# [2. CRITICAL SUCCESS FACTORS FOR PROJECT COMMISSIONING AND START-UP (RS312-1)](https://www.construction-institute.org/critical-success-factors-for-project-commissioning-and-startup)

**Report Summary:** Commissioning and start-up (CSU) is the critical last phase of a capital project before the facility is placed into operation to meet commercial objectives. Unfortunately, many project teams do not effectively plan and implement the activities needed to ensure a successful CSU phase.

This study identified 16 critical success factors (CSFs), characterized by their specific required actions and positions within the project phase sequence, and firmly demonstrates the need for early CSU planning. Additionally, the study developed a set of unique indicators of CSF achievement to determine whether the CSFs have been implemented effectively. Additional analysis was conducted to determine reasons that certain CSFs are implemented less frequently than others and thus should require the particular attention of project teams.

Further, CSFs can complement or be integrated with steps in the CII Planning for start-up best practice model, described in CII [IR121-2](https://www.construction-institute.org/planning-for-startup). CII [IR312-2](https://www.construction-institute.org/achieving-success-in-the-commissioning-and-startup-of-capital-projects) identified five technologies that add value to the efforts of CSU teams and project stakeholders: (1) smart piping and instrumentation diagrams, (2) building information modeling design/3D models, (3) asset data management/wireless instrumentation, (4) simulation-based virtual commissioning and operator training, and (5) a completion management system. The final product is a user-friendly CSU Critical Success Factor Implementation Checklist, a tool for developing project execution and CSU plans and for managing CSU efforts through to project completion. The checklist is found in [IR312-2](https://www.construction-institute.org/achieving-success-in-the-commissioning-and-startup-of-capital-projects), Achieving Success in the commissioning and start-up of Capital Projects, which is the second part of a two-volume publication that offers implementation guidance and case study summaries.

**Key Takeaways:**

## (1) Ensure that the importance of commissioning and start-up (CSU) is widely recognized among all key project participants.

## (Project Phase: Prefeasibility through Construction)

* Communicate clearly to stakeholders about the critical role that CSU plays in achieving project objectives and ensuring successful facility operation.
* Collaborate with construction planners to develop a comprehensive plan for CSU, highlighting its significance and interdependence with other project activities.
* Educate team members about the benefits of effective CSU, which include improved safety, reduced risk, and enhanced overall performance.
* Incorporate CSU considerations into all aspects of project planning, from design to commissioning, to ensure CSU’s seamless integration and coordination.
* Regularly monitor progress using metrics that track CSU success to provide transparency and accountability for all stakeholders.

## (2) Work diligently and collaboratively to achieve all 16 of the critical success factors (CSFs), listed under (7) below.

## (Project Phase: Prefeasibility through Construction)

* Establish joint meetings with the Construction and CSU managers when construction is about 50% complete to ensure a collaborative approach to the project.
* Conduct joint system walk-downs that involve both the Construction and CSU managers to facilitate their thorough understanding of the systems and to identify potential issues early on in the project.
* Establish short-term scheduling priorities at both the construction area and system/subsystem levels, with input from both the Construction and CSU managers’ teams.
* Involve CSU staff in construction planning when the system construction is approximately 60% to 80% complete for each single major system to mitigate punch list items, with particular focus on utility systems early in the process.
* Transition from construction progress tracking on an area basis to a systems completion basis. Involve CSU staff in this process to ensure the effective redirection of construction forces as needed.

## (3) Be attentive to the six ‘laggard’ CSFs that appear to be particularly challenging in the construction industry.

## (Project Phase: Prefeasibility through Construction)

* Include system milestone acceptance criteria and deliverables, CSU value recognition, adequate funding for CSU, CSU systems engineering during front-end engineering design (FEED), systems focus in detailed design, and CSU leadership continuity.
* Identify the six laggard CSFs mentioned in [RS312-1](https://www.construction-institute.org/critical-success-factors-for-project-commissioning-and-startup) and understand their relevance to the project.
* Analyze and assess ways that these CSFs may impact the project’s schedule, budget, and overall success.
* Prioritize the CSFs by determining which are the most critical to address for the specific project needs.
* Develop a plan to mitigate or overcome any challenges posed by the laggard CSFs identified in the analysis.
* Execute the developed plan to ensure that the laggard CSFs do not hinder the project's progress and success.

## (4) Make use of the CSF achievement indicators identified in [RS312-1](https://www.construction-institute.org/critical-success-factors-for-project-commissioning-and-startup).

## (Project Phase: Prefeasibility through Construction)

* Review [RS312-1](https://www.construction-institute.org/critical-success-factors-for-project-commissioning-and-startup), Table 3 to become familiar with the top 30 CSF indicators and their descriptions.
* Assess and evaluate the project's current status against these indicators to identify areas for improvement or to maintain existing good practices.
* Prioritize the most critical CSF achievement indicators that align with the project's specific needs and goals and implement them.
* Create a plan to incorporate these indicators into the construction management process, ensuring effective communication and collaboration between the Construction and CSU managers’ teams.
* Regularly monitor and measure progress against these indicators throughout the project’s lifecycle, making adjustments as needed to ensure successful outcomes.

## (5) Consider applying the five innovative commissioning technologies identified in [RS312-1](https://www.construction-institute.org/critical-success-factors-for-project-commissioning-and-startup).

## (Project Phase: Prefeasibility through Construction)

1. Smart piping and instrumentation diagrams (P&IDs): Enable accurate, accessible, and integrated P&IDs for effective CSU system planning and understanding.
2. Building Information Modeling (BIM) design models/3D models: Provide accurate, digital models that improve safety, quality, and collaboration throughout the CSU project’s lifecycle.
3. Asset data management/ wireless instrumentation: Enable easy asset management and commissioning through automated processes to reducing human interaction and speed up the start-up phase.
4. Simulation-based virtual commissioning and operator training: Simulate life-like tests and training environments to improve engineering checkout and operator training and to reduce start-up costs and time.
5. Completion management system: Allow remote field data collection and consolidated documentation to reduce errors and costs and improve project handover efficiency.

## (6) Seek out lessons learned from past CSU failures and share these broadly among project and CSU managers.

## (Project Phase: Prefeasibility through Construction)

* Review [IR312-2](https://www.construction-institute.org/achieving-success-in-the-commissioning-and-startup-of-capital-projects) to identify key takeaways from mini-case studies of past CSU failures.
* Conduct interviews with previous CSU teams to gather insights into failure and errors and determine ways to improve the process.
* Analyze industry reports and research papers on common causes of CSU delays or failures.
* Develop a lessons learned database to store and share best practices, pitfalls, and CSFs for future projects.
* Organize workshops or training sessions to disseminate the gathered knowledge among project managers, CSU staff, and other stakeholders.

## (7) Become aware of and exploit the full suite of knowledge and implementation guidance provided in [IR312-2](https://www.construction-institute.org/achieving-success-in-the-commissioning-and-startup-of-capital-projects), including the 16 CSFs.

## (Project Phase: Prefeasibility through Construction)

* Review [IR312-2](https://www.construction-institute.org/achieving-success-in-the-commissioning-and-startup-of-capital-projects) to gain insights into commissioning and start-up best practices.
* Become familiar with the 16 CSFs (see the list below) identified by RT-312 for successful CSU planning.
* Study the case studies provided in [IR312-2](https://www.construction-institute.org/achieving-success-in-the-commissioning-and-startup-of-capital-projects) to learn from past failures and successes in CSU projects.
* Explore the implementation guidance offered in [IR312-2](https://www.construction-institute.org/achieving-success-in-the-commissioning-and-startup-of-capital-projects), which includes tools and checklists, to enhance the project's chance of success.
* Utilize the information and resources provided in [IR312-2](https://www.construction-institute.org/achieving-success-in-the-commissioning-and-startup-of-capital-projects) to develop a comprehensive CSU plan for the project.

## CSF 1. CSU Value Recognition

## (Project Phase: Prefeasibility through Construction)

* Establish the business case (including the CSU staffing plan) for effective CSU leadership.
* Recognize the value added from a successful CSU (e.g., the value of one day of successful operations).
* Avoid being ‘dollar foolish’. The Owner and all contractors must buy into, and be aligned with, the economics of effective planning and the investment required.

## CSF 2. Critical Interfaces on Brownfield Projects

## (Project Phase: Feasibility through Detailed Design and Procurement)

* Identify all critical interfaces with existing plant facilities and operational approaches early in brownfield projects.
* Include examples such as isolation design, system controls, worker access, permitting, and interim operations.

## CSF 3. Adequate Funding for CSU

## (Project Phase: Feasibility through Detailed Design and Procurement)

* Ensure that project funding for CSU is adequate, budgeted up-front, and preserved.
* Recognize that a common threat from insufficient funding is the lack of operators, which leads to delays in CSU progress.

## CSF 4. Alignment among Owner, Project Manager, Operations, CSU, Engineering, and Construction

## (Project Phase: Feasibility through Construction)

* The project and CSU will benefit substantially by obtaining early alignment among the CSU, operations, project management, engineering, construction, and other key stakeholder representatives regarding CSU terminology, CSU success drivers, and CSU strategies. Lack of such alignment may pose a threat to CSU success.
* Sustained alignment between these entities can be achieved only with effective collaboration throughout the life of the project.
* Recognize that lack of alignment may be a risk that threatens CSU success.
* Achieve sustained alignment through effective collaboration throughout the project’s lifecycle.

## CSF 5. CSU Leadership Continuity

## (Project Phase: Feasibility through Operate Facility)

* Ensure continuity of CSU management leadership throughout the project.

## CSF 6. System Milestone Acceptance Criteria and Deliverables

## (Project Phase: Concept through Detailed Scope)

* Establish specific detailed systems/subsystems acceptance criteria and associated deliverables for each major milestone: mechanical completion, turnover, precommissioning, commissioning, and handover.
* Ensure that all project parties understand these expectations.

## CSF 7. CSU Systems Engineering during FEED

## (Project Phase: Concept through Detailed Scope)

* Conduct CSU systems engineering during FEED to define CSU systems within a facility.
* Focus on effective FEED efforts to reduce CSU challenges, as the facility design significantly impacts fabrication, testing, integration, and start-up.
* Use preliminary P&IDs as key documents for this effort.

## CSF 8. Recognition of CSU Sequence Drivers

## (Project Phase: Concept through Detailed Design and Procurement)

* Coordinate the planned sequence of commissioning with construction planners.
* Consider factors such as construction sequence, plant operations philosophy, ramp-up objectives, plant controls automation, HAZOP awareness, modularization scope, clean build procedures, flushing sequence, leak/hydro testing, preservation steps, system tagging, and loop check sequence.

## CSF 9. Detailed CSU Execution Plan

## (Project Phase: Detailed Scope through Detailed Design and Procurement)

* Ensure CSU success through timely and thorough execution planning that integrates project and CSU planning.
* Address the appropriate skill mix that is required in both CSU craft and CSU management within the execution plans.
* Involve plant operations as an effective contributor to the planning effort, and tackle common challenges such as Operations staff availability, continuity, authority, experience breadth, and timeliness of input.

## CSF 10. Systems: Focus in Detailed Design

## (Project Phase: Detailed Design and Procurement)

* Adopt a systems-focused approach during the design phase that involves CSU and Operations to raise awareness of system handover, testing, and start-up procedures.
* Increase design attention to key issues such as high/low point drains, removable spools for critical inline equipment, critical isolation points, lockout/tagout requirements/supports, and access for operations and maintenance.

## CSF 11. CSU Check Sheets, Procedures, and Tools

## (Project Phase: Detailed Design and Procurement)

* Ensure that the component and system function checkouts include adequate check sheet criteria, detailed system commissioning procedures, and certifications.
* Enhance implementation through the application of innovative CSU technologies.

## CSF 12. CSU Team Capability

## (Project Phase: Detailed Design and Procurement through Construction)

* Ensure that the CSU team thoroughly understands the operations performance metrics-oriented requirements as well as the CSU activities and deliverables needed to achieve those results.

## CSF 13. Integrated Construction/CSU Schedule

## (Project Phase: Detailed Design and Procurement through Construction)

* Develop a fully integrated construction, precommissioning, and commissioning schedule to achieve CSU objectives.
* Integrate all checks, tests, and approval milestones for each component and system into the schedule, and ensure the development of support documentation.
* Avoid CSU acceleration effects that may result from delayed construction.

## CSF 14. Accurate As-Built Information

## (Project Phase: Construction through Operate Facility)

* Ensure accurate as-built drawings and an asset database to support effective planning, implementation, and closeout of CSU activities.

## CSF 15. Transition to Systems-Based Management

## (Project Phase: Construction)

* Plan to transition from construction progress tracking on an area basis to a systems completion basis so that construction forces may be most effectively redirected as needed.
* Involve CSU staff in construction planning when system construction is approximately 60% to 80% complete for each single major system in order to help mitigate construction punch list items, with particular focus on utility systems early in the process.

## CSF 16. Collaborative Approach to Construction to CSU Turnover

## (Project Phase: Construction)

* Encourage CSU managers to work collaboratively with construction managers in managing construction completion and systems turnover.
* Implement proactive communications to minimize construction v. CSU conflicts.

## [(8) Tool: Achieving Success in the Commissioning and Start-Up of Capital Projects (IR312-2)](https://www.construction-institute.org/achieving-success-in-the-commissioning-and-startup-of-capital-projects)

## (Project Phase: Construction through Commissioning Start and Start-Up)

## Volume 1: Achieving Success in the Commissioning and Start-up of Capital Projects: Implementing Critical Success Factors

* Define and implement CSFs: Establish the 16 essential CSFs for effective capital project commissioning and start-up, as validated through industry feedback and project data.
* Align stakeholder objectives early: Ensure alignment among project management, engineering, construction, and operations teams to improve collaboration and prevent conflicts.
* Develop a comprehensive CSU execution plan: Create detailed plans, including milestone acceptance criteria and integrated schedules, to streamline the CSU process.
* Address barriers to CSF achievement: Identify and mitigate common challenges, such as inadequate funding, misalignment, and lack of CSU-specific skills, to improve project outcomes.
* Utilize innovative CSU technologies and checklists: Apply new technologies and a standardized CSF checklist to enhance CSU performance, quality, and safety.

## Volume 2: Achieving Success in the Commissioning and Start-Up of Capital Projects: Mini-Case Studies

* Emphasize the importance of proper CSU planning to avoid costly delays and penalties.
* Highlight common CSU failures, which include inadequate communication, training, and oversight in high-risk settings.
* Identify best practices for addressing CSU-related risks through detailed execution plans, system check sheets, and clear role definitions.
* Stress the value of integrating subject matter experts and comprehensive operator training for optimal system functionality.
* Recommend implementing corrective actions, such as clear testing protocols, thorough as-built reviews, and enhanced inter-team communication, for CSU success.