



SEMICONDUCTORS

Ramping up at warp speed

Fabs can reduce expansion costs and streamline ramps through a new approach that emphasizes data-driven decision making and better communication.

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Semiconductor manufacturers are in an aggressive race to win major new designs and meet their customers' demands for rapid time to market. This has led them to accelerate ramps—the process of bringing a new technology from development to full-scale production—with increasing frequency. To facilitate these efforts, leading companies are developing more sophisticated capabilities in their fabrication plants, allowing them to streamline manufacturing, increase wafer size, and shrink nodes.

Fab construction costs have soared over the past few years, and further increases are expected. According to Gartner, total industry outlays for expansion—retrofitting, upgrades, and new facilities—could rise to as much as \$75 billion by 2018, up from an estimated \$66 billion in 2015. Despite these high capital outlays, ramps are frequently plagued with problems that put them behind schedule or over budget. In addition to raising capital costs, such issues may interfere with a fab's commercial prospects,

since manufacturers that are first to market with an innovative technology gain a lasting commercial advantage. Additionally, a leading-edge fab that produces nodes at high volume can lose tens of millions of dollars in revenue for each week of delay.

Many serious ramp problems can be overcome or mitigated through a strong management approach that emphasizes fact-based decision making and increased communication in three critical areas: project planning, performance management, and capability building (Exhibit 1). While the new approach requires intense management attention, the rewards are substantial. Better planning and tracking could reduce ramp durations by 20 percent and overall capital spending by 15 to 20 percent. Contractor expenses alone could fall by as much as 30 percent. After a ramp is complete, managers may be able to accelerate future projects by codifying best practices and developing strategies to transfer knowledge to new teams.

This article focuses on applying the new approach in fabs, but it is also applicable to any large-scale manufacturing ramp requiring coordination of numerous stakeholders and careful sequencing of all activities, including those for production of cutting-edge advanced-material, energy, and electronic components.

A complicated process

Every ramp is unique, but they all require certain tasks, including accurate capacity forecasting, seamless tool handoffs, and timely ordering and delivery of equipment. To manage the complexity,

leaders must create detailed schedules, establish performance goals, and constantly manage performance. Since ramps require great precision and thousands of process tools, a single misstep or process change can cause delays. The personnel challenges are also daunting because each group—engineers, construction workers, and others—has different incentives and goals.

Faced with such an overwhelming number of details, fab managers may inadvertently omit some critical specifics from ramp plans, such as handoff procedures on equipment installation. Adding to

Exhibit 1

Fab leaders can improve ramp management by creating detailed plans, maintaining a central control tower, and bringing best practices to new ramps.

1 Get everyone on the same page

Plan well from project outset:

- Create detailed end-to-end plans for tool installation
- Make fact-based assessments about time lines, risks, and other important factors
- Appoint owners for each tool

2 Keep the ramp on course

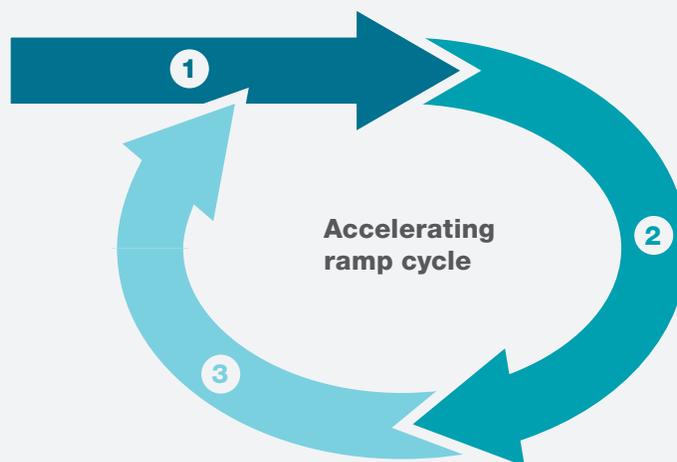
Maintain a central control tower:

- Set up a rigorous management system
- Maintain a central program-management database to facilitate communication

3 Maintain momentum

Bring the best to new ramps:

- Codify and share best practices
- Carry ramp talent forward



Source: McKinsey analysis

the confusion, many fabs lack the necessary benchmarks and metrics for ramp activities or do not record them for future reference. Without this information, team leaders may have difficulty spotting potential problems early, including those resulting from interdependencies or a change in plans.

Other ramp problems arise from inadequate communication, with teams and individuals making decisions in isolation because they lack established processes for sharing information. Manufacturing engineers, for instance, may not communicate important details about equipment throughput and capabilities to the capacity-forecasting experts who determine the number of production lines needed to meet volume requirements. If the experts base their decisions on incomplete information, they could underestimate the capacity needed, potentially delaying the entire project.

Project planning: Getting everyone on the same page

Fab leaders often struggle with ramp execution because they do not align on responsibilities, time lines, and goals. But they can potentially mitigate this problem by creating a detailed, end-to-end project plan that describes important milestones and activities. Important elements of the plan include the following:

- the sequence for installing tools
- major milestones and handoff points when responsibility for a tool transfers from one group to another
- required resources, including personnel, equipment, and materials
- productivity-rate assumptions
- lead times needed for the procurement or delivery of supplies, as well as the time needed to prepare for implementing various processes

- a time line that includes buffers to account for unexpected events

With this information, managers can see their next steps, understand if they are about to miss a deadline, and create a recovery plan. To manage change, project plans should discuss potential problems that could cause delays, such as a break in the gas line for a critical-path tool, and include contingency plans for managing these events.

Project plans should also include performance goals and related metrics that specify the expected duration of various tasks and weekly completion rates. These metrics will be most accurate if they are based on historical benchmarks for similar tools from prior installations or from partner fabs (either within the company or with technology partners). If this information is not available internally, tool vendors may be able to estimate the time needed to install a tool and undertake the qualification process.

Once managers have metrics—such as productivity rates and time lines for completing tasks—they will be able to identify areas of weakness throughout the entire project. Managers should inform all relevant contractors, vendors, and internal groups about project metrics, allowing them to follow a common strategy.

Creating an appropriate management structure

Ramps are so complex that they generally require oversight from the following three management teams, beginning with the planning stage:

- *An executive committee.* This group includes the fab manager and project lead. It makes all major decisions related to the project scope, schedule, and budget with input from leaders of relevant groups, such as finance, industrial engineering, equipment engineering, and construction. The executive committee also monitors performance and assigns accountability for various goals to specific groups.

- *A project-execution team.* This group includes functional teams, such as those from procurement or utilities, and tool-specific teams.
- *A tool team.* Each fab should appoint a single coordinator for every tool family to serve on this team. Tool owners are responsible for ensuring that handoffs between ramp teams are complete.

The tool team reports to the project-execution team, which, in turn, reports to the executive committee. Under this management structure, a single person on the executive committee has responsibility for coordinating all functions, with input and advice from frontline managers who are directly involved with execution or tool implementation. The frontline managers also escalate problems, as needed, and help resolve them.

Performance management: Keeping the ramp on course

Even if managers create a solid project plan, unforeseen events may cause delays or require a shift in strategy. But these problems can be mitigated by establishing better performance-management processes and establishing a central performance-tracking tool.

A better approach to performance management

The new, three-tiered management structure is critical to better performance management, as are the metrics that teams should create during the planning stage. Together, they can facilitate two important tasks: progress assessment and change management.

Assessing progress. While most fab managers now attempt to review performance during ramps, they generally do not compile detailed information for each tool and function. Since the managers rely on incomplete information when assessing progress, they may inadvertently overlook potential issues. To avoid such problems, fab managers should convene and chair weekly reviews that include the ramp leaders,

all executive-committee members, and leaders of the functional and tool-execution teams. By creating a shared understanding of ramp progress, these reviews will help fab managers identify areas for improvement.

At the beginning of each review, ramp leaders should receive updates about tool-installation progress, allowing them to estimate changes in future capacity. The project-execution team should announce any major project changes and their implications. The functional leaders on that team should then provide a progress update that includes important performance metrics such as the number of tools that have been installed or the percent of installations that were completed on schedule. The meeting should close with a discussion of important issues the executive committee will need to address.

Additional meetings are needed at the functional level to assess progress. These 15- to 30-minute stand-up meetings, which include members of the project-execution and tool teams, should occur daily and focus on the scope of work that must be completed over the following 24 hours, including deliverables, handoffs, and production time lines for all tools. For best results, functional managers should review the daily execution plan with the floor crew, highlighting the tools that could create bottlenecks or decrease capacity if problems occur.

If leaders detect performance gaps, during either the fabwide review or functional meetings, they should set ambitious yet realistic goals for resolving them. Meanwhile, leaders may need to adjust the schedule, always considering the complexity of the tasks involved, crew capability, and the availability of necessary resources.

Managing change. Even minor changes to the project plan can affect multiple ramp tasks, potentially causing delays. For example, a process-flow update might necessitate use of a different corrosive gas for

etching, a change that could require procurement of new chemical cabinets, construction of additional infrastructure, or development of different product-validation tests. To prevent major delays, fabs should convene a multidisciplinary forum to discuss any unexpected developments. This will help keep all functions aware of plan updates and give them an opportunity to discuss their impact.

Any team members who are requesting changes should supply forum members with relevant information well before the meeting. This prework will allow the forums to make immediate decisions or approve the resources needed to conduct further analyses, preventing bottlenecks. Ideally, the multidisciplinary forum will be led by select executive-committee members who rigorously assess the impact of any changes across the entire fab, lead the decision-making process, and propose appropriate mitigations.

An emphasis on accurate and accessible tracking data

To improve performance management, fab leaders should establish a central, easily accessible program-management tool that allows all stakeholders to view ramp information and input their latest data. Among other information, the system will contain the following:

- agreed-upon performance metrics
- a searchable database of past projects that allows managers to make benchmark comparisons and identify teams that could serve as models for others
- the latest milestone dates for tool installation
- tool-performance parameters, such as throughput
- the owner for each stage and tool

The program-management tool will facilitate communication and provide staff at all levels with a detailed snapshot of their tools' status, project time lines (including missed milestones), and next steps. For example, the capacity-forecasting group will be able to access up-to-date information when making decisions about production, rather than rely on data that was collected a few days before. It will then be able to route wafers to the tools that have the most spare capacity, mitigating the chance of bottlenecks.

By making it easier to see potential problems, managers may be more likely to work with the appropriate tool owners to resolve them. The program-management tool may also help prevent costly oversights at all stages, such as the failure to get timely bids for a critical-path tool, resulting in additional fees to expedite work.

For best results, fab leaders should incorporate the program-management tool into their standard management practices, primarily leveraging it to make data-driven decisions. They should also ensure that the tool has an easy-to-use interface and keep data-collection requirements to a minimum. For instance, leaders should ensure that information only needs to be entered into the tool once, after which it will be shared across the organization. When deciding what data should be collected, leaders should focus on important metrics that are necessary for making decisions or identifying deviations from the project plan.

In one recent ramp, a fab developed a program-management tool that could integrate large volumes of data. All stakeholders contributed content, and they could easily create and update performance dashboards. Since all relevant managers used the tool, it served as the single source of information for fab leaders who needed a comprehensive view of the project's status. To ensure that the tool captured all appropriate information, it directly connected

to multiple project-related databases at vendor and contractor sites and the fab itself. Among other benefits, the tool helped the ramp team quickly identify and resolve bottlenecks in the installation and qualification processes, accelerating the project time line. Exhibit 2 shows how a strong analytics tool can help eliminate some common ramp problems.

Capability building: Preparing for the next ramp

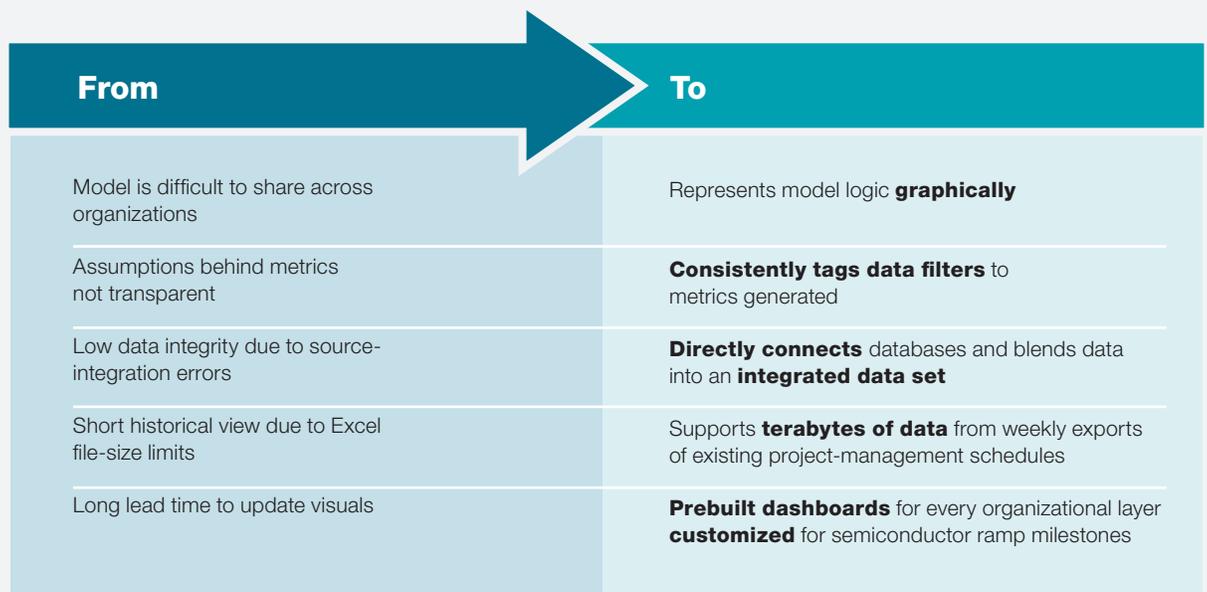
Teams may be tempted to sit back and celebrate their success after completing a ramp, rather than prepare for the next one, but this would squander their momentum. Instead, we recommend that fab leaders immediately codify all best practices and lessons learned about ramp management, tool templates, and communication strategies. To facilitate future projects, the information should be added to a continuously updated “ramp in a box”

that can be used to educate new teams and facilitate communication processes from day one.

Fab managers can also maintain momentum by having experienced staff serve as champions on new ramps, rather than appointing a fresh team for every project. These champions should have a broad set of capabilities, including knowledge of procurement, contractor-relationship management, equipment-supplier management, and end-to-end project planning. During a project’s early stages, champions can direct initial planning while also launching capability-building programs to help managers get up to speed quickly. Typically, they will first train a few people to serve as ramp leaders. This small cohort will then provide training to other staff, following a field-and-forum approach in which participants attend short boot camps and

Exhibit 2

Strong analytics tools can eliminate five common problems in generating performance metrics.



Source: McKinsey analysis

then apply what they have learned in the workplace before returning for more instruction. For example, trainers could provide instruction on creating a day-to-day deliverables plan for a critical tool and then help participants troubleshoot any problems that arise when participants attempt to apply this knowledge in the field. Trainer support, combined with the ramp in a box, will allow managers to deploy resources and equipment rapidly during new projects.



Because there are so many moving parts, problems are almost inevitable during a ramp, ranging from tools that fail to work as planned to slower-than-expected execution speed. What can be managed, however, is the frequency and magnitude of these problems. By following a data-driven approach to planning and central communication, teams can avoid many issues and spot the rest early enough to diminish their impact. And by ensuring that project knowledge and leadership flow from ramp to ramp, fab leaders can ensure that new teams learn from past experiences and that future projects reflect best practices. ■

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