New plant upgrades or expansion projects don't have to be late or bust the budget. With good planning and strong management, they can finish on time — or even early.

Process plant construction projects can be some of the most challenging undertakings a company can launch. This is true for projects ranging from a simple unit upgrade in an existing plant to a complex new greenfield production facility. Process control and automation systems are invariably involved in any type of plant upgrade or addition. Automation infrastructure may be the primary item, or it may be an element of a larger project encompassing a broader range of equipment.

Whether small or large, construction projects are complex and carry a high level of risk:

- Cost overruns involving capital (CAPEX) and operating (OPEX) expense budgets add to pressure when costs exceed expectations.
- Schedule delays can make a project take longer than planned, increasing CAPEX costs while delaying cash flow expected from new production capabilities.
- Companies often underestimate the true cost impact of a delayed startup because they consider out-of-pocket costs without factoring in the lost income from production beginning behind schedule (figure 1).
- Some improvement projects are ultimately considered failures even after they begin full production because they do not deliver expected production levels. Disappointment grows if product quality or quantity never reaches levels necessary to justify the effort.

There is no shortage of horror stories from companies launching projects with great expectations, only to see their costs balloon and schedules go out the window. Any company considering launching an upgrade or new plant has to ask, “Why do so many projects fare badly? Are there common characteristics of underperforming projects we might be able to avoid?”

Those horror stories offer plenty of useful information and direction as to things to avoid. Here are some common mistakes:

- **Inadequate planning or, more accurately, the wrong kind of planning:** Many companies understand the importance of planning, but simply don’t know how to do it. There are so many critical elements that it’s difficult to identify which ones need the most attention.
- **Planning too late in the schedule:** Planning can never begin too early, but many companies assign those tasks to people with too much to do already. When more pressing issues consume their time, procrastination becomes the reality and critical steps do not happen early enough.
“With proper management, new plant upgrades or expansion projects can finish on time and under budget.”

- **Bringing inadequate resources to the project:** Very few companies have extra people on the payroll. In fact, the opposite is more typical. How many of your people have time to work on an upgrade project? Do the ones with available time have the right skills to bring to the table?

- **Relying on inexperienced personnel:** Even the most well-meaning and conscientious people may not be able to help because they have no relevant experience. An individual may be exceptionally good at running a plant, but those skills don’t mean he or she understands how to manage an electrical contractor if they have had no previous opportunities to be involved in construction, let alone an entire project.

- **Linear or serial thinking:** The timeline for a project may end up being too long because some planners are convinced only one element can be worked on at a time.

- **Too few people recognize problems developing:** An inexperienced person trying to manage construction may not be able to tell when a minor problem threatens to turn into a big one. The skill of knowing which small action taken at a critical time can prevent a disaster is a rare thing and only comes from extensive experience.

The unfortunate results of underperforming projects are easy to see: the plant starts up late, costs are too high, the process doesn’t deliver the performance the owner expected, and documentation is inaccurate or incomplete. The new part of the plant may eventually start up and begin production, but for all those reasons, it is still viewed as a failure along with the people who tried to make it happen — unfair as such a judgment might be.

**It Doesn’t Have to Be That Way**

Yes, underperforming projects are a major problem, yet they can be prevented. Your projects can be managed skillfully so they get completed on time, on budget and within performance expectations.

There is a way for you to avoid pitfalls with the right kind of planning — planning done early enough to make a difference, implemented by people who know how to drive projects. Proper planning brings together people, tools and methodology all built around one goal: getting your project completed, on budget and on time. This combination, along with utilizing the latest technologies such as digital commissioning, can bring your projects to fruition to create the production and profitability they were designed for. Here’s how this methodology can work for you.
Preparation and Planning

The first and most critical step is to bring the right resources into the project team as early as possible, ideally during the initial planning stages of the startup.

Many companies underestimate the positive impact the right team can have in guiding a project. This group should include a variety of people, both employees and contractors, from all functional areas of the plant and representation from all construction trades that will be involved. Through the life of a project, the makeup of the team will change. Some individuals will be involved throughout, but others with specialties may come and go as needed. Good ideas can come from any direction, and engaging people who will be operating the facility ensures they will get what they need, along with a sense of participation and ownership in the process.

A good way to create such a team and assign proper responsibilities is to use a RACI matrix (figure 2) to clearly document who is responsible for what individual elements throughout the process. This keeps everyone focused on the right things, giving them a clear awareness of their part in the overall project.

Figure 2
Factory Acceptance Testing

Factory acceptance testing (FAT) is a crucial part of the early planning and preparation for a successful startup. Having the right participants involved early in this testing is of utmost importance. This is often overlooked, but utilizing members of the startup team to perform the FAT with plant personnel is certainly beneficial. This early engagement with members of the startup team provides intimate knowledge of the equipment prior to the startup. It also ensures that any punch list items identified during FAT are fully resolved prior to commissioning.

The right automation solutions provider will have the capability to test and verify control code for any major automation system platform using an off-process control system along with the right simulation setup. While an automation system OEM can test code for its own platform, and smaller system integrators may be able to test one or several platforms, a full-fledged automation solutions provider will have extensive capabilities over a variety of platforms, enabling a complete test.

Once the startup team has been defined and roles and responsibilities established, the commissioning manager can begin putting together the startup checklist and working with the project scheduler to add granularity to the specific startup tasks.

Driving Accountability

Eventually, a project moves from planning to construction. Such work may involve bulldozers and pouring concrete, or it may be less visible improvements to automation infrastructure. Either way, construction and related project activities of any kind must be actively managed to keep things on course and on schedule. Without proper supervision, projects can quickly fall behind.

Why do schedules get off track? Too many companies look at construction as a black box. They understand that it begins and ends, but there is little sense of what goes on in the middle. Without people who can quickly understand each element, companies feel helpless to drive or even manage the process.

Consequently, the project moves at its own pace, while plant personnel can only watch and hope. For example, when all the contractors are complete, a long period of testing begins, only to discover there are electrical system problems. The contractor finished and demobilized six weeks ago. Plant personnel end up fixing the problems using internal time and resources because it is too difficult to pull the contractor back. Time and money are both lost in the process.

A much better approach is to divide and conquer. The construction timeline needs to be broken into subsections so each can be managed and tested along the way. Steps able to run simultaneously should be managed to make the schedule collapse on itself and reduce the overall project time. Testing should happen at each step along the way to ensure every element is functioning properly before a contractor moves on.

Few companies realize these benefits until they see it firsthand. This process of moving “heel to toe” and integrating construction with testing drives the schedule and keeps everyone, employees and contractors alike, focused. It’s not good to wait until all parts are finished to begin testing.

On the contrary, it is important to overlap as many steps as possible. Individual contractors, regardless of where they fall into the schedule, will see their work tested and approved before they leave. While they are still on-site, the contractors are held accountable for correcting any problems found.
Testing Procedures

Keeping aggressive project schedules on track requires testing at each step of the process to verify performance and fulfillment of specifications. Given the critical nature of testing, it needs to be divided into three phases corresponding to the relevant stage of construction. In a large-scale project, all three phases can take place simultaneously in different areas.

Pre-static inspection is designed to identify installation issues early in the process. Don’t rely on piping contractors and electrical contractors to install instrumentation, instead have this work done by an automation solutions provider specializing in this area. Pre-static inspection also helps quantify the percentage of completion of a specific portion of the project. This is the first point where using an electronic commissioning tool to replace conventional paper check sheets can result in savings in both time and money. All the steps are automatically linked, sharing test data from each stage and eliminating entry of manually recorded information. This is critical to keeping parallel activity moving to fulfill the schedule and to track progress against completion. Without it, the timeline often stretches out because the desired overlap is eliminated. Successful tests are identified in the overall piping and instrumentation diagram (P&ID) or via some other tracking tool to show a step is complete and ready to move ahead.

Static checks help to identify wiring issues during electrical construction. These checks are performed before any of the equipment is energized. Checks include checking wiring continuity and wire tagging as designed. Electrical contractors don’t always understand how common types of electrical equipment functions in a process manufacturing context, hence the need for an automation solutions provider. For motors, thermal protection and correct rotational direction may be verified, but is each VFD interfaced to the DCS correctly? Like pre-static inspection, this step is crucial to verifying a contractor’s performance and percentage of completion.

Pre-dynamic testing is the first stage where equipment is energized. It confirms functionality of instruments, valves and motors, verifying operability from the appropriate controller. Process variables may be simulated to verify scaling, valves are given full-stroke tests, motors are bumped, VFD operation is confirmed. This is the last phase of functional testing prior to full dynamic testing.

Each of these tests is performed as early as possible, corresponding to the stage of construction. All testing is documented electronically and incorporated into the schedules in real-time to ensure all steps are moving through the process correctly.

Commissioning and Startup

As the final stages of construction are taking place, the project is nearing the point at which it is ready for full dynamic testing. Using the heel-to-toe process of testing at each phase of the project means there is no lengthy period at the end when all elements must be tested at one time.

Full-dynamic testing is the final stage where equipment is energized and the logic is exercised to ensure that adequate interlock protection is in place for a safe process and that the operational logic functions in accordance with the needs of the specific process. This live testing of the logic confirms that it operates as defined by the control narratives. If you are utilizing an electronic commissioning tool, your technician can now access the information for all installation activities electronically to ensure the equipment or sub-system being tested fits properly into the larger context.
Now the instrumentation and controls (I&C) team can see the results of their efforts as the last elements are put in place and late-stage design modifications are made. But there is still much to be done as startup begins. At this point in the process, ownership transfers from the I&C provider to the plant owners, including all electronic testing records. The I&C team members of the startup crew provide support as the process experts execute their full dynamic test plans:

- Cost overruns involving capital (CAPEX) and operating (OPEX) expense budgets add to pressure when costs exceed expectations.
- Complete control system functionality is verified.
- Final loop tuning is performed.
- Final instrumentation and loop documentation is available electronically.
- All instruments and final control elements were tagged during installation, which makes positive location easier should adjustments need to be made in the field at this stage. Some mounted outdoors can be equipped with GPS locating devices.

Considering all the project activities that must take place in a short timeframe, any company trying to carry out such a comprehensive range of management and testing must have huge resource flexibility. Over the weeks and months of a project, there will be times of relative inactivity as well as periods when many things need to happen simultaneously — such as when a major phase is nearing completion.

Keeping things moving as quickly as possible while maintaining peak personnel efficiency demands constant adjustment of not only personnel on a site, but also personnel with specific skill sets. The ability to have the right number and right type of people on the clock, requires a pool of highly qualified engineers and technicians ready to move as needed at a moment's notice. A major automation solutions provider will have that kind of flexibility supplemented by tools able to provide test and commissioning documentation electronically, and allowing all participants to access this information easily. Such capabilities are critical to realizing all the possible benefits of aggressive scheduling, while keeping costs under control.

A major upgrade project can require over 100 people on-site simultaneously for the startup and final commissioning of just the electrical and automation system portions of the project. Such demands virtually require the plant owner to engage outside assistance to stay on schedule.

**Hot Cutover Techniques**

For many production facilities, the costs of interrupting production to perform an automation system upgrade are prohibitive. However, in some cases the need to implement such an upgrade is also highly compelling. The resolution to this dilemma is performing a hot cutover while the plant remains in production. This stage of a project requires very careful planning and coordination between the plant operations team and the automation solutions provider.

A hot cutover moves one control loop at a time from the old to the new automation system. Each loop needs to be verified, tuned and documented in the process. All parts of the new system hardware must be thoroughly tested to perform flawlessly so there are no process upsets at any step. Both automation systems must be running simultaneously, so all digital communication networks must support an increased level of traffic.
Control code in the new system must also be tested and fully operational to ensure its ability to operate correctly during and after the transition. Output image tables of the new controller need to be compared with image tables in the live existing system for parity. Once 100 percent parity is confirmed, the cutover can begin without fear of problems during transfer.

This kind of transition can be carried out without incident if done carefully by technicians who know what they’re doing. The right automation solutions provider will have performed many such transitions without interrupting production during large DCS upgrades and migrations. Such a track record depends on having talented people and the know-how to perform a wide range of critical functions.

**Closeout and Documentation**

For new systems or those upgraded during an outage, a full-dynamic test is the final check prior to putting the new unit or automation system into production. At this point, every hour counts because everyone wants to close out the project and realize income from the new system.

Using traditional project management methods, full-dynamic tests can be slow and painful as bugs and problems appear. Inadequate testing at earlier stages can leave undiscovered problems behind. The start up process will stop and start and problems are identified and fixed. While a technician corrects the rotation of a pump or figures out why a valve won’t respond to a control system command, other personnel are left standing around — people who are still on the clock, costing you money. In many cases, test results prove inconclusive and engineers must burn up time with troubleshooting and fixes.

By contrast, the right testing and other procedures ensure this final stage moves quickly and deterministically toward a positive conclusion. This includes ensuring that:

- All systems and subsystems have already been verified at each critical stage.
- Commissioning and startup personnel don’t have to wait for components to be fixed.
- The process can run continuously without stops and starts.
- Safety incidents and damage to equipment are avoided.
- Plant personnel see a reliable representation of the live process for a conclusive test.
- All loop sheets are available electronically, supporting easy access.

Meanwhile, all the documentation compiled throughout the planning and construction process can be easily assembled so it is accurate, thorough, complete and ready for turnover.

As a final step, the automation solutions provider sits down with the plant project team to discuss collective reactions to the project. This debriefing is something of a celebration, but also a time to gather observations and lessons learned to pass to the operations and maintenance teams. Tribal knowledge should be collected and documented to support future projects.
Conclusion

SureStart®, by MAVERICK Technologies, is a well-established start-up and commissioning process designed to work in parallel with construction efforts, and tracks your project in real time with the eStart® electronic commissioning application. Digital loop folders save time, and up-to-the-minute progress reports eliminate scheduling issues and unexpected delays. SureStart with the eStart advantage lets you know exactly where we are at in the project so you can make smart decisions about how to allocate resources to finish on time or maybe earlier than projected.

When the project is completed, there can be ongoing support on-site or through the PlantFloor24® remote monitoring solution to ensure all gains made are preserved and expanded upon.

As a leading automation solutions provider, MAVERICK Technologies performs an enormous amount of project management, startup and commissioning work, making the level of experience and technical skill at your disposal unparalleled. Few companies want to take on these kinds of projects due to their complexity and risk, so MAVERICK takes on many jobs for automation OEMs as well as system integrators.

When MAVERICK participates in project planning and manages construction and testing, you receive the highest assurance the project will meet all performance expectations, finish on schedule and budget. The investment for MAVERICK's services are typically recovered quickly through improved performance and the increased production benefits of earlier startup.

With more than $1 billion of automation services delivered across more than 15,000 successful projects, MAVERICK has the experience, resources and know-how to make your project an unqualified success. If you have a tough and complex project, bring it on — MAVERICK will work with you to ensure successful execution.