Maintenance Program Development for New Assets: Prior Preparation Prevents Perpetual Poor Performance

This document describes the business value of preparing the transition from engineering to operations for new assets at the beginning of a project.

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Introduction

The June/July 2012 Uptime article "Bridging the Gap Between Construction and Operations for New Capital Assets" (Robert DiStefano, et al, 2012) illustrates the business value of preparing new assets to operate beginning in the design phase. With more than one trillion dollars in new capital expenditures planned per year (IDC, 2012) and potential savings exceeding one percent of lifecycle costs (Uptime, 2012), it is not surprising that operational readiness is receiving a great deal of attention. Moreover, with ISO 55000 slated for release in 2014, companies are likely to see increasing pressure from regulators and customers to have seamless control of asset data throughout the lifecycle. Bruno Storino expanded on DiStefano 2012 with "Capital Projects Operational Readiness and Business Risks: Maximizing Returns on New Assets" (Storino 2012), which provides an overview of a comprehensive program that optimizes the transition from engineering to operations for new assets. This paper adds to that body of work by illustrating how to manage the handover of asset data—the lynchpin of operational readiness for large-scale projects.

As demonstrated in Storino 2012, managing the handover of asset data is only one of many necessary activities, but it rises to the level of critical success factor because the business of operating complex, large-scale assets depends on the support of software systems. Today, no one who works in a plant with thousands of pieces of equipment will argue to the contrary. Indeed, preliminary drafts of ISO 55000 explicitly recognize the importance of software systems in managing assets across the lifecycle. Nevertheless, most plants still begin operations with sparse asset data in the enterprise asset management system (EAM) and rich asset detail locked up inside of engineering documents.

In the early days of operations, the lack of detailed asset data and the corresponding lack of documented maintenance strategies inhibited the efficient allocation of plant resources. With business pressure high to generate positive cash flow, personnel are applied to making assets run, and requests for the additional resources needed to catch up on asset data are often denied. Once a plant is operating, the cold hard reality is that the profit and loss statement rules resource decision making. Poor quality asset data, reactive maintenance, and poor profit performance create a self-perpetuating cycle that is difficult to break.

The Ideal Solution

Progress is being made in software technologies to facilitate the exchange of data between document-based and database representations of assets (engineering platforms and EAM systems, respectively). The asset data required by operators can be stored as metadata attached to engineering drawings. Several engineering platforms are capable of extracting metadata and organizing it in database format. In turn, the database of asset data can be loaded into the EAM. Metadata contained in the engineering documents originates from many engineering contractors and equipment manufacturers. The data quality challenge is to limit the values engineering contractors may enter into their documents to the values, field lengths, and data masks permitted by the EAM system. This means that the owner must specify data quality requirements very early in the contracting process and prepare the project's engineering platform to support them. Data quality requirements include: what data fields must be provided, the format it must be provided in, and the values permissible for each required data field. With a solid specification in place, data is created during the design phase following these requirements and minimizing rework to build an efficient EAM data structure to support the operate phase.

The data required to deliver a fully functional EAM on commissioning and start up are those asset data needed to build and sustain maintenance strategies throughout the balance of the lifecycle. The following data fields are generally considered essential:

- **Tag ID:** Naming and numbering conventions and field mask that enable the unique identification of equipment.

- **Location ID:** The end nodes of the asset hierarchy to which maintainable equipment records will be attached. The appropriate number of parent hierarchy levels should be set by the owner's asset data standards. All levels of the hierarchy down to the location ID must be provided. ISO 14224 provides good guidelines for the development of a hierarchy standard. Classification (Class, Subclass): between 1,000 and 2,000 equipment classifications. These fields are used to provide the richness and detail needed to categorize equipment objects, to associate supporting templates, and to support statistical analysis of equipment reliability.

- **Attributes (service, material, duty rating, power, etc.):** The additional details associated to classifications that help in identifying equipment characteristics, developing maintenance strategies, planning of work orders, and analyzing reliability statistics.

- **Manufacturer:** A listing of standardized manufacturer and vendor names. A large project may require more than 50,000 names.

- **Model:** Model naming conventions and field lengths must be provided. Small differences in model numbers and names can make a very large difference in equipment characteristics.

- **Serial Number:** Unique identifier of a physical piece of equipment. Some equipment manufacturers embed intelligence into the serial number related to characteristics of the equipment (e.g. metallurgy and material of construction, size, etc.).

- **Materials Data:** Classifications, attributes, manufacturer/vendor, and part number are the key fields that must be captured to organize these data and prevent duplicate catalog entries and purchases. Materials master records will be used to build bills-of-materials and optimize stock levels.

Specifications for each of these categories must be included in the project handover requirements. This list does not include maintenance strategy data elements (e.g. criticality, bills-of-materials, task lists, schedule, etc.) because these can be separated from data required of engineering contractors. As depicted in Figure 1, development of these data types is part of the maintenance work stream.
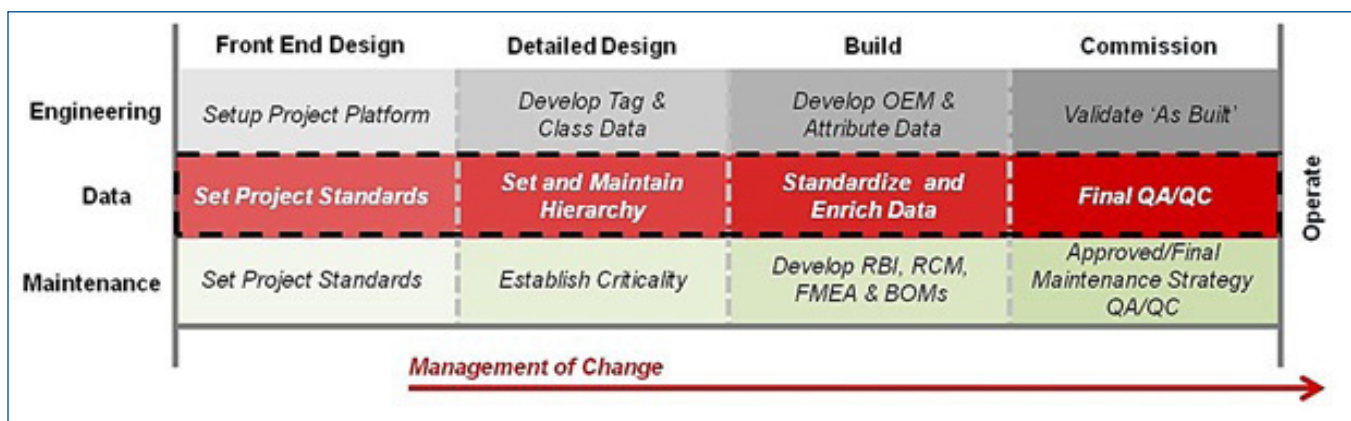

Figure 1 — *EAM Data Activities Early in the Lifecycle.*

Figure 1 illustrates EAM preparation activities from the earliest phases of an engineering project, describing how data standards introduced early in the process support development in each subsequent phase. Phases progress from left to right, beginning with Front End Design, and activities are divided amongst Engineering, Data, and Maintenance work streams. Generally, data originate in the Engineering stream and flow downward within a phase. The exception is in the Front End Design phase where project standards are established in the Data work stream and used to set up the project platform and to organize the project standards. Within the Maintenance stream, project standards for criticality ranking, failure analysis, maintenance strategy documentation, and project organization are all key components of standards that need to be developed prior to the end of the Front End Design phase.

Maintenance standards define the degree to which the maintenance program will utilize predictive technologies and condition monitoring. At a minimum, they need to define which technologies will be used on which equipment, which equipment will receive traditional time-based preventive maintenance (PM), and which equipment will be allowed to run to failure. The maintenance strategy standards should include the detailed specification of how maintenance plans will be put into the EAM system, how procedures will be broken down into steps, how procedures will be combined into plans, how plans will be rolled up into schedules, and what craft skills are expected to be utilized. These details are vital to ensuring that the operations team will actually be able to execute the program once the plant is turned over to their custody. Additionally, standards for potential-failure identification methods should include Reliability Centered Maintenance Analysis techniques, Failure Modes and Effects Analysis, and Root Cause Failure Analysis. Each of these standards should include a description of how the analysis is conducted, what the deliverables are, and where completed analyses will be stored for reuse or improvement.

Corporate standards for criticality ranking of assets and potential-failure identification methods are also important to guide the development of the program early in the asset lifecycle. Criticality helps to guide the application of resources both for analyzing potential failures and subsequently in planning the application of resources to mitigate potential failures (e.g. condition monitoring). Criticality standards may include criteria such as the impact of an asset failure on production, maintenance cost, safety, product quality, and the environment.

During Detailed Design, the associations between the asset hierarchy and equipment objects are initiated. Within the master equipment list, functional locations are differentiated from equipment objects because functional locations are permanent reference points and equipment objects may change. For example, within a given system, a pump may provide an essential function to the overall system and for a period of time, but a serialized asset may perform that function at a point in time. If a repair is required, the asset may be removed from service at the functional location and moved to another location both physically and within the EAM system. Throughout these moves, the costs and maintenance history should follow the equipment and also be traceable to the functional location.

The classification Data Standards loaded into the platform are in effect specification templates for each asset type, providing structure for the capture of asset class data and enabling association of the class data to a specific tag. From an engineering process perspective, the classification data may be entered directly into engineering drawings or into associated data sheets. Also given an asset hierarchy, criticality ranking can proceed in the Maintenance stream. During this and subsequent phases, the design and physical configuration of assets is fluid, necessitating a robust management-of-change process to ensure that the design, hierarchy, data, and maintenance strategies remain internally consistent.

In the Detailed Design phase and following on into the Build phase, asset data will begin to be specified. This is when the majority of information will be transferred and developed. Figure 2 illustrates the progression of data availability. Asset data from data sheets should be recorded as equipment records, using equipment standards to populate all values. The file name and version number of the data sheet should be tracked in the equipment record as the original source of the information, and a notification should be issued if any changes are made to the data sheet, allowing appropriate follow-through editing in the equipment record. Quality review of the mechanical data sheets is a critical component and depends on the management-of-change process (See Figure 1). Errors or ambiguities need to be routed back to the engineering and design team and reconciled before the team has moved on to other tasks or projects and the ability to make corrections is lost.
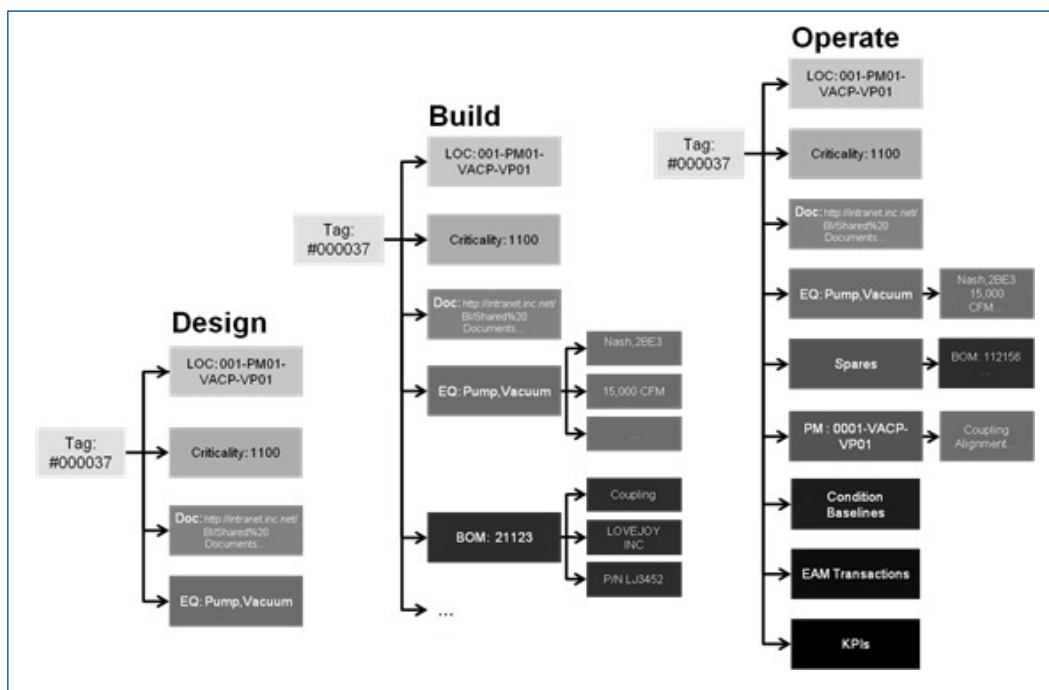

Figure 2 — *Asset Data Availability by Phase.*

The Build phase (Figure 1) is the time for intensive Data work stream activities. Standardization and enrichment are broad terms for activities directed at ensuring consistency within asset data, efficiency in populating data fields, and completeness of values within every asset record. With many parties involved and tens of thousands of data records to be managed, setting up the engineering platform is not enough to ensure successful delivery of quality EAM data. Even the most robust set of data standards will require "other" or "new" categories for unanticipated manufacturers and classifications. Such categories are notorious sources of data quality problems. Success depends on timely and continuous review of asset data and feedback to engineering contractors regarding inconsistent values and incomplete data.

Enrichment is a parallel activity to standardization and uses standardized values to populate records efficiently. By matching standard values entered in classification, manufacturer, model, and attribute fields to preexisting records, data fields that may be missing from records in the engineering data set can be augmented efficiently. As the project progresses and the catalog of detailed records grows, the need to reference OEM information diminishes and automation of enrichment increases. Additionally, the degree to which standardization and enrichment can be leveraged to reduce engineering data requirements should be fully explored and documented within the project. Data enrichment activities should be substituted for original data entry into engineering documents where possible because they are likely to be more efficient.

Failure analyses, maintenance strategies, and bills-of-materials can also be prepared during the Build phase. Since this program may fold new assets into a current enterprise program, existing asset-class-specific failure analyses and maintenance strategies should be leveraged as much as possible. For example, an existing program is likely to have failure analyses already developed for common equipment like AC motors or centrifugal pumps, which should be applied to these asset types. Similarly, for the existing asset base, application of predictive technologies, use of condition monitoring, maintenance task lists, and bills-of-materials are likely available for some equipment types and possibly even for the exact make and model. Standardizing the detailed asset data greatly simplifies the standardization of maintenance practices, which has the eventual additional benefit of providing a richer sampling across the enterprise of the effectiveness of the strategies. Coupled with a continuous improvement approach to defect elimination, standardization has a powerful impact on improving asset performance and lowering implementation costs.

The EAM master data framework needs to be functional prior to the commissioning phase to enable the capture of important startup information. As illustrated in the Build phase of Figure 2, when assets begin to become operational, it is very important to establish the PdM baselines for comparison to future operating conditions. These baselines provide the basis for identifying early failures that can be corrected prior to final commissioning. The paper "MSDGC's Reliability-Centered New Asset Turnover Process" (Janzen, et all, Management Resources Group, 2011) documents a good example of how early catches can be made. PdM routes should be conducted periodically before the assets are fully turned over to operations. This will enable the identification of any rework that may be needed prior to releasing the responsible parties in the Build and Commission phases.

Validating the EAM data during the Commission phase is a vital last step in data quality assurance. As the engineering documentation is reviewed in the field to finalize as-built condition, the corresponding EAM representation of the asset data should also be field validated. Mobile technologies enable efficient comparison of EAM data and engineering documents and allow modification or approval as needed, ensuring that the EAM, physical equipment, and engineering documentation begin operations in lock step.

When the Ideal is Out of Reach

Setting asset data standards for projects before they begin is by far the most efficient approach to transitioning to the Operations phase of the lifecycle. In contrast, the least efficient, highest cost approach is always to develop the asset data during the Operate phase. While many large companies have instituted project requirements that support the most efficient approach, many of the companies developing projects today have a range of obstacles preventing them from attaining the ideal. Projects may take five to ten years to develop and may have progressed too far to have standards interjected at the ideal phase. Operating organizations may be established specifically for a project and may have no pre-existing infrastructure of standards to deploy. Contractor handover requirements may be set already and may not be able to be modified without considerable expense. Even in situations where project realities prevent the ideal, steps can still be taken to lower the risk and expense of delaying development of EAM data.

Practical steps that operators can take to develop their asset data include: adding data standards to the contracting platform as reference information instead of using them to validate fields; purchasing standards from third-party vendors; and adding Data work stream activities independently of Engineering activities.

Standardization, Enrichment, and Validation are Key to Data Quality

The purpose of building data standards into the engineering design platform is to reduce the standardization, enrichment, and validation in the project, not to eliminate them. If the metaphorical "horse has left the barn" and the project has begun without standards in place, the validation and standardization benefits of the engineering platform will be missed, and more data work will be required to attain the same level of data quality. While this approach is less efficient than the ideal, it will still enable the plant to attain design production levels more rapidly than the alternative of delaying data and maintenance development until the Operate phase.

It's Never Too Late for Standards

Indeed, for many organizations that have not yet adopted the full set of standards discussed here, putting them in place and applying them to new assets, capital projects, and acquisitions is a good way to establish them. However, care should be exercised to avoid creating any conflicts with existing asset data structures in the EAM. For example, a complete redesign of the hierarchy structure will not be possible in SAP without also modifying the mask, structure, and transaction history for existing assets. Similarly, modifications to classifications and characteristics may require mapping of existing asset records to the new standard. While these details need careful attention, implementing standards can be accomplished progressively by beginning with new assets and then successively applying them in the management-of-change process and as a part of future shutdowns, outages, and turnarounds.

Maintenance Plan Development is Critical

Lastly, robust EAM master data are essential but only because they are put in place to enable development and management of the set of activities needed to manage and mitigate the consequences of failure. Maintenance strategies are designed to optimize asset availability given a broad set of constraints and, as a result, create savings benefits that drive the business case for preparing the EAM.

The preceding overview of the technical approach to managing asset master data through the early phases of the asset lifecycle is, of course, only part of the answer to how to manage the process. As described in DiStefano 2012, a gap exists in most companies between those responsible for capital construction and those responsible for operating. To address this gap, companies must bring together leadership from construction management and operations to ensure that gaps are adequately covered: construction phase deliverables meet operations phase requirements and money is allocated specifically to support these deliverables. Additionally, a parallel gap exists in the financial treatment of assets with the transition from a capital project budget to an operating plant balance sheet and profit and loss. Project budgets need to increase to bridge this gap and accommodate the cost of managing asset data and building maintenance strategies. The business rationale is solid: since readiness investments deliver returns throughout the asset lifecycle, they should be treated as a capital expense. By amortizing them across the lifecycle, the asset will deliver a higher cash flow throughout its operating life.

Technical capability and asset complexity continue to advance, driving the potential and need for changes in early asset lifecycle phases. There is a strong business case for increased investment in support of these changes. ISO 55000 will drive broad adoption of complete lifecycle approaches to asset management. We are on the cusp of a broad transformation in the way asset lifecycles begin.

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