Data Center Projects: Standardized Process

White Paper 140

Revision 1

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> Executive summary

As the design and deployment of data center physical infrastructure moves away from art and more toward science, the benefits of a standardized and predictable process are becoming compelling. Beyond the ordering, delivery, and installation of hardware, any build or upgrade project depends critically upon a well-defined process as insurance against surprises, cost overruns, delays, and frustration. This paper presents an overview of a standardized, step-by-step process methodology that can be adapted and configured to suit individual requirements.

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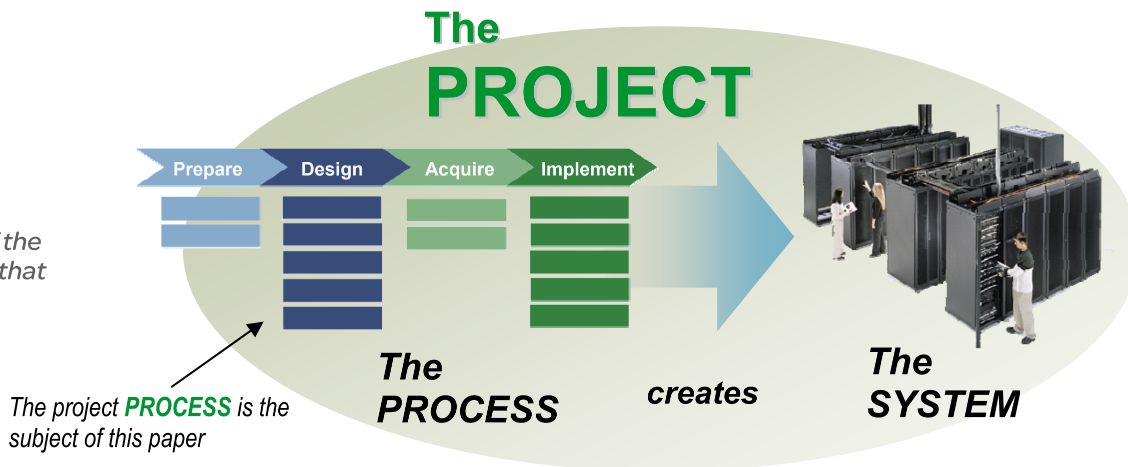
Introduction

A data center construction project can be large or small, new construction or retrofit, complete or partial. It can involve a change in physical room size or layout or electrical capacity, an increase in power density, a redesign of power or cooling architecture, or any number of other changes to the physical infrastructure of the data center. Regardless of the size or nature of the project, successful execution depends not only upon the purchase and installation of the equipment of the physical ***system***, but equally upon the process that pilots the project through its development and realization, from concept to commissioning. **Figure 1** illustrates this concept of a project as the combination of a system plus the process that creates it.

Figure 1

A PROJECT is comprised of the SYSTEM plus the PROCESS that creates it



The idea of a formalized process to guide the creation of a system is not new, but its importance to the success of data center physical infrastructure projects is just beginning to be understood. Just as standardization of the physical *system* improves reliability and speeds deployment[1], a standardized *process* contributes significantly to the overall success and predictability of the project and the system it creates.

It takes time for the combined experience of a maturing industry to evolve toward standardization – especially in an industry with a long tradition of custom system design – but the benefits of standardized *process* to both user and provider can be wide-ranging and profound. For the end user, a reliable and repeatable process delivers the system more quickly, with less expense and fewer defects. For the provider of engineering services or physical equipment, a reliable and repeatable process frees up time and resources for the real business at hand – system design and implementation – increasing the scalability of the provider's core competency. The goal of a standardized process is not to eclipse or minimize system expertise, but to *facilitate* it.

This paper covers projects involving new construction or upgrades to the data center's physical infrastructure – the power, cooling, and other physical systems that house and protect the data center's IT equipment (see box). Although the power consumption and physical size of the IT equipment drives the design of the physical infrastructure system that supports it, the design and architecture of the IT "layer" of the data center are outside the scope of this paper.

[1] See White Paper 116, *Standardization and Modularity in Network-Critical Physical Infrastructure* (link in **Resources** section).

What constitutes a "project?"

In the context of this discussion, a *project* is any change significant enough to need an orderly flow of tasks – a *process* – to coordinate and manage its execution. By this definition, building a new data center or server room is clearly a project. Adding racks of new blade servers is usually a project, but adding a single rack to an existing data center is probably not a project.

The following characteristics will generally elevate a data center upgrade to "project" status:

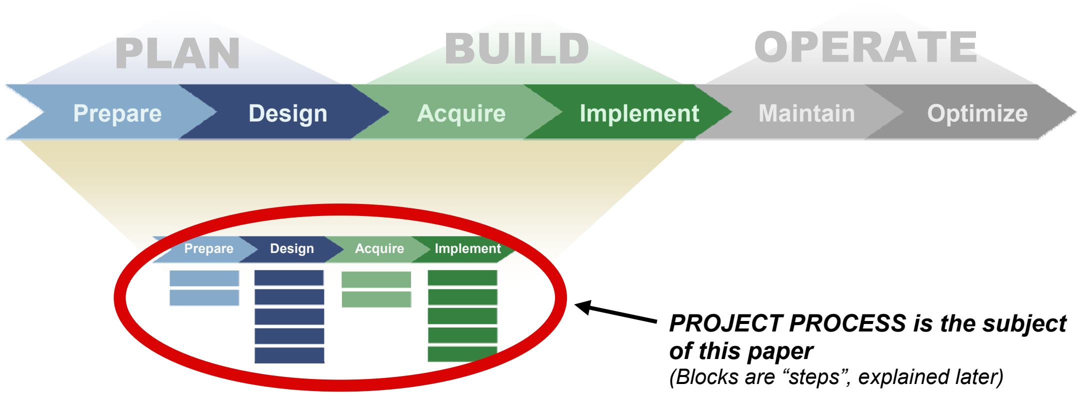
- Change in power or cooling architecture (for example, converting from centralized to row-based)
- Introduction of risk
- Need for planning or coordination
- Need to shut down equipment

Context within the data center life cycle

This process covers planning and building, which constitute the beginning of the data center life cycle. **Figure 2** shows this context within the complete life cycle.

Figure 2

The project process within context of data center life cycle



Why a standardized process?

A major problem common to many data center projects is wasted time, wasted money, or defects due to flaws in the *process* – dropped handoffs, ambiguous responsibility, misinformed decisions, and other errors of communication or execution. This is not necessarily due to flaws in the activity of the various parties to the process – the end user, the hardware provider(s), the design engineers – but rather to the lack of an overarching, shared process guiding all parties as a *team*, clarifying responsibilities and communication. The hazards of a non-standardized – or non-existent – process span the familiar spectrum of unnecessary expense, delays, and frustration:

- Reduced quality
- Higher cost
- Wasted time
- Poor documentation
- Inadequate testing
- Degraded service

Hazards of a non-standardized (or non-existent) process

Most defects that ultimately turn up in the later stages of a project, or even after the project is complete – including the ultimate defect, failed business results – are caused not by problems in the physical components of the system that was built, but rather by decisions that were made in planning the system and flaws in the process by which the system was deployed. A well-designed, standardized process has built-in intelligence and structure to avoid such problems, both in the planning stages and at every step along the way to project completion. The result is reduced re-work, accelerated cycle time, and a system that is ultimately deployed as expected, with no surprises.

Value of a common language

Besides the clarity, repeatability, and efficiency of its execution, a standardized process offers an additional safeguard against miscommunication and waste: a *common language*. Many of the pitfalls and missteps that typically occur during the course of a project can be avoided by using standard and familiar terminology in project communications among the vendors, partners, and users who have a stake in its success.

Standardization vs. customization

The standardized process described here does not mean that every project is the same, or that every process must be exactly like this one. It does, however, offer a best-practice framework and guideline for essential process architecture that can be adapted to the project at hand, whether wiring closet or multi-megawatt data center. Not all the steps in this process description will be executed for every project. As with any agile system, this process is organized into modular units (steps, and tasks within steps) which can be selectively configured or eliminated, according to the requirements of the project.

Customization through configuration of a modular, standardized architecture is a time-tested strategy – Lego® blocks are a familiar example. The data center physical infrastructure industry is already moving toward modular, standardized design in *equipment hardware* (the implemented "system" of **Figure 1**) in order to achieve efficient, predictable, and reliable results. Similar business benefits accrue from a standardized, modular process to build that system.

Link to resource
White Paper 116
Standardization and Modularity in Data Center Physical Infrastructure

For more about standardized modularity in the physical infrastructure *system*, see White Paper 116, *Standardization and Modularity in Data Center Physical Infrastructure*.

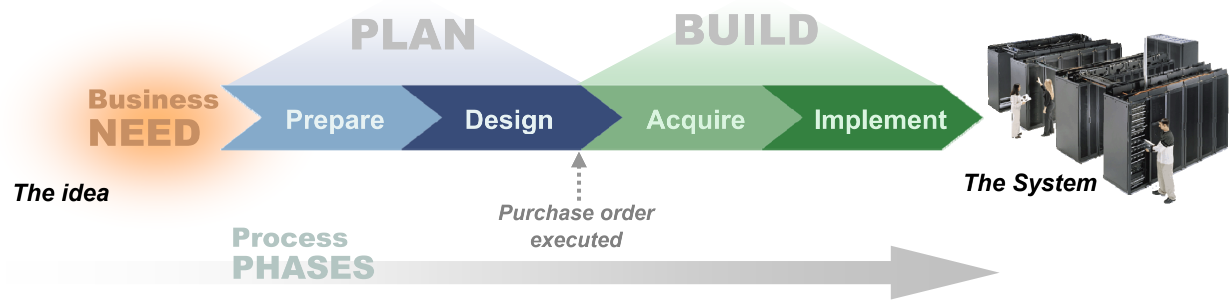
Basic structure of the project process

The project process begins with a business need, which may be a loosely articulated interpretation of a business concern, or some other general statement, such as "I need a backup data center." As the project advances through well-defined process phases – **prepare, design, acquire, implement** – tasks are performed, time dependencies are managed, information is passed to where it is needed at the right time, handoffs are coordinated, and the final outcome of the process is a fully deployed and operational system. **Figure 3** summarizes the sequence of activity through the four phases of a data center project.

The first two phases constitute the **PLAN** portion of the process, which translates the original stated need into a detailed design and a list of components on a purchase order. The last two phases are the **BUILD** portion of the process, taking the project from hardware acquisition to operational system.

Figure 3

The four phases of the project process



PLANNING is the critical foundation of the project

The **PLAN** portion of the process lays the critical foundation for everything that follows. Yet despite this crucial importance to the success of the project, planning has historically provided the greatest opportunity for confusion, misunderstanding, and miscommunication. Mistakes made here will magnify and propagate through the later **BUILD** phases; the typical result is delays, restarts, cost overruns, wasted time, frustration, and ultimately a compromised system. Proper attention must be given to the planning steps, using appropriate expertise to ensure that design elements are specified in a way that provides the necessary and sufficient information to the downstream **BUILD** portion of the process, to assure a successful outcome.

The technical and business considerations, variables, tradeoffs, and constraints can be daunting to even the most experienced professional. Even with an expert consultant engaged in system planning, there is a critical hierarchical sequence of user interaction and input that can be modeled by a standardized methodology that minimizes backtracking and wasted effort by all parties. Because planning activity is so crucial to the success of the project, and so prone to unintentional misdirection and errors, it is covered separately in White Paper 142, *Data Center Projects: System Planning*.

Link to resource
White Paper 142
Data Center Projects: System Planning

Once the **PLAN** phases have been successfully executed, the most critical part is done. The remaining **BUILD** phases can be carried out in a deterministic – almost automated – manner, providing they are under the control of a rigorous, well-defined process executed by a qualified project team.

Essential characteristics of the process

Regardless of the particular methodology used, the process must conduct the project efficiently, reliably, and understandably, with safeguards in place to eliminate problems such as missed handoffs, ambiguous responsibility, and lost information. It should include strategies for management of unplanned occurrences such as project changes and defects. It should be modular and configurable so it can be adapted to projects of different types and sizes.

A standardized process that meets the above general requirements will have the following characteristics:

- Every activity necessary for completion of the project is included in the process.
- Each step has clearly defined inputs and outputs.
- Every output produced is either the input to another step, or is a final output of the project. No effort is wasted on extraneous outputs that do not contribute to the progress or ultimate outcome of the project.
- Every step of the process has clearly assigned ownership responsibility, so there is no “dropping the ball” due to unassigned or ambiguous ownership of steps.

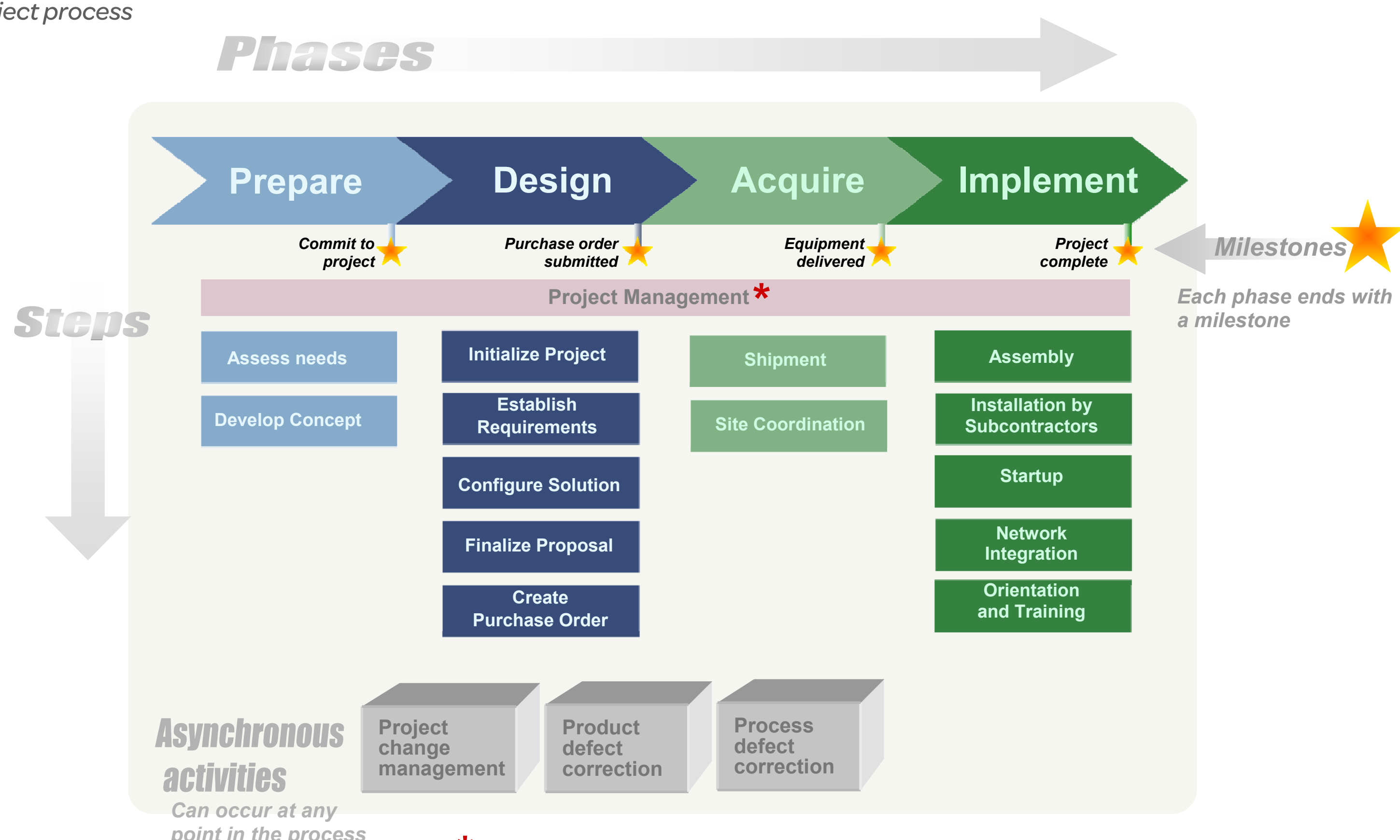
- There are no "cracks" or dead space between steps – every step is linked to prerequisite and subsequent steps by its inputs and outputs. Once a step has received all its inputs, it can complete its tasks and make its outputs available to other steps that depend on them.
- There are special "asynchronous" functions that remain on standby during the course of the project, to systematically deal with unplanned changes or defect correction.
- Steps can be deleted to configure the process appropriately for the project at hand.
- A Web-based tracking and status system is accessible to all stakeholders (both the customer and any parties providing project services), for shared documentation, data, and reports.

Phases, steps, and milestones

Figure 3, earlier, showed the four phases of the process that occur sequentially, left to right, carrying the project from the original idea of **business need** to the completed construction of the physical **system**. **Figure 4** below shows the next level of detail: each of those four phases consists of several steps listed below it, which occur sequentially going down. When all the steps of a phase are completed, the process advances to the next phase to the right. The end of each phase is marked by a **milestone**.

Figure 4

Process "map" showing basic elements of the project process



*The ***Project Management*** role can be configured in a variety of ways to suit the particular project and the parties involved. See later section, ***Project Management***.*

Asynchronous activities

In addition to the process steps that navigate the expected course of the project, it is essential to have built-in process structure to handle the unexpected. These ad-hoc or asynchronous activities can be triggered at any time during the project.[2]

- **Project changes**. Changes should be an expected part of a project. The process must be designed to accommodate changes without creating process defects, delays, or unnecessary cost. Changes can result from new information that was not previously recognized, changes to vendors' equipment or services, or changes in the user's system requirements.
- **Product defect correction**. At any time after delivery, part of the system may be found missing, damaged, or failed. While the responsibility for correcting these defects will primarily rest with the product supplier (as part of the supplier's project process), the user's project process must be prepared to interface with the supplier and manage delays during defect correction.
- **Process defect correction**. Any process, particularly a new one, should be considered a proving ground for evolutionary development. Missing data, sequencing errors – even missing steps – may be discovered during the course of the project. With a pre-planned recovery strategy, the delay and cost of process flaws can be minimized.

As with the sequential process steps, these asynchronous activities must be explicitly assigned to an owner in order to ensure process continuity when the unexpected arises. Whether defined and handled as a separate activity or incorporated into project management duties, pre-defined asynchronous procedures are essential to an efficient and successful process.

> How Schneider Electric uses this project process

The process described in this paper was developed by Schneider Electric as a best-practice blueprint for data center physical infrastructure projects.

Schneider Electric itself follows a similar version of this process, internally, when it becomes involved in a customer project (as a vendor of physical infrastructure products and services). Schneider Electric 's internal process includes additional vendor-related activities – risk assessment, order fulfillment, invoicing, and so on – but it also includes every customer-side step shown in this paper, to make sure that all are accounted for and executed, no matter who "owns" them.

Some process elements – or the whole process – are offered by Schneider Electric as services to customers who wish to hand off some or all responsibility. Regardless of who actually performs which steps (customer, Schneider Electric , or third party provider) Schneider Electric 's internal version of the process always includes tracking the ownership and completion of every step, to ensure that everything gets

Custom engineered projects (ETO)

The process described in the previous section assumes a system configured from standard hardware and software components; it does not include the extra steps needed for a project including engineered-to-order (ETO, or highly customized) equipment or services. A highly customized project – for example, a unique supercomputer installation – will require additional steps for engineering design, factory acceptance test (to verify that the system operates as designed), and commissioning (post-installation whole-system testing to confirm correct operation in the context of the on-site environment), which can be incorporated into this process as shown in **Figure 5**. In this way, the project process can be customized for a specific requirement by adding or removing steps form the standard process model.

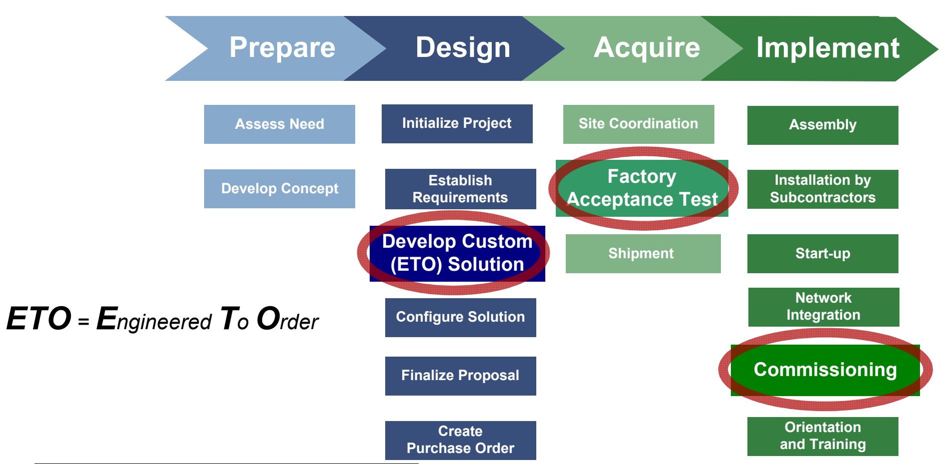


Figure 5

Project steps can be added to handle a custom-engineered (ETO) system

[2] Asynchronous activities are part of project management in standard business project methodology. They are highlighted here because they are often overlooked in data center projects.

Anatomy of a step

Each **step** of the process is a collection of related **tasks** that together accomplish the goal of the step. As an example, **Figure 6** shows the tasks within the "Start-up" step. (See **Appendix** for the tasks in all steps of the process.)

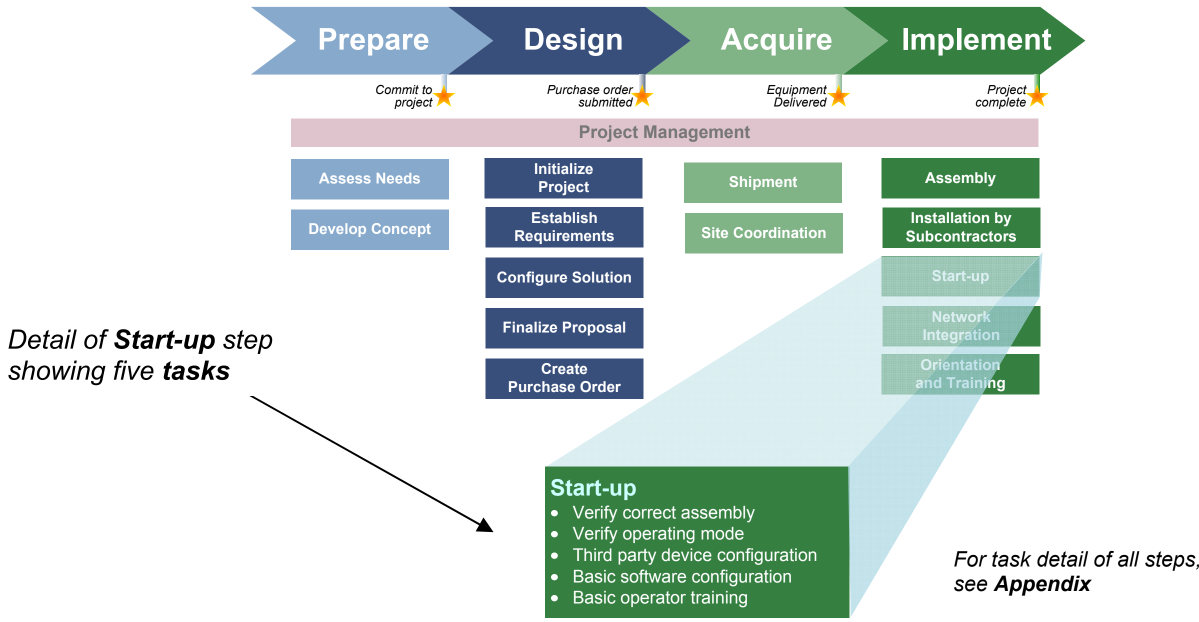


Figure 6

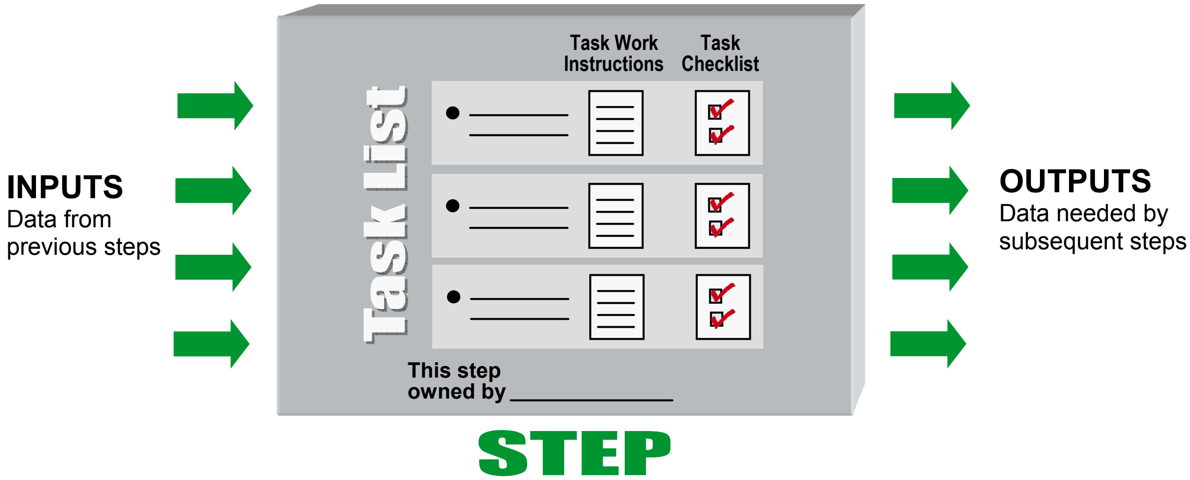
Detail of tasks within a step

As shown in **Figure 7** below, each step has

- **Ownership** – The party responsible for the execution of the step. Ownership might be within the user's organization, or it could be provided as an outsourced service by the equipment vendor or a third party service provider. Explicitly assigned ownership for every step, as in Table 1, provides insurance against missed handoffs, "dropped balls," and things falling through cracks.
- **Task list** – A description of the work that needs to be done to complete the step. Tasks define the actual work of the project. Each task has work instructions and a checklist of specific actions to be completed. Tasks within each step are determined by the type of the project, and by the physical infrastructure elements involved. For example, tasks associated with cooling will not be present if cooling is not part of the project. Each checklist item consists of one or more data elements, which may be as simple as a date, or as complex as a set of drawings. A task is completed when all its checklist items are completed.
- **Inputs** – Data needed in order for the work of the step to be completed. Each input to a step is an output of a step that precedes it.
- **Outputs** – Data produced by the step, needed as input to subsequent steps in the process.

Figure 7

Detail of step anatomy



Pull-based process architecture

Efficient process design dictates that every output produced by a step is generated at the right time and in the right form to be used by a subsequent "downstream" step as an input (or serve as a final output of the entire process) – otherwise the output amounts to wasted work.

Designing a process this way requires looking at the final intended result and asking "what is directly needed to achieve this result?" then working backward through each step of the process, asking "what does this step require from previous steps?" Providing what is necessary and sufficient for each step, at the right time, ensures that there is no wasted work (outputs to nowhere) and allows the process to flow efficiently from step to step. This "pull-based" approach to information flow – where downstream steps are "pulling" only the information they need from upstream steps – is a cornerstone strategy of this, or any other, efficient and effective process design.

Project management

As with any business project, a data center project needs dedicated and expert oversight, with documented procedures to address project-critical activities such as:

- Continuity
- Scheduling
- Resources
- Budget
- System changes
- Process defects
- Status reporting

The delegation of project management duties is an important element of process design that must be considered and determined up front, well before the time comes to execute them.

Link to resource
White Paper 141
Data Center Projects: Project Management

For a detailed discussion of project management roles and responsibilities for this process, see White Paper 141, *Data Center Projects: Project Management*.

Tracking responsibilities

It is essential that all the roles in a project be well defined and assigned, with complete clarity regarding who is doing what. Every block in the process diagram of **Figure 4** is work that must be done, so each one must be explicitly assigned to a person or party who will be responsible for executing it. Whether managed internally or outsourced to a service provider – either the primary equipment vendor or a third party – it is crucial that every element of the process be clearly accounted for by creating a responsibility list such shown in **Table 1**. An explicit and agreed-upon list of assignees for *every element* of the process provides protection from surprises, delays, and the common but unwelcome remark "We thought someone ELSE was doing that. "Responsibility" does not mean that the named entity is the only participant in the assigned work; it merely designates *responsibility* for ensuring that the work gets done.

Table 1

Responsibility assignment checklist – every process step must appear in this list

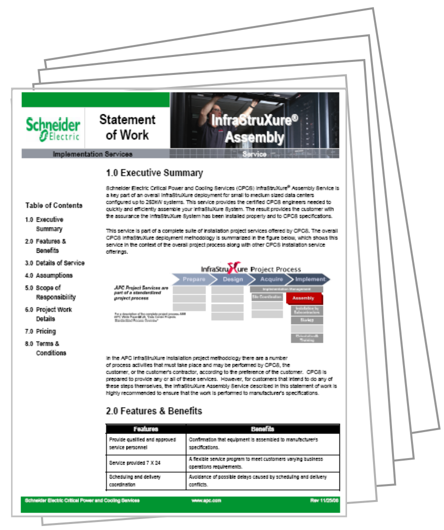
	Process step:	Who will do it? User (✓)	Primary equipment vendor (✓)	3rd party (who?)	Not needed (X)
Prepare	Assess needs				
	Develop concept				
Design	Initialize process				
	Establish requirements				
	Develop custom solution (ETO projects)				
	Configure Solution				
	Finalize proposal				
	Create P.O.				
Acquire	Site coordination				
	Factory acceptance test (ETO projects)				
	Shipment				
Implement	Assembly				
	Installation by subcontractors				
	Startup				
	Network Integration				
	Commissioning (ETO projects)				
	Orientation & training				
Asynchronous	Project changes				
	Product defect correction				
	Process defect correction				

Using services to execute process steps

To simplify data center projects, qualified suppliers should offer standardized orderable services that align with elements of the process model used by the customer. Such services may span a spectrum of offerings, from simple provisioning of equipment to various levels of responsibility in managing elements of the process, up to complete turnkey management of a major installation. The service provider can serve the role of parts supplier, partner, subcontractor, or project manager, according to preferences and capabilities of the customer. For example, in the Schneider Electric project process, there are services to handle several steps in the **acquire** and **implement** phases, site management, overall project management, and a variety of early planning services such as blade-ready assessment.

Statements of work

Regardless of the scope of involvement, any portion of the process that is outsourced to a service provider must have a "statement of work" that clearly defines the work to be done, including deliverables, assumptions, scope of responsibility, and work details. If a comprehensive, standardized, and proven statement of work is provided by the vendor, the customer can avoid the difficult task of creating a statement of work from scratch. A robust statement of work helps all stakeholders quickly understand benefits, outputs, cycle time, and pricing. Ideally, the customer should be able to quickly assemble a project that meets the project requirements using vendor-supplied, modular statements of work that can be "plugged in" to the overall project process.



Example statement of work: "Assembly" service

Choosing partners

In choosing partners for collaboration in the project process (to provide elements of the process as services), decisions regarding whether and whom to engage will be primarily guided by the availability of qualified expertise in project process activity. If that challenge can be met, the considerations in choosing service providers are similar to those generally stated for any IT outsourcing:

- **Optimize resources**. The main consideration in outsourcing is the prospect of freeing up scarce IT resources to focus on core competencies and strategic business activity. With a competent service provider, project process activities are in the hands of someone for whom project process is the core competency. The result, if the provider is qualified, will be lower cost, faster results, and fewer defects.
- **Minimize vendor interfaces**. A current partner, if qualified in the area of project process, provides the advantage of an existing (and presumably trusted) relationship, which means little or no incremental resources needed to establish or maintain an additional provider interface.
- **Minimize handoffs**. The process will be inherently more reliable if the number of handoffs between providers is minimized
- **Demand statements of work from vendors**. Detailed and accurate statements of work – in the context of a clearly articulated overall process – clarify in advance what the vendor will provide, enable understandable and predictable work results, and minimize wasted time.

Learning

For those involved in the deployment of data center physical infrastructure – either as self-architect of the project or as the customer of a service provider – informed engagement ranges from a matter of interest to a critical prerequisite, depending upon the level of responsibility for the outcome. Schenider Electric offers online courses (Data Center University) and white papers for education in the elements of data center design, implementation, and operation.

www.datacenteruniversity.com

Online courses

whitepapers.apc.com

White papers

As with another familiar example of a complex product, the automobile, the amount of interest and involvement in the product's creation depends upon the resources, skills, and temperament of the new owner – from completely do-it-yourself (rare nowadays for cars), to ordering from a list of standard options, to simple off-the-lot selection. The type of knowledge required is different at each stage in the process (**Figure 8**).

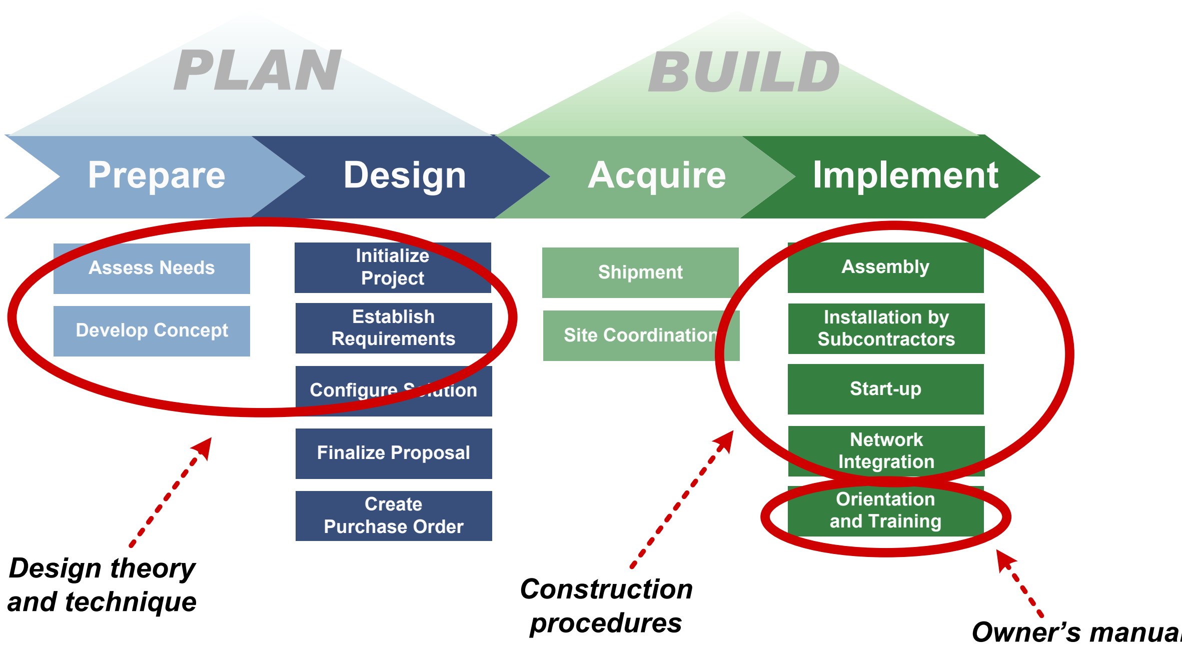


Figure 8

Types of learning at different places in the process

Note that in a mature industry such as automobiles, customers are not typically involved in design and construction, so they don't need detailed knowledge in those areas – they trust the manufacturer to have the knowledge required for design and construction. Data center physical infrastructure is moving in this direction, with standardized designs that can be ordered and configured much as a car is configured from standard options. However, for data center consumers who wish to do their own design and construction, education is available in the form of white papers and e-learning courses. Consumers can also engage the services of specialized consultants to assist in design and construction.

Conclusion

Data center projects have not historically been executed using a standardized, documented process such as the one outlined in this paper. Instead, data center builds and upgrades have typically been carried out in the realm of art rather than science, with one-time engineering, ad hoc management, and unique system design. As research and development move forward in this field, the concept of standardized process will integrate into the data center physical infrastructure industry, as it has in other areas of business activity. Services will become available to provide the time-tested benefits of a standardized – but configurable – process, much like in the automobile industry. Nowadays the process of building one's own car is relegated to the garages of an adventurous few – custom construction of ordinary data centers will someday be a similar historical curiosity.

As in other industries, a more standardized paradigm for data center projects will make planning and construction more predictable, efficient, and scalable for both the provider and the user. Further, a standardized process allows design talent to be redirected away from what has become routine and more toward the ongoing emergence of unusual, complex, or very large projects that will require specialized or exceptional expertise.

Users may not be particularly interested in the detailed workings of a standardized project process, but they want a reliable solution to happen as quickly and efficiently as possible. A process such as the one described here is an insurance policy for that outcome – a generic framework for the conduct of data center projects, from concept development to solution deployment. Regardless of the specific grouping and naming of the project tasks, whether the various steps of the process are combined or split, executed internally or outsourced to a service provider, it is the integrity of the underlying process that is crucial to the success of the project. If all tasks are clearly defined, assigned, and properly connected via the correct inputs and outputs, the process can be trusted to work.

> **Critical Keys to project success**
>
> **Focus on planning**
> Effectively executed planning is the essential foundation of a successful project. See White Paper 142, Data Center Projects: System Planning.
>
> **Eliminate responsibility gaps**
> Assign and track explicit responsibility for every element of the process
>
> **Let need drive activity**
> Avoid wasted work by linking all action to specific downstream needs ("pull-based" strategy)
>
> **Expect change**
> Have well-defined, dedicated procedures in place to handle changes and defects

The process described in this paper is the one developed by Schneider Electric to meet the requirements of effective project execution for their customers, who may choose to do some or all of the process themselves, or hire services to perform selected portions. A clear and complete definition of process elements enables steps to be captured as statements of work and offered as service modules, for customers who wish to delegate project responsibilities. Other organizations may have their own description of this same process, with different terminology and task grouping, but with the same project outcome.

A well articulated process should be standard operating procedure for any user-directed project, and demanded of any service provider. A standardized, documented, and understandable methodology assures a lean, predictable process that speeds deployment, facilitates communication, reduces cost, drives out defects, and eliminates waste.

About the author

Neil Rasmussen is a Senior VP of Innovation for Schneider Electric. He establishes the technology direction for the world's largest R&D budget devoted to power, cooling, and rack infrastructure for critical networks.

Neil holds 19 patents related to high-efficiency and high-density data center power and cooling infrastructure, and has published over 50 white papers related to power and cooling systems, many published in more than 10 languages, most recently with a focus on the improvement of energy efficiency. He is an internationally recognized keynote speaker on the subject of high-efficiency data centers. Neil is currently working to advance the science of high-efficiency, high-density, scalable data center infrastructure solutions and is a principal architect of the APC InfraStruXure system.

Prior to founding APC in 1981, Neil received his bachelors and masters degrees from MIT in electrical engineering, where he did his thesis on the analysis of a 200MW power supply for a tokamak fusion reactor. From 1979 to 1981 he worked at MIT Lincoln Laboratories on flywheel energy storage systems and solar electric power systems.

Suzanne Niles is a Senior Research Analyst with the Schneider Electric Data Center Science Center. She studied mathematics at Wellesley College before receiving her Bachelor's degree in computer science from MIT, with a thesis on handwritten character recognition. She has been educating diverse audiences for over 30 years using a variety of media from software manuals to photography and children's songs.

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Appendix: Task detail

The bulleted items in the process map below are the tasks that comprise each step of the process described in this paper. See earlier section, "Anatomy of a Step", for more about steps and tasks.