KNOWLEDGE TRANSFER BETWEEN SEMICONDUCTOR FABRICATION FACILITY STARTUPS

by

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Submitted to the Sloan School of Management and the
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Master of Science in Management
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ABSTRACT

A reduction in the time and resources required for startup and ramp of a semiconductor fabrication facility is necessary to maintain competitiveness in manufacturing operations. This research describes and examines a method developed to augment the knowledge transfer of startup processes, as well as some of the other methodologies currently used for organizing and managing the facility startup. The research focuses on what steps can be taken to learn from past startups and integrate that knowledge into future startup processes.

Questions arise for any company regarding what system to implement for knowledge transfer. The primary criteria that should be examined for any location should include a cost / benefit analysis, understanding the trade-off between flexibility and standardization, and the resources required to manage the knowledge transfer. For a factory startup, the incentives, benefits, and resource issues differ from that of an on-going factory. As the startup has limited benefits from transferring their knowledge, creating a system that is easy for them to use and/or is useful during the startup period is ideal. Also, as the startup is a period of high activity the system should be part of the regular activity for both the giving and the receiving sites.

The knowledge transfer system described in this thesis is made up of a documentation process, conference, and web site. The method of implementation and the effectiveness of each method will be discussed, as well as possible future developments.

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1. Introduction

Semiconductor manufacturing has traditionally been a high cost, high-speed business where falling behind can quickly lead to low margins and financial losses. The rapid price decline and performance increases for microprocessors in recent years require manufacturers to become even more adept at managing their products and processes. In order to manage the escalating cost of production, many companies are now examining ways of re-using and re-tooling existing factories, as well as reducing the cost of building new ones.

In order to meet new performance demands, starting up a new technology is an increasingly frequent event. New processes involving decreased feature size, larger wafer diameter, and new recipes demand different production techniques and equipment. As demand for microprocessors is also increasing, many of these startups are newly constructed 'Greenfield' facilities, which pose additional problems.

Intel is a leading semiconductor manufacturer that manages the technology transfer and factory startups to produce new generations of its processors quickly and cost effectively. The company understands the importance of knowledge transfer in its industry, and has many methods to address this concern. Still, this is an area for improvement as cost reduction and faster technology transfer is required to compete in the changing marketplace. With "nearly 85 percent market share in units and an even higher share of total microprocessor revenues"[Slater, p. 48], Intel produces semiconductors in high volume while controlling costs. Even with this production capability, Intel cannot cover all of the market and competitors battle Intel on price and performance.

The new focus on cost reduction in production has led to an emphasis on faster and more cost-effective factory startups. In order to implement these improvements, Intel uses many methods to leverage the learning from previous startups. The best known of these knowledge transfer methods is Copy Exactly! (CE!), but also include cross-site training plans, an organizational structure known as the 'Virtual Factory', Lessons Learned and Post-mortems, and informal communication channels.

For any company, the process of knowledge transfer is a difficult and widespread problem. This thesis examines startup specific problems and the methods Intel employs to deal with them. The focus of the research is on the process of Lessons Learned and the potential for using the web as a knowledge transfer mechanism, although other methods will also be discussed. The examination of these methods will be for their effectiveness for Intel specifically, but should also include how the methods might be useful for other factory startups as well.

Chapter 2 describes the specifics of the problems Intel faces in startup knowledge transfer. Relevant background about Intel, the semiconductor market, and the importance of learning in this environment is discussed. A general discussion of what are the characteristics for which a formalized startup learning environment is advantageous is covered as well.

Current methods of knowledge transfer used at Intel are the focus for Chapter 3. An analysis of the scope, advantages, and disadvantages will be included for each method. Chapters 4 through 8 will then move to the Lessons Learned documentation, face to face session, and web transfer areas that were the focus of my research.

Finally, Chapter 9 will examine potential future directions and what conclusions may be drawn about the effectiveness of learning at Intel, and the methods of Lessons Learned and the Web in particular.

2. Startup Learning: A discussion of the problem

The semiconductor industry relies on introducing new technologies with an increasing frequency. The ability to start up factories on new technologies will help determine which companies will be successful in the next ten years. Understanding the semiconductor industry's environment, start up specific problems, and current knowledge transfer activities is valuable for understanding the methods used in knowledge transfer and how and when they should be applied.

In order to understand the startup environment, this chapter will first cover why fast startup is important to the semiconductor industry. Next the chapter will discuss the value of learning and what the objective of startup learning is at Intel. An analysis of startup learning, obstacles to achieving this learning, and characteristics of effective learning are also covered.

2.1 Factory Startup in the Semiconductor Industry

A semiconductor fabrication facility, which is commonly referred to as a 'fab', is a factory that produces computer chips. The process is capital intensive and involves complex chemical technology that requires exact procedures and precise measurements to produce quality products. The workforce is highly educated, but the primary cost driver is the facility and equipment costs. A new fabrication facility, or fab, costs billions of dollars, and capital equipment is a major expense in starting up a new technology. The high cost of equipment and rapid depreciation illustrate the importance of utilizing and managing equipment effectively.

As semiconductor factories become increasingly complex and new technology startups increase in frequency, delays in startup will have costly consequences. The semiconductor industry has had a steady productivity growth of around 25-30% per year in reduction of cost/function. At the same time, factory costs have been escalating at a rate of around 20% per year. The growth is driven by improvements to feature size, wafer diameter, yield, and factory productivity. In order to meet this growth, the process has become increasingly complex with shorter cycles for the technologies. This causes higher factory costs through increasingly complex tools, process complexity, and factory changeovers. [Semiconductor Industry Association, p. 115]

In the future, productivity gains must come from faster more efficient technology startups. According to the 1997 National Technology Roadmap for Semiconductors, the amount of time from factory groundbreaking to first wafer start has doubled during the last twelve years. In order to reverse this trend, elements of factory construction and production preparation must be shortened and performed in parallel. The roadmap estimates that the amount of time to start up a factory in 1997 was approximately 23 months. In 1999, the amount should be decreased to 21 months, and by 2012 the total time for factory design, construction, tool preparation, and tool qualification should be 10 months. (As illustrated in Figure 1) With current solutions being pursued, the 21-month time frame is achievable but beyond that there is no known solution. [Semiconductor Industry Association, p. 116-117]

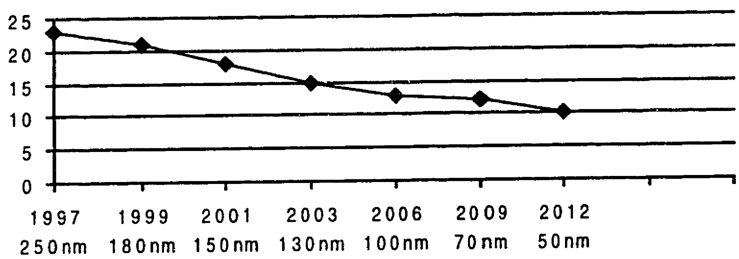


Figure 1: Time to First Wafer Start (months) (data from The National Technology Roadmap for Semiconductors)

In addition to reducing the time to first wafer start, the production ramp time should be reduced from 9 months to 1 month and the yield ramp from 4 months to .5 months in the same time frame The production ramp is the time it takes to bring the number of wafer starts from low/no capacity to full capacity. (Semiconductor Industry Association, p 116-117) As traditionally the market has been the bottleneck for companies such as Intel and the value of most chips are higher at the beginning of their lifecycle than at the end, lower production capacity through fewer wafers and lower chip yield at factory startup translates directly into lower revenues. Reducing the time to start and ramp up the fab is therefore also critical in maintaining and increasing profitability.

In order to achieve these productivity improvements, the roadmap has several suggested solutions. First is to maintain a highly educated, trained workforce. Second, the roadmap suggest using sophisticated data collection and decision support tools. Information management is an important part of the factory worker's job, and training and education is critical. Overall, learning and tools for improved decision making are emphasized as important factors in achieving factory startup productivity improvements. [Semiconductor Industry Association, p. 123]

2.2 Value of Learning

With increasingly complex systems and technologies, learning plays an important role in factory startup. Learning can be described as the method that is used to obtain knowledge. Knowledge is more difficult to define, as it relates to a level of understanding of the system or technology and how to use it. In Working Knowledge, by Thomas Davenport and Laurence Prusak, knowledge is described:

> Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices and norms. [p. 5]

In practice, knowledge is what allows the workers to make informed decisions and plans. Achieving efficient learning will lead to a more knowledgeable workforce.

In order to achieve optimal learning, the right level of information needs to get to the appropriate individuals. The appropriate individual is the person who is best able to make the decision and perform the action. The right level of information should be detailed enough for the individual to understand the tasks required and how these tasks affect the overall system. Depending on the individual's role or function, the level of detail and scope of knowledge may vary.

For example, the fab manager needs to know about problems that will affect the overall schedule, and knowledge that will help him or her to make informed decisions to allocate resources, commit to production numbers, etc. A tool operator also needs knowledge to perform his duties. The knowledge he needs may include detailed process specifications, how to handle exceptions, and how to prioritize the work in progress. The knowledge required for each of these roles varies, and the knowledge to be transferred to these individuals should be tailored to their needs and not include unnecessary detail or lack information that is useful to perform their job.

Learning is only valuable if it is useful in improving the ability to perform the jobs or tasks required. Getting the right level of information to the right recipient is one of the major obstacles of knowledge transfer. The ability to make informed decisions is critical to managing the startup, and defining and gathering the knowledge necessary to improve the startup process will be useful to meet this goal.

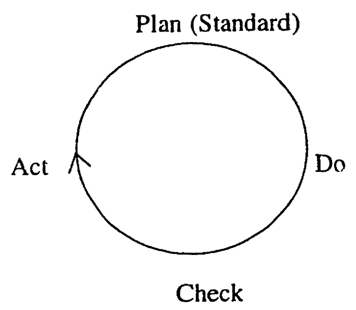
2.3 Startup Learning Objective at Intel

Startup learning is a term that will be used to describe the transfer of knowledge about how to start up a fab. The purpose of improving startup learning at Intel is to enable new fabs to startup faster and more cost effectively. As described in the previous sections, fast and efficient fab startup is critical in the semiconductor industry. By learning from previous fab startups, new startups can better manage problems by better understanding potential issues and utilizing systems and methods developed at other sites.

The research for this project focused on how to leverage knowledge gained during the Ireland fab startup in future fab startups. The Ireland fab startup involved the combination of a newly constructed or 'Greenfield' facility with an existing facility running an older technology. The knowledge from the Ireland site was to be gathered and transferred to sites in the United States and Israel. This system for transferring this knowledge was intended to work in conjunction with Intel's other knowledge transfer methods (described in Chapter 3), and to be a standard mechanism that could be developed and used for gathering and transferring future startup learnings.

2.4 Analysis of Startup Learning

Typically, when a team develops improvements or learning activities, they are based on realizing a need from past experiences. In Total Quality Management (TQM), continuous improvement has a basic SDCA (standard, do, check, act) cycle. SDCA entails having a standard (S) process. Acting on the process is to do (D) the process, whose results are then checked (C) and an appropriate action (A) is taken. (As shown in Figure 2) If the results are within specification, the SDCA process is continued and the cycle repeated. (Shiba, Graham, and Walden 65) If the results are not in the specification or improvements are required, the PDCA (plan, do, check, act) cycle is implemented. For PDCA, the first step is to plan (P) the course of action. This requires understanding the key problems within an existing process or activity and how they can be corrected. The next step is to implement or do (D) the plan. This is followed by a check (C) to confirm the plan works and performance is improved. Acting (A) on the improvement requires modifying the previous process as required, documenting the changes, and using the improvement in future iterations. [Shiba, Graham, and Walden, p. 56]



Characteristics
- Standard behavior
- Appropriate feedback
- Same players throughout cycle

SDCA/PDCA Cycle

Figure 2: Operational Learning

The SDCA/PDCA cycle works well for operational learning and improvements, but fails in meeting the needs for a startup. In operational learning, the standard behavior is understood and fully described to the team. When an improvement is required, the team is able to plan the change, implement, feedback the results, and make modifications to create new standards.

For a startup, determining the standard behavior is part of the improvement process. Most of the workforce is not experienced in using the standard, let alone implementing it. The team needs to understand the standard, figure out how to implement it, determine if they are following it correctly, and make adjustments if necessary. As the teams and activities may be short in duration, improvement activities may resemble the process flow described in Figure 3.

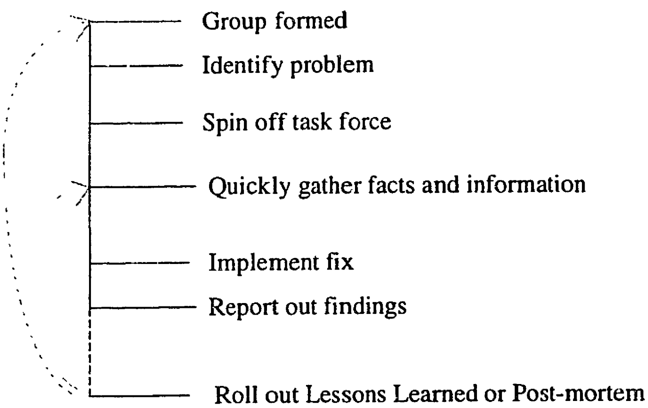


Figure 3: Startup Learning

For startup learning, the team is formed to implement an activity. When a problem is identified, a task force is often spun off to manage the issue. This allows a smaller group to focus on the problem and to quickly gather relevant facts and information. As time is a critical resource, the fix may be found and implemented without being properly planned. If the solution works, it is often accepted and incorporated. Modifications or future improvements tend to be limited, as the activity is of short duration. Feeding back the solution, knowledge of the problem, and other information to the next implementers of the activity can be limited. Unlike the case of operational learning, the cycles may not be repeated and the players may change between iterations.

2.5 Examination of Obstacles

Due to the differences between startup and operational behavior, there are several major obstacles to achieving efficient knowledge transfer. Three main areas of concern are the limited duration of the startup, the difficulty of communicating the knowledge, and determining the ownership of the problems and solutions.

Limited Duration

As the startup only lasts a few months, many of the problems experienced may be viewed as short-term and will go away once the startup has been completed. The effect of startup specific solutions can be measured in weeks rather than years, and there is little incentive to develop robust or effective solutions. There is a potential for a 'quick fix' for the problem to overcome the difficult period, and more errors and a higher level of stress often occur during the startup.

Some systems are developed for the startup, yet are more fully functional and robust. For instance, Intel has cross-site training for much of its personnel for a new fab. The personnel trained ranges from fab managers to manufacturing technicians. The training may involve managing hundreds of people at multiple sites. For each person transferred, the startup must carefully orchestrate their hiring, orientation, travel plans, securing a useful position at a host site, and returning them in time to fill their new position.

As the need for transferring personnel predominantly occurs during startup, this activity is startup specific. The duration of the activity can be for several years, as training can occur well before the new fab is constructed. The coordination of activities from hiring through training requires several inter-related systems and tracking methods. The new site needs to understand its hiring needs and when they need the workers in order to prepare. The several month lag between hiring and start date required by the training means delays or mix-ups can cost the factory time by not having the necessary personnel.

Still, most of the transfers occur over several months of peak activity. As with other startup activities, there was the possibility of creating a system that can only manage a low level of load. The complexity of the requirements for startup may have contributed to the systems and procedures developed, but the primary driver is probably the continual usage and improvements on the system through multiple startups. The staffing and assignment system was developed over the past five years and has served as the basis for managing many startups. The continual use and improvements are due to experienced personnel in charge of the process, as well as good documentation.

Communication

Communication between startups is difficult because of timing, location, and activity differences. When introducing a new technology, a schedule is determined for which fabs will introduce the technology and at what time. Introductions may overlap some, but do not occur in lockstep with the other locations. Also, activities such as design and construction only occur for Greenfield startups, and installation requirements differ between sites and technologies.

For example, a fab in the US running the previous technology needs to manage installation of the new equipment required without disrupting production. As the old technology is being ramped down, the new technology should be coming on-line. A Greenfield startup, such as the Irish fab startup, requires design of the new facility, construction of the fab, installation of the equipment, qualification of the equipment and process, preparing for manufacturing readiness, and then ramping into full production operations. (As shown in Figure 4.) Each of these activities represents a startup specific organization and is run as a separate segment. The division of activity into segments adds some complexity to managing the startup within the fabs. Communication between the segments, as well as handing off the running of the fab activities, was included as some of the startup learning developed.

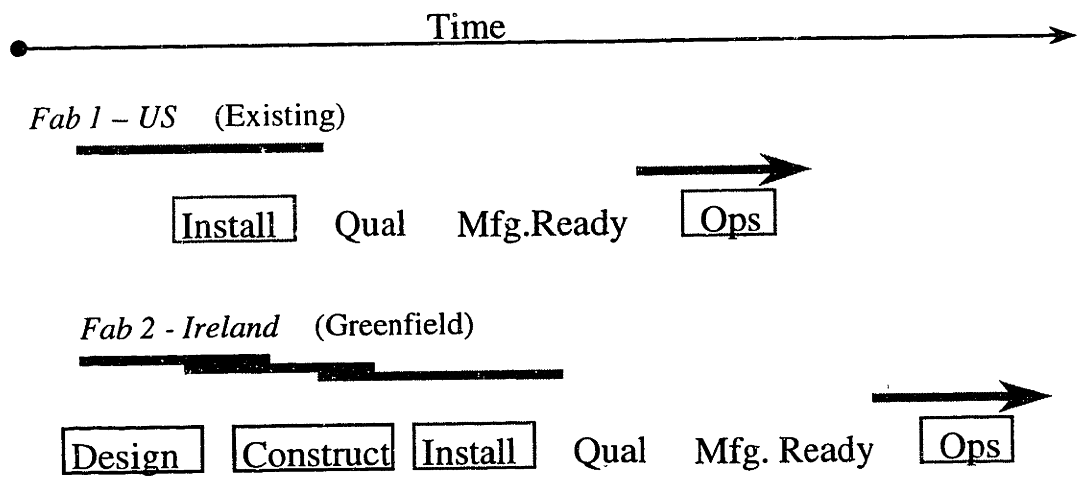


Figure 4: Different time of activities cause problems with communication between fabs

With different activities occurring at the different sites at different times, maintaining communication between locations is difficult. Although functional cross-site teams are an integral part of Intel's Virtual Factory, startup teams tend to be focused on cross-functional, startup specific activities. These teams may form, act, and disband, with little influence from past startups. Often experienced personnel are the link for these teams to past activities. Limited resources and time diminish the time available for documenting and communicating ideas and problems, and without communication the next startup has to approach the problems without the benefit of the past experiences.

Ownership

As startup teams tend to be cross-functional and of limited duration, ownership of finding long term solutions for the problems that occur in startup is difficult to determine. Typically, the factory personnel are different for the various startups, and it is difficult to determine who owns the problem. Without an owner, the problem discovered at one site may not be communicated to the next site. Even if a solution is found, it may not be communicated on to the next location. The most effective scenarios for problem ownership often involve personnel involved in multiple startups who take past solutions or learning and improve on them for the new location.

If the team or individuals are not involved in the next startup, there is little incentive to solve the problem once the difficult period is over. As teams disband and individuals take on new roles, the knowledge developed during the startup disperses. Tools and information gathered during the startup are removed from the fab web pages and replaced with operational information. The development of a solution and improvement activity ends when the tasks are complete, and often the work must be re-developed at the next site.

Sometimes, the best solutions cannot be developed within a single startup. Creating a system or tool to manage an activity may take more time than is available for the team, and some solutions require action before the group is formed. Taskforce teams are often spun off to take care of crisis issues. Often an issue would be better managed before the problem arose. For example, a piece of equipment was discovered to have some residual acid during installation. A group was formed to determine the cause of the problem and propose a solution for managing the clean up. A process was put in place to manage the cleaning for all of the equipment at that site. A preferable solution may have been to manage the cleaning with the supplier, as the problem affected every startup. Instead every startup discovered the problem individually and dealt with it in a similar and independent manner. In many cases, the similarity of the problem to other locations was not discovered until the fab had already found the cause and determined a plan of action.

In this case, the group that experienced the problem may not have been best suited to provide the solution. By the time the installation occurred, adjusting the machine at the supplier was too late. Providing the solution and performing the activity may require different resources and support, which may not be available at the startup site. The necessary tools to improve the startup may require complex software or automation systems. These systems may need to be developed by experts, and users may not have the experience or the resources to create them. Determining the need and implementing the solution in advance may be worthwhile only if used for more than one startup.

2.6 Characteristics of Effective Use of Startup Learning

As the startup is a critical activity, reducing mistakes and time spent in re-creating best practices translates into lower costs and higher profitability. Learning from the past startups is useful only if the knowledge can be put to use. The knowledge that is developed must consider the needs of the audience, and be communicated clearly and effectively. From the previous sections, a few basic characteristics of start-up learning can be determined. These knowledge characteristics are:

- Flexible enough to be used in multiple startups

- Available when required
- Provides appropriate level required by audience
- Conducive to improvement activities
- Involves strong communication between startups
- Determines clear ownership of tasks

3. Current Methods of Knowledge Transfer

Intel understands the importance of speed of technology deployment and high quality products for the semiconductor industry and currently employs several methods for knowledge transfer. Copy Exactly! is the most commonly known methodology, and the general philosophy and its implementation through the Virtual Factory will be discussed in this chapter. Tool kits, templates, and Best Known Methods (BKMs) are some methods for documenting specific processes, and Lessons Learned is a more general discussion of processes and their effectiveness. Personnel transfer is also a method of knowledge transfer, and is often used as an important component of factory startup.

For each of the methods described above, the communication and knowledge transfer between the sites is managed around a particular technology generation. When consistency of a process technology and methodology is described, the reference is to the diffusion of a particular technology to all of the sites involved. Copy Exactly! and the Virtual Factory structures center around transferring and maintaining a particular technology, and communication between sites involved in different technologies is limited. Personnel experienced in one technology often require training in the new technology, and starting up a new technology at an existing site still requires knowledge transfer particular to the new technology.

3.1 Copy Exactly!

The importance of time to market, high cost, and complexity of semiconductor manufacturing led to the development of the Copy Exactly! philosophy at Intel. This process is intended to "minimize the time required for a technology to be transferred and to ensure product quality and yields are not compromised."[McDonald, p 1] Intel decreases the time required to start up a new technology by creating an exact methodology copying that to the new site. By using the exact same methods at each fab, the output quality is identical.

In order for all output parameters (line yield, die yield, WIP turns, throughput, availability, etc.) to be consistent, all input parameters are copied exactly. These parameters include:

- Facilities - water, air, gases, etc.
- Equipment - production tools, automation systems, etc.
- Process parameters - gas flow, temperature, pressure, etc.
- Equipment parameters - tool configurations, software parameters, etc.
- Systems - time windows between process steps, CE! monitoring, etc.

Some exceptions are made if Copy Exactly! is physically impossible or there is an overwhelming competitive benefit. [McDonald, p. 1] For example, the voltage differences between the US and Europe is an inescapable physical difference and the cost of getting the European certification CE Mark was prohibitively expensive for fabs in the United States.

Copy Exactly! results in an efficient transfer of technology from development to high-volume production, but it has drawbacks to innovation and flexibility. Making improvements is very slow and requires getting all relevant productions sites involved to some extent in the change decision. No one is in charge of ordering new procedures or changes. Faster development cycles and reduced risk make up for the decrease in factory improvement. Since Copy Exactly! was implemented, yields have been much higher and the time required for introducing a new technology has been reduced. [Iansiti, p. 161]

Copy Exactly! is central to both the faster development cycles and the reduced risk, as it provides the consistency required to make experiments and adjustments made at one site applicable to the other sites and the detailed documentation and procedures required to operate the fab.

3.2 Virtual Factory

Intel developed the 'Virtual Factory' (VF) as the structure for its manufacturing organization in order to ensure consistency in processes and output quality. As the primary channel for communication during the operational phase of the fab's lifecycle, understanding the Virtual Factory's role and limitations is important to developing a method for transferring startup information. The Virtual Factory is closely linked with the previously discussed Copy Exactly! philosophy, and represents the methodology Intel uses to implement CE!. This organizational structure requires close communication between the geographically dispersed factories, as well as detailed documentation of processes and problem solving activities. The overhead costs and limitations of the consistency this process demands are outweighed by the benefits it provides.

The main benefits of the Virtual Factory structure are listed below.

- *Consistent Product Output* - Products produced at any location are identical to those produced at another location. This enables Intel to use a single certification process and for customers to receive exactly what they want irrespective of source.
- *Seamless Technology Transfer* - Identical processes at the development site and manufacturing sites allows the process to be easily copied to all locations.
- *Continuous Improvement* - A single baseline for all sites allows for a benchmark for continuous improvement. Focused improvement activities may be conducted at any site in the Virtual Factory, and different improvements can be developed concurrently.

- *Problem Solving* - Consistent output statistics at all sites reveals any performance outliers. Data gathered from different sites is useful in solving problems, making comparisons, and conducting experiments.

In order to achieve the communication necessary and to control process consistency, the Virtual Factory utilizes management systems and document controls.

Management System

The Virtual Factory is managed by Joint Management Teams (JXMs) consisting of departmental manager level representatives from different organizations at the various facilities. These teams are focused on general areas such as operations (Joint Operations Team -JOT), engineering (Joint Engineering Team - JET), etc. They report to the VF steering committee and meet weekly by phone and quarterly face to face.

The JXMs give direction to the JXTs, which are teams chartered with improving performance in a particular area of the VF. These sub-teams are made up of representatives who perform essentially the same role at different sites within the VF. The breakdown of teams follows technology and process divisions within the organization.

For instance, the JEM (joint engineering management team) oversees several JETs focused on different engineering related activities. Representatives from each site are members of the JET, and resources are pooled to minimize overlap of activities and maximize impact. These teams communicate current status of their various facilities and review improvement opportunities and plans. Problems common to the VF or site specific are discussed within the JET meetings and sites can share information or collaborate on developing solutions.

As every new process technology has its own Virtual Factory structure, integrating into the JXM/JXT organization is an important part of starting up a new technology. The connection and sharing the teams provide is important to communicate improvements and keep the startup site up-to-date. The structure does not work as well for general startup information because of the mismatch of startup needs described in Chapter 2 and the emphasis within the teams on operational improvements. Even startup teams that are aligned with a JXT activity often find it difficult to escalate a startup need to be worked on by the JXT. Other sites are focused on operational changes, and often lack the context and common need that drives the improvement process. The network of knowledgeable experts is useful for the startup team, but finding time for a knowledge review or transfer is difficult.

Document Control

The detailed documents describing the technology, processes, and other areas covered by Copy Exactly! are centrally controlled. All sites are expected to follow the plans, and any change is required to follow a process as illustrated in Figure 5.

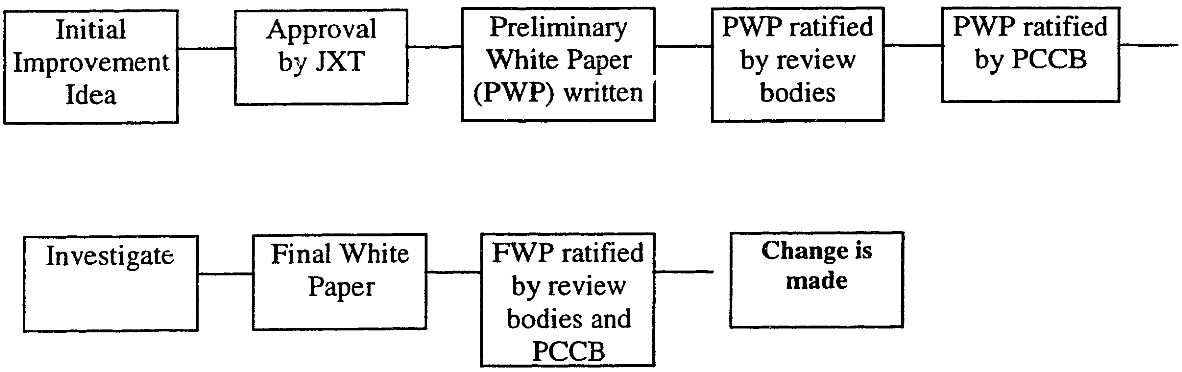


Figure 5: System for initiating process change

The first step in initiating change is developing an idea. Improvement ideas can come from any of the fabs, and are presented and discussed by the JXT. Once the JXT approves an idea, a preliminary white paper (PWP) is written to formally describe a plan for investigating the potential improvement. The PWP is then reviewed and ratified by the relevant technical review bodies. This group depends on the scale and potential risks associated with the improvement. The Process Change Control Board (PCCB) ratifies the PWP, where the plan is formally given permission to be investigated. The investigation is typically carried out at a site in the Virtual Factory that is determined to have the best match of resources and capacity to run the tests. If the investigation is successful, a final white paper (FWP) is written to formally set out the plan for rolling out the change to the virtual factory. Technical review bodies and the PCCB must also ratify this plan before the change is made.

The process is very rigorous, as a change will impact all of the company's output and not just that of an isolated factory. This process forces teams to prove the effectiveness of a change, and not just tweak or make adjustments without understanding the problem. The scrutiny and understanding required by this process slows down the rate of change and the process is not best suited for development or large-scale change. Startup processes are inherently variable by site, and require fast response to reduce the time for technology transfer. As only the fab in the midst of the startup is focused on startup related problems, the resources for developing solutions to these problems are located primarily at the startup site. As such, the review process and resource sharing provided by the process change process provide little benefit and would only serve to slow implementation of startup improvements.

3.3 Tool Kits / Templates / BKMs

Not all systems and processes fall under the Copy Exactly! umbrella. Some methodologies such as toolkits, templates, Best Known Methods (BKMs), and other supportive tools and processes are developed at different sites and proliferated based on need. Differences in site location or environment may require tailoring of some systems to meet certain needs. Other systems are developed to help manage the organization, and may fit a particular fab's organization structure. Implementing these systems is typically left to the discretion of the individual site, but some systems become more widely adopted.

For example, the Manufacturing Readiness Team has a Fab Startup BKM that describes activities relating to fab startup. The BKM includes timeframes and checklists for the various activities, and even details the team formation and membership. The team has a corresponding Joint Operations Team (JOT) that communicates and ratifies changes to the BKM to the Virtual Factory. This method of knowledge transfer includes detailed documentation, revision plans, and ties into the Virtual Factory communication system. Some of the difficulties include developing the document, managing site exceptions and differences, and maintaining the communication with the JOT when some sites are beyond startup. This communication activity is personnel intensive, and requires a well-constructed plan for the activity.

Other systems, tools, and templates are less formal, and are passed on by peer networks. Different teams can use general tools such as the 'integrated schedule' to manage their activities. The 'integrated schedule' is a scheduling method that allows the teams to see the inter-relationships of tasks and get a full view of what is required for the startup. This tool was developed and the idea 'sold' to other fabs, leaving the implementation flexible to the individual site's needs.

Tools, templates and BKMs offer a faster and more flexible implementation of systems than the processes formalized by systems such as Copy Exactly!. They can be tailored to meet the need of the individual location, and can be easily improved on or adapted. Often, due to the tool or system's localized nature, transferring information on how to use the tool or system, how it was adapted or improved, and when it should be used can be very difficult. Formal channels do not always exist for communicating this information, and sites rarely fully document the system. Awareness of solutions is also difficult to build, and these solutions need to be proliferated and sold to new users. Startup tools and systems are especially difficult to track and transfer, as the problems and benefits are soon forgotten.

3.4 Transfer of Personnel

The complexity and specialized processes of semiconductor manufacturing requires a highly trained and experienced workforce. In order for a new facility to start up quickly, Intel transfers personnel from existing sites to the new site. The experienced personnel often take on co-ownership of a team or organization for the duration of the startup. As start up is a period of extra activity, the added support is helpful in providing direction as well as reducing the workload of the local personnel. Some of the personnel are on temporary transfer, while others take on a permanent role at the new site. For activities such as equipment installation and qualification, many individuals move from startup to startup performing a similar role.

In addition to bringing experienced personnel to a new site, new personnel are generally trained at existing sites. The consistency of the processes at the various sites within the virtual factory makes training at an existing site especially useful for developing skills at the new site. Training periods range from 90 days to a couple of years. The most effective training occurs when transferred employees take on regular job responsibilities at the new site. Experiencing a technology startup at another site is especially effective, and individuals often have a more junior role at another site before taking on the senior role at their home site.

Planning and managing training assignments of personnel can be difficult with changing startup dates and technology needs. Each site would like for its employees to gain experience and training at the host site, and need to map out a plan of what type of experience the employee needs. The host site negotiates with the various transfer sites to determine where to place the temporary help. Placement is critical as the quality of the experience depends on the responsibility the employee has at the host site. During the host's startup, the need for additional headcount works well with the influx of new employees. For operational periods, finding a good position is more difficult as training and relying on a temporary headcount is not beneficial to the host. Additionally, personnel is a dynamic resource and employees may leave or transfer to new positions which changes the training requirements for the startup site.

Experience is the best form of knowledge transfer, and Intel utilizes this method of knowledge transfer through cross-site training. The employees have an intimate understanding of what needs to be done and can rely on their prior knowledge to develop improvements to startup plans. Although Intel relies heavily on cross training of personnel, gaps occur where the host site does not need additional support and the startup site does not know what areas need coverage. The high cost of transferring and training personnel at different sites is mitigated by the ability to move extra headcount to startups rather than over-hire for the period of high activity. Still, the needs of the host and the needs of the upcoming startup rarely match. Populating a startup with fully trained and experienced personnel is difficult, and the cost is prohibitively high.

For transferring startup knowledge, previous experience can be very effective. Individuals who have experienced a startup before often lead the best-prepared teams. Even with startup experience, gaps can occur because of the different start up needs, job scope, support systems, and schedule. Individual experience also may not include learning from other sites or be based on the current technology. The high cost and inherent gaps require additional knowledge transfer solutions to be developed.

3.5 Lessons Learned

Lessons Learned is a method of gathering information from a project in order to use the learning from one experience to make improvements for the next. The intention is to provide feedback for improvement, and may be part of the 'Check' step of the PDCA cycle described in Chapter 2. The definition and implementation of Lessons Learned can vary between organizations. A more complete discussion of this method is described in Chapter 5, as Lessons Learned was utilized in developing a startup knowledge transfer system.

4. Transferring Startup Learning

Improving startup knowledge transfer for fabs at Intel involves understanding the relationship between Copy Exactly!, the Virtual Factory, and the new Fab. Copy Exactly! covers all aspects of the technology that needs to be implemented at the new fab. In terms of knowledge management, this is the 'know-what' or the explicit knowledge of implementing the task. In order to do the work 'know-how', or the ability to put the 'know-what' into practice, is required [Brown and Duguid, p.90]. Much of this 'know-how' knowledge lies in the people in the organization, and transferring some of this knowledge is the focus of the startup learning transfer that is addressed by this project.

4.1 Determining what needs to be transferred

As Copy Exactly! covers most of the functional aspects of starting up a new technology, it is important to determine the scope of the knowledge to be transferred. The knowledge required to startup a fab extends beyond recipes, equipment procedures, and other operational aspects of running a fab. For the startup learning, the focus is on how the methods are implemented, as illustrated in Figure 6.

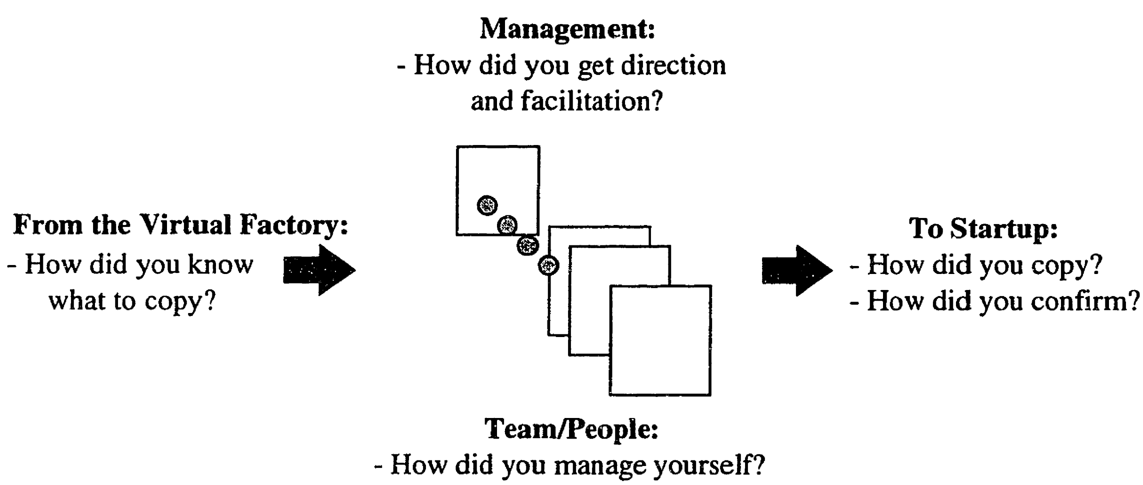


Figure 6: What knowledge should be transferred?

In order to startup the fab, the new location needs to determine what to copy. Copy Exactly! provides many details for operational behavior, and the startup fab needs to learn what is covered, how to implement it, and how to manage activities not included in the methodology provided. Once the activities are determined, the management and organization of the personnel must be planned. As each factory determines its own organizational structure and startup activities vary depending on the site's needs, selecting a management and team structure should be planned around the needs of the startup. With people and tasks in place, the last step is to confirm the outcome and implement the activity.

4.2 Knowledge Transfer System Criteria

The knowledge transfer system is a product that needs to be robust and user-friendly in order to be used. Creating a system that meets the needs of the users may be prohibitively expensive and needs to be weighed against factors such as:

Cost of Implementation and Maintenance - How much will it cost to implement the system? How difficult or expensive is the system to maintain? Whether contracted out or developed internally, creating a new system requires resources and time that will cost the company money. Even after the system is created, it will need to be updated to meet the changing needs of the user base. Additionally, knowledge based systems require obtaining information from users and this requires time from critical individuals and resources.

User Requirements - How difficult is it to use the system? Are there incentives for users to add to or improve on the system? Does the system meet the user's needs? These questions must be answered in order for a system to be an integral part of activity and not forgotten or ignored. Understanding the user's needs and motivations will help determine what kind of system to implement and whether a new system is necessary.

Marketing and Training - How do you sell the system to prospective users? How do you get them trained and comfortable using the new system? Marketing the system to new users may range from building awareness of its capabilities to requiring the system to be used at all startups. Determining what is required for the users and startups involved will decide the flexibility of the implementation requirements. Also, training new users requires resources and time. Few systems are self-explanatory, and often the benefits of the system need to be clearly outlined.

In addition, the system that is developed needs to be able to address the communication, duration, and ownership issues described in Chapter 2. Because people change roles during and after the startup, the system needs to provide knowledge not only about the task but who to contact for more information. Permanent teams are inefficient, as the sites are on a different time frame and problems arising at one location are of little concern to the others. The other extreme of providing documentation only will reduce the depth of information that can be provided, and it may be difficult to capture the scope and depth required on paper. A combination of documentation and a network of experienced personnel seem to be appropriate.

As the activities vary significantly depending on the startup, a detailed plan documenting the entire startup would not be an efficient transfer of knowledge. A single formula would not cover the variations required by a Greenfield versus a production factory startup. Also, some activities may make sense for certain technologies but not apply for a shift between other technologies. All of these differences require a more flexible system of knowledge transfer. Sites need to be allowed to select the tools they need to manage the startup, and make adjustments and improvements as needed.

Additionally, the system needs to encourage usage. Entering new information needs to be a natural activity in order for users in order for the knowledge to remain current. One way of enabling this activity is to make the system the primary source for recording troubleshooting information for the current startup. The system is only as useful as the quality of knowledge it contains and the ease of which the knowledge is retrieved. Making the system part of daily activity may require adjustments to how people work and possibly a culture change.

4.3 Codification vs. Personalization

As the content of startup learning is more variable and site dependent than operational learning, the learning stored in a startup system needs to be flexible. Users cannot be required to follow the prescriptive information described in the documentation, and must determine what applies to their situation. The information should therefore be richer in background and include the reasoning behind solutions, and not simply provide an answer.

Copy Exactly! is a very prescriptive and standardized solution which works well for transferring specific behaviors. This knowledge transfer process can be described as *codification*, where the knowledge becomes explicit and can be easily transferred and re-used. Although the startup learning needs to be codified to some degree to enhance re-use, the cost of codifying the knowledge and all of its implications can be significant. Some information must therefore remain in the personnel, and this tacit knowledge is called *personalization* and must be relayed through networks of people.(Hansen, Nohria, Tierney p107-109)

Managing both tacit knowledge and codified knowledge is difficult to manage both in creating the knowledge transfer system and in managing the incentives to transfer learning. In order to be effective, a single strategy of either *codification* or *personalization* should be maintained. .(Hansen, Nohria, Tierney p.115) For Intel, although information is codified in initial documentation for Copy Exactly!, most of the knowledge transfer for the fabs in the virtual factory is managed through personalization techniques such as the cross-functional joint teams and personnel transfer. The best method for transferring startup knowledge should therefore focus on linking people, and using documentation to augment the process.

5. Startup Knowledge Transfer System

In order to develop a Startup knowledge transfer system, the first step is to examine the existing systems of transfer as described in Chapter 4. The current systems are fairly effective for their purposes, but do not address the flexibility required for startup. The system that was implemented was based on the Lessons Learned. Methodology, as it allowed the system to be flexible, was relatively low cost, and was based on improvement methods already in existence. As most of the startup activity had already occurred, the method for creating the Lessons Learned was restricted to post activity learning. Resource time was limited, and the information gathering activities needed to maximize the output from participants with a minimal time commitment.

Many of the methods described below are based on previous methods used at this or other startups. Lessons Learned had been developed and documented at the previous startups, and some of the activities from Ireland had developed documentation and held a face-to-face session with the site in Jerusalem. These examples served as the basis for the work with the Technology Transfer and Manufacturing Readiness activities that were the focus of this project. As the project is focused on creating system and knowledge sharing, making improvements on an existing system fit the idea of knowledge transfer and continuous improvement.

5.1 Plan of Action

The first step in developing the project was determining the scope. Much of the startup activity had already occurred at the Ireland fab, and the activity needed to be centered on transferring what knowledge was learned to the new site. The information was based on past experience, and would need to be gathered after the fact. Additionally, the teams involved were in two different segments that had different goals.

A total of around 26 teams were involved in the activity. Each team was requested to set aside an hour of time as a team to meet and review what they had learned during the startup. The team leaders were approached individually as well as through the segments, and almost everyone agreed to participate. The Lessons Learned were gathered through a method described in Chapter 6, and then presented at a face-to-face conference described in Chapter 7. A web site (Chapter 8) was also developed in order to present the information, provide contacts, and serve as a tool repository. The results of the project are included in Chapter 9.

In order to examine the effectiveness of Lessons Learned in transferring the learning, as well as determining areas for improvement, a survey was conducted following the activity. The survey, which is included in the Appendix, asked questions about whether or not startup learning was useful, what should be examined in startup learning, and what are areas of concern. Most respondents were generally positive about the experience, and found the exercise useful. Many suggestions and new ideas also resulted, and hopefully will be incorporated in future startup learning projects.

5.2 Role of Knowledge Transfer

In order to better understand the importance of knowledge transfer to starting up the fab and how successful the project was, a survey was developed and distributed to participants in the Startup Lessons Learned process. The full survey and results can be found in the Appendix. Eighteen surveys were returned, most of which were from presenters from the site in Ireland. Additional feedback was also given by the other fabs during the Lessons Learned face-to-face regarding the information they had received and how they planned to make changes with respect to what they had learned.

All of the survey respondents felt it was important to examine past startups, and that it "shouldn't be an option not to." This reaction fits well with the Intel culture, which values Copy Exactly! and has seen the positive results of building from other site experiences. Most respondents did not feel that emphasizing learning from past startups limited flexibility, and generally felt like more emphasis should be placed on startup learning. Lessons Learned were considered useful, and Fab "14 was smooth because of what we learned, but we could have done even more." In general, respondents believed that documenting the lessons learned was worthwhile as problems were similar enough and the information was valuable to future startups.

5.3 What is 'Lessons Learned'?

Documenting the results of a project is an important way of transferring knowledge. The difficulty occurs in putting the information into a form that is usable by others. Many companies perform 'post-mortem' or Lessons Learned reviews to evaluate the effectiveness of a project. These reviews are intended to examine how well the team performed and how they should improve. The focus is on team learning and creating closure for the project. For the startup's Lessons Learned, the emphasis changes from reviewing to teaching. Past experiences are examined, but the expectation is now to pass the information on to an interested party.

The Lessons Learned methodology used at Intel is intended to document the results of 'learnings' from a project. For the startup, the documentation or information is created in order to be utilized by individuals at a different site. This requires a clearer channel of communication and focus on the customer's needs. The learnings should not be specific to the team, location, or other site-specific details. Instead the lessons need to be general enough to be applicable to other locations while conveying enough detail for the new site to understand the circumstances.

5.4 Creating a Successful Transfer

Intel has a history of emphasizing learning as part of the improvement process. Copy Exactly! and the Virtual Factory are forms of cooperative learning, as they both require a transfer of past experience to a new location. Knowledge is built into the process requirements and learning transferred through both experience and cross-site discussion forums. As learning from others and knowledge transfer is part of the Intel culture, it is not surprising that almost all participants in the Lessons Learned process thought it was important to examine past startups before starting a new fab. Past learnings were believed to have been useful in the Ireland fab startup, and most participants felt that even more could have been done.

A successful knowledge transfer requires gathering the 'right' information, involving the 'right' people, and having the 'right' attitude. What exactly constitutes 'right' in each of these cases may be debatable, but there are some common themes for each of these criteria.

Content of a 'Lesson'

Deciding what information to pass on, emphasize, or ignore is an important part of creating a 'Lesson'. For the purposes of this exercise, the lessons entail knowledge relevant to starting up a fab. This knowledge includes schedules, systems, task lists, problems, management tools, benchmarking data, and other general information.

A disorganized collection or overload of information may make it difficult for the new site to find the information relevant to solving their problem. As the receivers of the learning are not familiar with the context or magnitude of the tasks and issues they face, they need to be able to not only understand the material but to judge the relevance and timing of the solution. In order to be effective, the 'Lesson' should be specific about:

- Definition: What is the task, method, tool or issue?
- Impact: What problems or concerns are involved?
- Action Required: How to manage it? What actions should be taken?

- Participants: Who should be involved?
- Timeframe: When it should be performed?
- Contacts: Where can I get additional information and support?

In providing a definition, the user can understand the purpose and context, while the impact explains why you would want to use it. The action required explains the 'how-to' aspect, and should provide instruction on implementation. In order to implement effectively, it is important to know when in the startup the actions should be performed with respect to other activities. As it is difficult to completely cover all of the information required, knowing who to contact as well as their role in the startup is critical.

Experts

Creating a network of experts is an important part of transferring startup knowledge. All of the experience and knowledge cannot be captured through documentation, and it is important to connect together experts with new implementers. By providing contact information along with information, users of the knowledge management system can have educated dialogues with their counterparts at other sites. The contact info helps connect the new user to the right person, while the information helps them to know what knowledge can be provided.

Reciprocal Effort

In order for Lessons Learned to be successful, positive action must be taken by both the giving and the receiving fabs. Both sides must approach the session with an open and non-critical attitude. The giving fab has to be willing to reveal mistakes and give an honest appraisal of the content of their learning. Candid appraisal allows the receiving fab to effectively evaluate how they should implement and improve on the systems and methods.

Even with well-documented lessons, improvements will not occur unless the receiving fab is receptive to the information. Many teams may suffer the 'not invented here' syndrome, and believe they can create a better systems or methods independently. Additionally, some sites have experienced a previous startup and believe there is nothing new to learn. In either case, the assumption should be that the startup is a continuous learning process. Each experience should build on the past and have new information to impart.

6. Documentation Process

The documentation process for the startup occurred after most of the projects had completed. Ideally, much of the material should be generated during the project lifecycle, but as most of the activity had been completed before the project started this was not possible. As a post-mortem activity, the documentation process needed to jog the memory of the participants and attempt to gather all of the relevant information.

This chapter discusses the steps required to document the activity, and critiques the results of the process. The first step in creating the documentation was in determining the purpose or goals. Once this was determined, the method for documentation needed to be planned and organized. A template was developed based on previous documentation, and team meetings were conducted. Additional documentation and review were required before the documentation was finalized.

6.1 Goals of Documentation

The documentation was intended to be useful for the new fab to transfer the technology. As the technology and fabrication process details are covered in Copy Exactly!, the focus of the documentation was on how to manage copying the process. Overall, the learning was to give some insight into problems not yet solved and other areas for improvement.

In the startup survey, examining learning from past startups was almost unanimously rated as very important before beginning a new startup. Documentation was considered by some to be too time consuming, but most respondents considered it an important part of transferring learning. Time required was a consideration in creating a documentation plan, as well as the method of communicating the documentation. Presenting material to an audience has different requirements than reading a document or even viewing on the web. As the material was to be communicated through all of these methods, the documentation needed to consider what met the needs for each.

The documentation for the Lessons Learned was not intended to be a complete description of everything required to start up the fab. Instead, the focus was on including the important points that need to be examined in order to have a successful startup and to create a basis for a dialogue. One of the segment managers said that the purpose of the learning was not to copy the methods and tools, but to have a conversation around what they provide and what you need. The tools should be taken and improved upon, not simply used. The learning would not occur through detailed documentation, but through the conversations about the needs, solutions, and methods used at the various sites.

6.2 Planning

The planning stage involved determining which teams would be involved in the documentation process and what the process should entail. The time commitment for the participants was to be limited, as the startup and ramp was still being performed and the activity should not impact the schedule.

The documentation process selected was based on the Lessons Learned developed by the Installation and Qualification (IQ) segment. The format involves a template that is filled out by each team, and supplemented by additional documentation. The template had the advantage of being able to build on the past experience of another group, and had been fairly successful for presenting the material in a previous face-to-face session. Also, by using a standard template, the information would be presented in a consistent manner.

The Technology Transfer, Staffing and Assignment, and Manufacturing Readiness segments were selected to document their Lessons Learned. These segments were currently or recently involved in the startup and, for the most part, had not completed a post-mortem or Lessons Learned exercise. Segment managers determined which sub-teams should perform the exercise, and generally selected teams that performed startup functions or were an important task force. Other taskforce activity was typically included in the parent team's Lessons Learned.

As time was limited and many of the teams were still involved in startup activities, the minimum team time that would be required for the activity was set at one hour. This meant that the team would be required to meet for no more than one hour to complete the activity, although they would have the option of spending longer if they chose. The time constraint limited the documentation activity that could be performed by the team, and influenced the selection of the template and meeting plan. Even with the constraint, many of the teams had difficulty scheduling meetings. Some even staggered the activity through multiple meetings to increase the level of participation.

6.3 Template

The template used for documentation was intended to cover all of the major areas of importance for the success of the segment as well as what information was necessary to implement the activity during startup. The top half of the template shown in Figure 7 shows some of the areas important to the Manufacturing

Readiness Segment. Some of the questions these areas address are listed below, although each team had some freedom of interpretation of the major categories.

- Measurement System / Planning – What metrics were used to determine success? How did you plan your activities? How did you schedule your time?
- Organization / Resources – Who was involved in the activity? What was the team's scope or charter? How did the team manage itself? What support was required from other teams?
- Tools / Management Processes – What tools were used to support your activities? What processes were followed?
- Cost – How much did the activity cost? What purchases or resources were required? How did the team save money?
- Communication – How did the team communicate with other teams, segments, fabs? How did the team manage communication within the membership?

Within each of these categories, the team was to determine 'What Worked' and 'Areas for Improvement'. 'What Worked' was intended to suggest activities that worked well and should be considered by other fabs to manage their activities. 'Areas for Improvement' should include problems that required further examination as well as solutions that could be improved upon. The Installation and Qualification Segment manager had recommended using 'Areas for Improvement' instead of 'What didn't work' in order to allow for suggestions for improvement on existing solutions.

The bottom four sections were intended to emphasize important points. These sections would generally include issues referred to in the top half of the template, and were called out as areas that would be particularly relevant or important for other startups.

- Break Thru Systems / BKMs – Break Through Systems or Best Known Methods (BKMs) are systems or methods the team identifies as being the best way of managing or implementing an activity. A BKM is the best known way of performing an activity, while a break through system would be a new way of performing or managing an activity that is an improvement over existing methods.
- Taskforces – A taskforce is a sub-team spun off to focus on a particular problem or issue. Follow on startups should be aware of the taskforces in order to determine a course of action to manage the problem or issue.
- Recommended Tools and Methods – This includes tools and methods which aid the startup process. Unlike the Break Thru Systems or BKMs, these are not necessarily new or a best practice. Often this involves a tool that was particularly useful in managing the start-up that may be used in other startups or a methodology that should be used but has some problems that still need to be addressed.
- One Piece of Advice –The one piece of advice that the team would like to pass on to the next startup. Basically, what would the team have liked to know before they started up.

IFO MRS LESSONS LEARNED

(insert name of team/dept/area here)

	What Worked	Areas for Improvement
Measurement System/ Planning	•	•
Organization/ Resources	•	•
Tools / Mgmt Processes	•	•
Cost	•	•
Communication	•	•
Other	•	•

Break Thru Systems/ BKMís	•
Task Forces	•
Recommended tools/ methods	•
Our One Piece of Advice	•

Figure 7: Sample Template

6.4 Team Meetings

The team meetings was a central part of developing the Lessons Learned Documentation. The meeting was intended to bring all of the key participants in the team together to review what they considered the most important learnings from the startup. As much of the learning had not been documented previously, the meeting offered an opportunity to review the startup activity and determine what was important to be documented. From the meeting, the template was to be developed and follow on documentation determined. A sample meeting agenda can be found in Figure 8.

Although teams were generally requested to come prepared with major lessons for their team, some time was given during the introduction to outline and discuss the purpose of the activity. Giving an agenda and assigning roles of scribe and time keeper helped to keep the meeting moving and enabled the teams to complete the activity within the time constraint of one hour.

The meeting was structured following the template, with the general learnings being brainstormed first. Most teams began by listing the major categories important to the segment to keep in mind while brainstorming, but did not structure the brainstorm around these categories. The brainstorm was intended to help the team remember as much about the startup as possible, and aid them in seeing connections between activities. During this process, participants were to list 'What worked' and 'Areas for Improvement' without determining importance or detail actions required.

The next step was to group the brainstorm results and determine key items. The intention here was to create a manageable list with related activities grouped accordingly. From this list, the items were categorized for top half of the template. (See Figure 7, top 6 categories.) At this stage, the team was to clearly describe the problem or issue, impact, and action required. In order for the other fabs to determine the importance of the learning, they needed to understand the context of the problem, what impact it had on the startup, what action should be taken, and when it should be taken.

Following the categorization, the team needed to summarize their learnings by filling out the bottom half of the template. (See Figure 7, last four categories.) The session should end with the team coming to a consensus on the one piece of advice. Consensus is important because the piece of advice should focus on what the team considers to be the most central activity or issue they addressed, and what the following fabs should be most concerned about.

<table>
<tr><th></th><th colspan="3">Agenda</th><th></th></tr>
<tr><td>Introduction</td><td colspan="3">Lessons Learned are developed in order to help Fabs start up in a faster and more cost-effective manner. Leveraging the learnings from the Ireland fab will allow other Fabs to have a smoother startup.</td><td></td></tr>
<tr><td>Objectives

Outputs</td><td colspan="3">Gather the Lessons Learned during the startup to pass back to the VF and to other Fabs. Prepare for face-to-face session with other fabs. The information needs to be returned in a form that is usable by another group.

• Brainstorm all relevant learnings.
• Fill out output template.
• Gather supporting documentation including examples, tools, templates, and processes used.</td><td></td></tr>
<tr><th>Agenda Item</th><th>Objective</th><th>Materials Used</th><th>Process</th><th>Time</th></tr>
<tr><td>Introduction</td><td>• Outline agenda
• Discuss required output
• Assign roles - scribe, time keeper</td><td>• Foil of Agenda
• Output Foil</td><td>Presentation</td><td>5 min</td></tr>
<tr><td>Brainstorm</td><td>Generate key learnings.</td><td>Flip charts with "What worked?" and "Areas for Improvement?"</td><td>Brainstorm.</td><td>10 min</td></tr>
<tr><td>Determine Key Items</td><td>Use decision-making process to determine importance.</td><td></td><td>• Agree to key items.
• Group related ideas.</td><td>15 min</td></tr>
<tr><td>Categorize*</td><td>Clarify and categorize the output.</td><td>Output flip chart</td><td>• Determine appropriate category in output chart.
• Clearly describe the problem, impact, and action required.</td><td>25 min</td></tr>
<tr><td>Summary</td><td>• Determine one piece of advice.
• Review and agree on final document.</td><td></td><td>• Review.
• Determining one piece of advice might require some discussion. It is critical to have agreement on the primary learning.</td><td>5 min</td></tr>
</table>

* Categorization may be performed by the coordinator and key members after initial brainstorm if time is limited.

Figure 8: Sample Meeting Agenda

6.5 Additional Documentation

As part of the team meeting, or following the meeting, a list of additional documentation was developed to support the template. Typically, this involved any major system, tool, or methodology called out in the template. Delegating who would gather the documentation or develop new documentation was managed as part of this process, and time spent on these activities varied by team. Many teams had documents and procedures that were created during the startup, but some required additional work.

6.6 Critique

The success of the documentation sessions is indicated by both the high participation rates of teams involved in the startup. All the teams that agreed to document their lessons completed the exercise, and a couple of new teams were added during the documentation process. The support of the fab management and team leaders was critical to completing the project. Due to limited time and resources, making documentation a high priority is important for gaining the time and commitment of the teams. Belief in the usefulness of the process is also important, and the success and positive response generated by the Installation and Qualification segment Lessons Learned session helped to build confidence in the usefulness of the activity.

Many of the teams that participated in the Lessons Learned sessions spent more than the minimum of one hour developing their template content. Additional time generally translated into clearer definition of actions taken, impact, timeframe, and problem addressed. Ideally, the template would have led the participants through a more fully defined description of each recommendation or learning.

Another issue with the documentation was how the information was to be presented. The template was developed to be approximately one page in length, and was intended to highlight the important learnings. This format works well for presentations and as an overview for follow-up documentation, but may not give enough detail as a stand-alone document. As time is limited, a method for generating documentation that works well on paper, the web, and as a presentation would be ideal.

Although time consumed in documentation was a primary concern of the exercise, most participants did not find the documentation process too time consuming. One participant surveyed said, "It certainly takes some time to collate and summarize everything into the template, but it is very worthwhile. What I found is that a lot of our back-up documentation was already captured in some format (i.e. specs, desktops, white papers) which made the exercise easier."

Overall, the Lessons Learned documentation was a useful exercise and provided pertinent information to the other fabs who will be starting up. Improvements should be made on the process, and a format should be developed that works well for both presentation and stand-alone documentation.

7. Face-to-Face Learning Session

Part of the transfer of learning activity involved a face-to-face session with representatives from sites in the United States and Israel. The session was intended to help develop relationships between members of the startup teams from the various sites and to foster communication.

7.1 Channels of Communication

In the survey conducted on the participants of the Lessons Learned generation at the Ireland fab and from the attendees from the other sites, face-to-face communication received the highest rating for preferred form of communication of Lessons Learned. (Appendix, Question 3) Face-to-face works well for conveying information because it provides the richest context. The audience is able to view the presenter, visual aids, and other participants, while the presenter gains immediate feedback to what he or she is presenting.

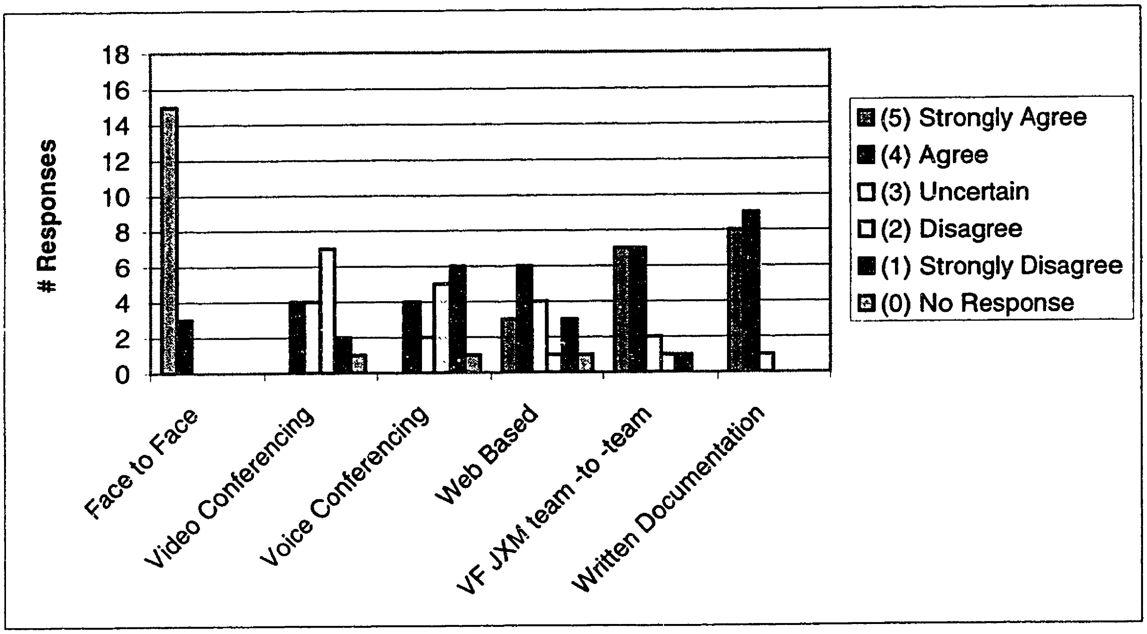


Figure 9: How would you like to receive Learnings?

Video conferencing may provide some of this context, but generally lacks the feeling of proximity of a small meeting. This option was rated approximately the same as voice conferencing, which was just slightly positive as a form of communication. This similarity may be due to video conferencing being rarely used at Intel, and that it is considered cumbersome and inconvenient to arrange. Voice conferencing provides less contextual information, and is more commonly used within the Virtual Factory. Utilizing the team-to-team meetings within the Virtual Factory received positive marks, but only works well for startup activities that translate directly into continuing functional teams. Written communication was rated fairly high, although many of those surveyed commented that they preferred this option as a supplement to other methods. The web was also preferred as a supplemental method, and will be discussed in more detail in Chapter 8.

7.2 Advantages of Face-to-Face Meetings

The importance of face-to-face meetings is part of the Intel communication culture. The JXM/JXT structure utilizes face-to-face meetings quarterly although most business is conducted over voice conferencing. Meeting someone face-to-face helps you relate to him or her easier over long distance in the future. Asking for help or advice is often difficult with strangers, and establishing relationships increases the likelihood that individuals will ask for and receive help.

A manager, who was a member of a joint operation team (JOT) in the Virtual Factory, described a situation illustrating the importance of establishing face-to-face relationships within teams. The situation involved a new member joining an existing team, and the misunderstanding that resulted from a voice conference meeting. Although JXTs traditionally meet quarterly, new members may join at any time. These members enter the voice conference meetings with little knowledge of the personalities or backgrounds of their counterparts.

During the first meeting involving the team and the new member, the discussion became rather heated and a conflict occurred between the new member and one of the other team members. The manager had previously worked with the new member, and he realized that the problem was a miscommunication and style difference. In order to avoid hard feelings developing, the manager was able to talk to both the members individually later and smooth the problem out. The manager believed that getting to know the other team members gives some context to their personalities and values. The voice conference meeting allows no time to socialize and does not provide the visual aspect of communication that may convey signals of emotion and emphasis. Without visual cues, facilitating the flow of conversation and commentary may also be difficult, and additional context and information may be lost in the rigid format required.

By providing face-to-face contact periodically within Virtual Factory teams, social networks develop and team communication improves. Allowing team members to meet helps individuals to determine whom they can rely on and aids in establishing supportive relationships for future activities.

7.3 Audience

When organizing a face-to-face conference, determining the appropriate participants is imperative to getting the knowledge conveyed properly. Surveys cited 'Information not reaching the right people' as one of the primary barriers for using the information from a Lessons Learned session. (Appendix, Question 2) Gathering all of the required participants together for a face-to-face conference is difficult to manage, as many individuals may be busy with other startup activities, teams may not have formed yet, the activity may have been introduced at the other sight, or participants may not be aware of the meeting.

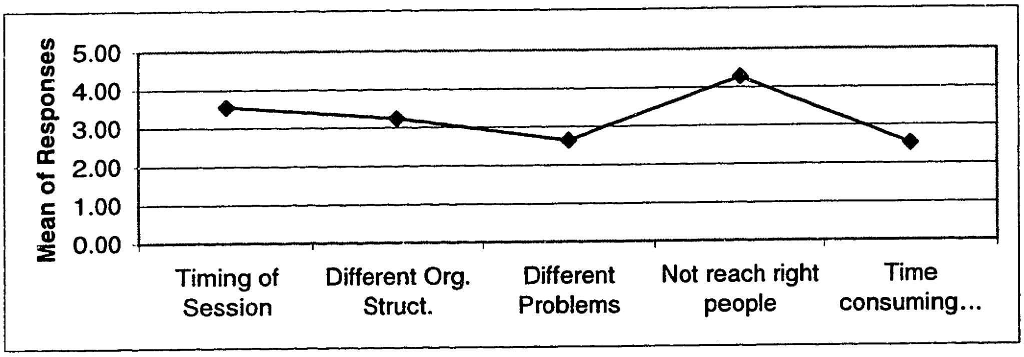


Figure 10: What barriers do you see for using information from a lessons learned session? (5 - Strongly Agree, 4 – Agree, 3 – Uncertain, 2 – Disagree, 1 – Strongly Disagree)

With all of these problems, the face-to-face conference can not address all of the needs of all of the potential participants. As the knowledge needs to build on past experiences, the single instance aspect of a face-to-face knowledge transfer may lead to lost learning. Lessons presented in one conference may be forgotten by the next instance, and participants may not recall the content by the time their startup occurs. Augmenting the face-to-face with physical documentation, either through the web or in hard copy, allows participants to review what they have learned and serves as a reference for later startups.

7.4 Agenda

The agenda for the face-to-face meeting involved a day of presentations for a particular segment followed by one-on-one meeting times with counterparts. Each group in the segment was given anywhere from 20 minutes to an hour to present their material. The presentation generally followed the format of the template, with questions asked throughout.

The presentations provided an opportunity for all of the learning for a single segment to be relayed. By having the audience include different group membership as well as management, the interactions and customer relationships between the groups could be examined. Since the problems experienced by one team may be solved by another, the ability to understand the complete segment startup is important in order to creating the best solutions.

The one-on-one meetings were useful for direct discussion of the new startups' needs, as well as an opportunity to demonstrate tools and other visual aspects of the presentation. These meetings were flexible in content and timing, and were generally managed by the visiting participants contacting their host counterparts. By working with counterparts directly, relationships could be established and context created for future discussions.

7.5 Critique

In the survey, the face-to-face session was listed as the best way of receiving learnings, but there are many problems with respect to timing and participation. Visiting participants found some of the topics included information on activities that they had already completed. Others noted that there were already requests for additional sessions on topics covered in the face-to-face. In general, the sessions were especially valuable for activities that were to be performed in the near future.

Concerns also existed about the time commitment required to attend a face-to-face session. With the heightened activity required at the startup, many found it difficult to take time out to visit another site for a knowledge review. Although some participants felt it was too much time out of the job, most did believe it was worth the investment.

Most participants felt that face-to-face meetings were an important part of the knowledge transfer, but that they needed to be combined with other methods. The face-to-face helps to align expectations and build relationships, while the web and other forms of documentation are useful in continuing the dialogue.

8. Startup Web Site

A startup web site was created as a repository of startup related information. The intention of the site was to make the information easily accessible for users, and to be an archive for the learning even after the startup is complete.

8.1 Remote Access

The web is well designed for remote access of files and for indexing information. By giving information about a file, the user can more easily find the information he or she needs and not spend time downloading unnecessary files. The ability to easily search for and browse through information encourages users to check for information that they otherwise might not spend the time examining.

In the survey of participants, most individuals used the web for activities involving information gathering, with less emphasis on search and directory services. Most individuals used regular locations for information retrieval, and were less likely to search outside sources for more information. The site needs to be part of the regular startup activity to be used, and having a single source for startup information becomes important to reduce the search requirement.

8.2 Repository of Information

Once the startup is complete, startup-specific systems and tools often languish on individual contributor's computers. Even on the factory web site, startup specific pages and information are removed from the main server and become inaccessible. By creating a central repository for the startup-related information, the information is less likely to be lost. Additionally, a central site for all startups will reduce the search costs for users accessing information on multiple sites.

The creation of a single site for startup knowledge is useful for individuals at multiple sites to be able to access the same information and have a common context for discussing the startup related issues. For users who have completed their startup, a common site is helpful for indexing the information and for reminding them of past activities.

8.3 Technology Concerns

The web is a relatively new technology and there are common concerns for managing its adoption and usage for knowledge transfer. One concern for this method is the comfort level of the users with the technology. Some potential customers for the system may not be comfortable using the web, or believe it is a useful medium. The lowest ratings for web use as a transfer mechanism matched with respondents who do not currently use the web for other activities. Although it is possible to provide a compelling tool that will encourage the use of a new technology, changes in work behavior by examining past experiences combined with adapting to a new way of accessing data may be difficult to overcome simultaneously.

Another area of concern is the dynamic aspect of data stored on the web. In allowing information to be linked easily through pointers to data at different locations, control over content and existence of the data is difficult to maintain. For example, while searching the web for other lessons learned or startup related sites and documents, many of the links returned 'File not Found' errors. Even during the course of the project, startup information initially available at the startup web site was removed or had references deleted.

8.4 Content Creation

For an initial web site, the focus was to display the information in an accessible fashion. As most of the content was created by teams, the main index was developed following the segment and team structure. As the teams and segments are formed around startup functions, this form of indexing translates fairly well between startups.

Each team or activity included a Lessons Learned template, contact list, and back-up documentation. The templates can be viewed as web pages, or downloaded if the user prefers a hard or soft copy. Additional documentation was indexed with title, document type, and a short description of usage or purpose. The contact information included name, department or functional area, and role they played on the team. For instance, yield is a department which may have engineers represented on the startup team centered on the certification and qualification of the process. The role played on the team tells the new site who to contact to find out more about a particular tool or activity, and saves time searching out the expert.

Additional pages included how the Ireland fab managed the hand-off between the segments and other non-team specific documents.

8.5 Expected Usage

The web site should be used by new startups to examine the learnings of the past startup, and to see if there are any gaps in their plans or potential alternatives. Most of the information requires familiarity with the activity, and may require additional contextual information to be useful. By providing a list of contacts, users should be able to find the most knowledgeable source to inquire about specific issues. In this way, less time will be spent finding the right source or in general information transfer. Users will be able to determine what is most useful to solve their problem and to concentrate on finding out the information relevant to their needs.

The intention of the site is to create a common reference for the various users to find out more about a particular startup. For example, a survey respondent was contacted regarding a question about some information his team had posted. The web site was used as a common reference for their discussion, and both individuals were able to view the same information simultaneously.

8.6 Critique

The web worked well in conjunction with the face-to-face conference, but was not considered an effective stand-alone tool. The web allowed easy access to the information and a common reference, but does not establish relationships or encourage interactions. Also, improvements could be made with regard to format and content to help communicate the information more effectively.

The site developed was useful for organizing and displaying the startup information gathered, but it will require many improvements in order to become a regular part of the startup. In order to address the problem of timely communication of learnings, teams should be able to post new learnings as they occur. This will require implementing a system to manage automatic posts, and will need to have a framework developed to automatically organize and categorize the information. Incremental additions require less of a time commitment, and can be useful to the current startup as well as future startups.

With a centrally developed framework, the teams should be able to post the information as needed while still maintaining a consistent format and structure. The framework will help the team to provide complete background and information. Different templates can be used for posting a tool or problem methodology, but most frameworks should center around meeting the criteria described in Chapter 5.2, which are definition, impact, action required, participants, timeframe, and contacts.

Using the web for startup issue tracking will enable other sites to gain real time information on problems that arise at the startup fab, as well as providing useful information for individuals at the current startup.

Combining the real time data collection with an end of startup summation as described above will provide an organized view of the important learnings, as well as more content rich details of particular issues.

Overall, the web site was useful to the site in Ireland for reviewing details on the lessons learned exercise and for retrieving information, as well as a resource for startup information for the new startups. In the survey (See Appendix), some respondents had already used the site in order to gather information for other sites. Respondents from the other sites said they had used the web site to prepare for the Face to Face, examine Lessons Learned, access tools, and as a general reference. The site was considered easier to use than searching through paper work. Still, users who do not use the web regularly were not interested in accessing information through a web site, and alternate methods may need to be examined.

Some respondents were concerned about the long-term usage of the site, and several had suggestions for improvement. Some of the improvements suggested were to add a search engine, a dialogue page for additional comments, and on-line entry of problems. The long-term concerns included ownership, continuation plans, and how the site was to be communicated or advertised to other sites.

9. Evaluating the Knowledge Transfer System

In order to evaluate the knowledge transfer system, the system will be examined based on two metrics described earlier in the thesis. T! . first is the ability of the system to address the startup issues of duration, communication, and ownership. The second involves the metrics for any startup system of usability, cost, and how the system is presented to the users.

9.1 Addressing Obstacles to Startup Learning

One of the metrics for success of the knowledge transfer project implemented at the fab in Ireland is the ability of the system to address the obstacles of limited duration, communication, and ownership.

Limited Duration

By implementing the Lessons Learned system described, awareness of the potential problems can be developed earlier in the process and more robust solutions may be developed. Solutions developed at one site can be transferred to other sites and improved on. In this way, some of the problems associated with the limited duration of individual startups can be mitigated and more effective solutions may result.
Some of the duration related issues that remain are examined as part of the communication and ownership sections. The primary disconnect between life of activity at one site and overall duration of the problem throughout the system is only partially addressed by the system. Systems and tools can be incrementally improved and transferred between sites, but radical, large-scale solutions that benefit all startups may not appear worthwhile to pursue on the basis of individual experience.

Communication

In order to communicate effectively, the knowledge must be relayed to the new startup in a timely manner. This transfer should require little resource drain on the past startup site. Once one phase is complete, the startup activity team generally disbands and moves to other roles. With the high level of activity and changing responsibilities, the past startup site may not have much time to dedicate to educating the new site.

The knowledge transfer system implemented aids communication by establishing links between those involved in startups at the various sites around the world. This area is the primary improvement provided by the system, as individuals involved in startup can find the information and support they need to manage their activities. The disconnect between functional and startup activities is solved by creating relationships through the face-to-face meeting and allowing learning and contacts to be more accessible through the web site.

Improvements need to be make the system more timely, as some problems may not reappear for several startups and others may occur before the previous startup has wrapped up. Developing the web site into an on-going project to which all startups will contribute will help manage this problem.

Ownership

The knowledge transfer system is only useful in transferring the knowledge between locations. It does not solve the problems or manage the issues regarding ownership. Although additional features may be added to make sure that important activities are flagged for following startups, the basic problem of best solutions requiring development before startup team forms may require an organizational change. In some cases, ownership of activities and problems that occur before fab startup may require some resources that oversee startup activities across multiple fabs.

Another issue with managing ownership involves the incentive to solve the problem once the site startup has occurred. The motivation to solve, or even document, the problem once the critical period has passed is very low. Without an incentive or reward, individuals may even neglect to aid other startups who request help or support when the follow-on startup occurs. Populating the knowledge transfer system was an act of good will on the part of the Ireland fab, and continued support of transferring knowledge requires resources willing to spend time to help transfer additional learnings regarding the startup.

9.2 Meeting Knowledge Transfer System Criteria

The criteria described in Chapter 4.2 are general issues for a knowledge transfer system. Each of the factors will be examined with regard to the Lessons Learned knowledge transfer system.

Cost of Implementation and Maintenance

The first question to examine with developing a knowledge transfer system is whether the cost of the system will outweigh the benefits.. As indicated in the survey, learning from previous startups is considered valuable and applicable to future startups. The value and need for learning in factory startups may not always be worth the cost of system development if the knowledge is not readily usable due to variation in the startups or if the financial cost of delays and re-development of systems is not critical. The high cost of starting up a semiconductor fabrication facility, financial implications of production delays, and frequency of facility startups indicate that the development of a startup knowledge transfer system may be worthwhile for Intel. Similarities between processes, products, and equipment mean the knowledge from one startup may be directly applicable to another

Knowledge transfer does not come without a cost. This cost includes the time and resources involved in developing the system, the content, and maintaining the information. For example, the time required for each team to complete the Lessons Learned documentation meant that valuable startup resources had to coordinate their schedules to meet for an hour to review their learning. Additional time was spent individually to gather additional documentation, presenting material, and meeting with counterparts. In developing a startup system, the cost of time to resources should be weighed versus the benefit to the future startup resources.

Additionally, the development and maintenance of the system will require dedicated effort and support. For the Lessons Learned methodology described in Chapters 5-8, time was required to manage the team documentation, organize the face-to-face session, and develop and maintain the web site. More time should be spent in improving the process, and the system should be a continuous improvement project.

User Requirements

In order to develop a knowledge transfer system, the user requirements should be considered. Users include both the individuals inputting information as well as those receiving. For those receiving information, the information needs to be easy to access and directly applicable to their activity. In the Lessons Learned activity, the template highlighted major points for the teams to examine with emphasis on major issues. By presenting the material face to face, questions could be asked directly and relationships developed. The web is useful for long term access to the information, so that when the need for the knowledge arises the information can be accessed easily and with minimal search cost.

The startup obstacles discussed in the previous section must be addressed in order to improve on the user experience. Making the information timely for recipients will require additional activity from the startup learning generators. When the startup is in progress, tasks that do not move the startup forward are not considered critical and will be prioritized accordingly. Therefore, the generation of startup learning documentation needs to benefit both the current startup as well as the future startups.

Marketing and Training

In order for the system to be used, the potential users must be aware of the information and be able to use the system without difficulty. Learning from a previous U.S. startup had been compiled into a book that was provided to the fab in Ireland. Although some individuals found the book to be useful, many teams were not aware the book existed or that the documentation encompassed their activity. Using the startup material needs to be part of the startup activity. Reminding teams of the existence of startup material and making that material easily accessible will increase the probability that the material will be used.

As mentioned earlier, one of the fabs in the United States is requiring all startup teams to refer to the startup web site as part of their team formation activity. Making startup documentation and reference of learning a standard activity in startup will increase user awareness and help to build better startup knowledge transfer systems.

10. Conclusion

Questions arise for any company regarding what system to implement for knowledge transfer. The primary criteria that should be examined for any location should include a cost / benefit analysis, understanding the trade-off between flexibility and standardization, and the resources required to manage the knowledge transfer. For a factory startup, the incentives, benefits, and resource issues differ from that of an on-going factory. As the startup has limited benefits from transferring their knowledge, creating a system that is easy for them to use and/or is useful during the startup period is ideal. Also, as the startup is a period of high activity the system should be part of the regular activity for both the giving and the receiving sites.

The results of this project will not be fully realized until the following startups occur. Some indicators of success are in whether the information is being used in the startups, and how the information is used. Gathering the information is only part of the solution, the learning needs to be disseminated and built on by including the review of the information as part of the startup activity. One of the sites in the United States is doing this by requiring startup teams to review the information from the startup site as part of their team formation. The team needs to review the learnings and see if they address all of the issues brought up, or have a plan to manage them.

Developing and maintaining a knowledge transfer system is useful in reducing the cost of starting up a fab. The system described above describes one methodology for transferring that knowledge. Although this method appears to have experienced some success, there are several areas in which it can be improved. Some of these, such as using the web for real-time startup issue tracking will better address some of the communication concerns about the current system. A method for escalating startup issues and determining Virtual Factory wide ownership for some startup specific systems may help solve the problem of ownership. The problems of content and organization will require modifications to the current system as well.

Overall, transferring startup learning between fabs can be an effective way of reducing costs and startup time. Developing an ongoing system for managing this knowledge is important, and the method described above is a step in the improvement process.

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Appendix: Startup Lessons Learned Survey Results

18 people responded to the survey described below. Most of the respondents were participants from the F14 site in Ireland. Quantitative results of the survey are listed and graphed below. General observations of qualitative responses are also included.

Lessons Learned:

Ratings: 1 - Strongly disagree, 2 - disagree, 3 - uncertain, 4- agree, 5 - strongly agree

1. I believe that it is important to examine past startups before starting up a new fab. _____
2. A problem with emphasis on past startups and lessons learned is that it limits our flexibility to deal with problems the way we think best. _____
3. I believe that our startup will be substantially smoother because of the lessons learned from past startups. _____
4. Problems experienced during startup are significantly different between various fabs. _____
5. Documenting lessons learned is too time consuming. _____
6. Our last startup experienced many of the same problems as previous start-ups. _____
7. Startup functions should be systematized and clearly documented. _____

Response Values:

	Q1.	Q2.	Q3.	Q4.	Q5.	Q6.	Q7.
# of 5	17	1	6	1	0	1	12
# of 4	1	0	9	5	1	10	5
# of 3	0	2	2	0	4	2	1
# of 2	0	8	1	11	9	4	0
# of 1	0	7	0	1	3	0	0
# no resp.	0	0	0	0	1	1	0
Mean	4.94	1.89	4.11	2.67	2.18	3.47	4.61
Median	5	2	4	2	2	4	5

Additional Comments:

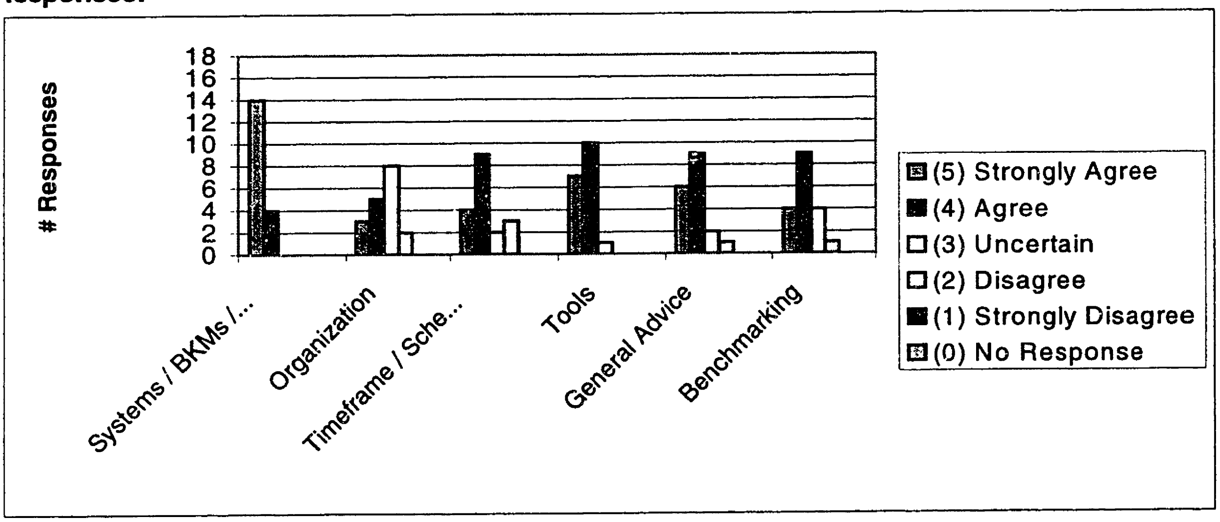
Respondents generally felt it was very important to examine past startups, and that it "shouldn't be an option not to." Most respondents did not feel that emphasizing learning from past startups limited flexibility, and generally felt like more emphasis should be placed on startup learning.

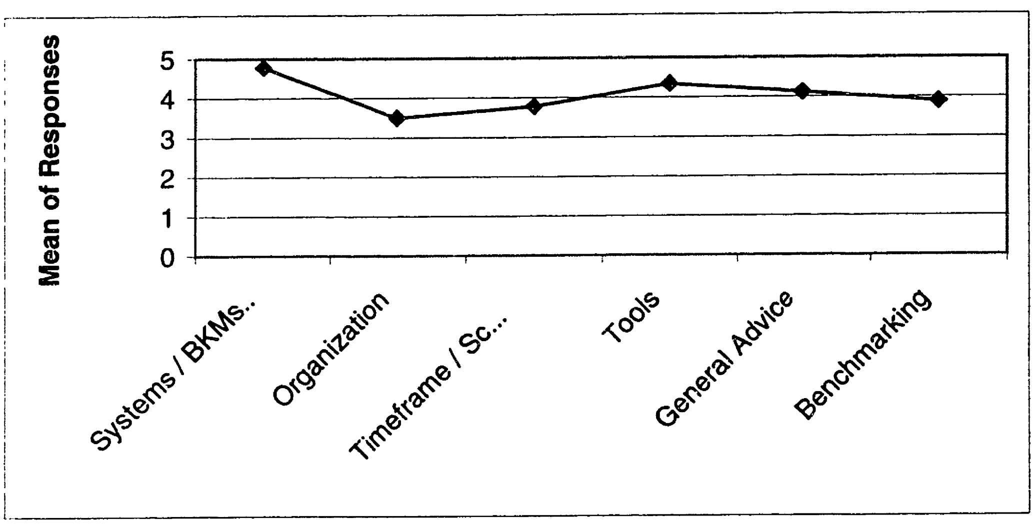
Lessons Learned were considered useful, and Fab "14 was smooth because of what we learned, but we could have done even more." In general, respondents believed that documenting the lessons learned was worthwhile as problems were similar enough and the information was valuable to future startups.

Please rate _each response_ to the next 3 questions from 1-5.
Ratings: 1 - Strongly disagree, 2 - disagree, 3 - uncertain, 4- agree, 5 - strongly agree

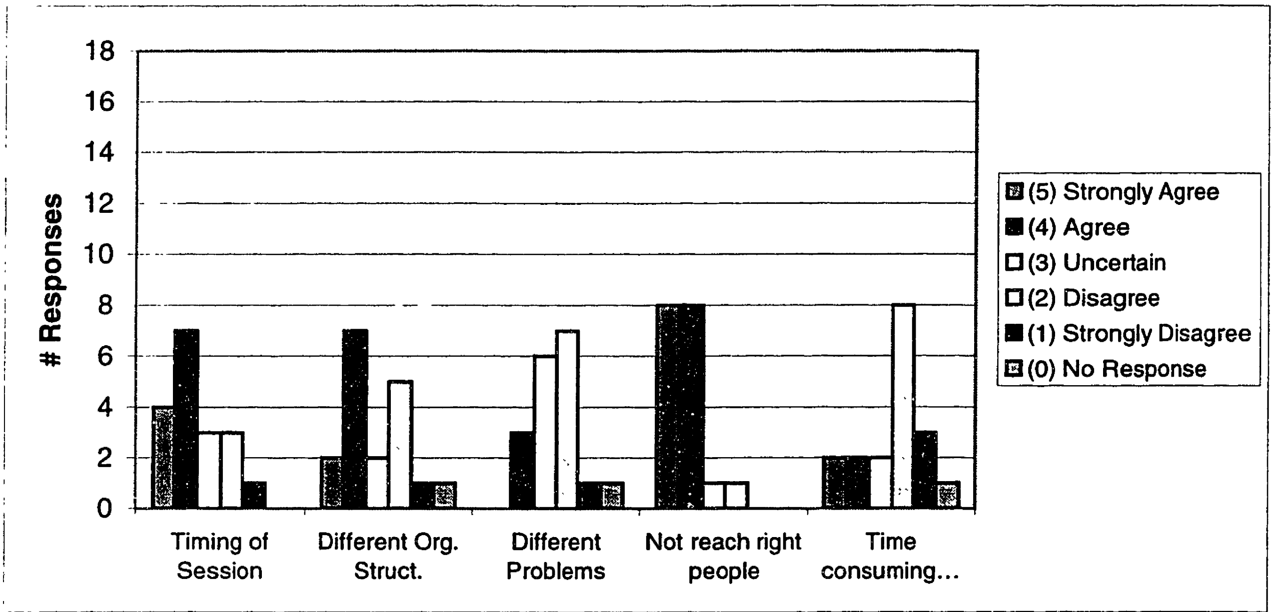
1. What type of lessons learned do you find most useful?
    - ___ Systems / BKMs / Processes
    - ___ Organization (i.e. organization structure, team development, etc.)
    - ___ Timeframe / Schedules
    - ___ Tools
    - ___ General Advice
    - ___ Benchmarking
    - ___ Other: ________

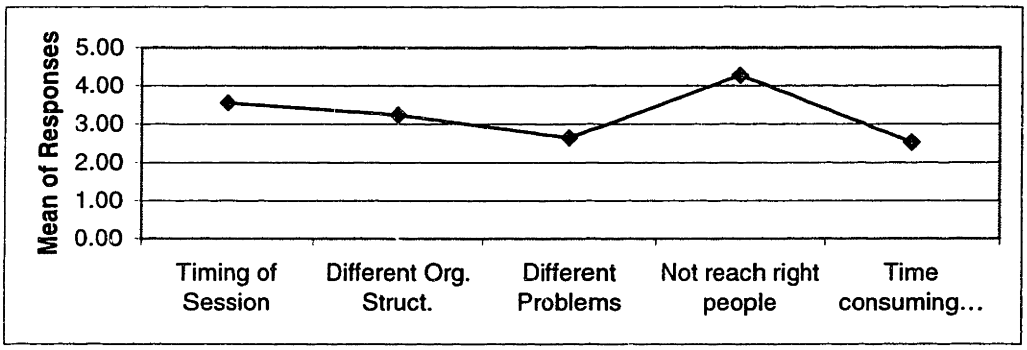
Responses:





2. What barriers do you see for using the information from a lessons learned session?
    ___ Timing of session
    ___ Different organizational structure
    ___ Different problems
    ___ Information does not reach right people
    ___ Time consuming / Too much time out of job
    ___ Other: _________

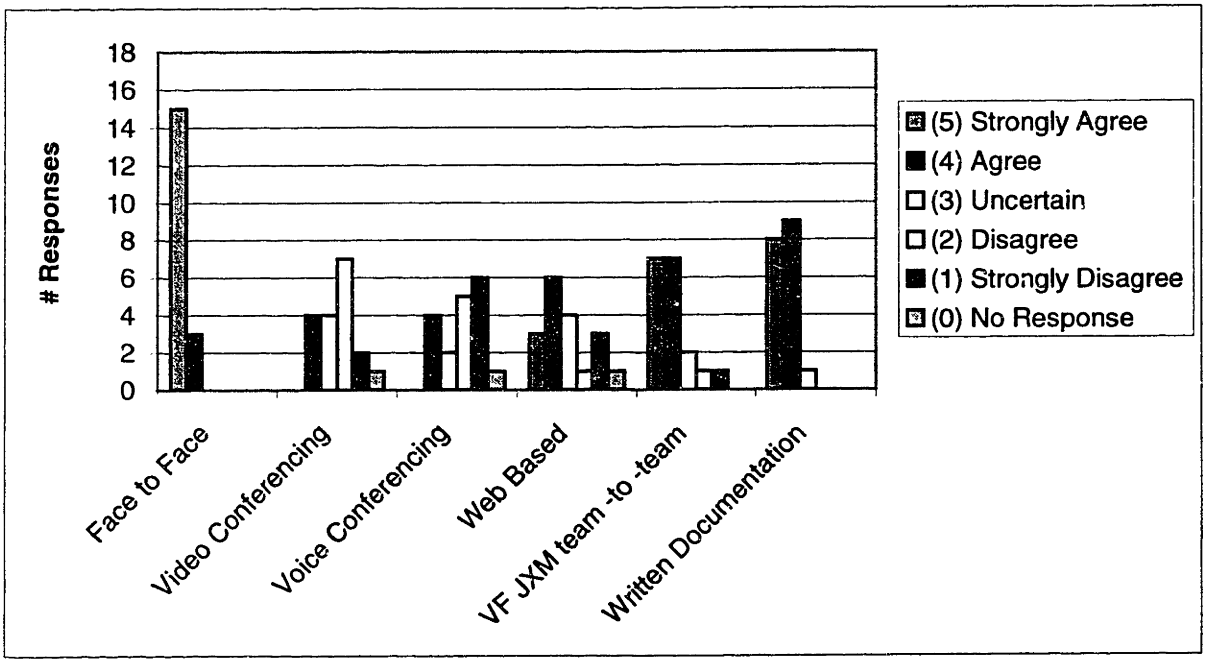


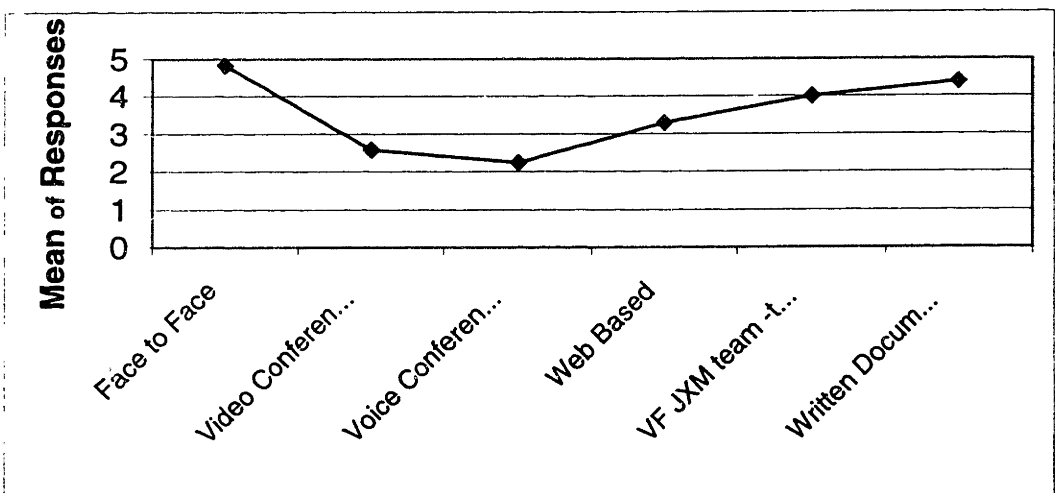


Additional Comments:
Biggest barrier was considered to be the information not reaching the right people. Respondents felt that the information should be delivered to a broader audience.

Issues were believed to have a commonality between sites, and the time spent on documenting the Lessons Learned was worth the investment.

3. How would you like to receive learnings?
   ___ Face to Face
   ___ Video conference
   ___ Voice Conferencing
   ___ Web based
   ___ VF JXM team-to-team
   ___ Written documentation
   ___ Other: _______





Additional Comments:
Many respondents were interested in a combination of methods such as Face-to-Face and Web based. Other suggestions included external fab training for 3-6 months or developing startup Best Known Methods (BKM)s.

For those who were involved in WW43 Lessons Learned Session:
1. Do you feel this was an effective way of passing on startup learning?

Most respondents felt that the Lessons Learned methodology was useful. Some have already had continuing conversations with the other fabs with references to the material provided. One respondent has used the web as a common reference while reviewing the material with a participant from another site.

There were concerns about having the right people at the session. The cost, timing, and time commitment of the session are drawbacks.

2. Did you find this a useful way of documenting Lessons Learned? Suggestions for improvements?

The template with backup documentation was generally considered an effective mechanism for gathering and providing learning. The template was considered useful in driving consistency, with the web providing backup details.

Suggested improvements included having on-going web documentation and a separate template format for presentations. A startup BKM or book that would include all processes and activities was also suggested as an alternative. Overall, the documentation effort was considered fairly successful.

For those who attended WW43 Lessons Learned Session:
1. Which sections did you find most useful? Why?

Sections that were found most useful were those which were current topics or concerns at the other startups. Individuals were also most interested in topics relevant to their startup activities.

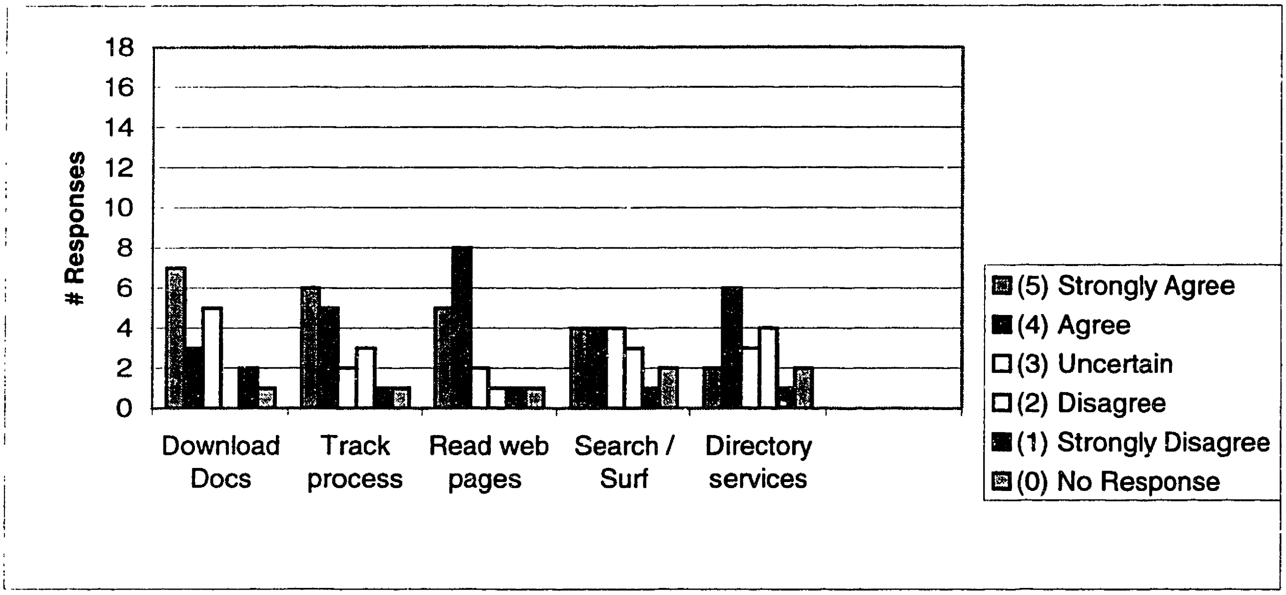
2. What did you take away from the session?

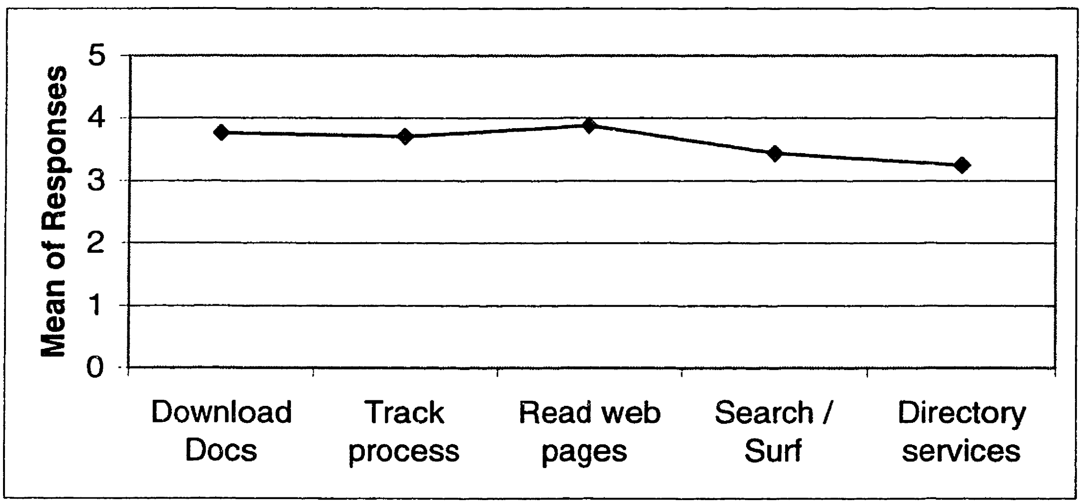
3. Did you find this a useful way of receiving the information? Suggestions for improvements?

Web Site:

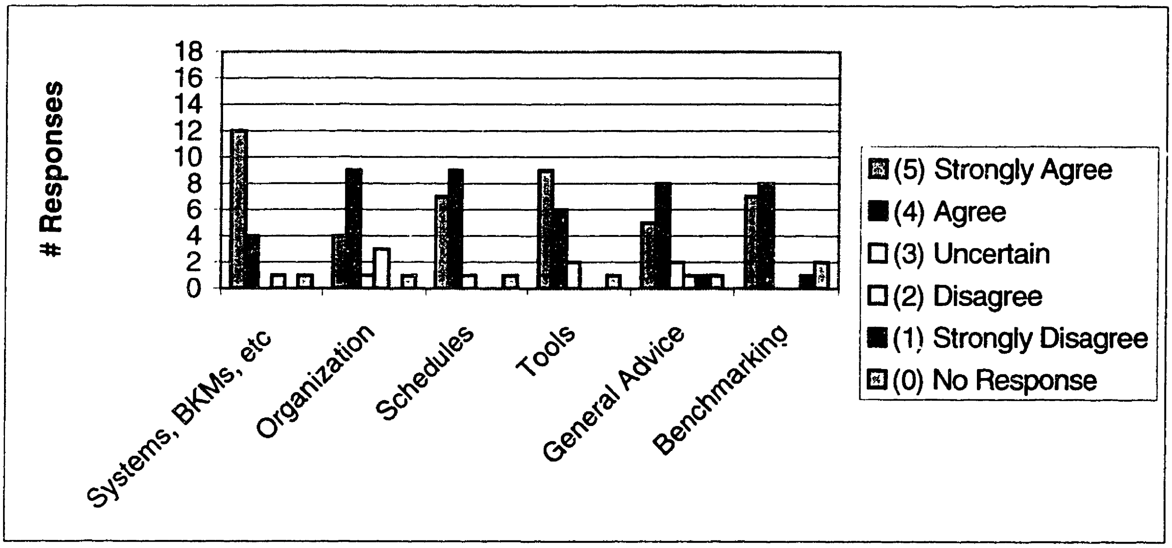
Ratings: 1 - Strongly disagree, 2 - disagree, 3 - uncertain, 4- agree, 5 - strongly agree

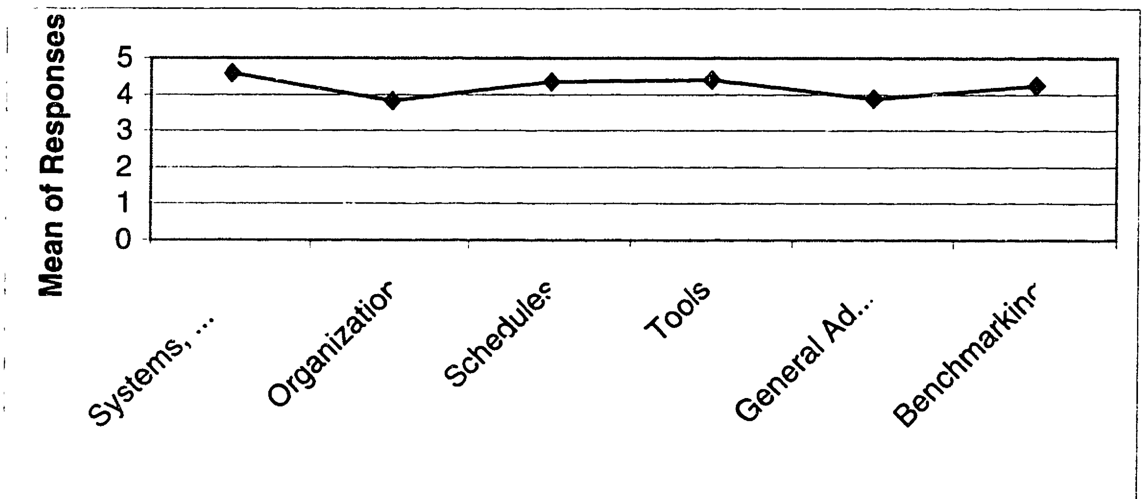
1. How do you use the web at work?
   - ___ Download Documents / Tools
   - ___ Track current process status / data
   - ___ Read web pages for information / research
   - ___ Use search engines / surf web to find relevant information
   - ___ Use directory services for contact information
   - ___ Other: ________





2. What type of information would you like to see on a start-up web site?
    ____ Systems
    ____ Organization
    ____ Timeframe
    ____ Tools
    ____ General Advice
    ____ Benchmarking
    ____ Other: ________





Additional Web Comments:
The Ireland Fab Startup web site was used by the site in Ireland to review details on the lessons learned exercise and for retrieving information. Some users had also used the site in conjunction with information requests from other sites. Respondents from other sites used the web site to prepare for the Face to Face, examine Lessons Learned, access tools, and as a general reference. The site was considered easier to use than searching through paper work, but those who do not use the web regularly were not interested in accessing information through a web site.

Concerns centered around whether this was a one time document or would it be continued in the future, as well as whether the web site was communicated / advertised to other factories. Some improvements suggested were to add a search engine and a dialogue page for additional communication.

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