Data-Driven Maintenance Operations

Training Session for Competency

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Agenda:

- Purpose of the training session
- Competitive North Star for maintenance
- Structure North-Star maintenance processes
- Description of the North-Star processes
  - Mandatory practice and process
  - Workload and service interval processes
  - Maintenance capacity processes
  - Recountive insight processes

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Purpose of the training session:

The first step to becoming a data-driven operation is that process role holders must reach a clear, implementable understanding of what it entails. Training to distribute the understanding is the prerequisite to this session—First Step to Becoming a Data-Driven Operation.

The purpose of this session is to describe the particular data-driven maintenance processes to achieve a plant's inherent maximal uptime, stay abreast of its site and facility deterioration, and match a plant's maintenance capacity to those ends. The subject processes are remarkable because they are only possible through data-drivenness.

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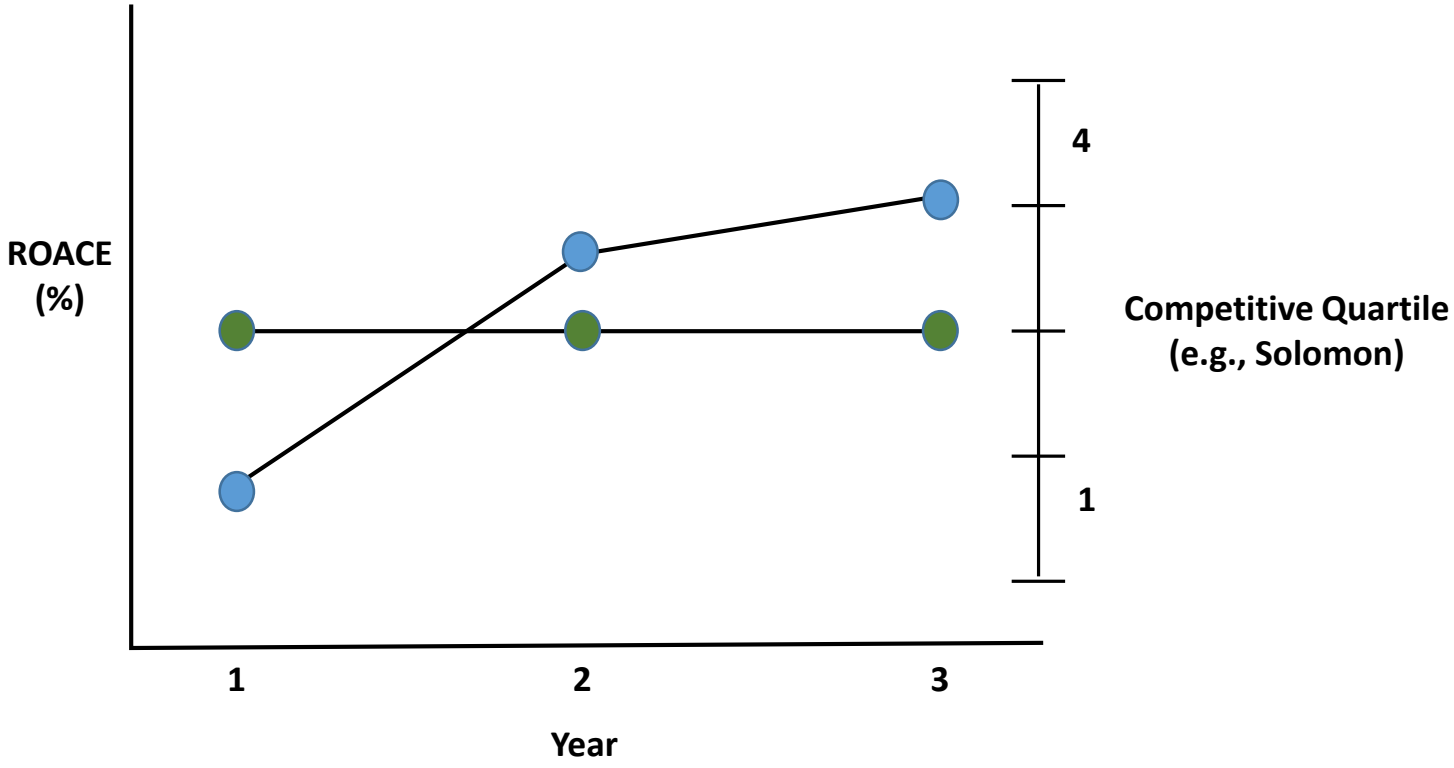
All firms chase the same prize regardless of the basis of competition—a rate of return above the average of its industry



Losers are eventually consumed or pushed out by the winners; something most of our careers have been stung by at some point.

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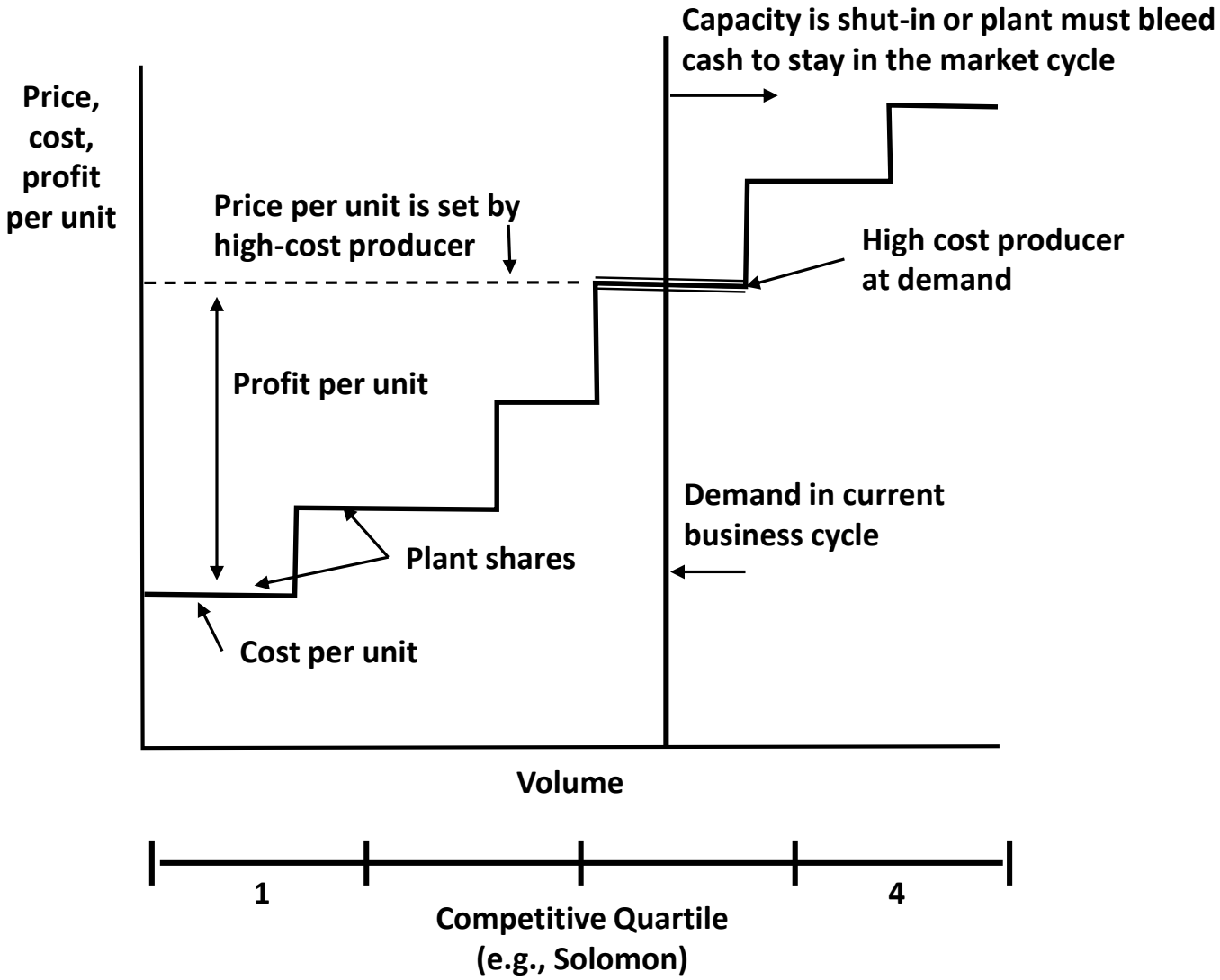
To link plant maintenance and reliability to competitiveness let's look at the core-most basis of competitiveness to commodity industries—cost leadership



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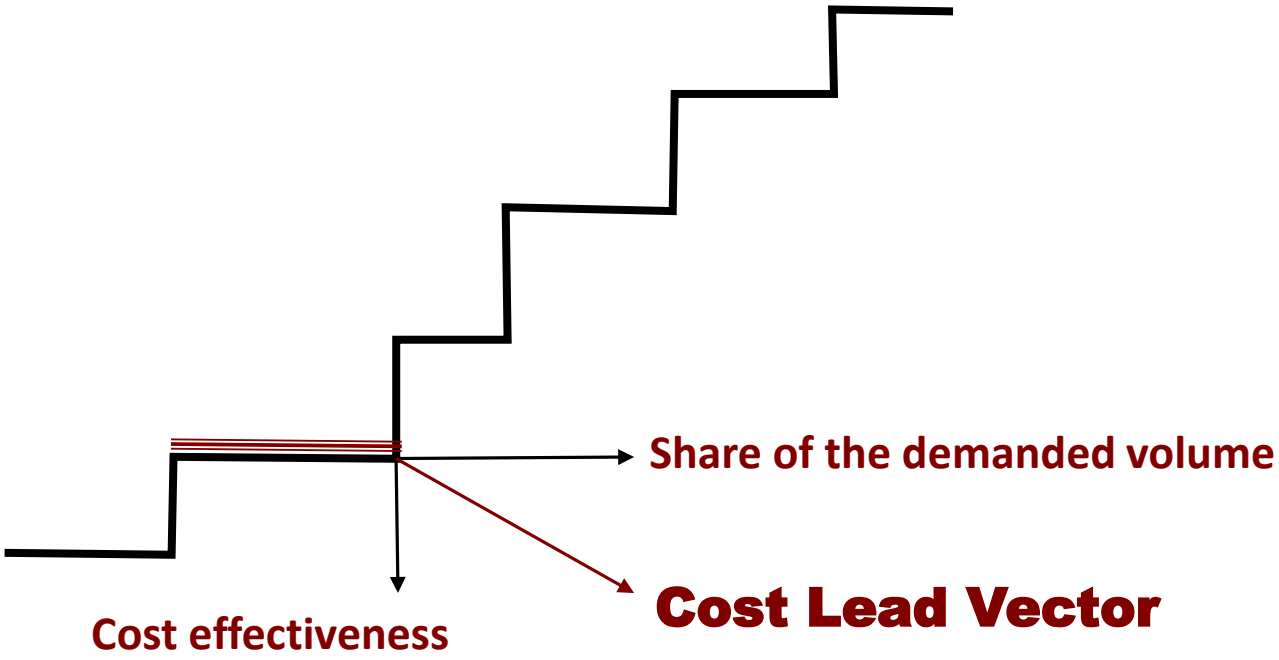
The competitive purpose of maintenance and reliability can be depicted as a firm's place in an industry's hierarchy of cost leadership



The overall objective is to drive the Cost Lead Vector to the right and downward.

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Maintenance operations have a direct mandate with respect to the **Cost Lead Vector**

- **Recognize and do the work at all levels of the maintenance operation to:**
  - **Sustain the readiness of production assets to deliver the aggregate and weekly production plan.**
  - **Stay abreast of site and facilities deterioration.**
- **Establish and function with the maintenance capacity that matches the workload of readiness and deterioration—craft and staff head count, parts and materials, equipment and facilities.**

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A firm's success in the mandate for maintenance operations can be measured as a readily constructible proxy to ROACE (Return on Average Capital Employed)

$$\text{ROACE} = \text{Unit profit as Percent} \times \text{Ratio Revenue to Assets}$$

$$\text{Proxy ROACE} = \left[\frac{\text{PricePerUnit} - \text{MaintenanceCostPerUnit}}{\text{PricePerUnit}} \times 100 \right] \times \frac{\text{PeakProductiveCapacity} \times \%\text{Uptime} \times \text{PricePerUnit}}{\text{AssetReplacementValue} + \text{MaintenanceAssets}}$$

- The proxy will compute a higher than overall ROACE, but allows to isolate influence of the workload of uptime and maintenance capacity on ROACE.
- The training session will focus on the factors to ROACE that operational practices directly influence—maintenance cost per unit and delivered inherent Uptime.
- Assets in the P-ROACE:
  - Replacement value (RAV) is decided by engineering and maintenance assets by policy.
  - Maintenance assets have minor effect on Ratio Revenue to Assets, but play through the effect of service interval on Uptime

See paper, "ROACE: Financial North Star to Maintenance and Reliability Operations" for explanation of standard ROACE.

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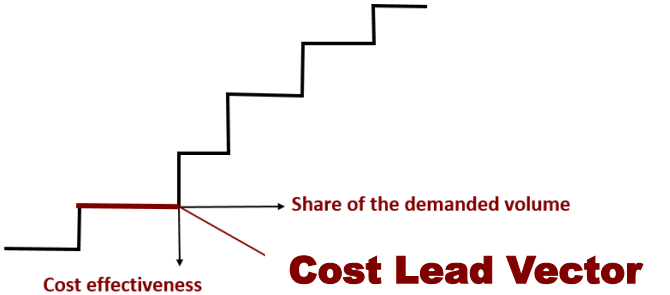
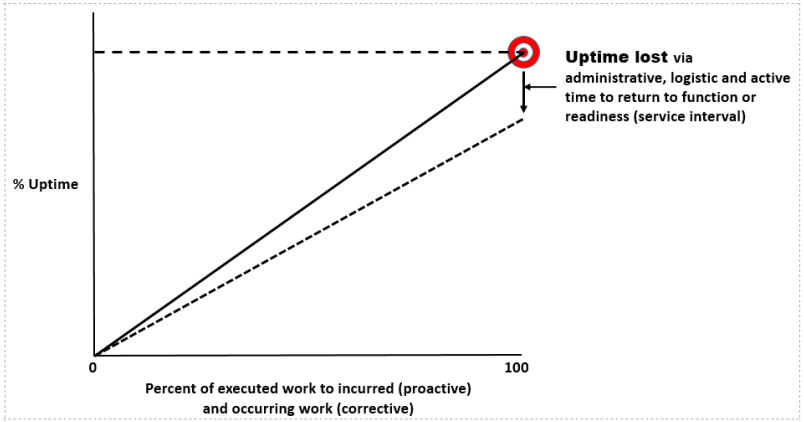
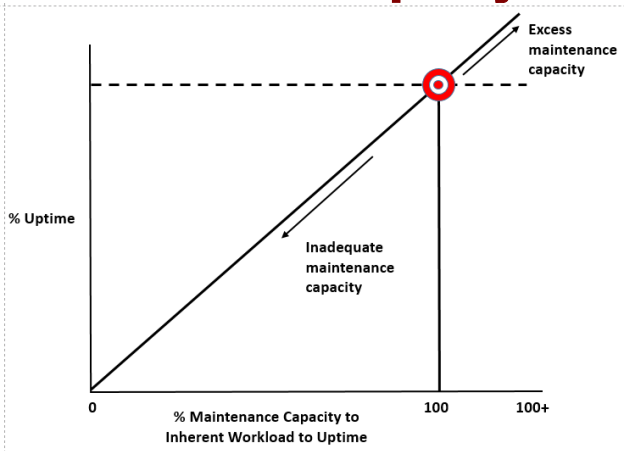
Uptime and cost per unit in the Cost Lead Vector are linked to two specifiable, manageable dimensions of a data-driven maintenance operation



Workload and Service Interval



Maintenance Capacity



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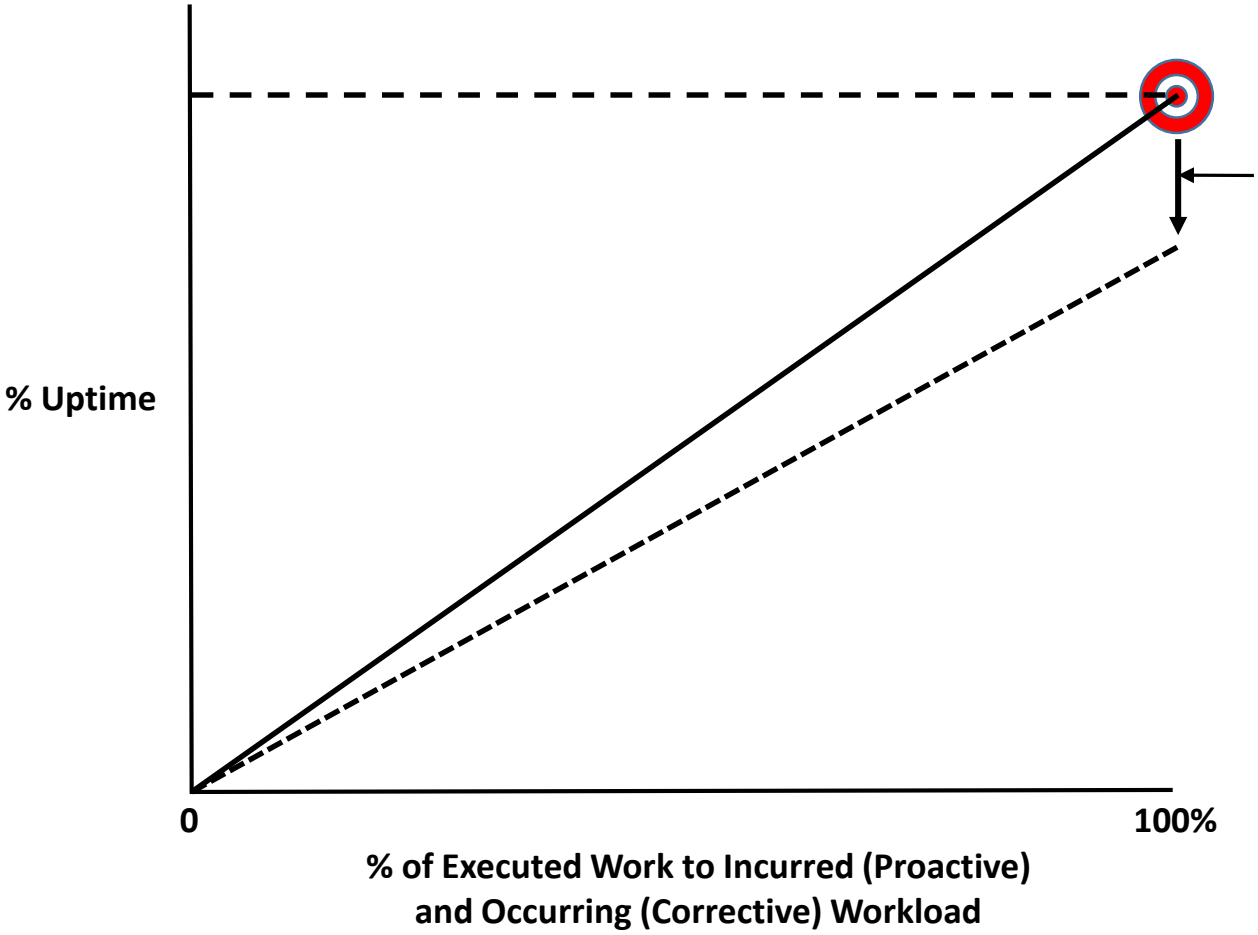
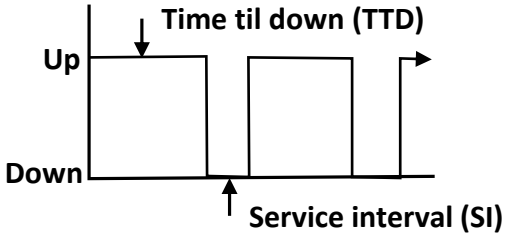
All plants have a workload inherent to targeted uptime and deterioration control, and an inherent service interval to both



Uptime lost via administrative, logistic and active time to return to function or readiness (service interval)



$$\%\text{Uptime} = \frac{TTD}{TTD + SI} \times 100$$

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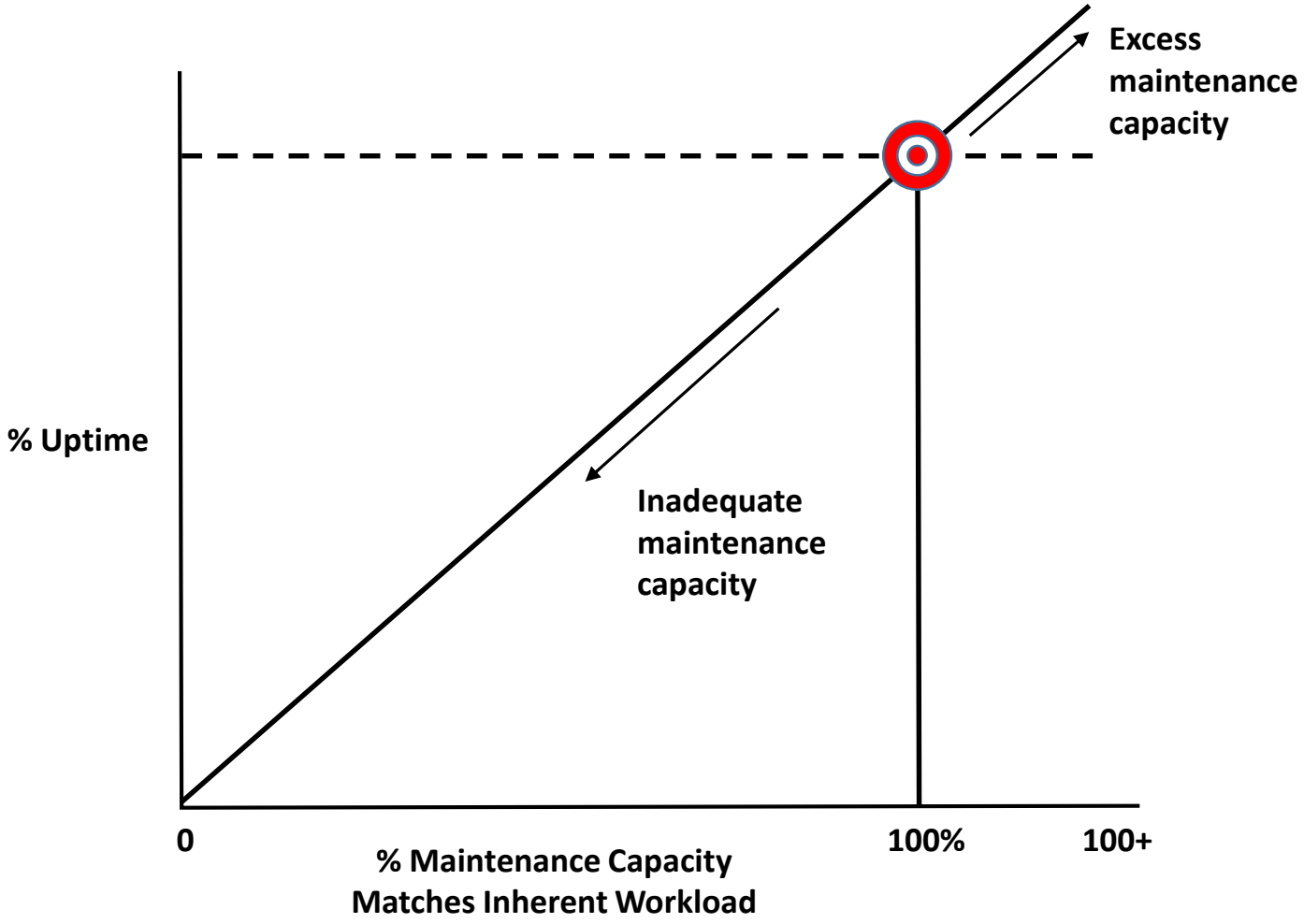
Maintenance capacity decides whether or not inherent workload can be executed, but excess capacity reduces P-ROACE



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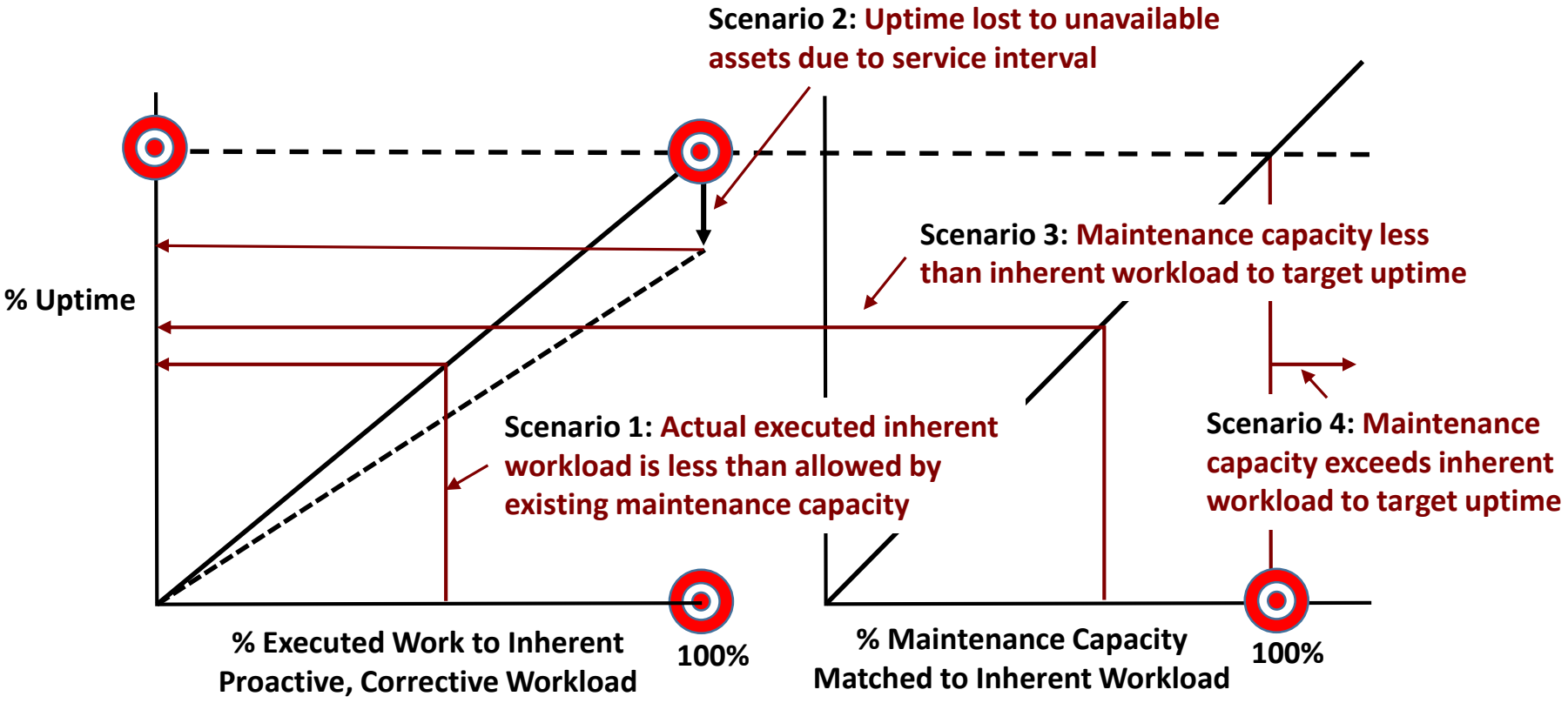
A plant's inherent workload, service-interval effect and maintenance capacity can interplay in four **scenarios** contrary to P-ROACE



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The four contrary scenarios of workload, service interval and maintenance capacity variously have a direct **multiplicative** impact on P-ROACE

Scenario	Consequence for Proxy-ROACE	
	Unit Profit as Percent	**Ratio Income to Assets**
1. Executed inherent workload is less than capacity for maintenance.	Reduced by increased maintenance cost per unit.	Reduced as Uptime is less than achievable at existing capacity.
2. Uptime lost to unavailable assets due to service interval	Reduced by increased maintenance cost per unit.	Reduced as Uptime is less than achievable.
3. Maintenance capacity is less than inherent workload	Unchanged.	Reduced as Uptime is less than achievable target.
4. Maintenance capacity exceeds inherent workload to target Uptime	Profit as percent is reduced as cost per unit is increased	Unchanged.

P-ROACE = Unit profit as Percent X Ratio Revenue to Assets

Multiplicative impact

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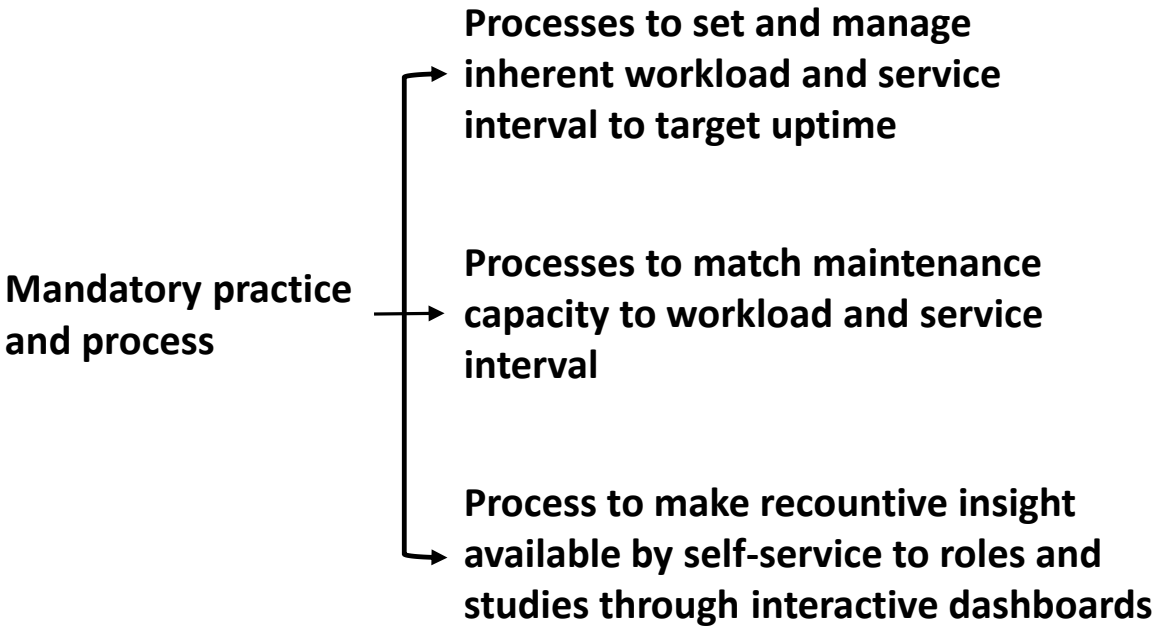
Downward from the outcomes of workload, service interval and maintenance capacity to P-ROACE are groups of particular data-driven processes



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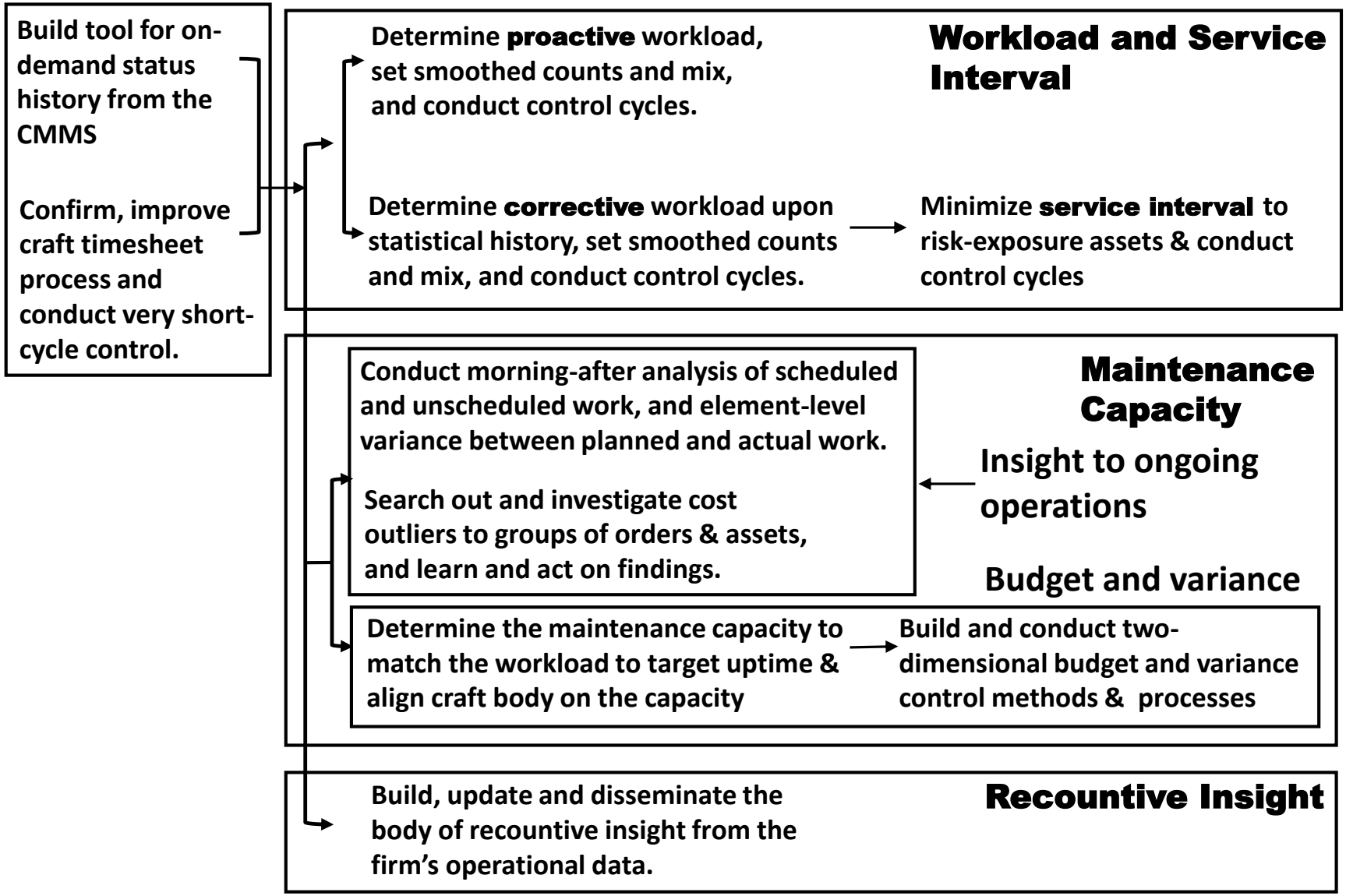
Working down from the proxy P-ROACE; there are top-level process in which all other best practices of R&M are subordinated



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Each process of the structure of processes will be explained in dedicated sections to follow

- **The explanations will chart the high-level activities, but are actually frameworks upon which each process will be designed in detail to reflect the firm and plant.**
- **A generalized implementation plan is by provided and explained in the training session, "First Step to Becoming Data-Driven Operation."**
  - **Section titled, "Generalized Implementation Plan."**
  - **(download https://analytics4strategy.com/train-frststpdtdrvnops with link provided in the session description).**
- **Threaded throughout each of the processes is the practice of building super tables by joining multiple tables from one or more sources.**
  - **Introduced in the section to this session title, "Processes for Recountive Insight."**
  - **A deep explanation is provided by the section titled, "Gather, Join and Cleanse data, and Form Super tables," which is also provided by the first step training session.**

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In the charted process, the placement of insight deliverables will be annotated as the following code

Code	Insight Deliverable
KID	Know-thy-data
RID	Recountive
MID	Modeled

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Throughout all data-driven processes there are control cycles as will be coded in their flowcharts

Code	Definition
VSCC	**Very Short Control Cycle:** Cycle is less than weekly, next or same day.
WCC	**Weekly Control Cycle:** Done with respect to a completed business week.
MCC	**Monthly Control Cycle:** Occurs in conjunction to the reporting cycles at the closing of the books at the month.
YCC	**Yearly Control Cycle:** Control annually and year-to-date.

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Without two types of data—captured in all CMMSs—a plant will be unable to determine and manage workload, service interval and maintenance capacity

- **Status history to lists of work orders.**
  - Incredibly CMMS's do not offer the report, but the history data is captured automatically as work orders progress from notification to full close out.
  - Status history is actually a simple query that data engineers can develop as a standard on demand report from the CMMS.
  - Creating and deploying the data as on-demand report is an easy several day project to one of the firm's data engineers.

- **Craft hours accurately recorded to the work done.**
  - It is not unusual to find that hours are recorded to less than 50 percent of the work orders.
  - It is also not unusual to find the users of hours data are not aware that they are working with the resulting misinformation.
  - Cause is typically poorly designed or unenforced timesheet process.
  - Redesign and compliance requires management support one level up from the organizational units that conduct the daily and weekly steps to record craft hours to the plant's payroll process.

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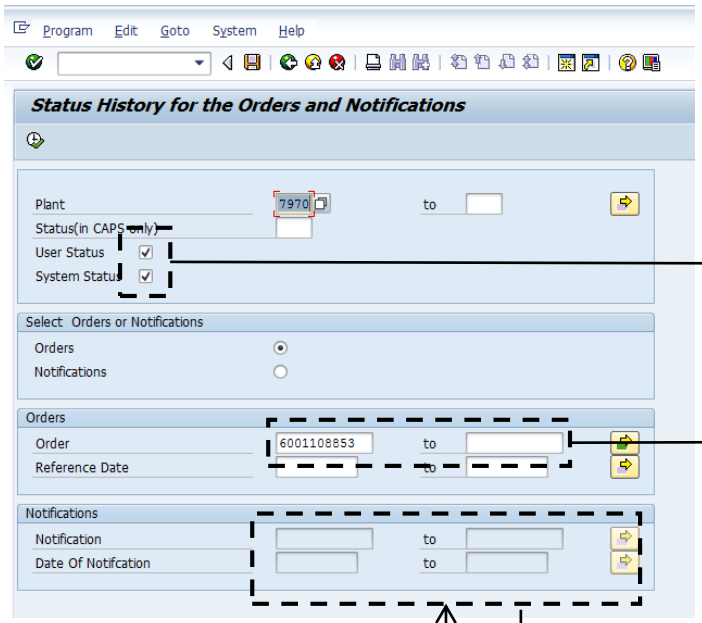
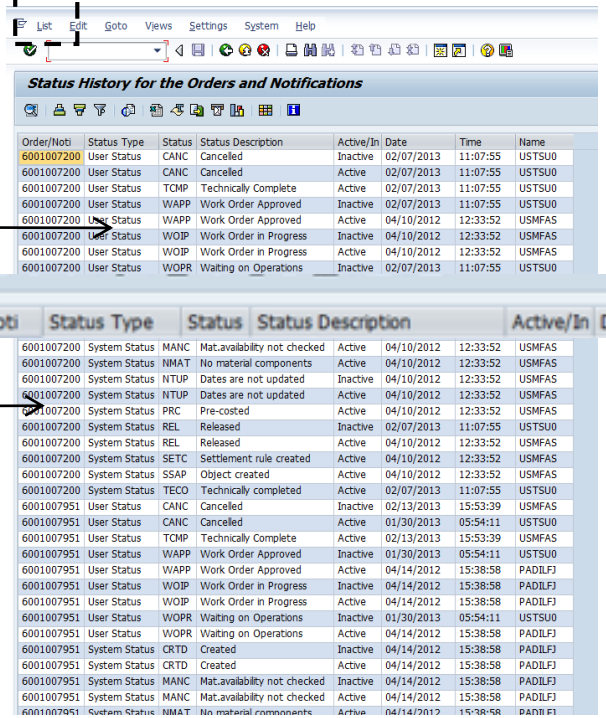
Mandatory Practice: Build tool for on-demand status history from the CMMS

SAP transaction: ZPM_WO_HISTORY

Export to Excel Table





Take same route with respect to notifications

1	Notification
2	Order
3	Description
4	User status
5	System status
6	Cost center
7	Planner group
8	FunctLocation
9	Created on
10	Changed on
11	Description2
12	Main WorkCtr
13	Notif.date
14	Notifictn type
15	Priority

Join the status history to the detail of the notifications through SAP IW29: List of notifications (Done with MS Access query functionality)

Note that the example (SAP CMMS) delivers the what-when detail that is foundational to the analyses and control of any operation through its processes

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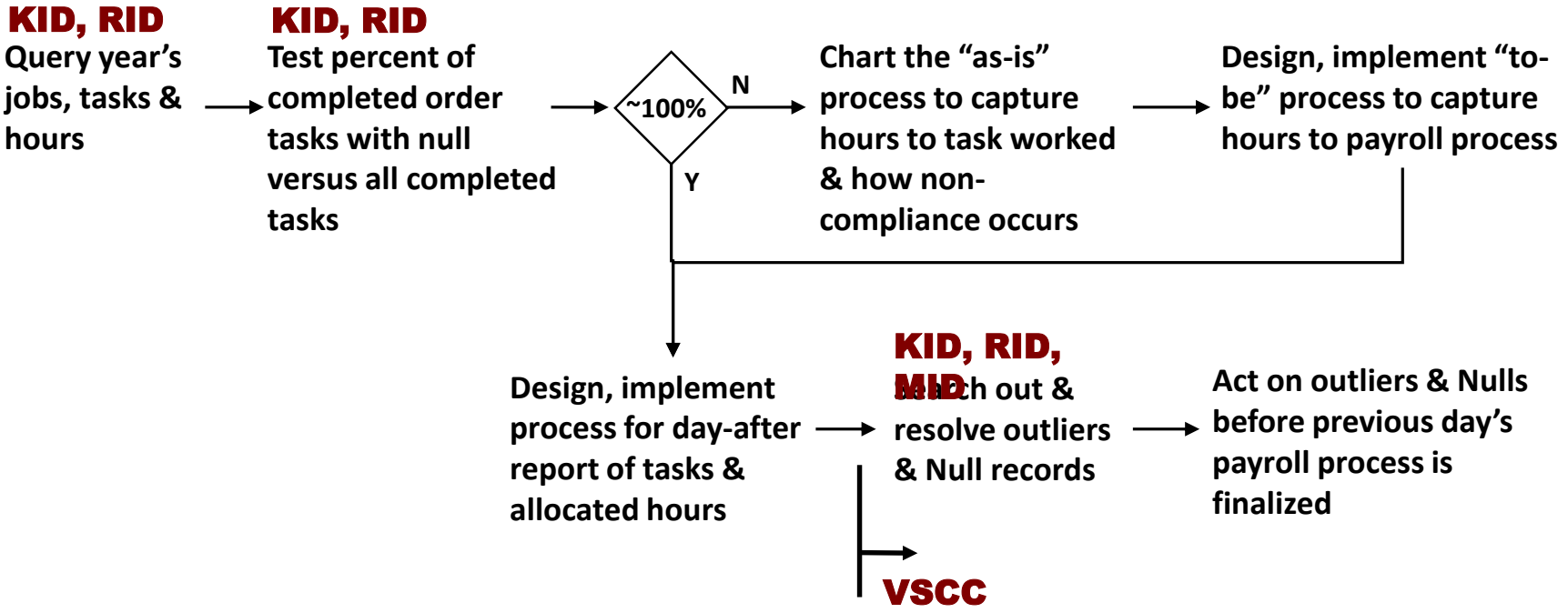
Mandatory Process: Confirm, improve craft timesheet process and conduct very short-cycle control



- Day-after VSCC is warranted because accurate allocation is life-is-blood data to maximizing P-ROACE.
- Without accuracy, data is only valid at the boundary that a particular body of crafts operate, all below that data is misinformation.

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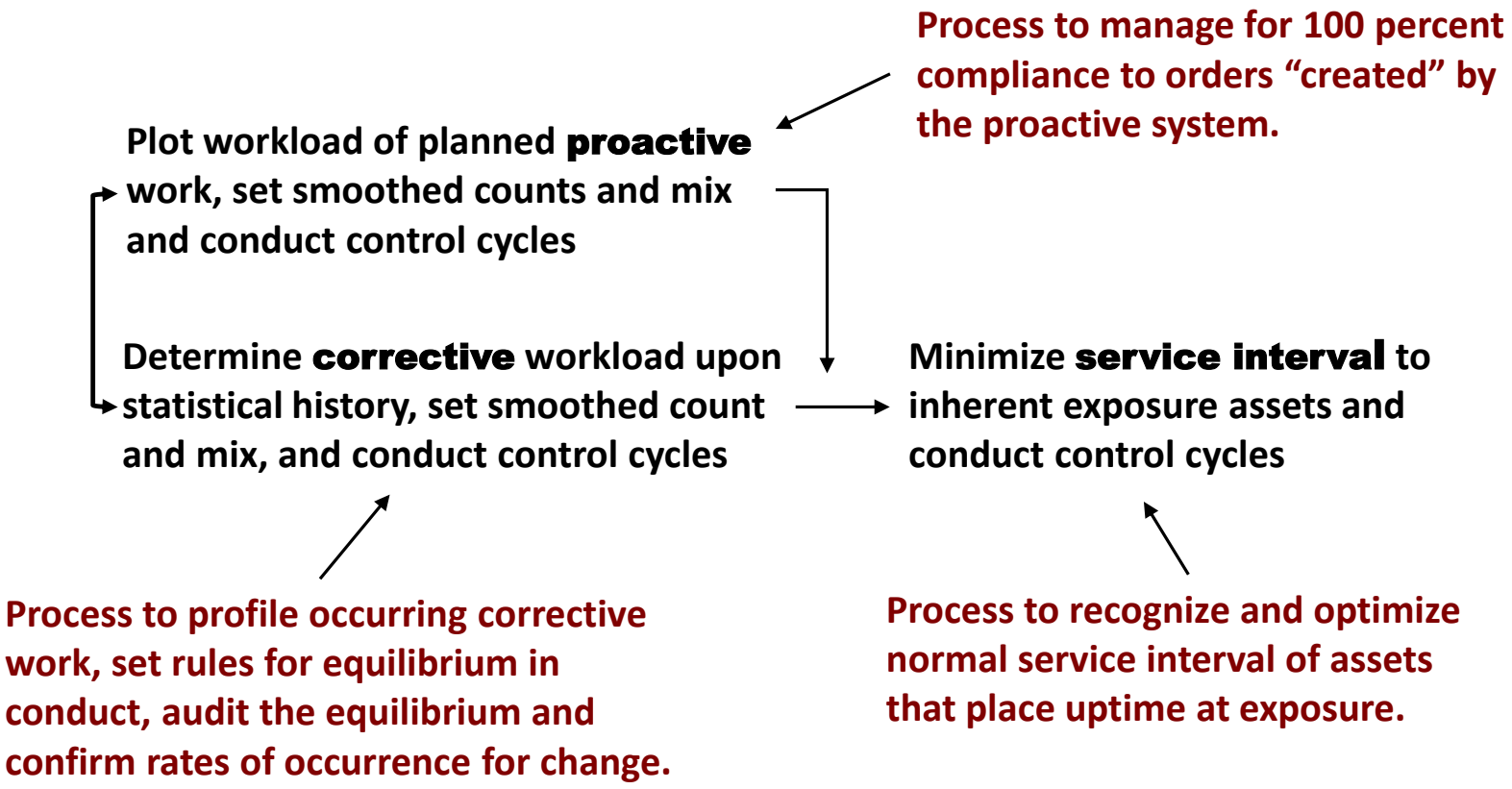
The platform determinate of realizing targeted uptime and protecting asset value is to quantify and timely execute the workload to sustain both



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There is a set of principles that are inherent to establishing the year's workload

- **All plants have an inherent workload to any given level of aggregate production for the year.**
- **The workload is quantifiable by plan (proactive maintenance) and by statistical analytics (corrective maintenance).**
  - **See paper: "Setting the Budget for Maintenance Workload."**
- **The link from workload to maximally cost effective matching maintenance capacity is the outcome of smoothing the count and mix of work orders.**
  - **See paper: "Size Maintenance Craft Capacity on Forecasts, Not Backlog."**
- **Time series analytics looms large to determining inherent workload and smoothing.**
  - **See paper: "Explore what Did and May Happen with Time Series Analytics."**
- **Duration analytics looms large to determining maintainability for risk exposure assets.**
  - **See paper: "Find the Time that is Money By Asking Durations Questions."**
- **The determined workloads are the target metrics to plant function rather than rule-of-thumb to maintenance metrics.**

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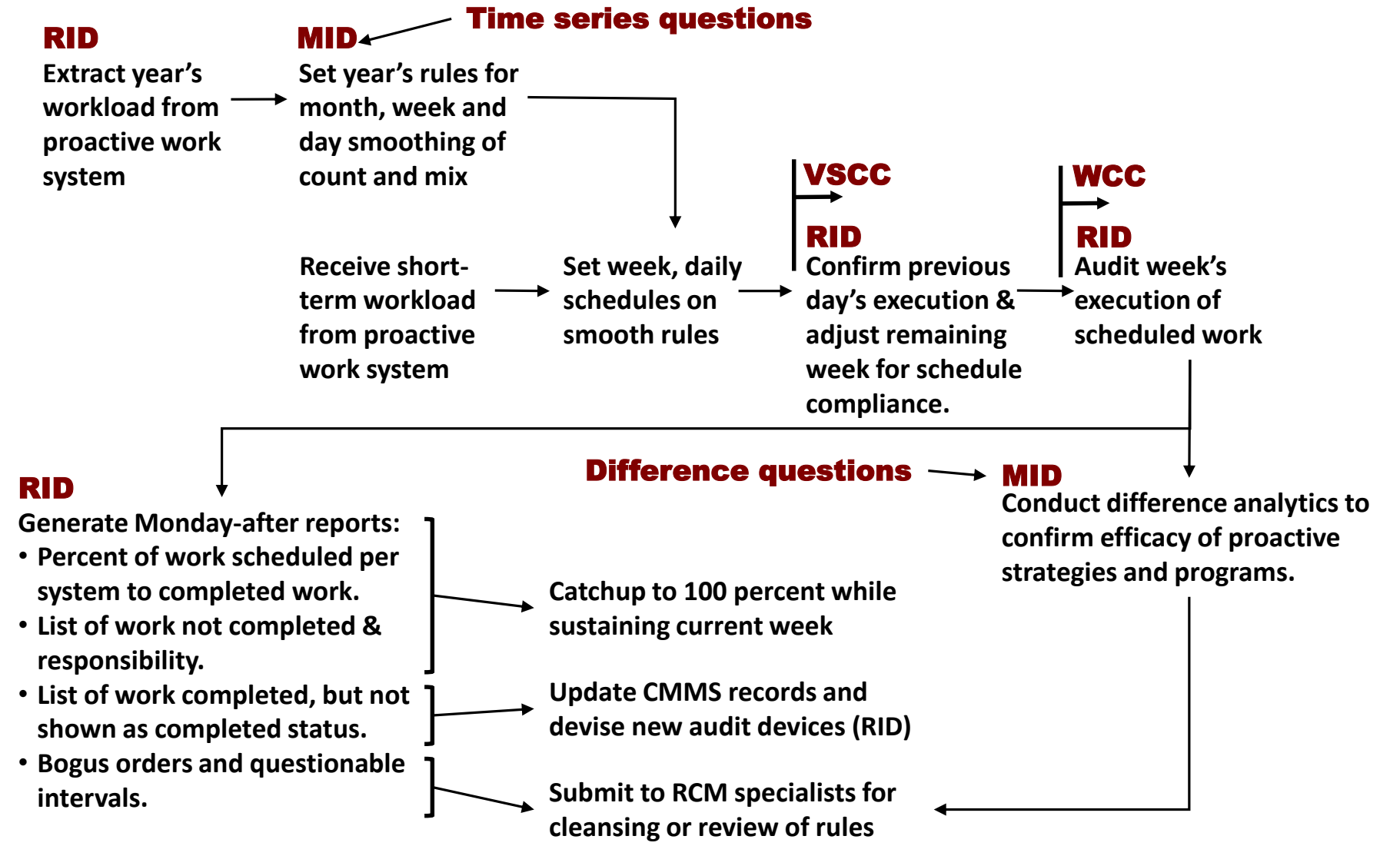
Process: Plot workload of planned **proactive** work, set smoothed counts and mix, and conduct control cycles



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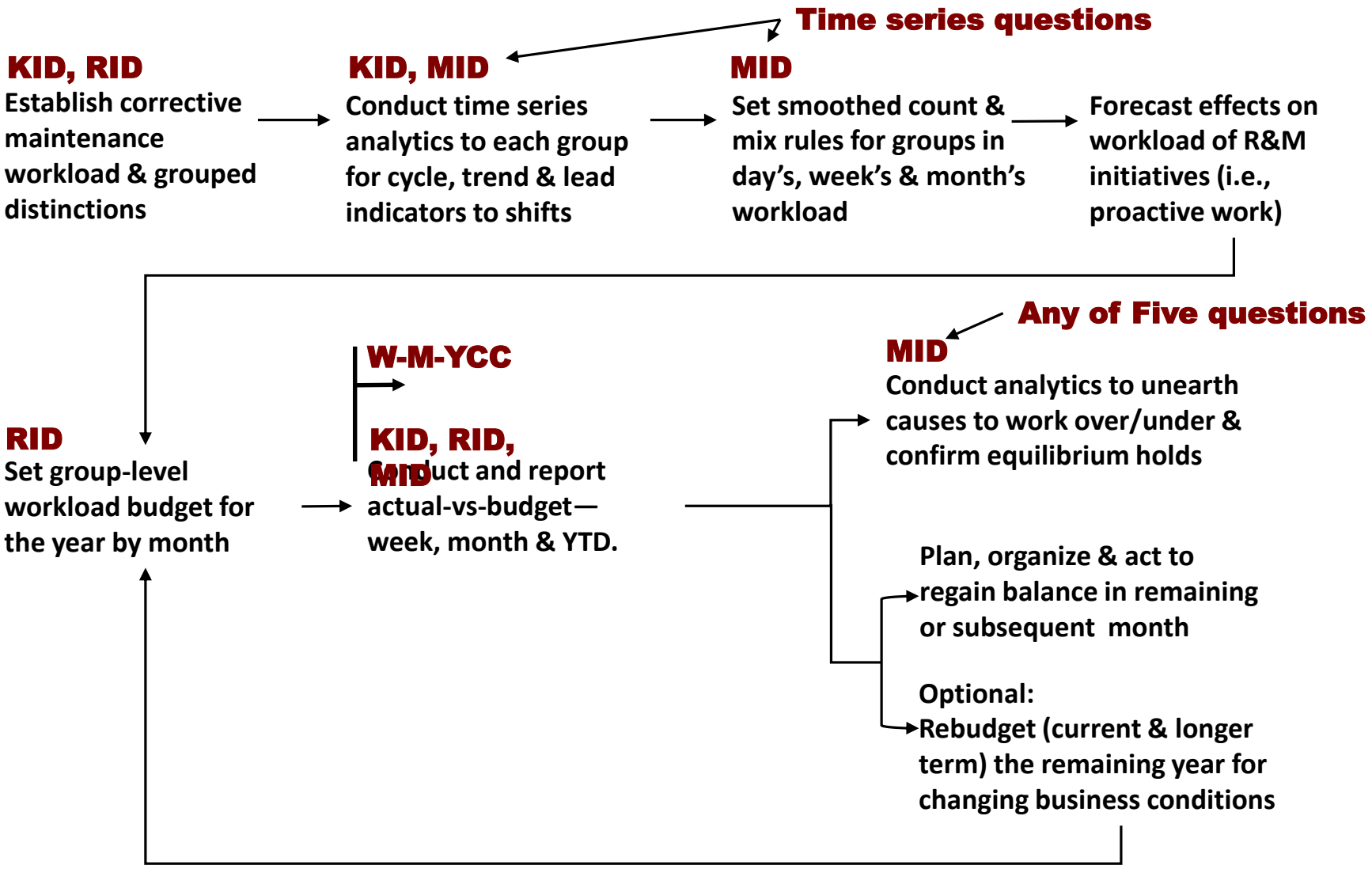
Process: Determine **corrective** workload upon statistical history, set smoothed count and mix, and conduct control cycles



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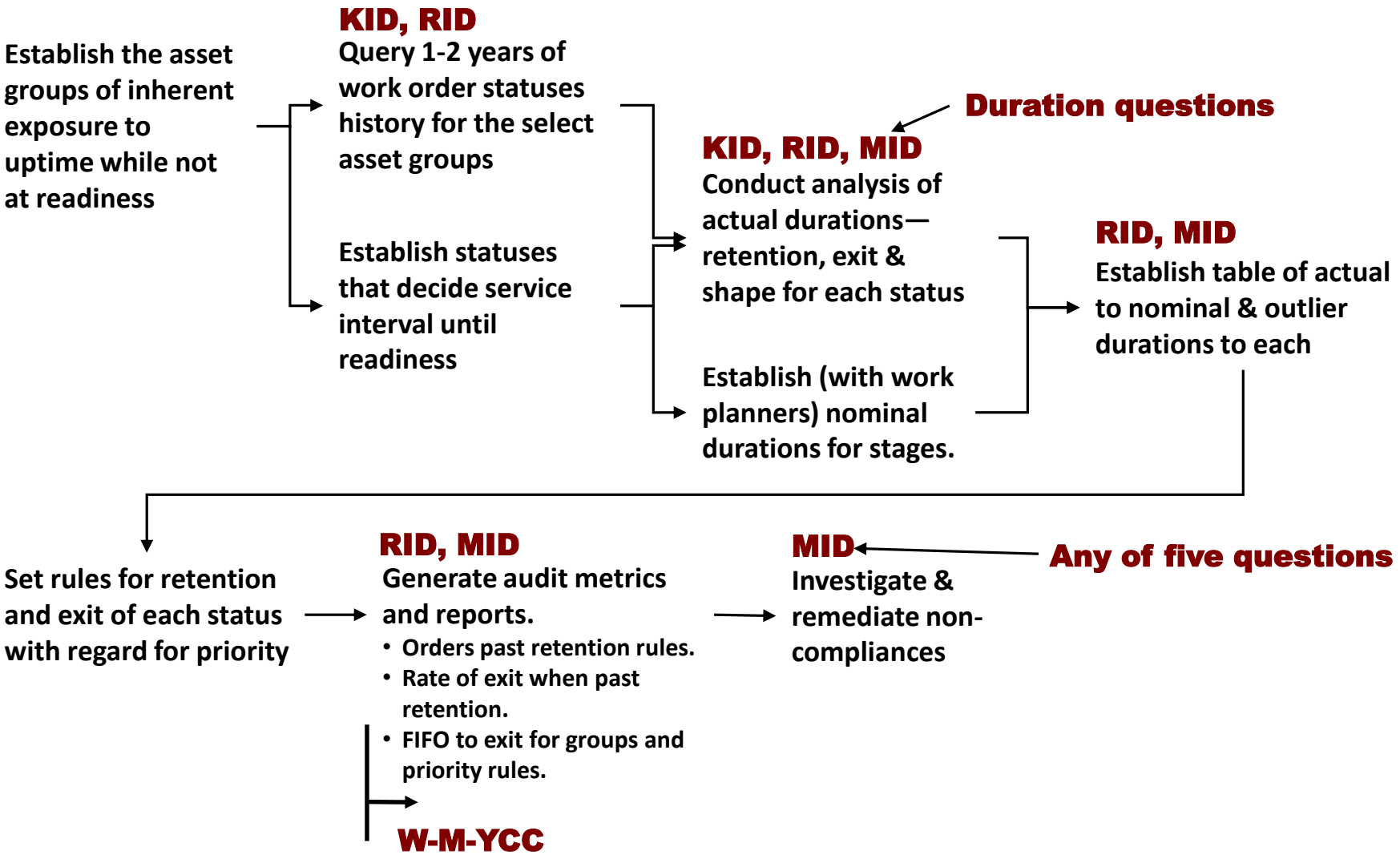
Process: Reduce to feasible minimum the **service interval** to inherent-exposure assets and conduct control cycles



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Maintenance Capacity is. . .

The workload that can be conducted by a plant's system of crafts and support headcount and skills, parts and material inventory, equipment, facilities, training and instructions, processes in the plant's working environment.

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Maintenance capacity decides the cost of maintenance per unit of production, but we should note the characteristics of the cost

- **Maintenance may be the largest cost per unit; after production materials and plant energy.**
- **Most cost elements are inherent to the work done rather than controllable—e.g., maintenance parts and materials.**
- **The assets of maintenance capacity—parts and materials, equipment and facilities:**
  - **If not expensed, pass through denominator of the turn-over side of the P-ROACE calculation.**
  - **Because of relative size to RAV, P-ROACE is largely insensitive to them.**
  - **Can loom large in their influence on the service interval for inherent-exposure assets.**
- **Craft labor is felt directly and significantly in maintenance cost per unit of P-ROACE.**
  - **Is also the most influenceable cost of maintenance capacity.**
  - **Actual hours per work order are decided by crafts in a plant's current maintenance capacity rather than the work job plans.**
  - **Maintenance SMEs believe that maintenance cost is excessive by 15 to 35 percent—something that can only be largely driven by craft body.**

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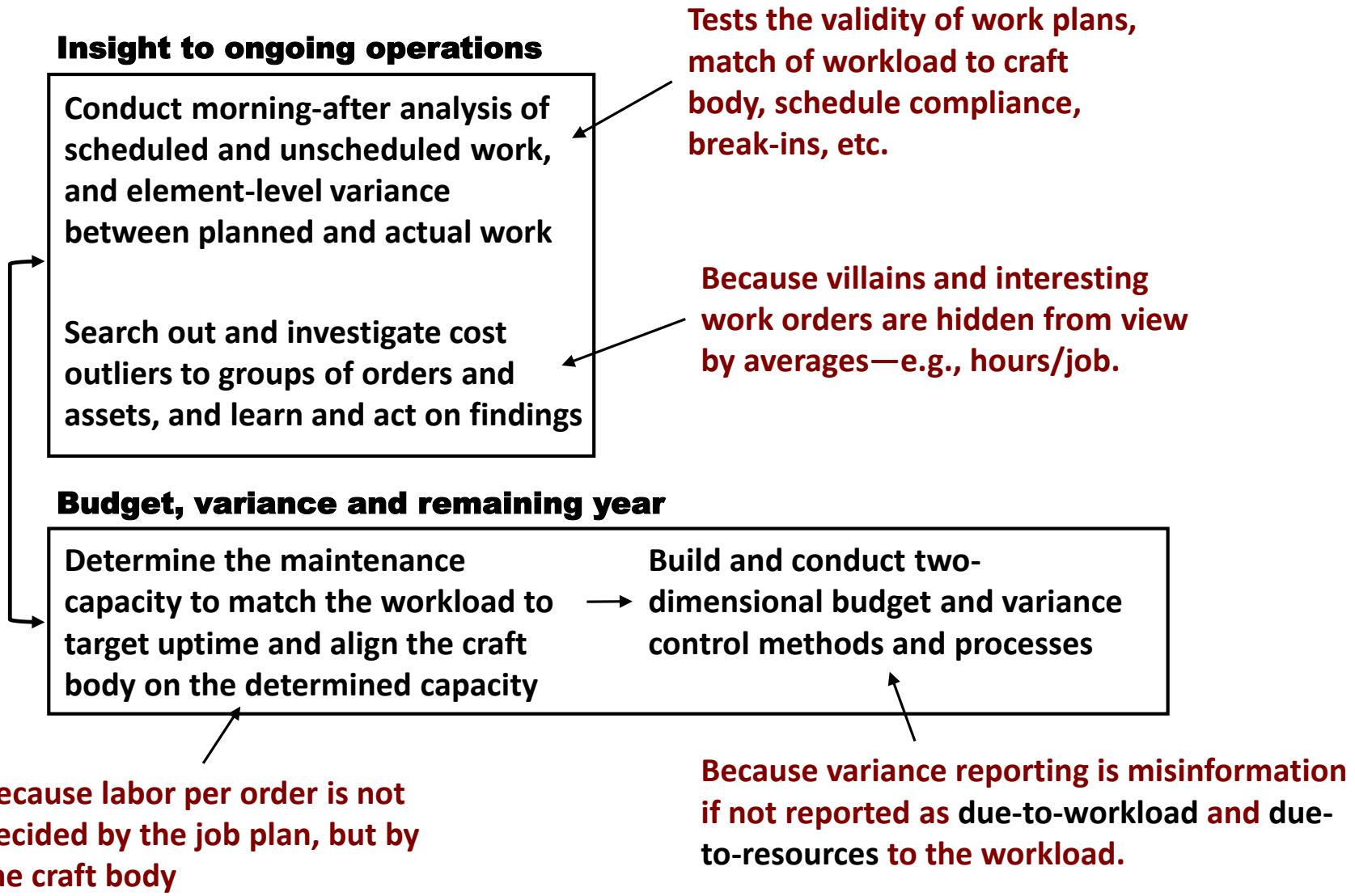
The processes of maintenance capacity focus on the match of the plant's quantified workload to the resources to execute them



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Process: Conduct morning-after analysis of scheduled and unscheduled work, and element-level variance between job plans and actual work

Set schedule for day: tasks, crafts, headcount, hours, interval → Record craft hours to day's scheduled & unscheduled work → **KID, RID** Join previous day's schedule detail and timesheets in running super table → **VS-M-YCC** **KID, RID, MID** Conduct morning-after & longer interval variance analyses (1):

- Craft head count to plan.
- Hours by craft to plan.
- Compliance statistics.

↓

KID, RID, MID

Capture, act on lessons learned to:

- Tighten or loosen job plans.
- Tighten ability to derive craft body.
- Block failures of compliance.

(1)

Element-level variances visible through super table:

- Craft types
- Headcount for craft type.
- Hours per craft type.
- Active and delay, logistic hours in a day's workload.
- Scheduled, break-in work.

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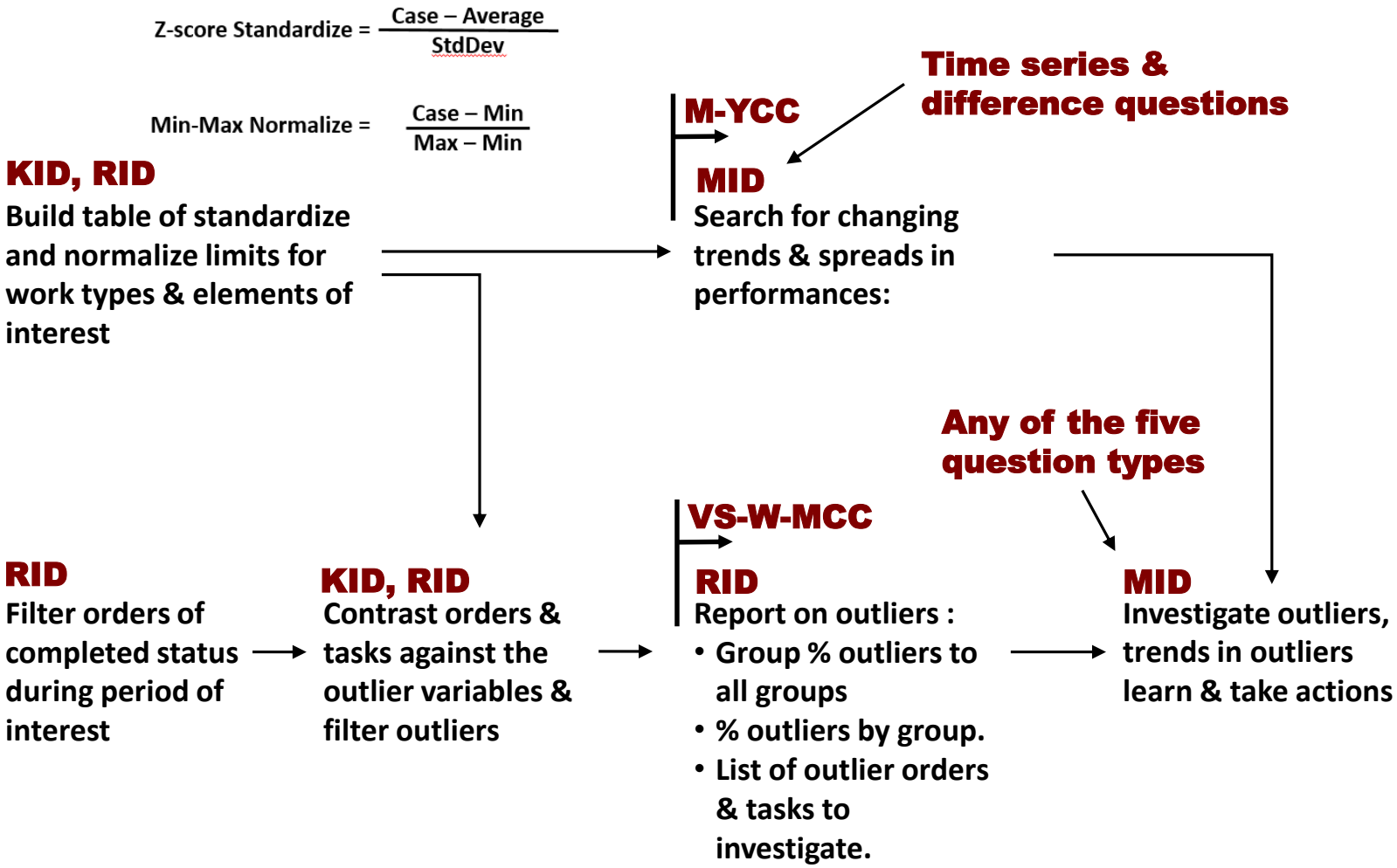
Process: Search out and investigate cost outliers to groups of orders and assets, and learn and act on findings



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We seek outliers because, without process to find them, they will go unnoticed in typical averages-type presentations—e.g., hours per job

The search is a dragnet to all sorts of anomalies.

- **Find hidden excess maintenance capacity.**
- **Unusual events during the period of interest.**
- **Bad actors revealed as outliers in hours, parts and materials, status and related work orders.**

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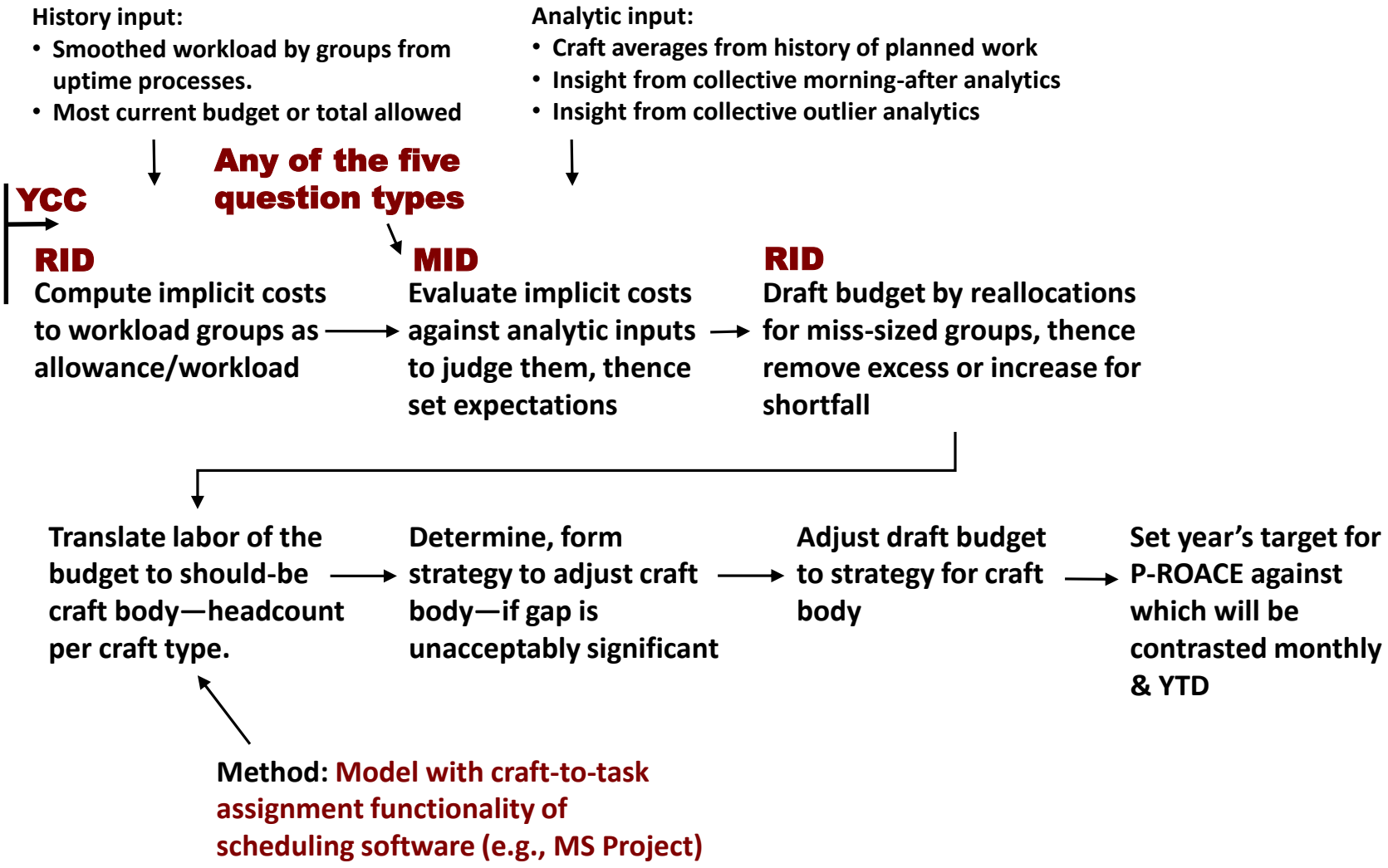
Process: Determine the maintenance capacity to match the workload to uptime and align the craft body on the determined capacity



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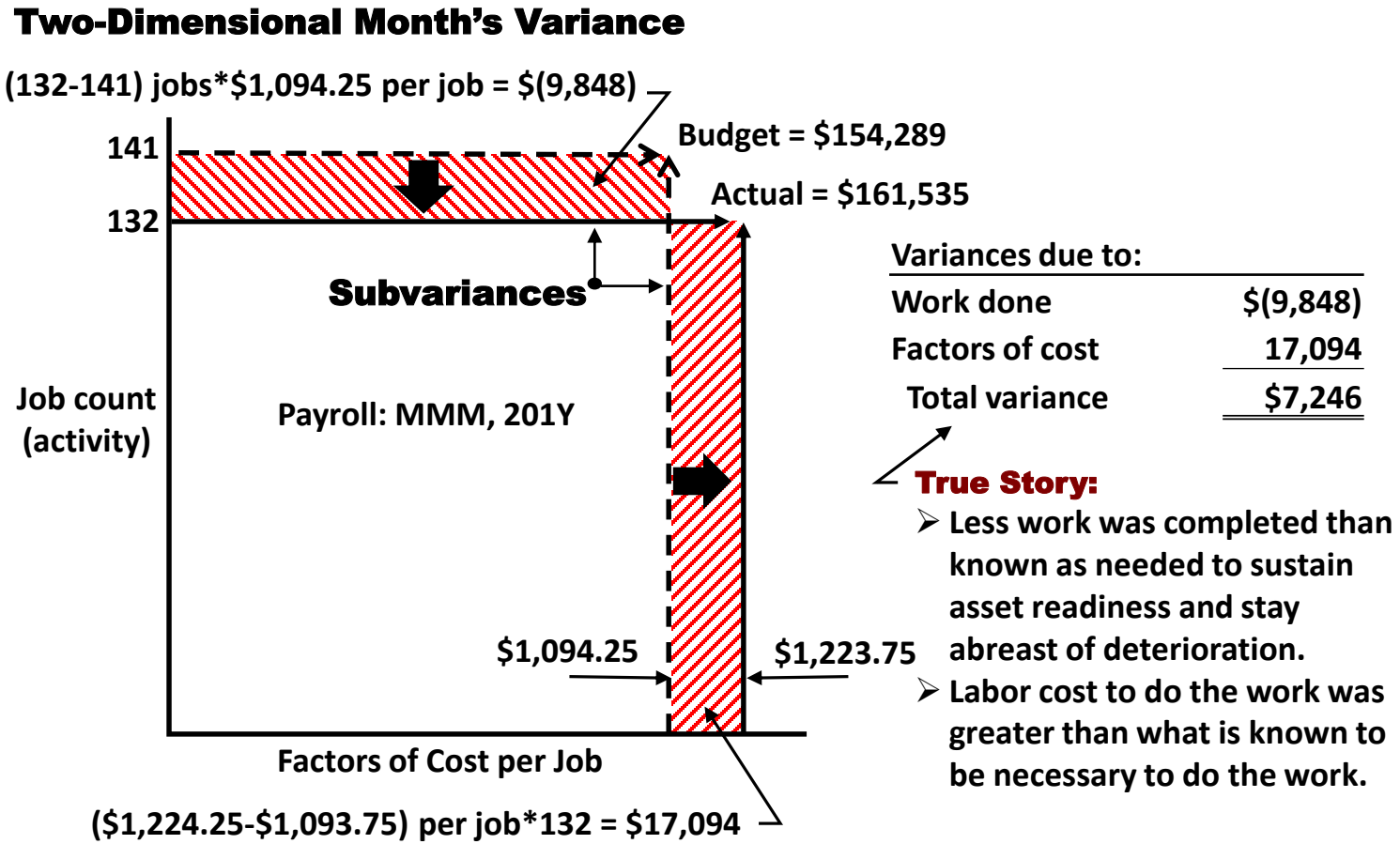
A month's and year's to date true variance can only be known through dimensional subvariances



Variances due to:	
Work done	$(9,848)
Factors of cost	17,094
Total variance	$7,246

True Story:

- Less work was completed than known as needed to sustain asset readiness and stay abreast of deterioration.
- Labor cost to do the work was greater than what is known to be necessary to do the work.

See paper: "The Secret is to Budget and Control Maintenance Opex Dimensionally."

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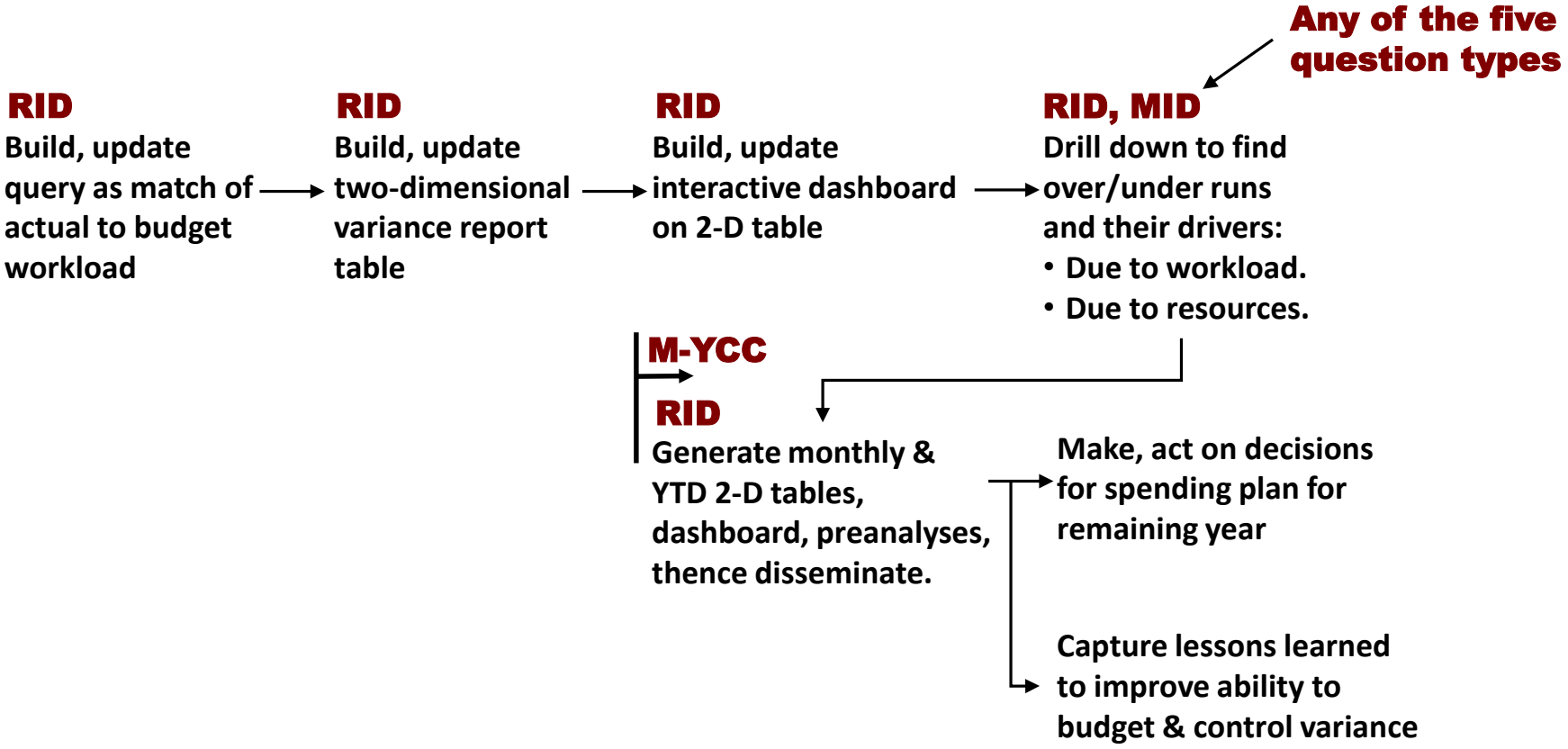
Process: Build and conduct two-dimensional budget and variance control methods and processes



See

- Paper, "The Secret is to Budget and Control Maintenance Opex Dimensionally," (https://analytics4strategy.com/scrtbdgtcntrlmntcopxdmly)
- Actual case, "Activity-Based Budget and Control," (https://analytics4strategy.com/casecostmgt)

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  - ➢ **Recountive insight processes**

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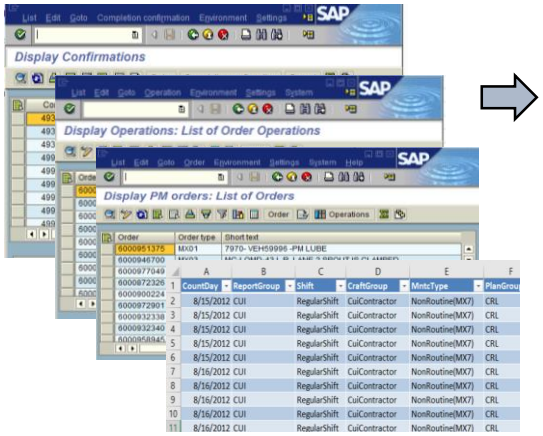
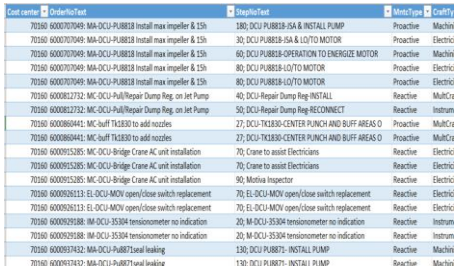
Recountive insight is the plant's body of data transformed to all possible insights that are inherent to the data, without purpose other than insight



Single tables have some of all needed variables to all envisioned insight deliverables.



A "**super table**" does not, cannot and never will exist in any one operating system.

Interactive **Dashboards** transform the massive data of super tables into a consumable table and visual form.

The structure of recountive insight has three layers:

1. Identified individual tables available in operating systems or Excel spreadsheets records.
2. Individual tables joined together in a super table by the unique identifiers they have in common.
3. Dashboards that rollup or drill down into the data of one or more super tables.

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It is important to recognize that the ease by which we can play in the three layers has changed the "rule" that all insight must be connected to a user need

- **Cost of data is not an issue to all types of insight because operating systems are natural sources through their role in a firm's operations.**
- **Building and updating super tables upon the firm's natural data has become largely effortless done with click-and-drag.**
- **Recountive insight can be open-ended because. . .**
  - **Every imaginable variable of interest to constructing insight resides in tables behind the curtain of one or more operating systems or other sources.**
  - **Every imaginable recountive insight can be constructed upon one or more of the imaginable variables.**
  - **Every recountive insight does not need to be predefined, is generated as speed of thought with interactive dashboards.**
- **Recountive insight is prepared automatically or by one for many—real-time, daily, weekly, monthly and annually.**

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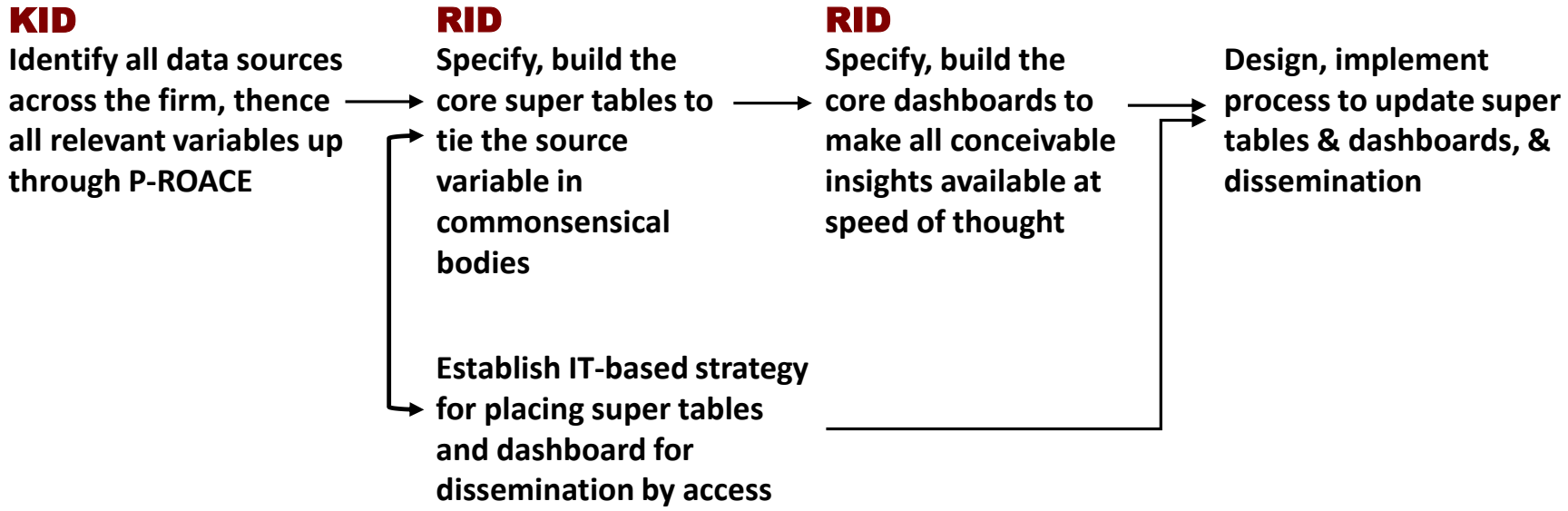
Process: Build, update and disseminate the body of recountive insight from the firm's operational data



Note:
How to build super tables is explained by the slides for download at the webpage to the training session, "Build Super Tables from Operational Data." (https://analytics4strategy.com/train-builddatatables)

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