

Operations Practices for Emerging Fabless Companies

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Having just received the first round of funding, the Emerging Fabless I.C. Company has many technical, marketing and sales challenges. Operations issues are generally not on the minds of the principals. We have discussed the Operations Dilemma facing such companies and have outlined a systematic, Concurrent Engineering approach to addressing the Operations activities in two previous papers.^{1,2} The objective of this paper is to outline the Operations Processes and Practices that must be addressed at Emerging Fabless companies in order to position themselves as a Leading or Best-in-Class supplier of Integrated Circuits. In established companies the concept of Best Practices has usually been explored and implemented in some or all of these Business Process/Practice areas. The four key steps to determining a Best Practice are: Current Assessment, Benchmarking, Cost Benefit Analysis, and Revising the Process.³ Establishing Best Practices involves integrating business processes and allows the Fabless companies to measure and improve their efficiencies, improve effectiveness of working relationships and environment within the organization as well as with Customers and their Supply Chain Partners. However, establishing a Best Practice is also time consuming and expensive. Judicious business decisions need to be made whether to elevate established Practices into Best Practices.

Since managing cash flow is a very important aspect of life at a start-up, we will suggest a min-set of Operations Processes and Practices that must be in place during the various stages of development and production ramp. An understanding of these Processes and Practices will be of assistance to senior managers at Emerging Companies. Practice areas will include Engineering, Quality, Customer Support, Production Control and Finance.

Operations Effort and Resources

Operations Tasks and Practices vary as the Emerging Company grows. This was shown for the Chip Development phase in previous publications.^{1,2} Here we have extended the non-linear curve to include the production phase. Figure 1 is a conceptual illustration of the Operations Resources required. We have developed a model for calculating Order of Magnitude ("OOM") estimates of Operations Effort and Cost as a function of Company

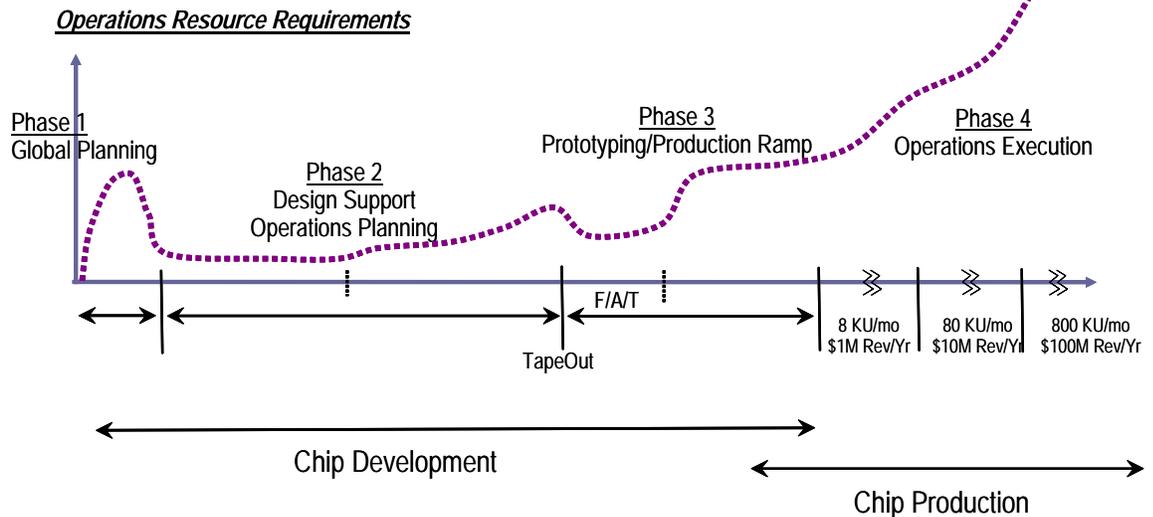


Figure 1

revenue. For simplicity, we assume a Single Product Company, a First Time Right Design approach and three Revenue 'plateaus' - \$1M, \$10M, \$100M annual revenue. Outsourcing of Production Wafer Fabrication, Assembly and Test is assumed. It is also assumed that the Fabless Company will manage the Supply Chain and will have ownership for the WIP (work in process). An overview of the typical Operations related Processes and Practice areas that a leading Fabless Company needs to have in place will be presented first. In the last section we will also present the reduced set of Operations activities required if the Fabless I.C. Company chooses to embrace an alternative ASIC Sourcing Model via the use of either an ASIC Supplier or an "Aggregator" of Supply Chain Services. The Fabless Company must trade off this reduced Operations cost with a higher Product Unit Cost, which is generally the case.

An Illustration

As an example of some of the production management challenges at the emerging company, we have summarized the number of units shipped and the number of wafer lots that have to be managed for the three revenue plateaus. The Table in Figure 2 also shows an estimate of the number of Operations Resources required to support the three revenue streams. Our model also estimates the Operations expenses, both Manpower and other Infrastructure, as a fraction of company revenue. This is a good measure for senior management to track their Operations investment. Embedded assumptions are that the chip size is 6mm x 6mm, 130nm 1P6M CMOS Logic technology, 200mm silicon wafers, a \$10 ASP (Average Selling

Price), \$100K per Man Year. It should be recognized that these are typical/guideline numbers that could vary from company to company due to individual company specifics.

Revenue/Year, \$M	\$1	\$10	\$100
Units Shipped/Year @ \$10 ASP, M	0.1	1	10
Wafer Starts/Month	14	140	1400
Wafer Lot Outs/Month	0.7	7	70
Operations Resources Required:	1 - 3	3 - 5	10 - 17
Ops Cost to Rev Ratio	15 - 35%	5 - 7%	2 - 3%

Figure 2

Operations Activities and Processes in Production

Within the Fabless Company, Operations usually has the Ownership to procure and deliver Product to Customers on schedule and at a favorable cost. The following is a simplified view of Operations Tasks and Activities. Within the Fabless company the Operations group should also be the Focal point for coordination of cross-functional issues with Customers and Suppliers. Some of these Roles and Responsibilities can be shared with other parts of the Organization. For simplicity we will assume that Operations is the “center of the universe” within the company. How the total company manpower can be optimized through sharing with the Finance, Sales, Engineering is beyond the scope of this paper.

We categorize Operations Activities into three major Practice areas:

1. Manufacturing Engineering
2. Quality, Reliability, Documentation and Procedures
3. Business Processes

Figure 3 is a simplified illustration of the relative importance of Operations Activities and Practices in the different phases of the company. In a start-up company with a \$1M revenue stream, the major focus in Operations should be on Manufacturing Engineering while the Quality and Business Processes can be accomplished with an “Ad Hoc” set of processes (Yellow blocks). At this stage it should be recognized that some of the Business processes such as WIP and Inventory tracking can be extremely important to managing Deliveries and Cash Flow and must have a high priority. We recommend a “Systematic” focus for establishing the processes and Practices as the company approaches a \$10M revenue stream (Light Green blocks). A company must have established Practices in all the areas (Green blocks) as its revenue stream approaches \$100M. The company may choose to invest in establishing a Best Practice only in some of the areas – areas that are critical to its core strengths and to its success.

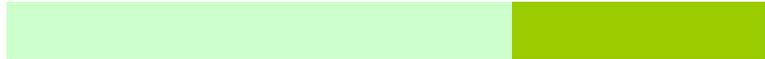
Annual Company Revenue: \$1M \$ 10M \$ 100M

Operations Activities

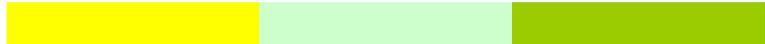
Practice Areas:

Manufacturing Engineering

Product Support / Unit Cost Management
Supply Chain Management



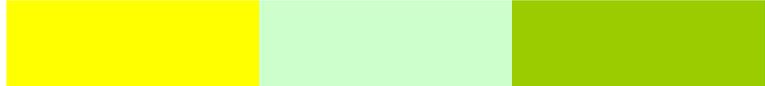
Q & R, Documentation



Business Processes

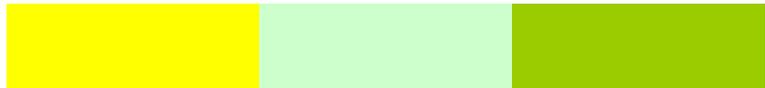
Production Planning and Control

Demand Forecast
Order Management and Fulfillment
Supply Chain Management



Financial Processes

Cash Flow for WIP and Inventory
Material and Cost Tracking
Product Cost – Actual vs. Plan



Customer Support

Response
RMA

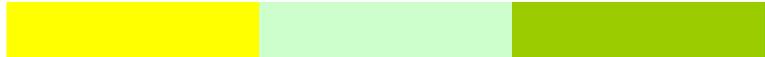


Figure 3

Manufacturing Engineering

This function is fulfilled by a group that usually has a broad set of Technical responsibilities for the Product Release to Manufacturing, maintaining the Yield and Quality of the Product, Interfacing with the Supply Chain and providing Technical Support to the various Business groups. The following is a list of typical responsibilities. Formalizing and documenting the processes associated with each of these responsibilities is the first step towards establishing a Best Practice in this area.

- Definition and Documentation of the Product, Procedures and Reports to Monitor and Control Product Yield, Cost and Performance
- Supplier Interface to address Product, Design, Process and Test related issues
- Yield Monitoring and Tracking
 - Lot to Lot variances
 - Wafer to Wafer variances

- Design Sensitivities
- Yield Enhancement Projects, if any
- Yield issue(s) Resolution
- Quality and Reliability issue(s) Resolution
- Quality and Reliability Maintenance Coordination and Execution
- Engineering Support of Customer Returns
- Failure Analysis, Debug and Reports
- Engineering Support of Production Planning
- Cost Reduction including Test Time Reduction, Price Negotiations, Supplier and Technology Migrations

Quality and Reliability

This function plays a key role towards the graduation of a fledgling start-up into a Best-in-Class supplier of Integrated Circuits. Setting up, monitoring and maintaining the Quality Processes within the Fabless I.C. Company and its Supply Chain are the major responsibilities. The following is a list of items around which processes can be set up as a first step towards establishing a Best Practice.

- **Quality Manual Documentation**
 - Documents the Company Quality policy, Quality System, Organizational responsibilities, Control Mechanisms
- **Formalize Document Control and Related Procedures**
 - Verify Product Design, Manufacturing and Qualification Documentation
- **Product Qualification Documentation**
 - Qual Plan, Specification and Report
 - Supplier Data – Foundry, Assembly, Test
 - Incoming and Outgoing QA Specifications
 - Reliability and Quality Maintenance Program
- **Process Certification Procedures and Maintenance**
 - SPC
 - Yield
- **Continuous Improvement Program**
 - Certification and Reliability Maintenance
 - Supplier Audits
 - Change Control Procedures
 - Incoming and Outgoing Quality Level Improvement

Business Processes

These are some of the processes that seldom get the priority they deserve. Since most companies need to establish the basic financial processes early in their existence, the perception usually is that extending these processes to include Operations and Supply Chain issues will be straight forward. While the Operations activities can and should leverage existing business infrastructure at the company, we advise a comprehensive look at developing the proper processes required to become a leading Fabless I.C. Company. We

have categorized the processes into three major areas, as outlined here. We will then elaborate on these processes. Formalizing and documenting the processes in each of these areas is a first step towards establishing a Best Practice.

- **Production Planning and Control (PP&C)**
 - Demand Forecast
 - Order Management and Fulfillment
 - Supply Chain Management
- **Financial Processes**
 - Cash Flow for WIP and Inventory
 - Material and Cost Tracking
 - Product Cost – Actual vs. Plan
- **Customer Support**
 - Response
 - RMA

PP&C - Demand Forecast Generation Processes

Operations has a key role in pulling the Demand forecast together. This is clearly a multi-disciplinary function and can be coordinated by different pieces of any organization – Sales, Marketing, Finance or Program Management. Since Operations is the group that has to communicate the Build Forecast to the Suppliers and to manage the Order Fulfillment Process, they are an excellent candidate for this very critical function. Operations roles are summarized here and the process is represented pictorially in Figure 4.

- Coordinate Cross Functional Process
- Receive Sales/Marketing Input
- Receive “Do-ability” from Engineering and Suppliers – Quantity, Schedule, Quality,..
- Coordinate “Judged” Forecast Generation
- Keeper of Updated Demand Forecast
- Communicate Forecasts to Suppliers
- Capacity Allocation Management

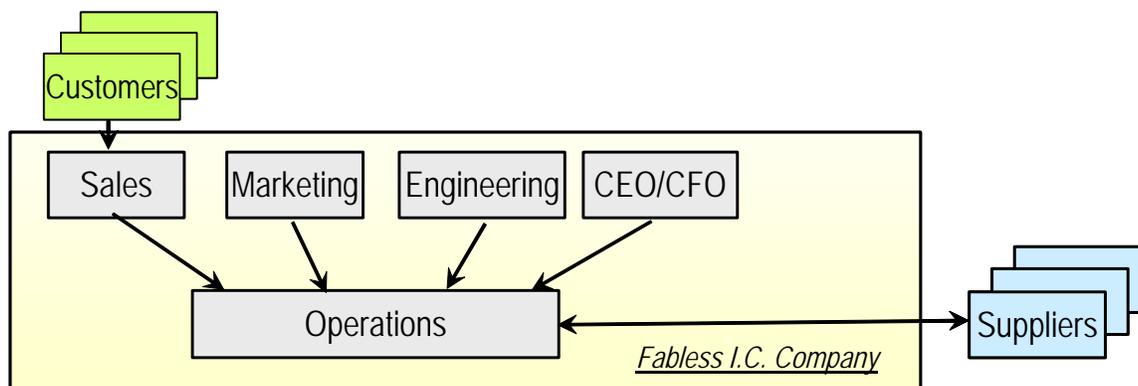


Figure 4

PP&C - Order Management and Fulfillment Process

The following is a list of Processes that must be followed and documented. In a Best-in-Class operation these activities are usually linked together in an ERP/MRP system connected to the company's Financial System to control Inventories, Cost, COGS, and Lead Time.

- **From/To Sales**
 - Verify Availability and Pricing
 - Receive/Acknowledge P.O.
- **Order Entry**
 - Enter Order into WIP/Inventory Management System
 - Trigger Shipment from Inventory or WIP or New Starts
 - Notify Production Control
 - Acknowledge P.O. and Advise Delivery Date to Customer
- **Parts Shipment and Logistics**
 - Monitor Ship Readiness, Advise Sales 48 hours prior to shipment
 - Generate Shipping/Freight Forwarding/Import/Export Documents
 - Generate Drop Ship Forms, if required
 - Pack
 - Follow thru with Sales and Customer
- **Invoice and Payment**
 - Generate and Send Invoice
 - Receive payment

PP&C – Supply Chain Management

The Supply Chain in a conventional, COT (Customer Owned Tooling) implementation Methodology is represented pictorially in Figure 5. While the drawing shows Operation as the only organization within the Fabless company, in reality Operations should leverage many of the functions such as Invoicing, Accounts Payable, Accounts receivable etc. that service the rest of the company. However, Operations must shoulder the responsibility for coordinating and reporting on these activities.

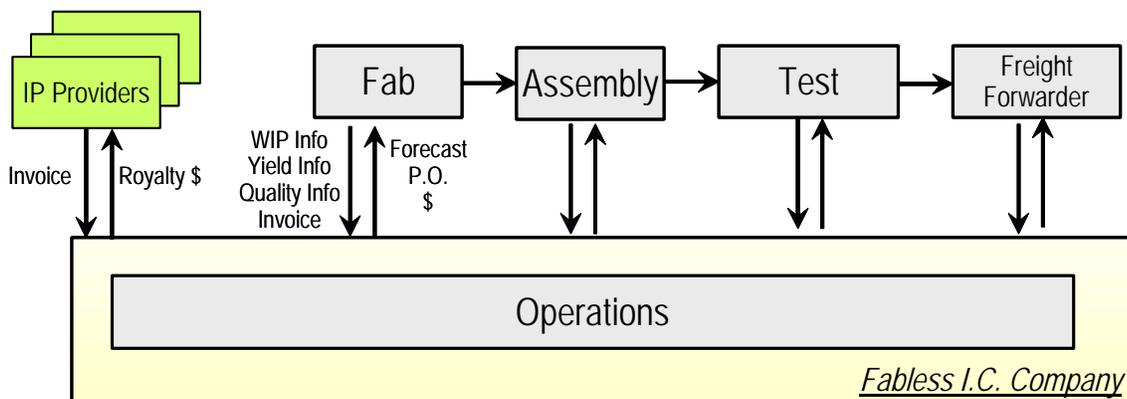


Figure 5

Financial Processes

In executing these activities it is assumed that the Operations group works in conjunction with the company's Finance Group but is held accountable for achieving the Operations goals.

- **To/From Customer(s)**
 - P.O. Receipt
 - Order Fulfillment
 - Invoice Issuance
 - Payment Receipt
- **To/From Suppliers**
 - Forecast
 - Committed forecast
 - Order Placement
 - WIP Ownership and Liability
 - Inventory Ownership and Liability
 - Special Materials Order Liability, if any
- **Management Reporting**
 - COGS – Plan vs. Actual
 - Cash Flow
 - Demand vs. Build Forecast Reconciliation

Customer Support Processes

Having an efficient and responsive Customer Support organization and the associated Practices is another key element of a leading Fabless I.C. Company. We categorize these processes into three areas – Quality Assurance, Customer Service and Product Planning. The interface to the customer needs to be clearly identified – it could be a Sales person or a Program Manager.

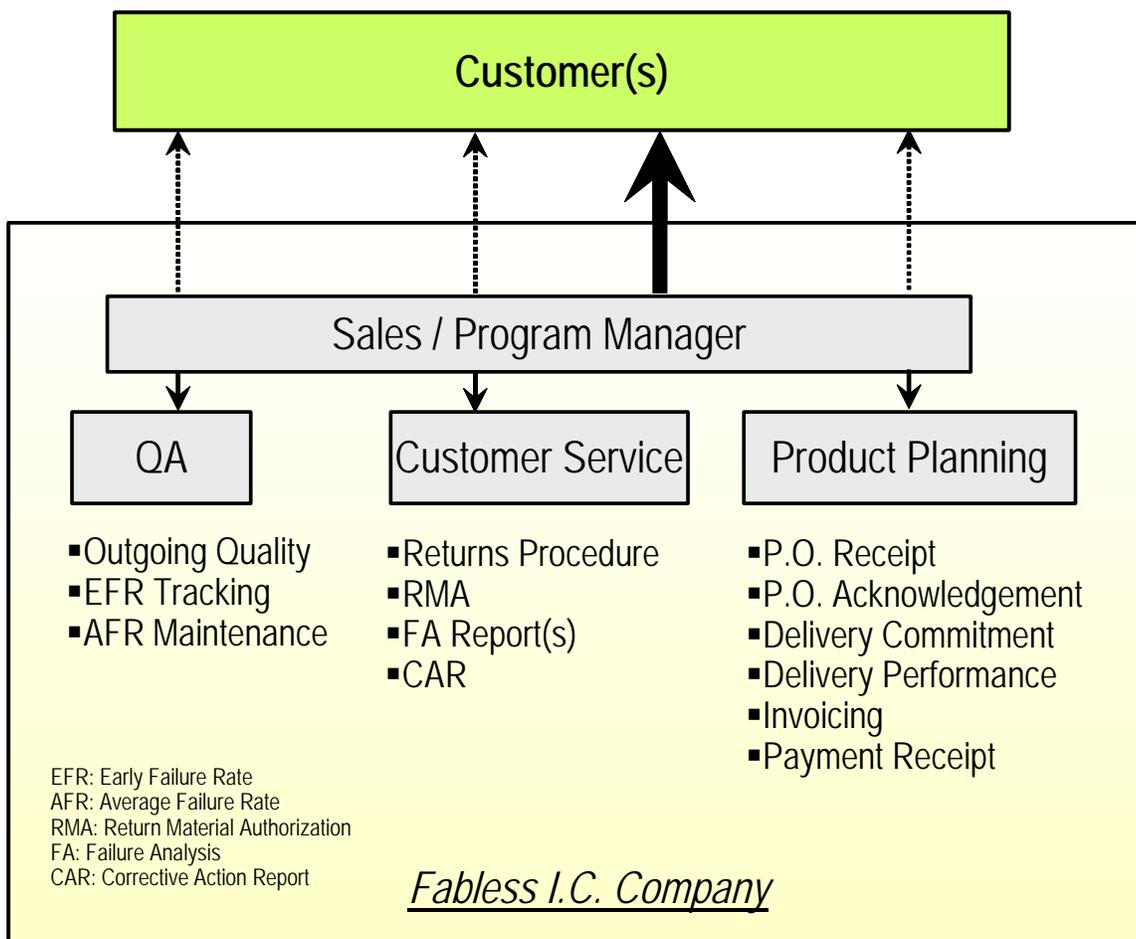


Figure 6

Effect of Alternative ASIC Sourcing Models

In this paper we have considered the COT (Customer Owned Tooling) Methodology. There are at least two other approaches that are important to consider – using an ASIC supplier and using an ASIC Aggregator. It is important to touch on this here because there is a general perception that the Operations Infrastructure required at the Fabless company is eliminated when using these alternative methodologies. It is our belief that the requirements for Operations Best Practices gets reduced by 30 -50%, but not eliminated.

If one compares Figure 5 and 7, we illustrate the simplicity of Supply Chain Management in the ASIC Supplier and ASIC Aggregator methodologies. So, the Operations resources associated with managing the Supply Chain – the Fab, the Assembly and Test get reduced to a minimum. However, since the Fabless company is responsible for the Product Quality, Delivery and Order Fulfillment for their customer(s), it is very important to still focus on establishing all the other Practices discussed in this paper. It is also important to note that while there is some cost reduction associated with the reduced Operations infrastructure, this must be traded off against higher unit price usually charged by the ASIC Supplier/Aggregator.

A more thorough discussion of the specific Operations Best Practice solutions and trade-offs for these methodologies is beyond the scope of this paper.

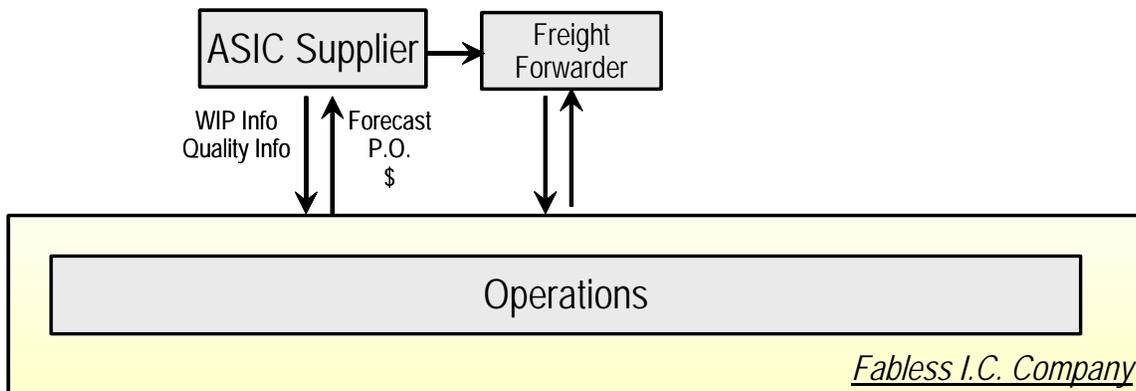


Figure 7

Conclusions

Emerging companies that aspire to be classified as a leading supplier of Integrated Circuits need to make investments in establishing many Best Practices in the Operations area. This paper has provided an Overview of the Operations Processes and Best Practices required as the company goes from being a Start-up to a mature I.C. supplier. The core Best Practices must be in Place regardless of the Sourcing Model used. While the ASIC Sourcing Model requires less resources compared with the COT approach, the Fabless company must trade off the reduced Operations Cost with a (generally) higher Unit Price.

Acknowledgements:

The author wishes to thank B. Henderson, R. Moro and M. Vinson for their valuable comments.

References:

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