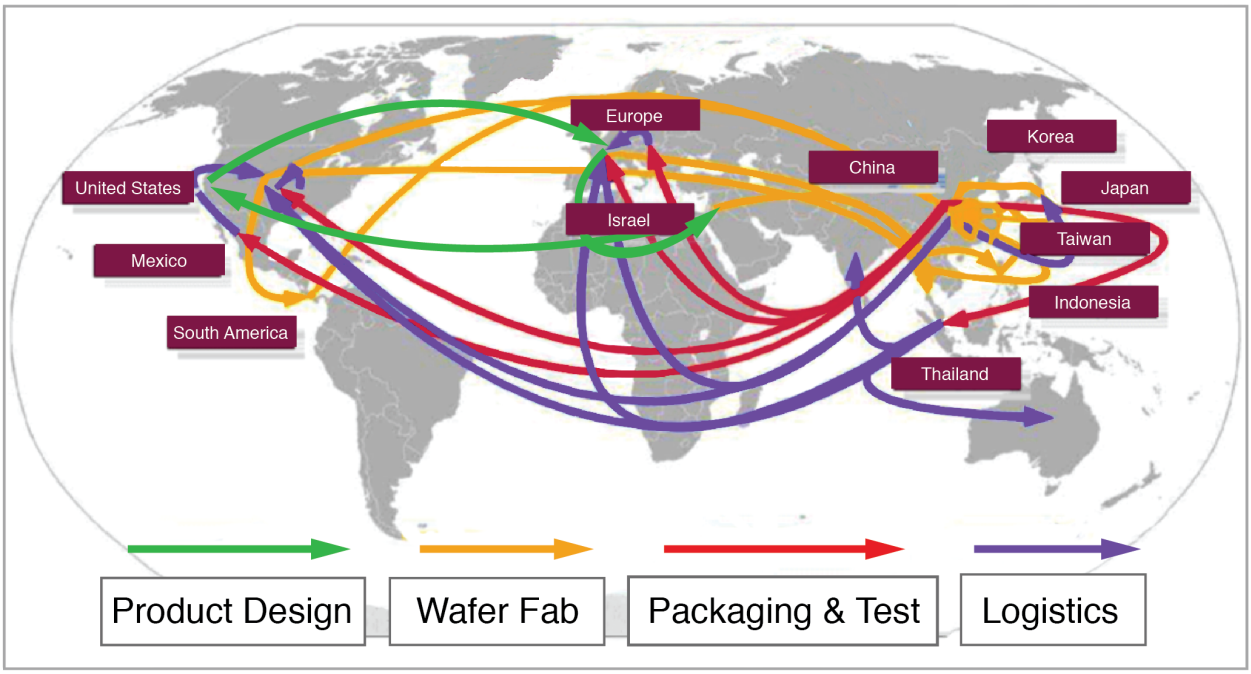
Outsourced Operations:
Reduce Risk, Accelerate Ramp, Manage Complexity



Outsourced operations is an economically attractive approach that can reduce risk, improve speed of implementation and mitigate against the potential costs of failure.

Current Trends

The internet of things (IoT) is driving exponential growth in the number and variety of smart, connected devices. Companies that want to develop new devices to take advantage of these opportunities face significant challenges in gaining access to and successfully navigating a supply chain that evolved to meet a very different set of production requirements. These companies are often relative newcomers to semiconductor manufacturing. They typically do not have the experience and in-house resources needed to manage the supply chain, and the opportunities they pursue do not allow time to develop them. Moreover, they must compete for manufacturing capacity against large volume production runs from the more traditional manufacturers the industry evolved to serve. Outsourcing their manufacturing operations (known as "outsourced operations") provides a way for this new generation of companies to leverage the knowledge and relationships of an experienced team to reduce risks (and potential costs) of failure, accelerate the ramp to production volume and manage the complexity of semiconductor supply chain.

Competition for Fab Capacity

The semiconductor manufacturing supply chain evolved to meet the needs of integrated device manufacturers (IDM) and fabless device manufacturers/foundries, who focused primarily on the production of relatively few devices in very large volumes – initially personal computers at 1M to 10M per year, then mobile phones at 10M to 100M per year, and then smart phones at 100's of millions per year. The first fabs were IDMs who designed and produced their own products. They were followed by the evolution of fabless device manufacturers, who designed new products, and foundries who produced them. As the industry has consolidated and mega-producers like Apple have appeared, we are seeing increased competition among foundries for the highest volume applications and the evolution of a new generation of IDMs. These mega-fabs do not have the resources to deal with typical IoT products that have volumes of tens of thousands to a few million per year. The large fabs and foundries are most efficient, and most profitable, running advanced processes and high volumes and have little incentive or capability to work on complex, widely varying products that must integrate a range of technologies (digital, analog, power, RF communications, data storage, etc.) in a single device.

Compressed Volume Ramps

There is also a mismatch between the timelines of the older and newer generations. The traditional semiconductor start-up followed an extended time line that began with raising capital and proceeded to assemble a team, design the product, drive market adoption and only then to ramp production to high volume. New industrial applications have long lifetimes but must collapse development timeline, reacting quickly to take advantage of short-lived market opportunities in a highly competitive market. Often the application and business case are already well proven; adoption is easy, driven by the addition of new smart features and reductions in cost of an existing product; funding is readily available based on the proven business case and time-to-market in high volume is the primary determinant of success.

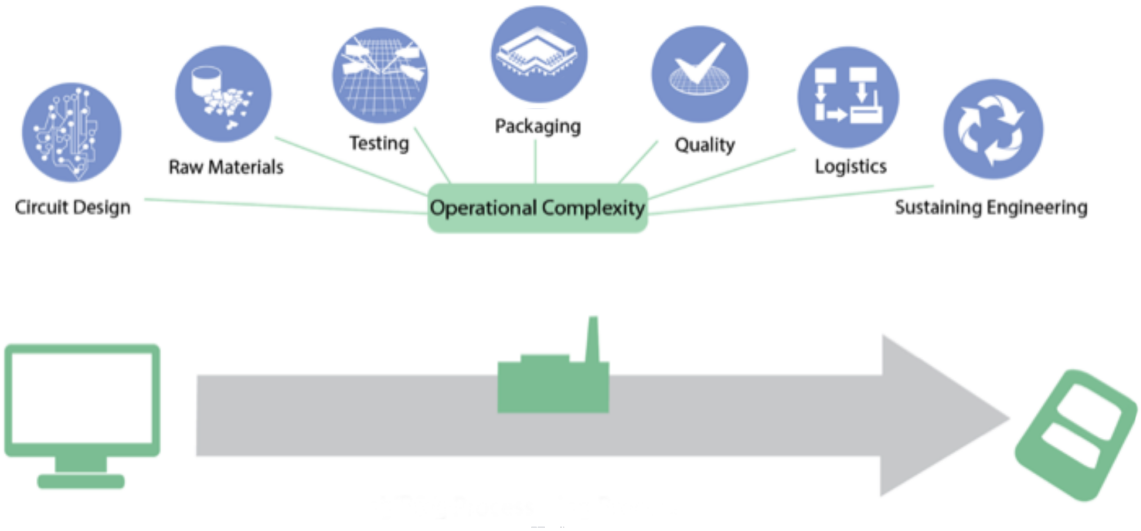


Figure 1: Semiconductor Manufacturing Supply Chain

Mitigating Risks

The semiconductor market is immensely complex, long and intricately connected (figure 1). The choice of foundry, test, packaging and other key partners are all critical decisions. Making the best decision requires detailed, intimate knowledge of the multiple process steps involved. The choice can have a massive impact on performance and time -to-market for the final device. Most importantly, once made these choices can be very hard to change without significant investment losses and crippling (12 to 24 months) delays in product introduction. Mitigating these risks requires a skilled operations team that has knowledgeable interaction from the first day with a strong design team.

Even if these skills are readily available for recruitment, the time and investment required to build an in-house team and the required infrastructure resources would challenge almost any business plan. Outsourcing the operations function to an experienced partner with an existing team that includes the necessary skills and supply chain relationships can address these challenges.

Outsourced Operations

The model for outsourced manufacturing is well-established, as in the electronics manufacturing services (EMS) which produces larger scale electronic components and subsystems. The vastly more complex nature of the semiconductor industry supply chain adds another level of complexity in operations over and above the manufacturing process itself.

The operations team must include experts in at least 10 highly specialized skill sets. These include:

- **Supplier Management:** selection and management of vendors, writing contracts, auditing performance and monitoring deliverables. Considering the highly technical nature of wafer production, test and package assembly, solutions and suppliers must be carefully selected, and business relationships correctly established; specifically,

consideration related to yield management, inventory exposure and material (mostly customer-owned) handling must be expertly managed.

- **Planning:** demand conversion (into raw material scheduling), lot starts and inventory management. Wafers are converted into units based on expected yield, very little common/raw material can be shared, and planning is therefore a critical function, especially when capacity is shared (foundry, assembly) and/or dedicated (test).
- **Purchasing:** purchase orders, managing backlog and tracking work-in-progress (WIP). Most products are more than a one stock keeping unit (SKU) or bill of materials (BOM) line time. Semiconductor products are identified by their mask ID and package but also by test flow, wafer backend process, embedded code, marking and packaging. This needs to be knowledgeably managed and communicated with the supply chain, as well as customers or customer agents, usually electronics manufacturing services (EMS) companies.
- **Logistics:** shipping, customs and warehousing. Supply chains span multiple countries, wafers must be shipped and stored in specific ways and products (increasingly secured within the supply chain) handled with evaluation assurance level (EAL) -certified flows.
- **Information Technology:** interface with business-to-business (B2B) supplier data systems, disaster recovery planning (DRP) and business continuity planning (BCP) – see below.
- **Device Engineering:** analyze yield and interact with foundry; this function is responsible for tape-out (including intellectual property clearance and mask review) then yield monitoring directly from the fab.
- **Test Engineering:** test solution development. Test is a critical step in industrializing a new product (validation, characterization, qualification, production release) and is in some ways almost a “black art”, especially analog and radio frequency (RF) testing. Test solutions include custom hardware (probe cards, loadboards, handler kits) as well as software (test programs).
- **Reliability Engineer:** qualification plans and stress solution development. This skill set encompasses development of all stress activities (electrical and environmental, at die- and package-level), including custom hardware (sockets, adapters, burn-in-boards), sometimes complex setup through I2C (or I^2C -inter integrated circuit), SPI (serial peripheral interface) and other buses, and advanced understanding of material science.
- **Quality Engineering:** retuned materials authorization (RMA) process, customer interaction and 8 disciplines (8D) process/product improvement. There are specific standards for reporting, often under collapsed deadlines (typically, a down production line) which require training and knowledge of all the problem-solving techniques available.

- **Product Engineering:** managing/improving yield and interface with designers. This is the link between device engineers, test engineers and design teams. They must be able to understand a product as a black-box (how it functions) and white-box (how it is built).
- **Failure Analysis:** analyze returned products, reporting. This is a lab role that requires expertise in multiple techniques used to diagnose (and sometimes fix) a failed product, including:
  X-Ray microanalysis
  C-SAM – confocal scanning acoustic microscopy
  FIB – focused ion beam
  SEM – scanning electron microscopy
  EMMI – emission microscopy
  AFM – atomic force microscopy
  TEM – transmission electron microscopy
  SIMS – secondary ion mass spectroscopy
  SDL – soft defect localization
  LVx – laser voltage imaging, laser voltage probing
  XPS – X-ray photon spectroscopy
  … and many more

In addition to individuals with the proper skill sets, significant investments are required in support infrastructure, including:

- Enterprise resource planning (ERP): semiconductor ERP must accommodate a production process that begins with wafers, that are then diced into chips, that are then packaged into finished devices – a process that is not entirely predictable as each step is a function of yield. Off-the-shelf ERP platforms are not designed to handle this yield variability well, and semiconductor ERP is best provided by a custom solution.
- DRP/BCP (duplication): semiconductor manufacturing uses expensive equipment that must produce 24x7; production disruptions are not tolerated, to the extent that most production requires recovery times to be less than a few hours, even for the most dire emergencies. Disaster recovery and business continuity plans require a level of duplication that significantly increases the cost of the underlying infrastructure.
- WIP Tracking/manufacturing execution system (MES) integration with suppliers: inventory reconciliation: considering the complexity of the material transformation, and the criticality of yield monitoring, work in process must be tracked exhaustively; this requires fully automated communications with multiple suppliers (B2B), each often using a different file format.
- Quality processes (certifications): in addition to the traditional and mandatory international standards organization (ISO) certifications, many operations need to carry market-related (automotive, medical, defense, etc.) and security-related (EAL) certifications.
- Laboratories (engineering test floor, and reliability and failure analysis labs).

Infrastructure costs can add quickly to millions of dollars.

Access to Supply Chain

In addition to the specialized skill sets needed to navigate the semiconductor supply chain, outsourcing operations also provides access to manufacturing capacity and critical supply chain elements through trusted, long-standing relationships. Fabs, OSATs (outsourced assembly and test) and other key suppliers prefer to work with trusted aggregators. Their bottom lines are driven by the successful completion of a production run with a minimum of rework and no residual liability. They look for an outsourcing intermediary that:

- has years of experience in semiconductor manufacturing and a proven track record,
- is self-sufficient in planning and logistics,
- has deep technical expertise in characterization, test and validation,
- has strong program management capability,
- will take return processes and sustaining engineering away from the fab.

Economic Benefits

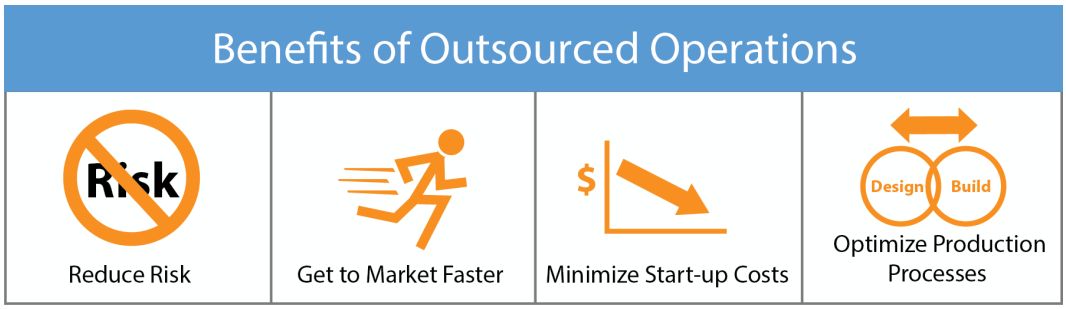


Figure 2: Benefits of Outsourced Operations.

Outsourcing always comes down to a make-or-buy decision comparing the cost of outsourcing production to the cost of hiring and retaining a multi-disciplinary team and the depreciation of infrastructure investments. Semiconductor operations outsourcing decisions must also consider:

1. Cost of inventory: turns are relatively slow since all wafers are custom, and their cycle times range from 4 to 9 months.
2. Cost of yield: when it comes to analog and RF (very common in IoT), yields may be very bumpy; having a set price into a BOM is a significant benefit, especially considering the breadth of the technical challenges related to understanding and managing yield.
3. Cost of logistics: a typical semiconductor supply chain spans several countries, often on different continents, bringing substantial shipping, logistics and customs-related costs and delays.
4. Cost of quality: semiconductors are complex products that are very expensive to test; defining test coverage is a business decision that balances the cost of test against the cost of field returns. Diagnosing failures in returned units can be challenging, taking considerable time and requiring familiarity with multiple disciplines.

5. The risks and potential costs of mistakes and delays.

Summary

1) The barriers to entry in semiconductor manufacturing are getting higher as scarce manufacturing capacity is sought by more, larger players.
2) The semiconductor supply chain evolved to support the fabless business model that cannot easily adapt to the needs of the new industrial OEM and IoT customers.
3) Assembling an in-house operations capability requires at least ten specialized skill sets and a significant investment in support infrastructure.
4) Long commitments and slow, costly changes to supply-chain configuration increase the cost of mistakes and the risk of failure.

For industrial and IoT projects, outsourced operations is an economically attractive approach that will reduce risk, improve speed of implementation, manage complexity and mitigate against the potential costs of lost opportunity.

About Presto Engineering

Presto Engineering, Inc. provides outsourced operations for semiconductor and IoT device companies, helping its customers minimize overhead, reduce risk and accelerate time-to-market.

The company is a recognized expert in the development of industrial solutions for RF, analog, mixed-signal and secured applications – from tape-out to delivery of finished goods. Presto's proprietary, highly-secure manufacturing and provisioning solution, coupled with extensive back-end expertise, gives its customers a competitive advantage.

The company offers a global, flexible, dedicated framework, with headquarters in the Silicon Valley, and operations across Europe and Asia. If you would like to discuss your operations outsourcing needs in more detail, please contact us at 408-372-9500, info@presto-eng.com, or visit our website at www.presto-eng.com for more information and local contacts worldwide.