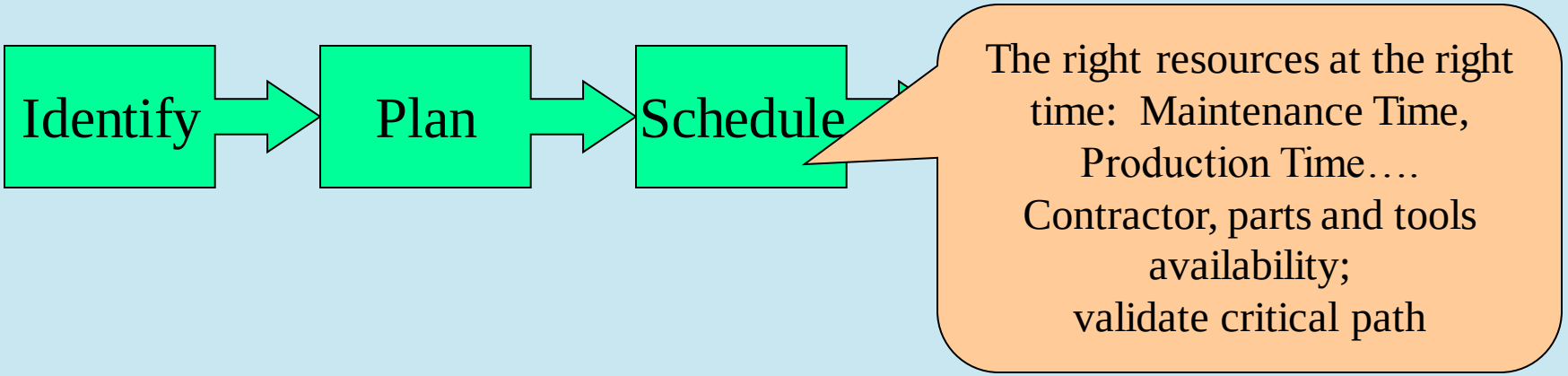
1. Strive for quality improvement in the work request – better observation, better problem definition, more training
2. Use smarter condition monitoring to define thresholds for work requests
3. Ensure Conditions being monitored are predictors of functional failures
4. Insert approval process between Work Request and Work Order – duplication, budgetary, functional, technical, priority.

Planning, Scheduling & Control - Step 2



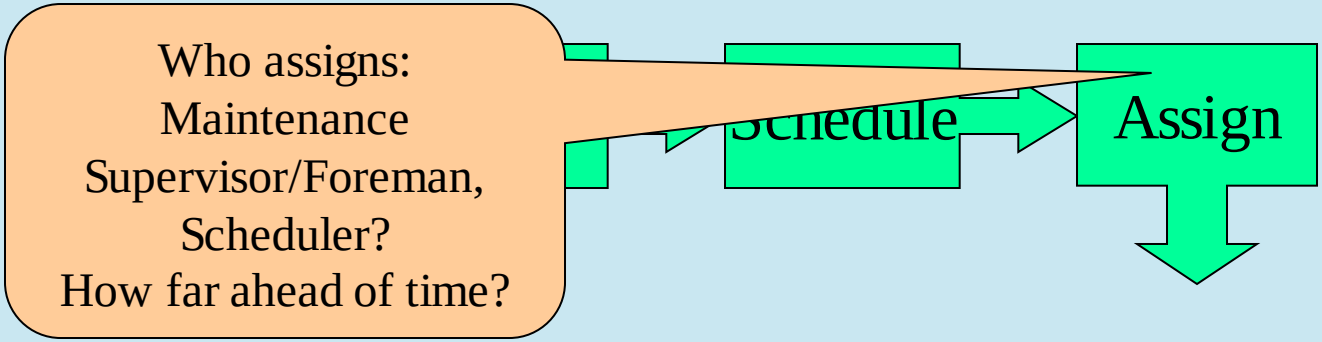
1. **Always work from a template wherever possible – update previous work order version**
2. **Use Company's internal Best Practice and Best Knowledge – which should be continuously updated from experience**
3. **Ensure that all work elements are included – Equipment, Tasks, Resources, Permits, Supervision, Data to be Collected, Analysis**
4. **For complex jobs, ensure job sequence will facilitate scheduling by stages**
5. **Plan Critical Path**
6. **Review for budget, quality, timeliness, priority and need before releasing to scheduling**
7. **Weekly Planning meeting to review work load, priorities etc**
8. **Attend at Weekly Backlog meeting**

Planning, Scheduling & Control - Step 3



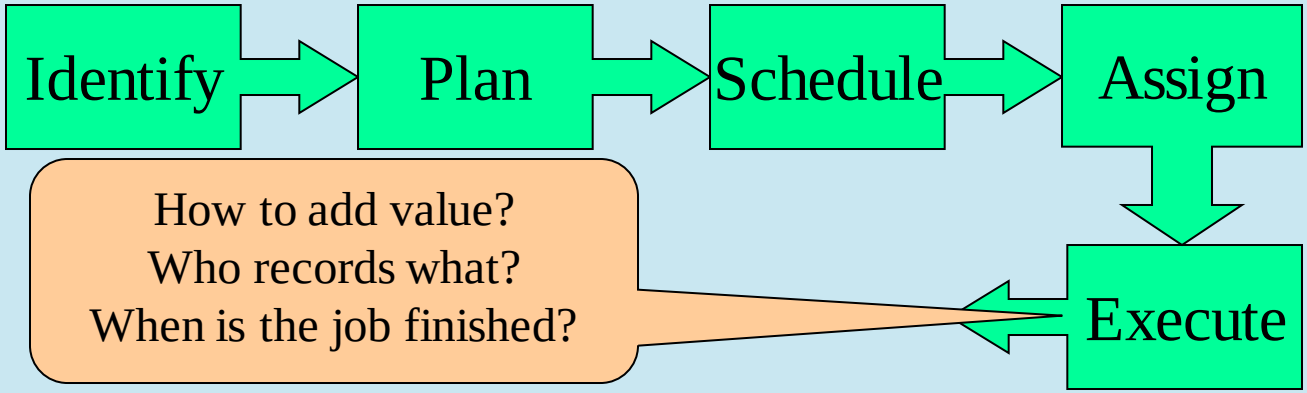
1. **Ensure all Work Order elements are in place before issuing**
2. **Integrate with related maintenance and operational schedules to optimize resource use, equipment downtime, production schedule**
3. **Pay attention to Resource leveling**
4. **Where job staging is required, ensure resources for stage 2 are available JIT before releasing after stage 1**
5. **Ensure adequate time is scheduled for each job step**
6. **Validate Critical Path**
7. **Adjust for reliability of Contractors re on-time job start and job finish, suppliers for materials lead times etc**
8. **Weekly Schedule meeting (also Daily??), Weekly Backlog Mtg**

Planning, Scheduling & Control - Step 4



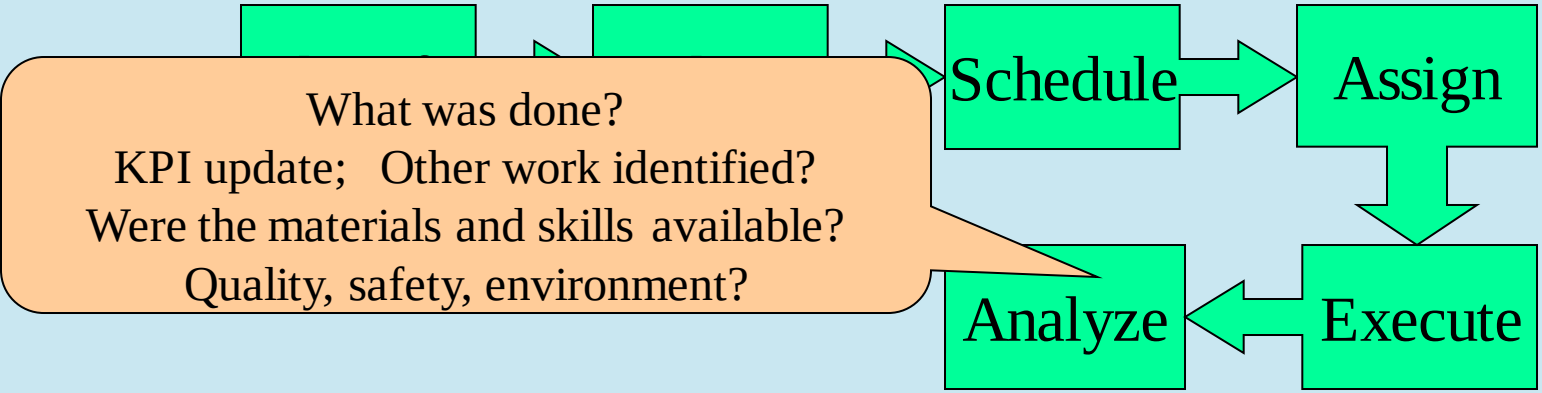
1. **Decide whether assignment is Scheduling task or Work Team Leader task - ie assign to individual or to crew/contractor**
2. **Make sure required priority and skill level are supported**
3. **Check availability (vacations eg)**
4. **Depending on job, experience (and confidence), assign work to be completed in a block (eg one week or one month) versus single day**
5. **Decide on level of details provided based on experience level of crew.**

Planning, Scheduling & Control - Step 5



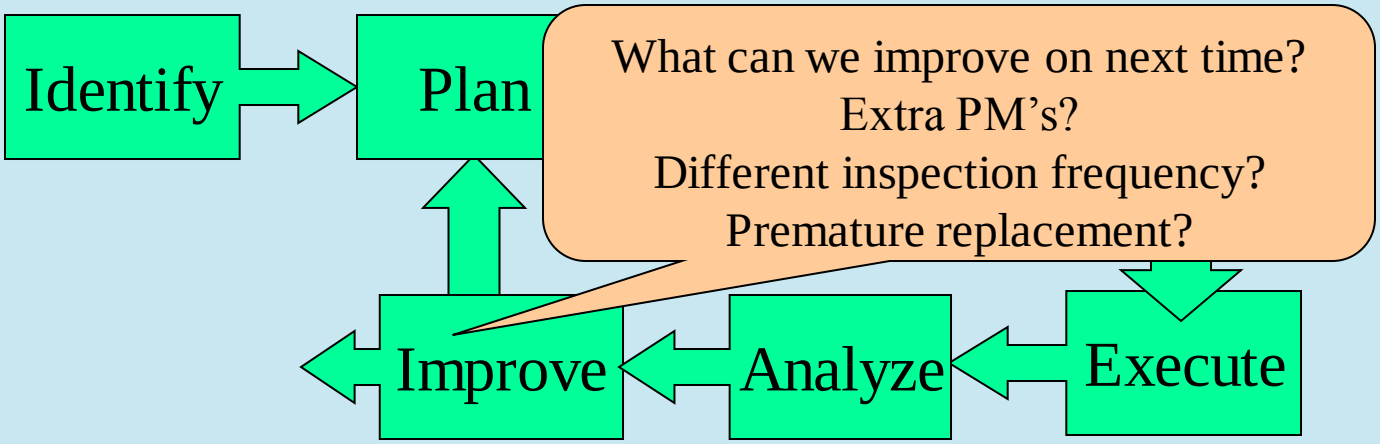
1. **Set rules for time definitions within "Execute" - travel time, wait time, wrench time etc**
2. **Ditto for materials consumption/disposal**
3. **Train for data collection – consistency, accuracy, completeness**
4. **Encourage feedback re all job elements**
5. **Validate quality and completeness of work and reporting – accountability must be clear**

Planning, Scheduling & Control - Step 6



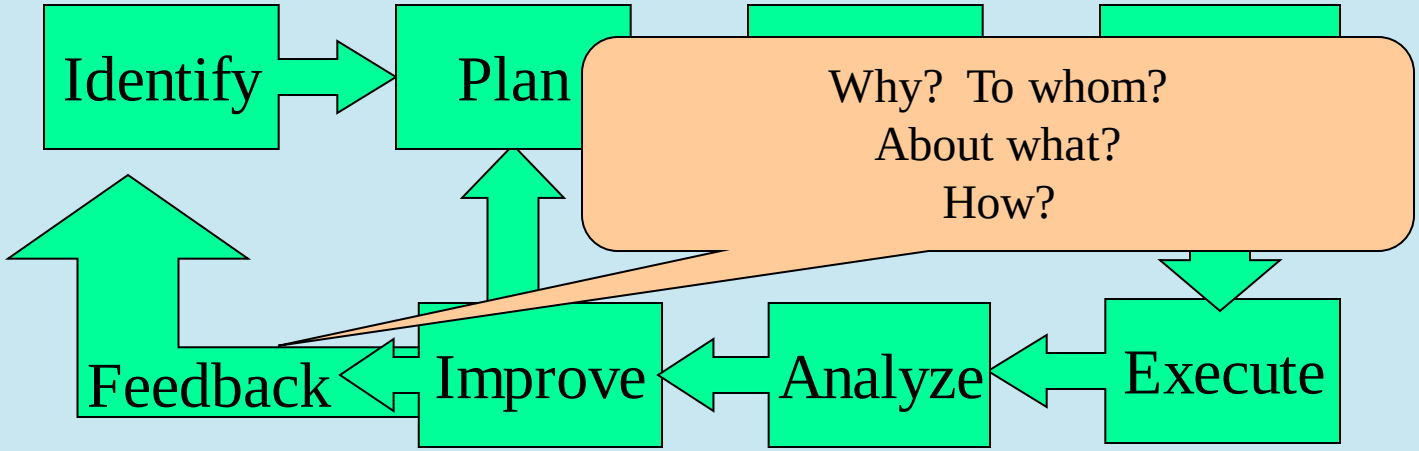
1. **Review details and feedback -- What can be done better next time?**
2. **Cross reference to RCM??**
3. **New knowledge gained re jobs, equipment?**
4. **Test correlation between Condition Measurement and Failure**
5. **Change in frequency?**
6. **KPI's updated and published**
7. **Make sure Analysis task in on a work order**

Planning, Scheduling & Control - Step 7



1. **Ensure proposed improvements are integrated into Maintenance Plan - contents, frequency, priority.**
2. **If failure is on critical RCM'd equipment, check RCM logic and adjust in maintenance plan for similar equipment.**
3. **Use KPI's to drive changes in behaviour**
4. **Set new KPI targets**
5. **Introduce new procedures and tools**
6. **Train and retrain**

Planning, Scheduling & Control - Step 8



1. **Ensure Feedback is provided to Technicians, Operators, Supervisors and Management**
2. **Broadcast successes, acknowledge failures**
3. **Announce new goals**
4. **Encourage future participation and feedback**
5. **Emphasize Continuous Improvement added value**

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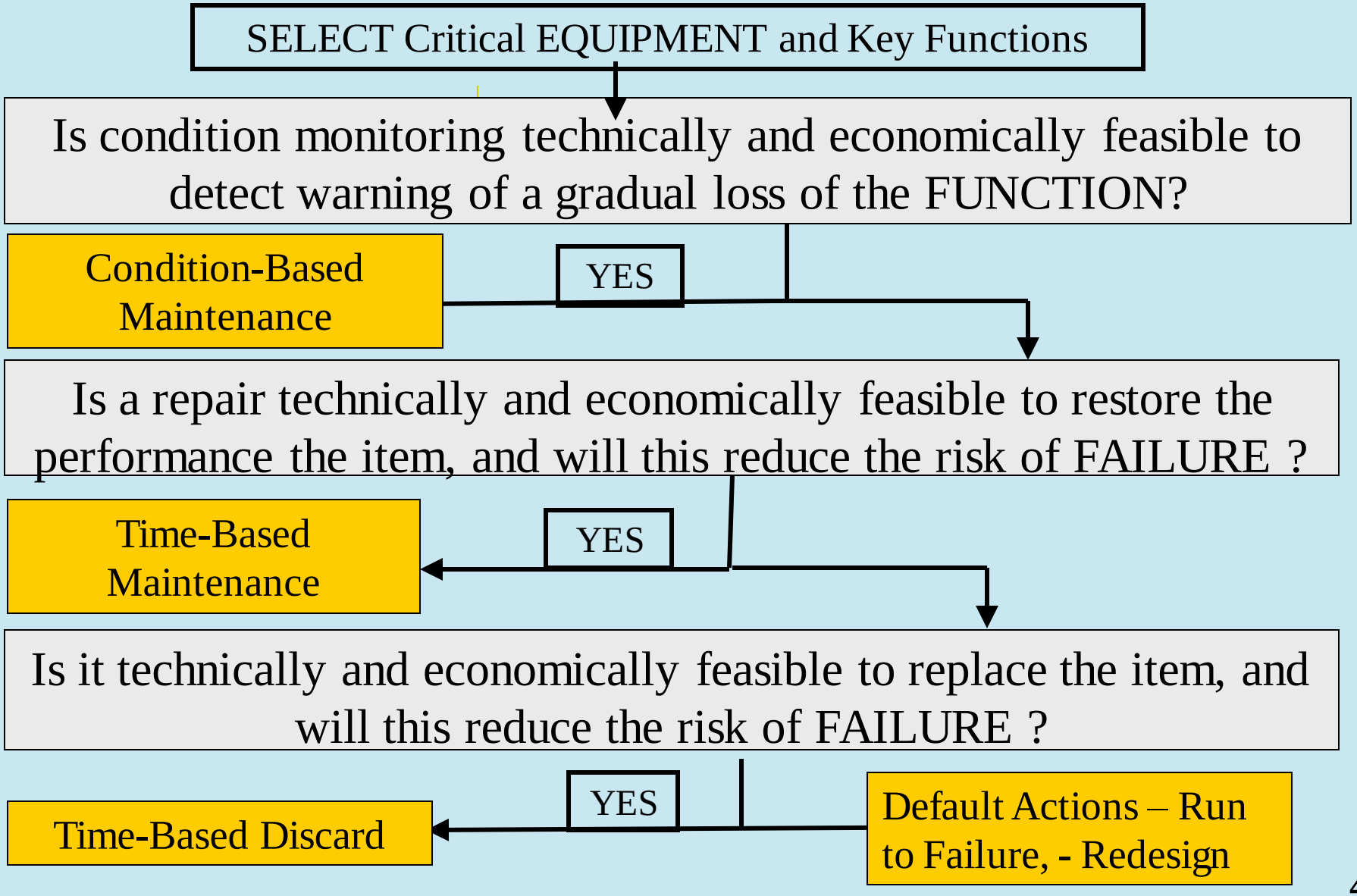
Equipment Management

1. Determine criticality through the critical functions of your critical equipment
2. Learn about failure curves for critical equipment
3. Determine functional failure and potential failure performance levels
4. Develop the right tactics – (measures to prevent or delay functional failures)
    1. preventive (PM, PdM)
    2. protective (back-up, stand-by, parallel process)
    3. failure cost reduction (fast replacement, spares management, inventory building)

Equipment Management

5. Use Work Order system to track history and continuously improve practices
6. Use inspections as the basis for tracking performance against required standards
7. Develop and track KPI's
8. Track Potential Failures versus Functional Failures
9. Investigate failures, Focus on remedial plans, ensure improvements are fed back to work order system
10. Modify tactics related to degree of degradation

RCM Methodology for selecting Work Tactics



Maintenance Tactic Selection Best Practices - Condition Based Maintenance (CBM)

Designed as preventive and predictive techniques to test the condition of the equipment and use it as the basis for deciding whether the appropriate response is to be triggered. Hence the sequence is:

1. perform an inspection to determine whether a potential failure has occurred
2. if not, then record that fact and close the inspection report
3. if yes, then initiate the appropriate preventive maintenance action to prevent or delay the consequences of the functional failure.

Criteria for using CBM

- It is possible to detect degraded conditions or performance
- The failure process is relatively predictable
- There is a practical inspection interval
- You can define a potential-failure condition that is detectable by a specific test or task.
- The warning interval is long enough that corrective actions can be taken
- The cost is less than the cost of failure

Maintenance Tactic Selection Best Practices Time–Based Maintenance (TBM)

Where CBM is not feasible (eg due to the inability to measure degradation), then TBM Time–Based Maintenance (repair or replacement) is the next tactic

1. Will be effective if the failure patterns correspond to a known narrow range in time
2. or if the maintenance is dependent primarily on a seasonal or external time-based event.

Criteria for using TBM

- The item has an identifiable “life”
  - ie Most items survive to that age and …
  - Few items last beyond that age
- The tactic restores the item's condition or performance
- The condition degradation is not measurable
- The cost of the TBM is less than the cost of failure

Maintenance Tactic Selection Best Practices Re-design

If CBM and TBM are not feasible, then a Redesign of the equipment or the system is the next best practice

1. To design out the causes of the failures
2. Or design in a way of exposing degradation and potential failure
3. And is the re-design cost effective
4. May apply to a process or procedure as well as an equipment

Criteria for Redesign

Redesign is required when scheduled maintenance (CBM or TBM) cannot:

1. Reduce exposure to safety/environment related failures, or
2. Reduce exposure to failures resulting in loss of operational capability or in major repair cost, or
3. Make a hidden failure visible

Redesign is Desirable

1. For hidden failures where the risks of multiple failures remain unacceptable
2. for operational and non-operational failures to reduce the total cost of failure

And the cost of the redesign lower than the cost of failure

Maintenance Tactic Selection Best Practices Run to Failure

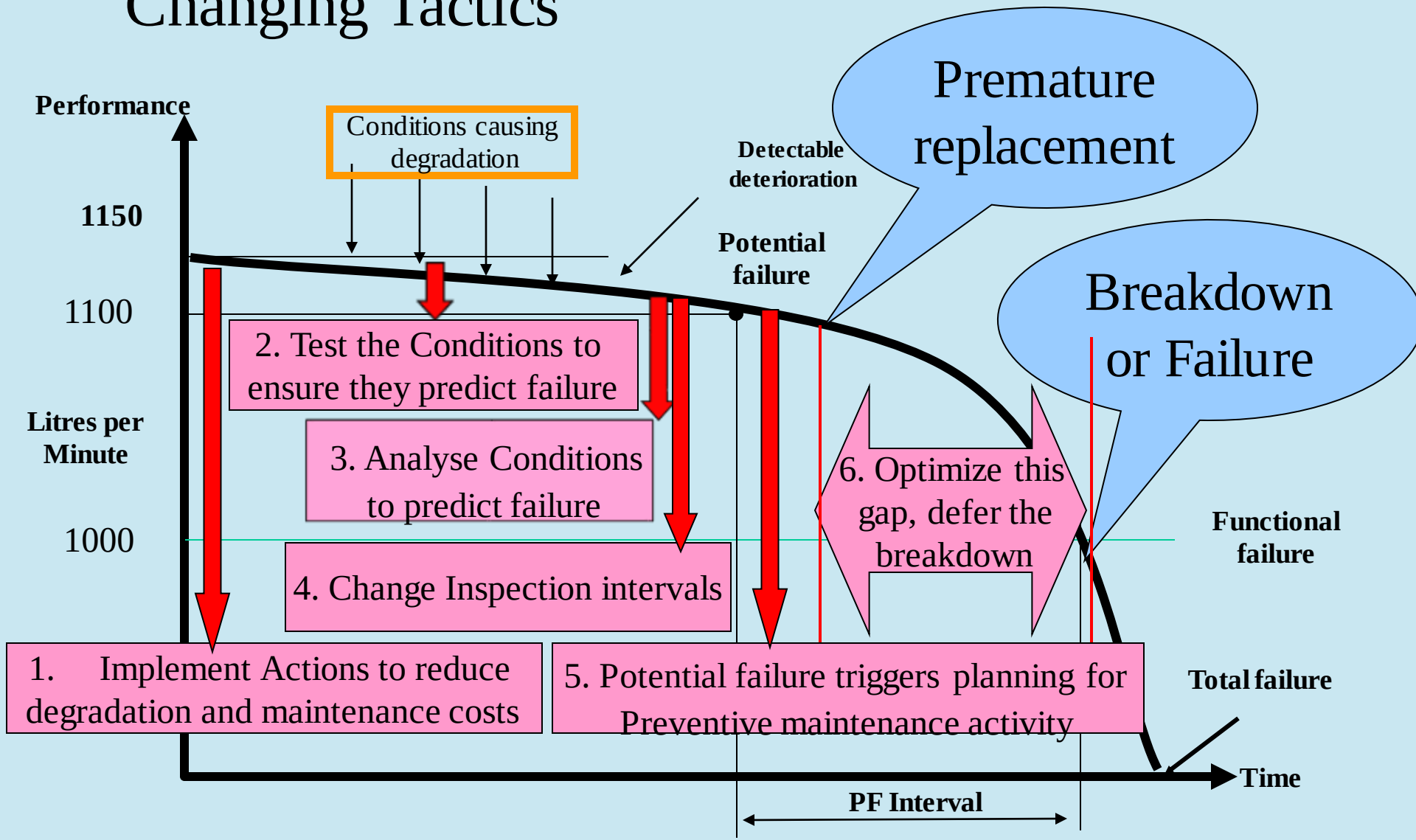
Where CBM, TBM and Redesign cannot prevent the consequences of failure….

1. Allow run to failure
2. Followed by repair or replace.
3. If the cost of prevention is higher than the cost of the failure, then Run To Failure (RTF) is Best Practice

Criteria for Run to Failure

- Applicable to non-critical failures if
  - Feasible and cost-effective preventive tactics cannot be found
  - Suitable preventive or failure-finding tactics cannot be found for hidden failures
- Applicable for equipment that usually runs to the end of its useful life:
  - Electronic Circuit Board Assemblies (PLC's)
  - Fuses
  - Circuit Breakers
- Applicable where the cost of prevention is higher than the cost of failure

Changing Tactics



Work Identification

Work originates from:

1. work requests – including:
    1. observations from maintenance
    2. operations or other staff
    3. inspections identifying a potential failure
    4. work identified in the performance of repair or PM activities
2. pre-determined (PM) Preventive Maintenance activity
3. functional failure (the failure of an equipment to perform its required function) leading to a repair or replacement
4. breakdowns – again, leading to a repair or replacement

What's the Purpose of an Inspection?

- To identify a Potential Failure
- To monitor a Condition (a CM Task)
- To measure an "Actual" against a standard
- To find out the status
- To decide on action if there is a Functional Failure
- To meet a regulatory requirement
- To make sure things are ok?
- To fill in another point on a trend?

The test of a good inspection task is that it alerts in time to action a cost effective preventive task

Inspections Best Practices

1. Inspection readings are recorded as actual readings (not just a check box)
2. Inspection sheet should show an acceptable range; readings outside this range should be considered potential failures
3. Only those inspection readings which are valid should be collected – typically those where the condition is tied to a functional failure
4. Inspection sheets should be signed off by the inspector collector who is attesting to the accuracy of the readings.

Sample Inspection Sheet

Inspection Sheet for Pump xxxxxxx		**Inspection date:-**			**Inspector:-**
Item	Normal Reading	Potential Failure	Functional Failure	Actual Reading	Action
Shaft Vibration	< 0.01	> 0.008	> 0.01	0.005	none
Operating Temperature	80-110 deg	< 85 > 105	< 80 > 115	110	PF has occurred, FF pending. PM Needed
Volume Capacity	> 300 l/m	< 300	< 300	250 l/m	FF has occurred – PM Urgent – STOP THE MACHINE
< --------Pre-printed on Inspection sheet ---------- >				< -To be completed by the Inspector>	

Control of Work Execution

Who is responsible for quality of work execution?

- Post-completion inspection
- Usually done by supervisor or QA
- Needed to control quality, timeliness
- Work Order is a key document (task sequences, materials, tools, right skills etc)
- For complex or new jobs, hold a job-site meeting led by the technician to describe what was done, what was learned, what should be improved

Control of WO Completion

- **Usually very poorly done**
- **Technicians don't like paperwork – want to get on with next job**
- **Set the standard and be consistent.**
- **If a number of tasks, add a check box and sign-off that work was done**
- **If the technician completing the work has the responsibility for completing the records (paper or computer), make sure the task is included on the Work Order task list and time is allotted to it.**
- **If not completed properly, then it must be rejected – by supervisor or CMMS clerk.**
- **Ensure that the authority for accepting (or rejecting) the data quality is clear and is enforced.**
- **Any attempt to do reliability analysis, predictive trends etc will fail if this is not done well.**
- **Where equipment failures occur, ensure that the feedback information is especially clear and the reasons for failure are well understood and documented.**

Work Analysis Best Practices

1. Include the Work Analysis step on a Work Order, assign a resource and a priority; make sure that uncompleted work analysis is included in the backlog review.
2. At the completion of the work, review the details and feedback – asking the questions:
   - What can be done better next time – in terms of task sequences, materials and tools required etc?
   - Have we learned anything new in terms of the failures, failure modes, failure effects?
   - Is the correlation between Condition Measurement and Failure sound?
   - Is a change in frequency suggested?
3. Update the Key Performance Indicators (KPI's)

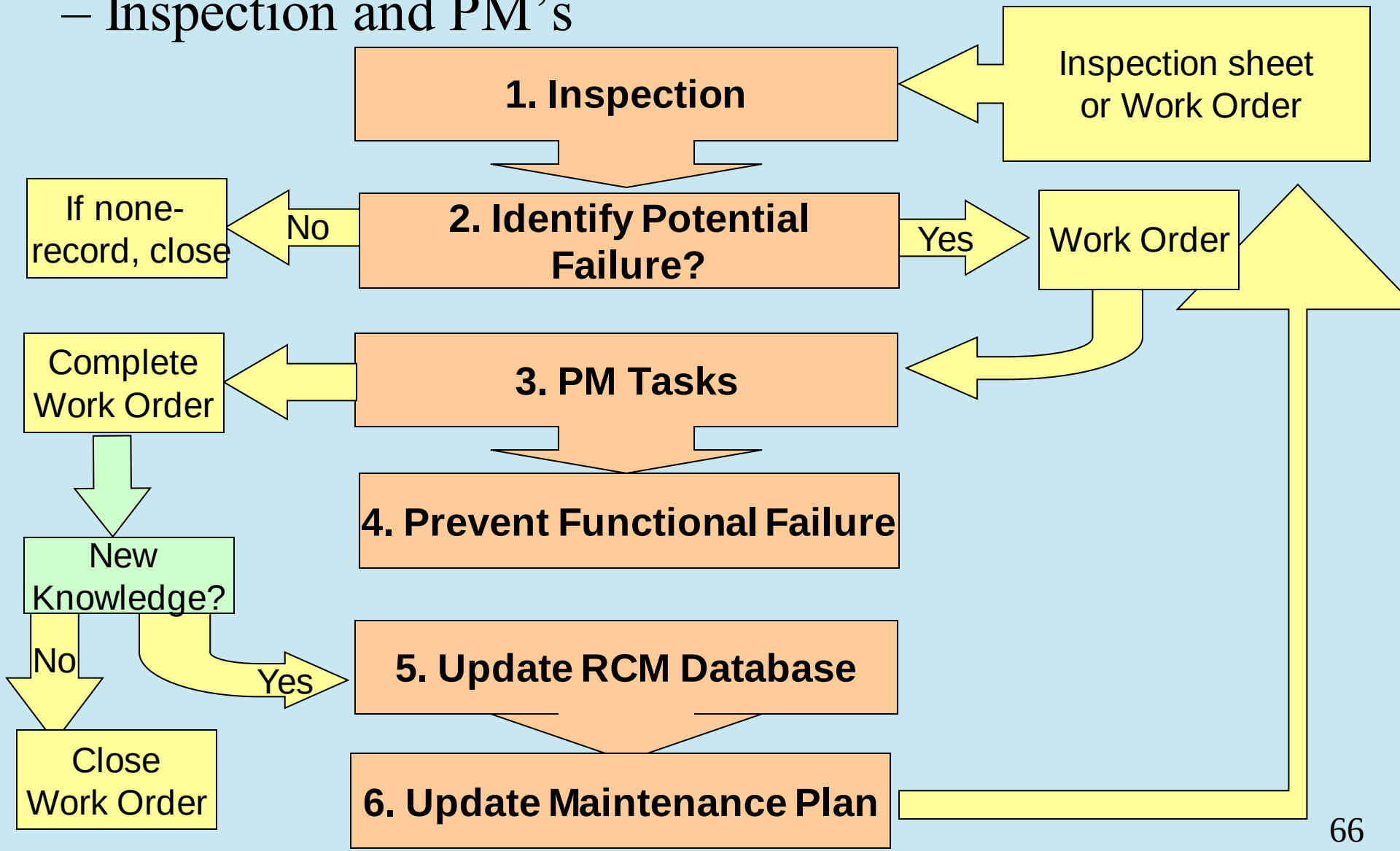
Work Improvement Best Practices

1. Where new knowledge is gained in failures, failure modes, failure effects, then that should be passed to the RCM team for validation and subsequent update of the RCM database and the Maintenance Job Plans.
2. Where improvements in the Work Order are required in terms of content, frequency, priority etc, then ensure they are integrated into Maintenance Plan so that the next iteration will include them
3. If failure occurs on critical equipment that has been subjected to RCM analysis, then check the RCM logic and adjust in maintenance plan for this and similar equipment.
4. Use KPI's to drive changes in behaviour and set new KPI targets
5. Where new procedures and tools are introduced, ensure that the technicians are sufficiently trained.
6. Where comments have been made on the work order, ensure feedback is provided to the originator
7. Broadcast successes, acknowledge failures, announce new goals
8. Encourage future participation and feedback; emphasize Continuous Improvement

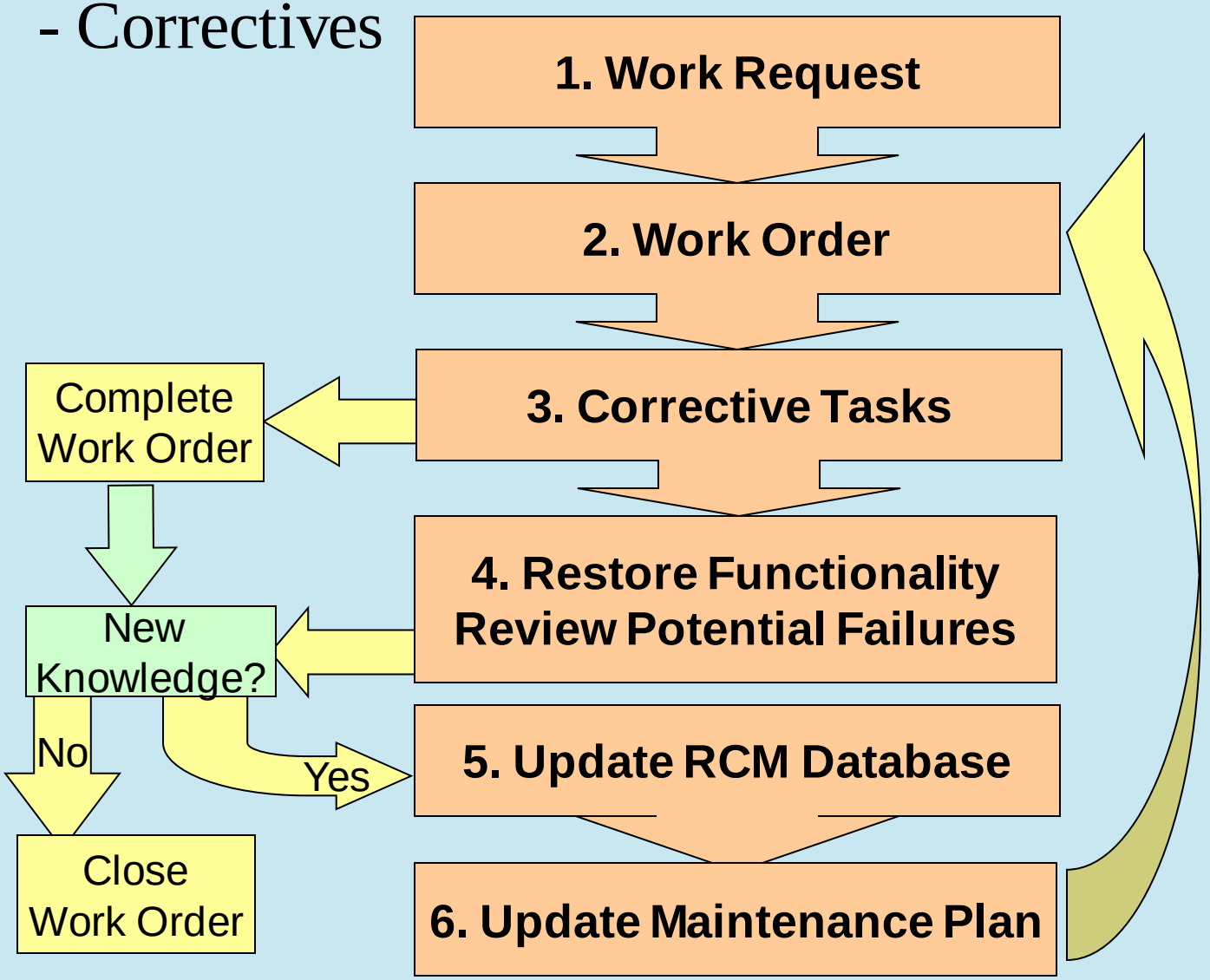
Agenda

1. Introduction and definition of Best Practices
2. The Maintenance Cube of Excellence
3. Maintenance Assessment
4. Best Practices for Maintenance Strategy
5. Using KPI's to drive Best Practices
6. Work Orders , Planning, Scheduling and Control Best Practices
7. Equipment Management and Work Tactics
8. ***Continuous Maintenance Improvement Best Practices***

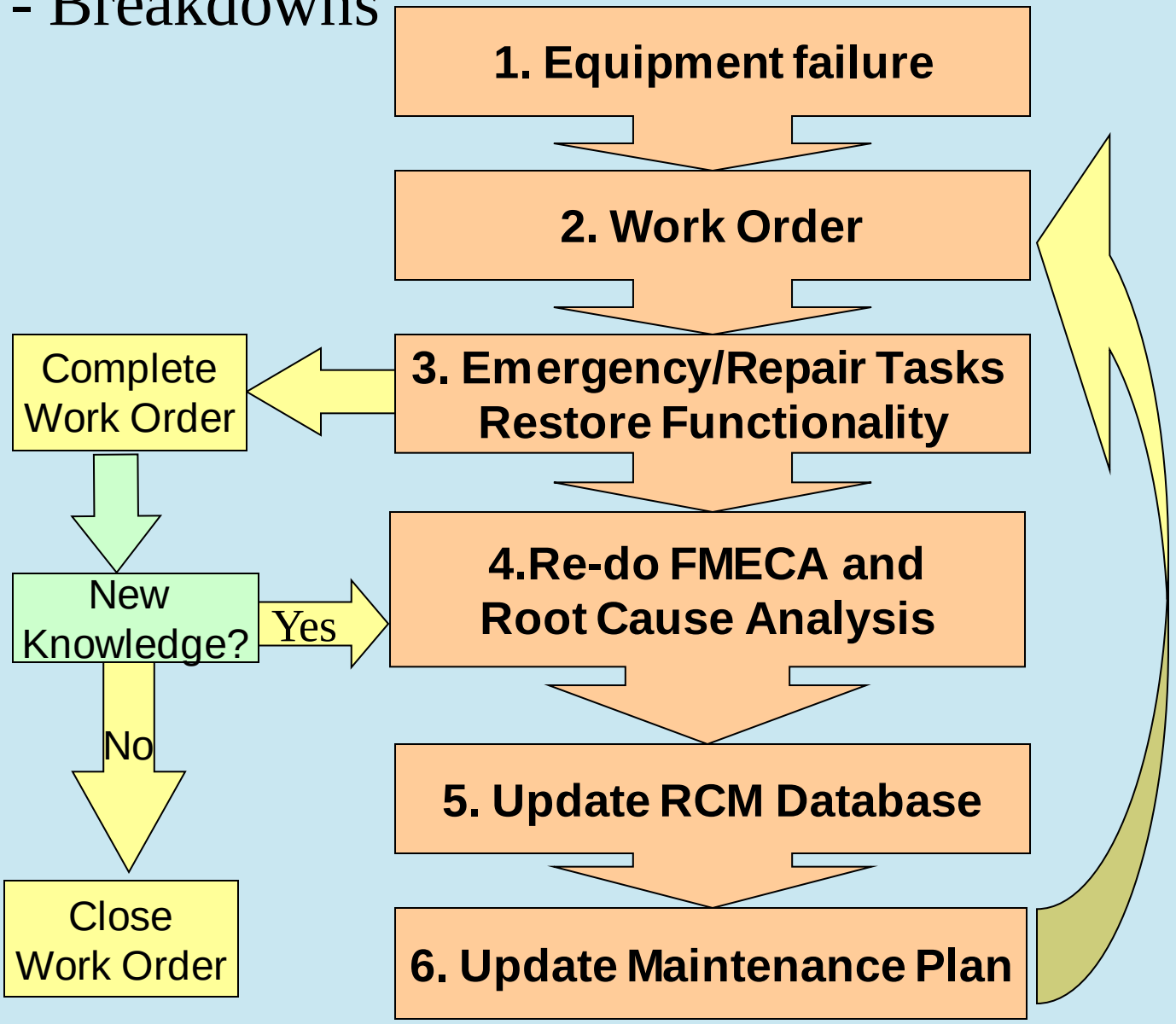
Continuous Maintenance Improvement:
– Inspection and PM's



Continuous Maintenance Improvement - Correctives



Continuous Maintenance Improvement - Breakdowns



Personal Development Plan Workshop:

1. Review what we have talked about today
2. Select at least three ideas that you like to implement or would like to know more about.
3. Prioritize
4. Develop an Action Plan

Idea #	Idea	Priority
1		
2		
3		
4		
5		
6		
Exam-ple 1	Build table showing Equipment Criticality	High
Exam-ple 2	Set measurement levels for Potential Failures	Top

Questions???
Results…… Successes?
Let me know!

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