IMPLEMENTING VARIOUS LEAN METHODOLOGIES AND CREATING A BUSINESS DEVELOPMENT PLAN AT AN ABB GREENFIELD SITE

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Submitted to the Sloan School of Management and the Department of Mechanical Engineering in Partial Fulfillment of the Requirements for the Degrees of

Master of Business Administration
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Master of Science in Mechanical Engineering

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ABSTRACT

As part of its strategic initiatives, ABB inaugurated a 100,000 sq-m campus for an Engineering, Sourcing, and Manufacturing Operations center in San Luis Potosí (SLP), Mexico in May 2008. The ramp-up of the SLP site encompassed two focus areas that are the topics for this thesis. The first area of focus was to create a business development guide that supports Mexican and North American division managers, plant managers, and their supporting personnel to successfully establish new business in SLP. Having such a guide available is expected to reduce start-up time of operations, increase decision-making speed, improve productivity in multi-divisional projects, and ultimately increase potential internal business opportunities. This thesis presents a case study on how this guide was designed, developed, and implemented.

The second focus area was to implement several Lean principles, the most significant one being "5S." A case study on its planned application, procedure to measure implementation level and effectiveness on quality, productivity, and on-time delivery is discussed. A discussion on the stronger emphasis by management on implementation measurement versus effectiveness measurement and possible reasons for this gap of expectations is also presented. Finally, the production area for the Robot Refurbishment line was redesigned based on the target of reducing factory floor space for use in other ventures, meanwhile simultaneously increasing lead times in the manufacturing process.

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GLOSSARY

5S: A methodology to improve organization, orderliness, and cleanliness in the production area, for increased quality and productivity.

BDG: Business Development Guide, a strategic and operational guide created for assisting SLP's management in business expansion.

Lean: a manufacturing term that focuses on reducing the expenditure of resources that do not contribute to a customer's need

OTD: On-Time Delivery

SLP: San Luis Potosí, referring to the ABB site in San Luis Potosí, Mexico.

SPC: Statistical Process Control.

TQM: Total Quality Management.

1 Introduction

The Leaders for Manufacturing (LFM) program at MIT has as part of its program curriculum, a six-month internship in which students apply engineering and management knowledge to real-world applications. The thesis is the culmination of both the academic courses and the internship, and combines knowledge learned from the coursework with a problem addressed during the internship.

The author carried out his internship with ABB Group at a Greenfield site in San Luis Potosí, Mexico.

1.1 ABB Inc.

ABB Group, formerly known as Asea Brown Boveri, is a large multinational corporation headquartered in Zurich, Switzerland. It specializes in industrial power and automation technologies, and operates in more than 100 countries with approximately 115,000 employees.

The company's history stretches back to 1883, when ASEA was first incorporated in Stockholm, Sweden. In 1891, Brown Boveri & Cie was formed in Baden, Switzerland. In 1988 the two companies merged to form Asea Brown Boveri, which was changed to ABB[i].

In July 2008 Joseph Hogan was named Chief Executive Officer of ABB, replacing interim CEO Michel Demaré. The previous CEO, Fred Kindle, departed earlier in the year after being credited with returning the company to profitability.[ii]

The company is currently organized into five divisions under two business focuses: Products and Services. Under the Products group are the Automation Products, Power Products, and Robotics divisions. Under the Services group are Process Automation and Power Systems divisions.

1.2 ABB Mexico

ABB has a long history of presence in Mexico. Brown Boveri established facilities in 1900. In 1947, BBC Mexicana was formed to manufacture induction ovens and high voltage interrupters. ASEA has had a presence since 1928 as a local sales office. In 1960 a subsidiary was established and in 1962 production of electrical motors, relays, and control panels began.[iii]

In 1988 all ASEA and Brown Boveri facilities were changed to ABB following the merger, and in 1992 ABB de México was formed as an independent legal entity. In 2000, the entity was changed to the equivalent of a limited liability corporation to ABB México, S.A. de C.V.

1.3 ABB San Luis Potosí

As part of its strategic initiatives of focusing on production in low-cost countries to produce for regional markets, ABB is finishing the construction phase and entering the execution phase of a 100,000 sq-m campus for an Engineering, Sourcing, and Manufacturing Operations center in San Luis Potosí (SLP), Mexico. The ABB San Luis Potosí site is unique in that it is the first site worldwide to house all five of ABB´s divisions. The site contains production areas for varied products from all five divisions, as well as a separate engineering and design center. It also has shared group functions such as Human Resources, IT, and Supply Chain and Operations Management.

The SLP facility currently produces or is expected to produce by EOY 2009 high-voltage switchgear and control panels, medium voltage electrical panels, low-voltage switchgear, control panels for system automation, and final assembly for new robots, both standard and custom produced. The site also has a refurbishment line for used robots, and a service center is being set up for high-voltage transformers.

Additional land has been set aside for future expansion, both on the existing grounds and adjacent to them. By 2011, 25 hectares of land will occupied with engineering and manufacturing activities, making this facility the largest, most inclusive facility in ABB's history.

2 Problem Description

The SLP campus, housing all divisions of the company and with its integrated shared functions, presents both unique opportunities and challenges that ABB has never before seen. Historically, each division has operated fairly autonomously of the other divisions (because of previous divisionally focused facilities), making a product-focused organization appropriate. However, because of the multiple divisions and products now in SLP, a matrix organization is more appropriate.[iv] Therefore, with the successful implementation of this new structure, the overall improvement opportunity for this six-month LFM study was to implement site-wide, cross-divisional initiatives that will help to reduce waste and increase knowledge flow, decision-making, productivity, and integration across all five divisions.

2.1 Aim & Scope of Problem

The implementation of the matrix organization in itself provides a challenging area for improvement; however, this topic lies outside the scope of the current problem definition. The LFM project at ABB focused on two other areas for improvement; one focusing on the strategic aspect of the business, and the second on the operational aspect. Figure 1 shows the three main issues that SLP management must address with the site launch. Though the detailed scopes of the projects overlapped little, both provided solutions for improving the knowledge flow and productivity, albeit from separate management and engineering perspectives.

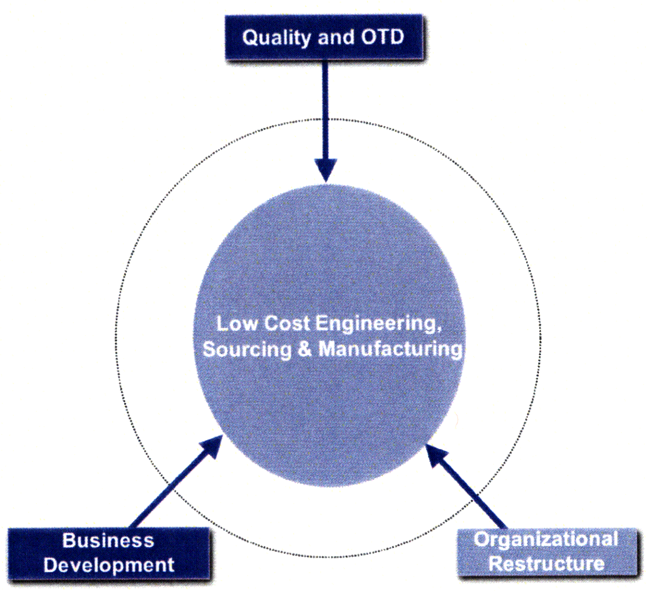


Figure 1. Areas for improvement at ABB SLP. Dark blue boxes show focus of internship.

2.1.1 *Business Development Problem*

ABB's overall strategy of moving away from worldwide sourcing and manufacturing to low-cost production facilities supplying regional markets resulted in the aggressive expansion plan for SLP. The expansion plans have already been undertaken with some business unit transfers already occurring from facilities in the U.S. and Canada to SLP. However, no method exists for executing these business transfers effectively; since most of the U.S. based managers and the SLP managers have never performed a business transfer, uncertainties exist on what to focus on first, and what areas are critical for success. Potential risks include slow or incomplete transfers, resulting in delayed production, high indirect labor costs (SG&A), and foregone revenue from lost business opportunities.

2.1.2 *Operational Problem*

Production in SLP began in May 2008 and has been ramping up in stages. Because all of the employees as well as all of the production processes are new, field quality, on-time delivery, and productivity are low. Operators are rushing to build products on-time while still learning the assembly process. New local suppliers that are just being developed provide products late or defective, and manufacturing must again rush to produce on time while inspecting incoming raw material. Finally, no coordination exists between the different divisions on strategic sourcing and continuous improvement in production.

2.2 Structure of Thesis

Because of the two-phased problem described above, this document describes both problems and approaches towards solutions separately. The next section (Part I) describes the business development problem, and the following section (Part II) describes the operational problem.

PART I

Creating a Business Development Plan at a Greenfield Site (A Case Study)

3 SLP Site and Business Development

The facility in San Luis Potosí (SLP) began production in May 2008 and since then, production volume has been slowly increasing as new business opportunities arise and as the workforce is ramped up to meet sales expectations. Additionally, the site was designed so that site capacity would increase in stages as sales grew; that is, only ten hectares were constructed for operation in 2008-2009. Within the next two to four years, twenty-five hectares are expected to be used for a variety of design, engineering, and manufacturing tasks. Pre-existing business units are expected to transfer from U.S. and Canadian facilities to SLP (where operational costs are less), and entirely new business units will be created for new opportunities.

3.1 Problem Statement

Because of the large expected increase in business in SLP, and the historical lack of coordination between business units, setting up and initializing these business units will undoubtedly prove challenging. Conversations with veteran managers have shown that, in their experience, lessons learned in ramping up new business are not always communicated across divisions; mistakes are easily repeated and best practices are missed. Additionally, individuals involved in a business transfer may not know where or whom the best source for "business development expertise" is. Finally, learning curves in ramping up a new business contribute to longer implementation times, and thus lost opportunities for additional revenue capturing.

3.2 Solution Approach

To prevent the problems previously mentioned, a standardized "guide" would have to be developed for use across all divisions. It would have to collect the best practices and lessons learned in one integrated source in order to avoid repeating mistakes, and it would have to flow out best practices information to reduce the time necessary to establish a new business.

Additionally, though this new process definition would be developed for the specific needs of the ABB SLP site, it also had to be comprehensible and applicable to ABB sites around the world. Since no guide had ever been developed to assist with business transfers to low-cost countries, the guide would have to at least provide enough guidance to assist other sites in developing their own tools.

This "San Luis Potosí Business Development Guide" (SLP BDG) would assist in the successful planning, roll-out, and execution of new projects after financial approval, and would provide checklists, methods, and best practices for a smooth transition of business from another country to the SLP site.

3.2.1 Project and Organizational Scope

This business development guide (BDG) is meant to be a strategic handbook for how to approach ramping up a business. It is not meant to outline day-to-day operational processes, as this would repeat currently established processes. It was also designed as to allow quick turnarounds of process updates and availability of new information, and to include this information as quickly and effortlessly as possible.

Additionally, though there are three main stages in the development of a new business unit, the guide is also meant to focus on the final, or implementation stage of a project. Figure 2 shows the stages, along with descriptions of each stage. Though the guide was designed for the implementation (third) phase, it must also provide some guidance for managers wishing to assist in the capital expenditure (second) phase, as occasionally some U.S. based managers may approach SLP management for assistance in developing a financial model (which cannot move to the final phase without executive management's approval). Therefore the BDG must also provide information on this topic.

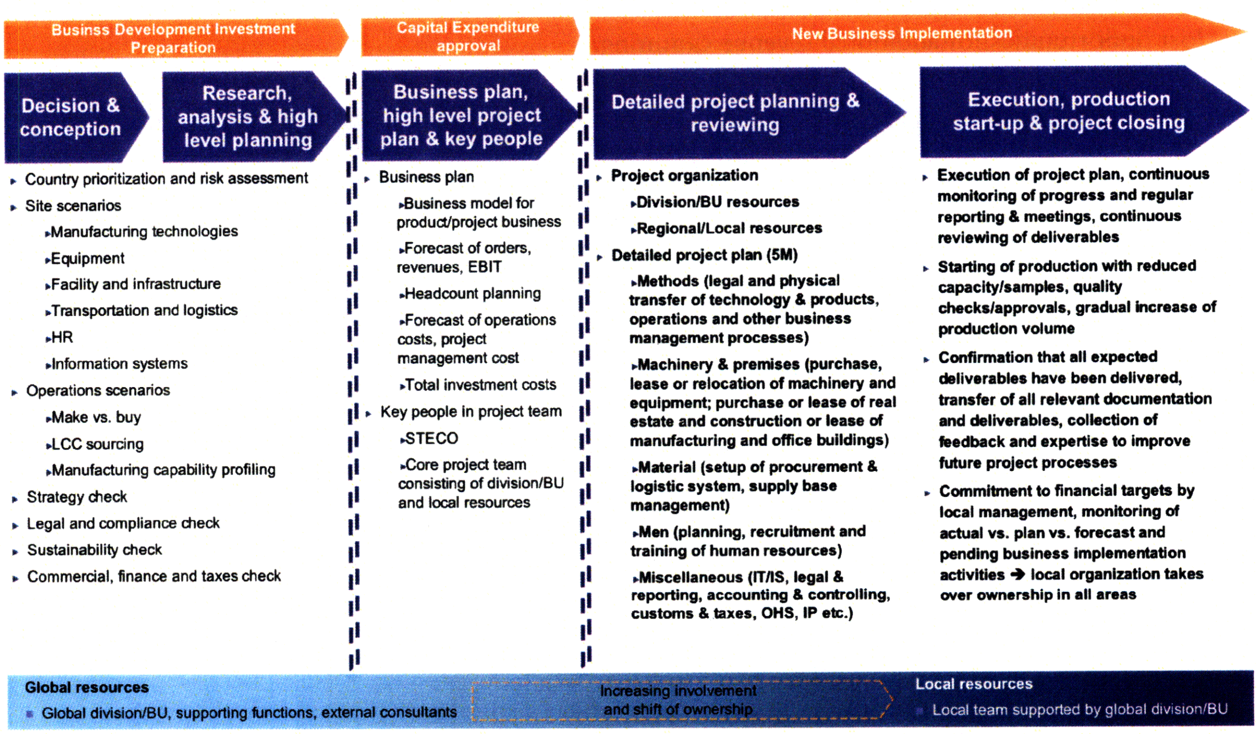


Figure 2- ABB's formal process for approving large financial endeavors. The SLPBD Process guide will focus on the third stage, but must also be able to provide support for the second stage.

3.3 Previous Business Development Processes & Guides

3.3.1 External (Literature Review)

One can say that this initiative is inherently similar to Business Process Management (BPM), the field of management that focuses on achieving an organization's objectives through the improvement, management, and control of essential business processes.[v] Both BPM and the business development guide are driven by similar circumstances; Figure 3 contains some examples that the two share.

	Drivers and Triggers for both BPM and SLP's BDG
Organization	High Growth
	Reorganization- changing roles and responsibilities
	Need for business agility and responsiveness to opportunities
Management	Lack of reliable management information
	Create ability to obtain more capacity from existing staff for expansion
Employees	Expectation of a substantial increase in the number of employees
Processes	Need for provision of visibility of processes from an end-to-end perspective
	Unclear roles and responsibilities from a process perspective

Figure 3- Issues that faced SLP and are drivers that may cause an organization to consider BPM.[vi]

Indeed, the *Organizational Strategy* and *Process Architecture* stages of BPM align well with the needs of a dual level SLP guide. However, although BPM provides a good foundations for the SLP business development guide, the similarities end here, as the subsequent implementation method dictated by BPM (including the use of specialized software tools), ceased being an ideal technique for defining a business strategy (in SLP's case, discussed in Section 3.2) and more importantly, in executing the strategy into a deliverable, detailed process guide.

Two better sources for implementing strategy are *The Execution Premium* (Kaplan & Norton) and *Strategic Planning and Management* (Karger). Karger focuses on developing a corporate strategy while considering external factors such as economic, technological, political and social issues, and making the necessary analysis and consideration in successfully developing a viable strategy.[vii] Kaplan and Norton focus more on describing specific steps in adapting the overall business strategy into action.[viii] This resource offers an outstanding outline of creating a strategy map, planning the implementation of the strategy into a detailed plan, and establishing operational review meetings and aligning them with process improvement programs.

Finally, a useful resource for low-level implementation is *The Business Knowledge Repository* (Breslin & McGann, 1998). This resource provides information regarding specific tools that can be used to creating a repository for business processes. Though the tools mentioned are specific and alternatives exist to the tools referenced in the text, it nonetheless provides an informative guide on tool design and implementation, challenges likely to be faced, and case studies of successful applications.[ix]

3.3.2 Internal

Within the company, very little work had been done in this field. The first major effort was done in Raleigh, North Carolina, in 2007-2008. This guide was named "Footprint Investment Implementation" (FII) Process Overview, and focuses almost exclusively on the "New Business Implementation" stage, and does not address the "Capital Expenditure Approval" stage. Furthermore, of the four stages identified as necessary ("Define, Plan, Execute, Release," see Figure 6), only "Define" and "Plan" are addressed in great detail in the FII. Therefore, the FII is a good tool for use in the general ABB community regarding high-level implementation strategies.

3.4 Business Development Procedure

The creation of the SLP BD Process was done in three stages. The initial baseline to start from was the IFF created in 2008 in Raleigh, North Carolina. Since this "Raleigh guide" contained a high-level strategy when developing new business processes, a new SLP guide required outlining more detailed process steps. This SLP guide was based on interviews with business managers that had been previously involved in expansion projects. Additionally, it was necessary to incorporate template documents that have been used in these other SLP business implementations. Finally, after the guide and accompanying templates were put together, the web-accessible repository tool and all the associated websites had to be created and placed online.

3.4.1 Initial Template

To be successfully used for SLP's needs, the new Business Development Guide (BDG) required more detail than currently offered by the Raleigh guide (including sample documentation), as well as requiring a time sequential method of implementation. It also needed to address additional topics specific to SLP's situation, such as cross-border business agreements. Finally, the guide needed to be a living interactive document, one that could be navigated non-sequentially if necessary (much like a website), and be updated easily by anyone having input. Figure 4 shows the functional topics that are addressed in this Raleigh guide. As one can see, the guide is organized by functional topic, and not organized into a time specific method of execution. It nonetheless provided an excellent foundation for the new guide.

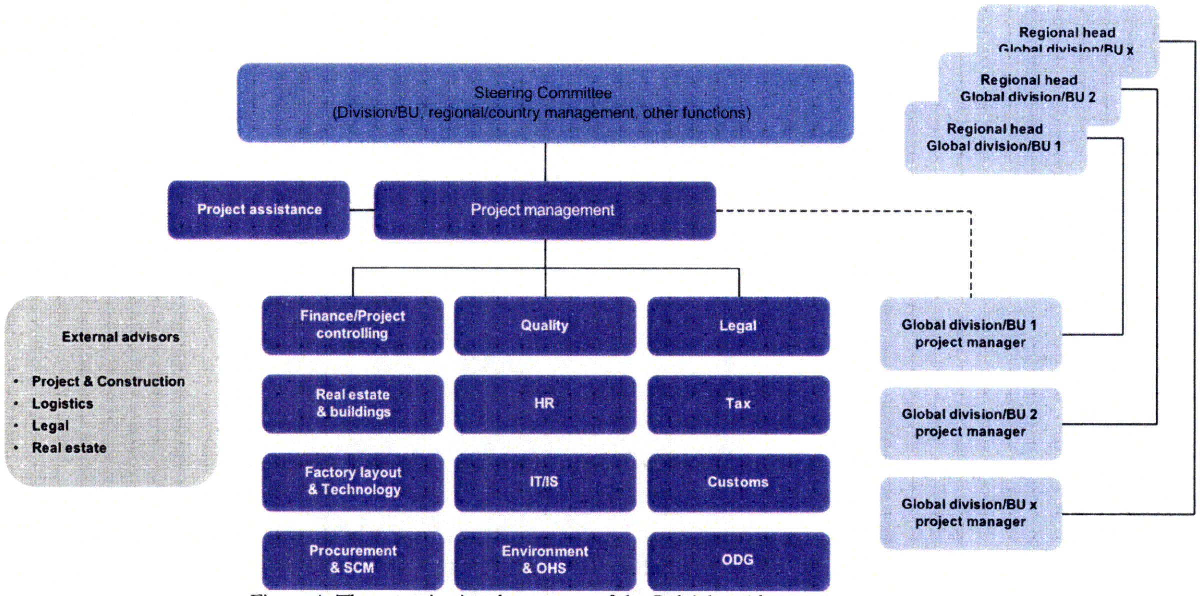


Figure 4- The organizational structure of the Raleigh guide.

3.4.2 Interviews and New Guide Formation

The principle drivers behind the creation of a new guide were to include additional characteristics that the Raleigh guide lacked. Firstly, a clear sequential order to the different business functions that needed to be addressed was developed as the top level strategy. Figure 5 shows the most important business functions, and the order in which they would be implemented in a new business.

The BDG implements four stages of project execution: Define, Plan, Execute, and Release. Though business functions overlap each stage according to specific needs, none (except for Supply Chain Procurement and Logistics) span all four stages of the business development plan. This is done intentionally as it follows a top-down approach from high-level strategy development to operational execution and release. However, Supply Chain Procurement and Logistics spans the entire four stages because of the criticality of the topic. The availability and costs of reliable suppliers is taken into account when creating a world-wide search for a new site, and continuous development of supplier relationships is done after ramp-up and release.

The business functions were categorized using a "5M" method: Mexico, Material, Machinery and Premises, Men, and Methods. These broad categories were created to assist managers in addressing all the necessary topics in business development. The 5M method is applied to lower-level topics as well.

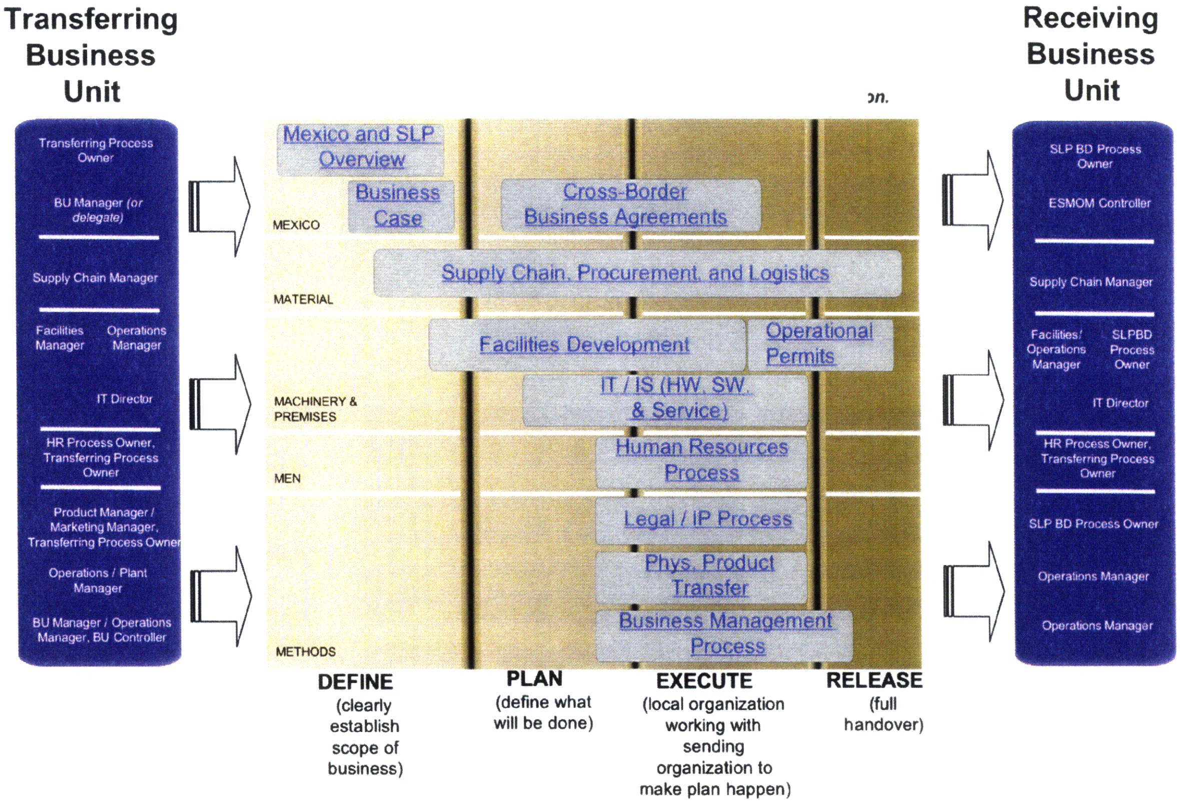


Figure 5- The top-level strategy in the business development guide. Time progresses from left to right. See Appendix A for full business development guide.

The boxes on either side of Figure 5 represent the stakeholders in the transferring business unit (outside of SLP, on the left) and the receiving business unit (in SLP, on the right). Each individual has a corresponding counterpart with whom he or she can coordinate in his or her responsibilities.

It also serves to identify a relationship with each of the 5 "M's" and to ensure ownership and informational accuracy of the topics as time progresses, through updates of the guide's content.

Process ownership by individuals is crucial to the continuing evolution of the information it contains. Each title in the "Receiving Business Unit" box in Figure 5 is associated with a specific individual that is accountable for the process, and although not necessarily involved in all new business transfers, is the resident subject matter specialist on that particular topic.

As current process owners, these same individuals were also the main source for developing the lower-level guides. They provided the information in the lower level procedures, as well as sample templates. For example, in the Physical Product Transfer category, additional in-depth information was obtained from the site Operations Manager. As Figure 6 shows, its operational level processes practically serve as a week-to-week outline of how to manage the physical reassignment of a production process (equipment, documentation, and all related schedules). In addition, below this level, templates are available for use by the individuals responsible for the business transfer. See Appendix A for the entire set of sub-processes and the accompanying templates.

Product and Component Transfer -- High Level Process Map

	TR0	TR1	TR2/3	TR4
Objectives	• Define Program Objectives: Cost, Quality, Schedule • Cross Functional Resources Committed to Core Team	• Scope/Strategy of Transfer finalized • Team Commits to Cost, Quality, Schedule	• Catcher's Process Capability Evaluated • Performance of evaluation units Verified • Catcher ready to ship pilots	• Catcher's Process Capability Proven • Pilot prod'n Issues Resolved • Quality/Cost Goals Achieved • Catcher ready for full prod'n
Key Deliverables	• Risk Assessment and risk retirment plans defined • Manufacturing / Sourcing Strategy defined • Resource costs/savings estimated • Catcher identified • Program Scope defined • Core Team & extended core team defined	• Risk assessment complete, major risks retired • Manufacturing/Technology/ Sourcing Plans Complete • Resource costs/savings fully defined • Commitments for Schedule/ Cost/Quality goals • Pitcher/Catcher Scorecards established • Drawings/Specifications/ Structure updated • Service plan complete	• Evaluation units Verified to drawings/specifications • Phase-in/phase-out plan updated/old suppliers notified • Catcher's Suppliers selected and contracts signed • Schedule/Cost/Quality goals on track • Catcher's readiness for pilot production confirmed • Drawings/Specifications released for pilot production • Importation requirements complete • Regulatory Requirements Met	• Verification/Validation of Pilot units complete • Phase-in/out plan finalized • Cost/Quality goals achieved: Catcher's Zst >= Pitcher's • Catcher's facility/equipment/ tooling/procedures complete • Drawings/Specifications released • OTR/Importation/Exportation requirements complete • Service plan in-place
Actions Authorized by Milestone Approval	• Resources assigned to Retire major risks • Complete Zst Baselines • Complete detailed definition of Resource costs / savings • Execution of TR1 Deliverables	• Catcher to tool-up & procure evaluation & pilot materials • Catcher builds evaluation units for verification/validation • Pitcher executes Verification plan when parts/assemblies available	• Authorize Pilot Shipments to Pitcher for integration and/or shipment to customers • Begin phase-out of old parts • Place production ramp-up demands on Catcher	• Full production ramp-up • Final phase-out of parts from old suppliers • Final phase-out of production at Pitcher's site
	Product Transfer Program Established	**Program Commitments Defined**	**Catcher Pitcher Ready for Pilot Production**	**Full Production Quality Monitoring**

Figure 6- Physical Product transfer high-level process map. For additional process maps (including this one), see the Appendix.

3.4.3 Release to Company Intranet

After creating the interactive guide and linking all the appropriate documents and templates, the entire packet had to be made accessible to the ABB community, yet kept within the limits of this community. It was deemed that using the company's intranet would best fit these needs, as it is easily accessible to ABB employees around the world, yet protected from non-ABB persons through the company's standard computer security provisions.

An administrator with dedicated responsibilities to the local intranet site updates the guide. Managers make suggestions for changes or improvements to this site administrator, who then incorporates them into the guide. However, it is each contributing manager's responsibility to ensure that the uploaded files are "generalized," or purged of any specific information, and that these specific file are linked to a strategic level process.

3.5 Results & Gap Analysis

Other formats for implementation were considered. In theory, any implementation plan that published the results to the ABB community could have been just as effective, but in reality marked advantages and disadvantages appeared. For example, the option of having an eRoom repository for the business guide was considered and initially pursued. [eRoom is an easily adopted web-based collaborative workspace that enables distributed teams to work together. It allows project teams in different locations can work towards the development and delivery of products, services, and business processes[x]]. However, major disadvantages were encountered in initial testing of the eRoom's features. For example, it is a proprietary software owned by EMC, and as such it required an annual fee to be paid on a per user basis. Additionally, to use its full functionalities requires the installation of software on the local machine, hampering flexibility if one user were using a computer other than his own. These two requirements were the largest obstacles to using this software for the guide.

Another option that was briefly considered was wikis. A wiki is a page or collection of Web pages designed to enable anyone who accesses it to contribute or modify content, using a simplified markup language.[xi] While this option resolves the issues encountered with using eRoom, a new set of issue were encountered. Firstly, a secure, internal mechanism for wiki creation and editing would have to be designed, which nobody at SLP had the expertise to do. Secondly, it was observed that management was hesitant about creating an open-source set of documents, and desired a mechanism with more formality in the change control process. Thus when the opportunity for creating a microsite with all the business development content surfaced, it was decided as the best alternative to pursue. In addition to providing the ability to control the change control process, the infrastructure to create it was already there in the form of a company intranet site (including the supporting IT individuals). This allowed for very rapid creation of the site and adaptation of it as needs arose.

From the development to its final publication and use, the business development guide is successful in providing an integrated repository of information to assist in the transfer of ABB businesses to the SLP site. It is readily accessible to any individual that needs additional information on growing or relocating a business function, and is easily updateable by each process owner. However, in addition to the different tool options mentioned above, some research has corroborated the approach taken in developing the BDG. Two main topics will be briefly discussed; guide features and implementation method. In Breslin & McGann, four essential features are mentioned: *graphics model* *visibility, navigational ability, training component, and repository ability.*[xii] All of these features were considered and included. As shown in Appendix A, all of the high and medium-level processes were captured as graphics or diagrams, and created in an interactive, navigable manner on the company intranet. The training component was addressed through the availability of templates, sample files, and explanatory presentations all available at a detailed level. Finally, the repository function was completed through making the guide in one, secure, and integrated physical location, though available worldwide to any user that demands it.

3.6 Future Opportunities and Recommended Actions

Since the business guide was released and implemented towards the end of the internship project, long-term observations on its actual utility and effectiveness are not available. However, because of the fact that every business unit transferred to SLP is unique in its circumstances and needs, it is exceedingly challenging to set up an experiment in a controlled fashion that can validate the business development guide's effectiveness. However, once the guide is in use, creating a survey or feedback form for managers to fill out is a viable method of estimating its effectiveness. This survey can collect in a more detailed manner each manager's estimated or actual savings that the guide provided, be it in terms of time, cost, or some other metric.

In terms of future expansion of the guide, issues exist that were not addressed in the first iteration but were subsequently deemed to be important. Some of these are: Environmental Health and Safety, Transnational Legal Issues, and Taxes.

PART II

Implementing Various Lean Methodologies at a Greenfield Site

4 SLP Production Process

The SLP site is a Greenfield facility that replaces older facilities that ABB had in Tlalnepantla, Edomex for its Power Products division, and simultaneously initiates production for the four other divisions. Therefore, production lines were either transferred from Tlalnepantla or from other facilities in the U.S. Management took advantage of the change to SLP to modify the processes and the factory layout of some production lines. Thus even production and manufacturing engineers that had been familiar with the process at the previous site were not so familiar with the new process (and had to design and learn the process while managing the production transfer).

Additionally, over 80% of the employees at ABB SLP are new to the company and the majority are new to the interrupter and switchgear industry. Because of these two situations, issues in production are likely to appear.

4.1 Problem Identification

Because of the circumstances described above, the expected problems eventually became reality. Compared to previous measurements at other sites, defect rates became unacceptably high, productivity was low, and on-time delivery suffered (though this was partly due suppliers' late or incorrect shipments, it was also due to poor standardization of manufacturing processes). On-time delivery has a direct impact on company profits because timeliness is guaranteed to the customers through contracts and lateness is penalized with fees or discounts. Quality also has an impact the bottom line because poor quality increases direct labor costs, raw material costs (through scrap and waste), equipment and utilities use, and warranty costs (through reshipment and/or employee travel).[xiii] Finally, low productivity increases total costs because of higher per-product cost allocations.

4.2 Problem Approach and Project Scope

Several different approaches could be taken in addressing these issues separately. However, because some aspects of quality, schedule compliance (timeliness) and productivity are interrelated[xiv], an approach towards one integrative solution was decided. Specifically, using Lean techniques was deemed as the best approach towards a solution.

Lean is a broad term used widely across the manufacturing industry. This section is meant to describe the Lean topics that were specifically used to address SLP's difficulties. For a more thorough discussion on Lean, its origins, and its different approaches, see Chapter 5. The Lean focus areas for this project are "5S", and Production Layout Design. Though other initiatives were conducted during the site ramp up, these two provide the most meaningful material for discussion.

5 Previous Lean Research

Lean is a manufacturing practice that deems the expenditure of resources for any purpose other than the creation of value for the end customer to be wasteful, and thus a target for elimination. James Womack and Daniel Jones in the book *Lean Thinking* have an alternative definition:

> [Lean thinking] provides a way to specify value, line up value-creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively. In short, lean thinking is *lean* because it provides a way to do more with less—less human effort, less equipment, less time, and less space—while coming closer to providing customers with exactly what they want.[xv]

Alternatively, it can be summarized as "creating more value with less effort." Indeed, the topic of Lean has been discussed extensively in the last twenty years. While this work is by no means meant to be an exhaustive discussion on the topic, there are a myriad of resources available to the interested reader. For a list of the most thorough works on the topic, see the bibliography at the end of this work. This chapter will focus on a brief history of Lean as it evolved until today, and descriptions on the Lean tools that are most relevant to the problems faced at ABB.

5.1 History of Lean

Although the term "Lean" was coined in a 1988 article in the Sloan Management Review,[xvi] the concepts surrounding Lean originated much earlier. Some concepts originated from Henry Ford and the moving assembly line, where the manufactured product moved instead of the factory worker, allowing workers to spend more time assembling instead of transporting (themselves or material), and in turn causing productivity to soar. However, though Ford was very efficient in his production scheme, it lost significant competitive advantage by ignoring one vital aspect of Lean: creation of value *for the customer*. Thus Ford was unable to evolve with the market, and struggled for years after the Model T dropped in popularity.

Toyota was the next major innovator in Lean thinking with its "Toyota Production System (TPS)."[xvii] One of the basic tenets of the TPS is "Just-in-Time (JIT)" manufacturing, where raw materials are not received until needed, and final products are not manufactured until requested by the customer. Reducing this inventory frees up inventory and decreases carrying costs.

JIT manufacturing has a second, stronger implication. Because a product is not made until a customer requests it, it assures that inventory (and thus production) will not be excessive. This is the second important aspect of Lean that was missed by Ford in the 1920's.

Lean has involved today into creating value by focusing on processes that add value to the customer and removing processes that do not create value (known as *muda*). *Muda* is the Japanese term for "waste," and in the Lean methodology there are seven traditional types of wastes that a process or product can experience: waiting, overproduction, rework, unnecessary motion, inventory, over-production, and transportation.[xviii]

5.2 Lean in Practice Today

It is stipulated by the author that there are two focus areas for Lean at present-day; one that removes *muda* from time dependent processes such as production scheduling, and procurement and inventory planning, and one that removes muda from space dependent processes such as production areas, equipment, and other physical resources. While these two approaches overlap in many areas and ultimately serve the same goal, the following sections explain the differences between the two.

5.2.1 Time Dependent Lean- Production Flow and Pull

Toyota's TPS focuses on the time-dependent improvement method. Its JIT strategy attempts to reduce waste twofold: the first being the aforementioned cost savings in inventory and carrying cost avoidance, but the second and subtler manner avoids rework. If defective items are produced and stored in inventory, then large amounts of inventory will necessitate more rework (and thus higher costs). Thus high levels of inventory lead to three types of waste: overproduction, waiting, and a higher propensity for rework. The Just-in-Time (JIT) production method is meant to address and implement both concepts of flow and pull in a Lean environment.

Womack and Jones describe flow and pull quite succinctly in this description of JIT:

> Just-in-Time, an innovation pioneered at Toyota in the 1950s... was designed to deal with [uneven product ordering]. This technique was envisioned by Taiichi Ohno as a method for facilitating smooth flow...JIT is helpless unless downstream production steps practice level scheduling to smooth out the perturbations in day-to-day order flow unrelated to customer demand. Otherwise, bottlenecks will quickly emerge upstream and safety stocks will be introduced everywhere to prevent them.[xix]

However, SLP enjoys the added advantage that almost all of the products are made-to-order, therefore greatly reducing (if not eliminating) the need for forecasting and production leveling that is common in other manufacturing industries.

5.2.2 Space Dependent Lean- Tools for Waste Elimination

The "space-dependent" or "visual-dependent" tools for lean vary from the concepts of value flow, pull, and JIT mentioned in the previous section. These tools focus on the physical production space and the interaction between workers and machines in this space, and seeks to improve productivity in this worker-machine interaction and/or reduce defects. The following concepts are the most well-known of these types of Lean tools.

5.2.2.1 Kanban

Kanban comes from the Japanese word for "card" or "board," and is a signaling system meant to display or trigger an action, usually a request for additional raw material but occasionally also used to indicate product transport or completion. The kanban, usually a card, contains the information about the needed product or process to its original source, to be sent back to the requesting station.[xx] The Kanban system was inspired by supermarkets, which supply what the customer needs at the time requested and in the amount requested.[xxi]

5.2.2.2 Poka-Yoke

Poka-Yoke is a translation from Japanese that roughly means "fail-safing" or "mistake-proofing." It is a method of preventing errors or defects by making non-standard work clearly evident or impossible. An example of this would be a jig for sustaining a part only allows parts to be secured in one direction, thus avoiding defective processing. There are two main types of poka-yokes: the control type (in which the processing equipment does not permit for the activity to continue if it detects a fault), and the warning type (in which the processing equipment emits a flashing light or sound to notify the operator).[xxii] Most of the poka-yoke designs familiar to the general public are of the control types, such as an electric AC plug with one plug larger than the other to ensure one orientation in its insertion, or a microwave oven that disconnects when the door is opened.

5.2.2.3 "5S"

5S is a methodology for cleanliness, organization, and orderliness in the workplace. Its intent is to reduce time and effort wasted in searching for tools or equipment. The name comes from the original five Japanese terms, which all started with "S." See Table 1 for and explanation of each term.

Original Japanese Term	English Transliteration	English Conceptual Term	Meaning
Sieri	Sort	Organization	Plainly differentiate between items essential to the process from unneeded items that create clutter; get rid of the latter
Seiton	Set in Order	Orderliness	Maintain the required items in an the workplace in an orderly and neat fashion, which permits easy access
Seiso	Shine	Cleanliness	Maintain the work area tidy and clean
Seiketsu	Standardize	Standardized Cleanup	A results of continuous maintenance of the first three "S"
Shitsuke	Sustain	Discipline	Making the above the first four "S" an everyday practice

Table 1- The five "S" as defined in Japanese, and their English equivalents and meanings *Source: Hirano, 1996; Hirano & Talbot, 1995*[xxiii][xxiv]

5.2.2.4 Production Layout Design

The redesign of plant layouts can be done with a variety of tools, the most common being the Value Stream Map (VSM). Value Stream Mapping is a technique performed in determining how materials or information flows in a production process, with the intent of focusing on the value-added flows (the value streams), and reducing the waiting, unnecessary motion, and transportation of the materials or information.[xxv]

Though this technique might fit more appropriately in the time-dependent aspects of Lean, it has been placed here because the results of a successful value stream mapping exercise frequently impacts the layout of a production line, which *is* space-dependent.

Other techniques focus exclusively on reducing the work area footprint. This is the approach described in Section 6, because it had as its main objective *space* reduction due to the high opportunity cost of using extra factory floor space.

5.3 Alternatives to Lean

Lean techniques are just one of several manufacturing and production improvement methods that are in use. Others, such as Six Sigma and Statistical Process Control (SPC), focus on reducing variation and improving quality (and thus reducing costs). Though these methods applied originally to medium to high-volume manufacturing, it is now widely practiced and applied in a variety of service and production industries.

Still other methods such as Reliability Centered Maintenance (RCM) and Theory of Constraints (TOC) exist. These focus on reducing equipment failure and reducing the production limitations (bottlenecks), respectively, though neither of these have achieved the widespread use and prominence of the previously mentioned Lean methods, perhaps due to their limited application or complexity.

6 5S Implementation at SLP

SLP identified two areas that would have the most impact on operational revenue; quality, on-time delivery, and productivity as explained in Section 4.1. It was decided early on that the approach for resolving these issues would be through implementing 5S, which is one of the concepts of Lean.

From a scientific standpoint, it may seem counterintuitive to select the solution method before carefully identifying all the aspects of the problem. In this case, though other improvement methods such as Six Sigma or SPC would undoubtedly work (though we cannot know for sure if these would have been more or less effective without performing careful experimentation with each method on similar circumstances), there were stronger reasons for using the Lean 5S approach. These methods have proven to be effective countless times both in academia and in industry experience. Indeed one of the main reasons behind Lean's popularity is its inherent effectiveness, and has outlasted other "fad" approaches.

6.1 Hypothesis of 5S Implementation

It is the author's postulation that the implementation of 5S would help improve quality and on time delivery. By organizing and standardizing the work area, workers will have better access to the necessary tools and the product being worked on, resulting in better work flow. Because the products being assembled are very labor intensive and complex, implementing this technique will have a large impact on the mentioned focus areas.

However, this large complexity also creates difficulties in the measurement of the results; because there are so many variables that influence the quality of a product, it is challenging to set up an experiment that can completely and effectively isolate the implementation of 5S as an independent variable and quality as a dependent variable.

The planned procedure was to create a baseline measuring quality by using the existing quality metrics in use by each division. Additionally, baselines would be created to measure the level of 5s implementation through auditing and photographs.

6.2 5S Implementation Procedure

Initially, management had decided to perform "pilot projects" on key divisions, and then roll out to the entire factory. However due to time constraints, a plan was subsequently devised to introduce the 5S training to the employees to all product divisions simultaneously. Two dimensions would be used to measure a baseline and improvements. The first is capturing the status quo by taking pictures of the production areas. This would provide extremely useful evidence to document how the plant had changed over time. The second is performing regular 5S audits of the areas by a trained team and using a standardized audit sheet and template, to measure the level at which 5S had been implemented.

Measuring quality directly was considered but later deemed impractical for two reasons. Firstly, products were built based on customer orders, and thus each production run was different than the last. If all the products were standardized, it would be simpler to track an improvement (or lack of) in quality. Secondly and more importantly, because each production run was different and usually lasted four to eight weeks, the relationship between 5s and quality is not exclusively causal, and many other factors would be involved in influencing the final products' quality. Stated another way, implementing 5S would be a factor that contributes towards better quality, but better quality cannot be solely attributed to successful 5S since operator training and experience, tool availability, and production scheduling are also important factors.

6.2.1 Audit Baseline and Measurement

An audit template was developed by the author and a 5S team and was written in such a way as to be applicable across the widely different production lines. The document measured each "S" separately and each was developed as a matrix, with the rows having different physical area descriptions and the columns having spaces for degree of compliance. See Figure 7 for a sample of the audit form.

ABB

LISTADO DE DIAGNOSIS (3 's')
SELECCIÓN

Area a Auditar: ______________________

Firma Responsable de área: ______________________

N°.	3 's' / DIAGNOSIS / UBICACION	SELECCIÓN Todos los objetos son utiles para la operación o están indicados los que se necesitan y los que no.	CRITERIO: CRITERIO DE DIAGNOSIS PARA SELECCION (SEIRI)	ACCIONES RESULTANTES
1	PISOS, PASILLOS PAREDES, TECHOS, SALIDAS DE EMERGENCIA Y EXTINTORES	1	1- Absolutamente todas las áreas son necesarios en: •Pasillos, áreas de trabajo, de dispositivos, de unidades, acceso restringido 0- Pasillos, áreas de trabajo, de dispositivos, de unidades, acceso restringido	
2	MATERIALES y MATERIA PRIMA		1- Absolutamente todos los materiales determinados como útiles están dentro de la ubicación asignada 0- Existe uno o más materiales que que se determinaron como útiles están dentro de la ubicación asignada	
3	RACKS Y TARIMAS PARA MATERIALES		1- Absolutamente no existe ningún rack o tarima que no se utilice. 0- Existe uno o más rack o tarima que no se utilicen.	
4	ANAQUELES Y CAJONES PARA PARTES		1- Absolutamente no existe ningún anaquel o cajón que no se utilice. 0- Existe uno o más anaquel o cajón que no se utilice	

Figure 7- Sample audit form (in Spanish).

The final result would be a percentage score for each production line and each "S," after which each score would be combined into one aggregate score and compared across the six different production areas. Management set multiple stage goals for which each division should strive to, the first being a 70% goal for all divisions, and the second being a 90% stretch goal.

6.2.2 Photographic Baseline

As a complement to the audits (and for a more vivid documentation of progress), pictures would be taken of each production area during some of the audits. Though it is difficult to convert pictures into quantitative improvements, they assist immensely in illustrating to upper management the efforts that have taken place in 5S implementation. Figures 8 and 9 show samples of some pictures taken to set the baseline.

Figure 8- Pictures of production areas before 5S implementation.

Figure 9- More pictures baselining the production area before 5S implementation.

6.2.3 Employee Training

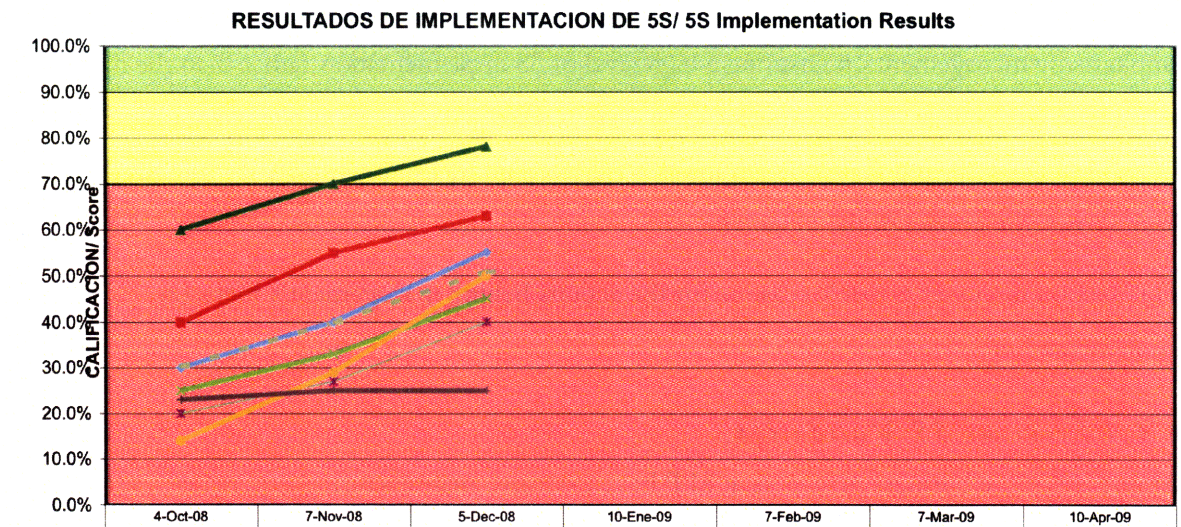
To make the 5S program a success, the operators on the production lines needed to be introduced to the concepts of 5S and trained in its continuous application in the workplace. An initial training course was organized by the author and involved all the operators, supervisors, and production managers at the plant. Customized booklets containing basic 5S information were handed out to operators for use as reference guides.

After this initial training session, *action workouts* were held in each workstation within all production lines, and involved all the operators and supervisors. The purpose of the action workouts was to implement the newly learned 5S skills on the factory floor. The course instructors would gather in small groups with the operators and supervisors to help provide implementation ideas in the actual work areas. These action workouts would also be held in subsequent sessions to reinforce the 5S concepts and to help create ideas for further 5S implementation in a workstation, similar to a *kaizen* event.

6.3 5S Results, and Observations

The 5S implementation project lasted approximately three months. Figure 10 shows the results of the 5S project by business unit from September to December 2008. The background is meant to reflect the goals that SLP management set for each business unit, the first being at a 70% 5S rating, and the second at a 90% 5S rating.

The rates of improvement varied for each business unit, and it was observed that the Business Unit that improved the most had the strongest support of management for 5S success. For example,



	4-Oct-08	7-Nov-08	5-Dec-08	10-Ene-09	7-Feb-09	7-Mar-09	10-Apr-09
Bus. Unit A	30.0%	40.0%	55.0%				
Bus. Unit B	40.0%	55.0%	63.0%				
Bus. Unit C	60.0%	70.0%	78.0%				
Bus. Unit D	25.0%	33.0%	45.0%				
Bus. Unit E	20.0%	27.0%	40.0%				
Bus. Unit F	14.0%	29.0%	50.0%				
Funct'l Area A	23.0%	25.0%	25.0%				
SLP CAMPUS	30.3%	39.9%	50.9%				

Figure 10- Measured implementation of 5S for each ABB Business Unit.

Business Unit F had the lowest measurement of 5S implementation, but qualitatively had the strongest support from management. Thus after three months, Business Unit F was well placed in the middle of the field with regards to audit ratings. Because most of the line operators had similar levels of enthusiasm for the 5S implementation effort (again noticed through observation) and drew heavily from management's attitude towards the effort, it is thus concluded that success in its implementation of 5S relied principally on management's support and drive for a successful 5S project.

While there were improvements overall, one can see from the audit results that there is still opportunity for improvement. None of the business units were in the green stretch goal that management has defined. Since continuous improvement is one of the foundations of 5S (and Lean), it was equally important to set up a transfer process to ensure the continuation of the program after the author's departure. A process leader was identified and a schedule for subsequent monthly audits was set up in advance and accommodated into the overall production schedule.

6.4 Gap Analysis of Observation to Hypothesis

Though the implementation of 5S was successful (if at least in a beginning stage as success also depends on long-term continuation), throughout the 5S initiative there was a much stronger emphasis by management on ensuring a high level of 5S implementation rather than the measuring its actual effectiveness. The only metrics that were tracked were the 5S implementation metrics shown in Figure 10, and very little emphasis was placed on measuring the quality metrics that might have shown the impact of the initiative.

This section discusses possible reasons for the actions behind management's focus on implementation.

6.4.1 Previous 5S Validation

Almost all of the business managers at SLP have extensive manufacturing experience and are very familiar with Lean principles. Some examples of industries that managers were previously involved are the automotive sector, heavy industries, and consumer goods, fields where Lean manufacturing practices is pervasive. Thus very little explanation of the reasons for this project was needed; there was site-wide consensus on its utility and no need existed for validating 5S. Expending additional time and effort in a validation exercise was seen as unnecessary given also the constrained resources because of the site's ramp up.

Additionally, given the complexity of the product and the evolving production process, it would have been fairly difficult to isolate 5S's impact on quality. The line operators were previously unfamiliar with the products and are learning as they build (in addition to having access to a slowly increasing number of process and standardized work documents), and the site is slowly ramping up in volume as well. Therefore, these would have introduced economies of learning and economies of scale variables into the level of quality, making it very difficult to attribute increases in quality solely to 5S.

6.4.2 Perceived 5S Value

The immediate value that 5S provided was the recognition of good manufacturing practices by customers. Because of the high cost, make-to-order nature of the industry, customers frequently requested site visits to the plant to see the status of their orders. It was observed that almost every week a customer came to inspect the facility and the production lines. Additionally, a great amount of effort was placed in implementing other Visual Management principles, such as electronic monitors displaying production status information, and posterboards with workstation descriptions (see Figure 11 for some examples). Bringing in customers and potential customers to the site and showing them a "Lean factory" also has intangible value, in the form of real and *perceived* high quality production, translatable to repeat customers and higher sales. Though this perceived benefit exists in the short term, it can also translate into real long term benefits, given that the initiative is successfully sustained.

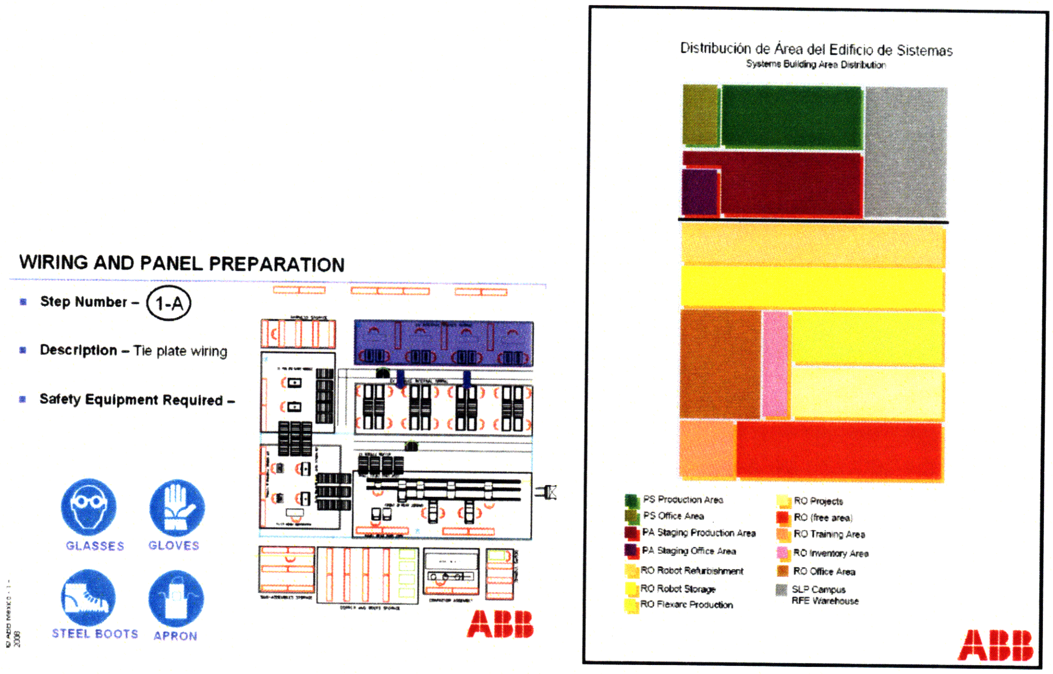


Figure 11- Samples of additional Visual Management efforts completed that complement the 5S initiative.

6.4.3 Management Involvement and "Common Goals"

Lastly, this initiative can also be effective as an indirect method of improving productivity through common efforts. Because each division is historically accustomed to working independently, it had been difficult for the plant manager to coordinate continuous improvement efforts across divisions. Therefore, creating a site-wide initiative and setting common step goals can increase the willingness of divisions to share knowledge and lessons learned, as well as the level of "healthy competition."

6.5 Areas of Future Research Opportunities

Two main areas of future research are apparent here. The first is to create an experiment where quality improvements can be measured. The ideal environment would involve a mature process with experienced workers to minimize the economies of learning and experience variable described in Section 6.4.1. Additional business units are to be transferred from existing facilities in 2009, making the availability of mature process for experimentation feasible in SLP. If experienced workers can be found in the new business units' field, then this experiment can be successfully executed.

The second area of future research is to test for the gaps described in Section 6.4. For example, a customer survey can be created to learn whether customers truly do value 5S and Lean, and if they perceive Lean when implemented in a supplier's site. Additionally, an experiment can be carried out to see if site-wide initiatives improve quality across different divisions and production lines more so than localized, divisional initiatives.

7 Production Layout Redesign

The production layout of the Robot Refurbishment line was identified to have large opportunities for improvement. This line received used robots purchased back by ABB from customers, and were taken apart, refurbished, tested, painted and subsequently sold to new customers. This business has potential for large profitability given the low cost at which the robots are purchased (usually from recently closed facilities or bankrupt companies), and the comfortable markup at which they are resold because of the company's brand-name backing.

Two areas were identified for improvement for this particular line: production footprint and lead time. The footprint was important because an opportunity arose to use the soon-to-be available factory space for a revenue-generating proposal from a U.S. business unit, and space had to be made for this venture. This line was specifically identified as ideal for improvement because the floor space used in the current layout was commonly believed to be excessive. This layout was originally designed on paper, and once it was implemented it became evident that the space it occupied was unnecessary. The second focus area was lead time. Because volume was relatively low on this line, management decided to improve lead time in order to set up a more effective make-to-order (MTO) production system for customers who valued short lead times very highly.

It was thus decided to improve the layout design with footprint reduction as the main goal. Ideal workstation sizes would first be determined through interviews with the operators, and several designs would then be developed. Once the overall footprint was reduced for each workstation by an acceptable margin, a brief comparison would be done to determine the cycle times for each station. The station(s) with the longest cycle times would thus be the bottleneck and new workstations would be added to operate in parallel with the existing stations. This should result in an overall improvement in lead time.

7.1 Data Collection and Development

Two types of data were collected; workstation size and estimated processing time at each workstation. The collection of the workstation and reducing each station was quite straightforward; the layout redesign team discussed with each station operator how much room he needed and still be able to work effectively, and the new dimensions that the operator provided were recorded for use in the redesigning process. The processing time of each workstation was provided by the line supervisor, who provided estimates of each station based on a few training and production runs that had already been held.

Actual processing time averages and variances would have been ideal in this exercise instead of estimates, as one can draw a more precise conclusion of the lead times as well as the bottlenecks in the line. However, because of the newness of the line and the lack of historical data, estimates for averages and variances must be used. Though no solid conclusion can be drawn from an experiment and analysis of this type, the results can be useful to management in identifying the likely bottlenecks. Additionally, it can also encourage a more accurate data collection method that in the future could provide a more detailed and actionable conclusion.

7.2 Layout Redesign Procedure

The layout was redesigned by looking at flow patterns and number of workstations. Because either a forklift or an overhead crane must be used to move the robots from workstation to another, reducing the travel distance will free up these resources and may allow additional capacity. Since the number of workstations would be increased, it was important to ensure that these limited resources do not become the bottleneck in the production process.

Figure 12 shows the original layout of the refurbishment line, as well as the process steps and flows. The robots were separated into two units upon arrival, the controller and the manipulator, and these are represented by blue flow lines and process squares for controllers, and red flow lines and process circles for the manipulators. Table 2 shows the footprint area of each workstation, and the number of workstations that the production line contained.

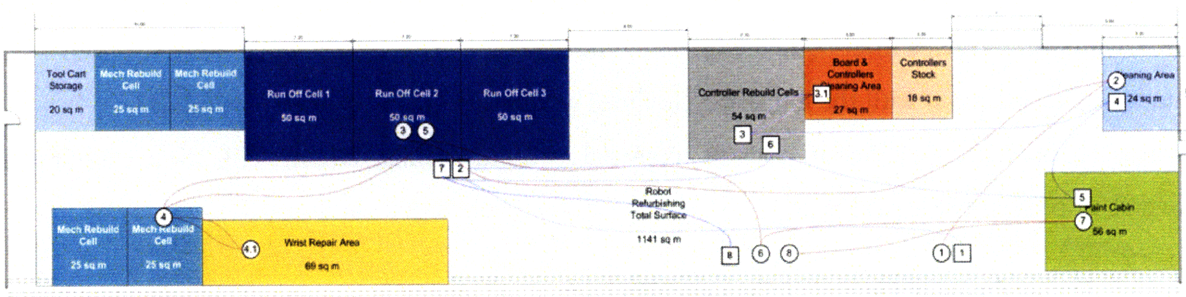


Figure 12- Original factory layout for the Robot Refurbishment line, with product flows. Different shades of coloring in the boxes represent different workstations.

Workstation	Surface [m^2]	Quantity
Run Off Cell	50	3
Mechanical Rebuild Cell	25	4
Wrist Repair	69	1
Tool Cart Storage	20	1
Controller Rebuild Cells	54	1
Board & Controllers Cleaning Area	26	1
Paint Cabin	47	1
Cleaning Area	23	1

Table 2- Surface area in square meters for Robot Refurbishment workstations.

The excessive layout design resulted in a total surface area of 516 square meters used by workstations, out of a total usable surface of 1141 m^2, resulting in a 45% used area vs. footprint ratio.

Once the physical dimensions were obtained, a comparison of the estimated cycle times was done to determine the bottleneck. Table 3 shows the estimated cycle times for the manipulator for each process step. [Because the controller portion of the robot is done in parallel to several manipulator processes, and the controller times are shorter than the manipulator times, the controller times were not considered]. The final test and the mechanical rebuild are both likely to be bottlenecks, a suspicion that was also confirmed by line supervisor. This information was taken into account when considering the creation of additional workstations.

A crude model of each workstation was then created using paper cutouts, and different layout options were evaluated. Figure 13 shows some of the designs considered using the paper modeling approach. Taking into account cost, physical restrictions, and the need for new stations, Layout 4 was chosen as the design to proceed forward with.

Manipulator Work Step / Station	Estimated Cycle Time
Unload of Robot	2.1
Robot Wash	4
Assessment Test	4.08
Mechanical Rebuild -Wrist Rebuild	13.25 8.33
CTQ Final 24 hr Test	37
Preparations for robot painting	4
Robot painting	1.25
Packaging	1.25

Table 3- Estimated cycle times for each of the manipulator processes.

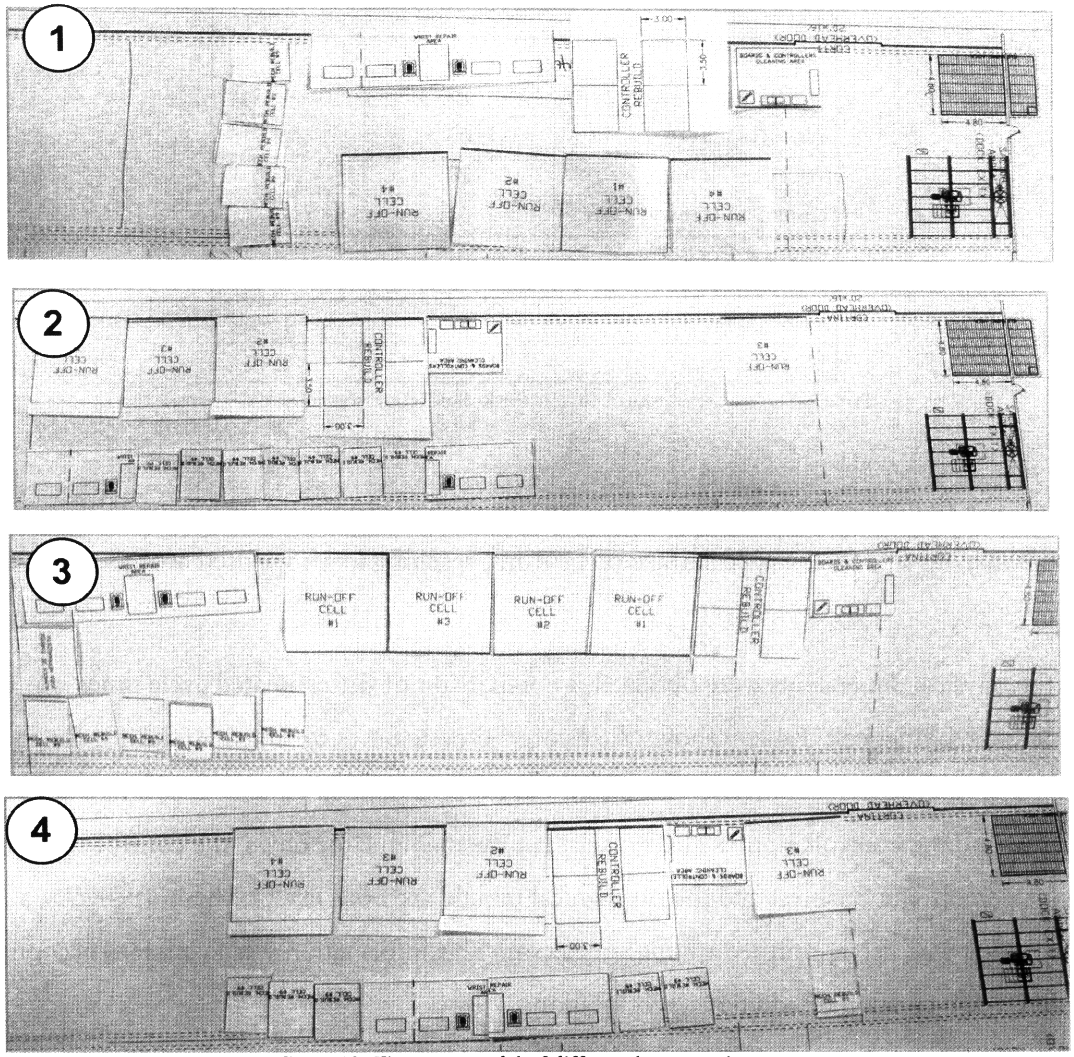


Figure 13- First pass model of different layout options.

Figure 14 shows the new layout in a computer diagram. One additional Testing cell, one Wrist Repair station, and two Mechanical Rebuild stations were added to alleviate bottleneck pressures. Even with additional workstations the total footprint area for the entire line was reduced to 816 square meters. With the workstation surface area at 516 m^2, the overall used area vs. footprint increased to 60%. Thus the used floor space was reduced from 1141 m^2 to 867 m^2, resulting in a 24% reduction in floors pace used by the line. The shaded green area represents the actual floor space that was made available with this new design, amounting to 274 square meters of space available for additional ventures. This space was eventually used to store finished products at a monthly fee to the customer.

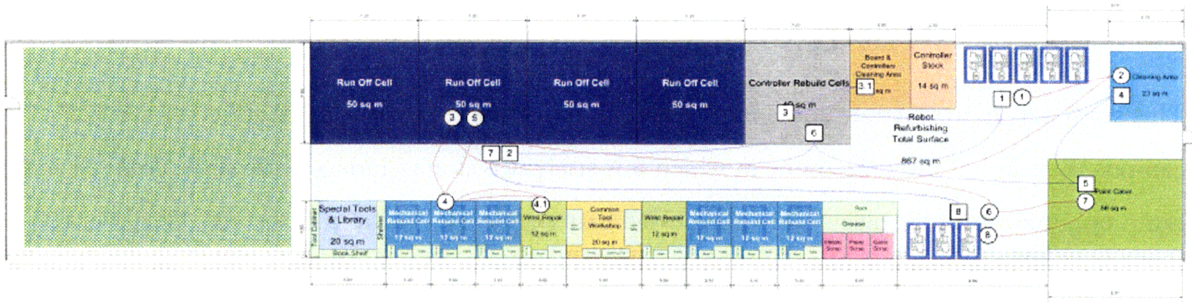


Figure 14- The redesigned layout for the Robot Refurbishment line resulted in a 24% reduction in used floor space.

7.3 Future Opportunities and Recommended Actions

The recommended layout was implemented in the latter part of 2008. In addition to resulting in reduced footprint, it likely contributed to a shorter overall lead time through the increase in bottleneck workstations. To validate these results conclusively would require historical averages and variances for process times at each workstation. With such data, a workflow simulation can be constructed, and the bottlenecks, lead times, and work-in-process more accurately determined.

Additionally, the same simulation principle can be applied to other production lines in the SLP site. Though some products are made in a low-volume job shop environment, opportunities do exist in the medium voltage and high voltage equipment manufacturing spaces that produce at medium volumes. Since historical data for these lines are more readily available, accurate analysis and optimization is quite feasible.

8 Post-Analysis Inference and Conclusion

This study serves to illustrate some improvement opportunities that were identified at the SLP campus. Because of the time frame in which this study was done (during a site wide "go-live" and ramp up), many other projects were performed that were excluded from this study. The overall rationale for mentioning these three is that they provide the most academic contribution, or were the topics of most interest for the author to discuss and develop.

However, there is a common thread of lessons that can be drawn from these projects. First and foremost, the author realized the importance of proper planning and documentation of proposed projects. Not only is a plan at the outset important, but continuously comparing the actual results to this plan is just as important. This second phase, the *documentation* of the progress through a project, is important because it tracks the problems and advancements through a project's development, and it captures these lessons for future instances.

Another important lesson to be taken away is the importance of measurement for success. Even in management projects or other types non-quantifiable efforts that may be difficult to measure, it is still important to determine a baseline at the beginning, assess progress throughout, and calculate the final results and improvement at the end. The benefits of this were clearly evident in the quantifiable projects (5S Implementation and the Production Layout Redesign), and left a sizeable opportunity for improvement in the Business Development Guide. However, care must be taken in projects that are difficult to measure. In the BDG's case, given the limited time frame and resources it was preferable to not develop a measurement reference for the project, rather than to develop one that would be at risk of being irrelevantly inaccurate.

A third takeaway from these undertakings is the need to develop steps for additional improvement. A project cannot merely stand alone; even if greatly successful, it must have opportunities for future growth or improvements. It is important to not attempt large, unwieldy projects for the promise of great rewards if successful. It is preferable to do several smaller, sequential projects that can build on each other. This drive to continuously improve will help ensure that companies (and the employees that drive companies) achieve world-class operations.

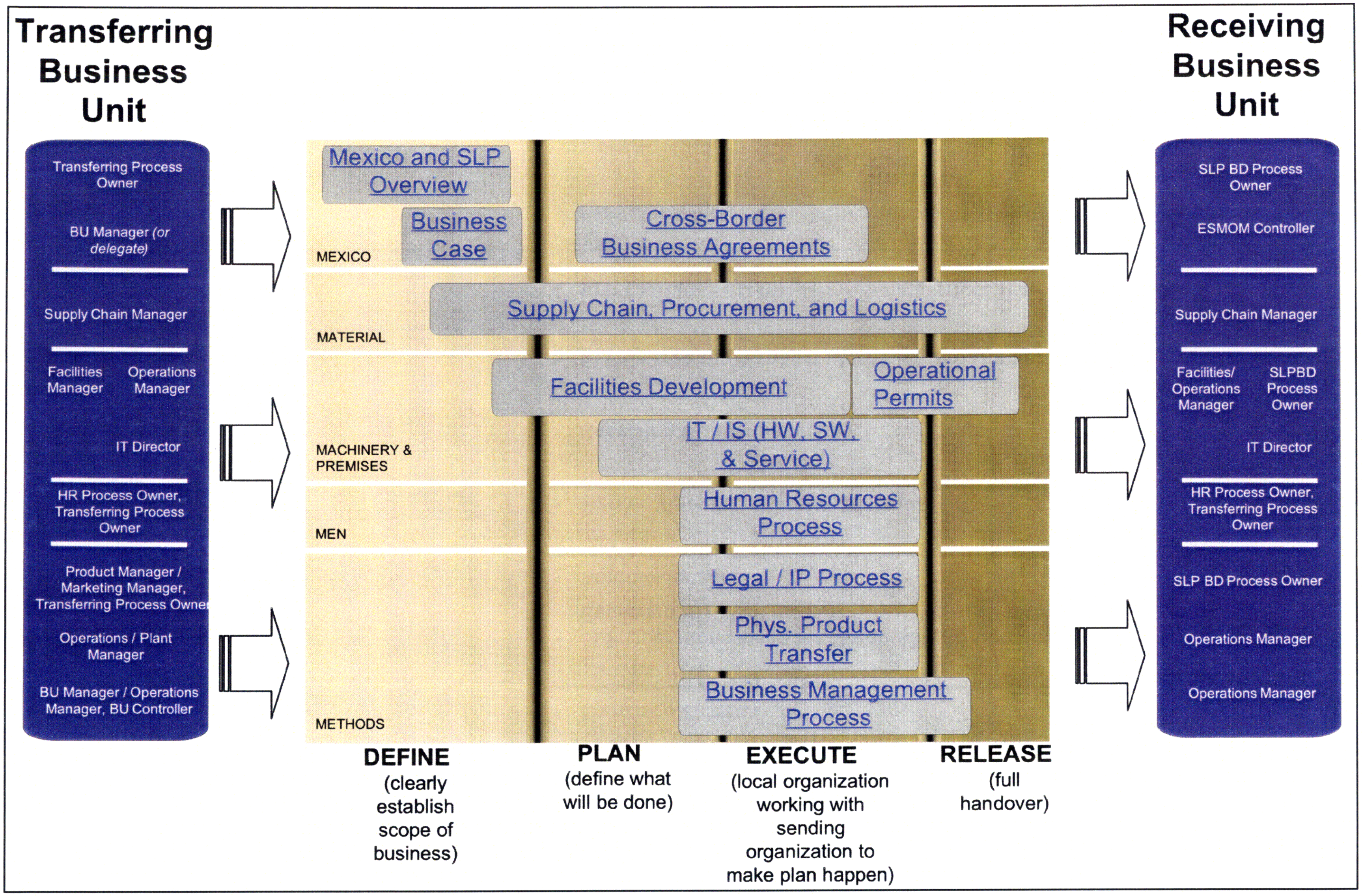
Finally, the last example of achieving effectiveness in a company is the dire importance of properly guiding and motivating employees in a business. The author learned invaluable lessons regarding how to effectively lead teams, manage conflicts, and help drive results from fellow coworkers. It is also very important to tie all projects directly to the importance of the company and employees' contributions to the company's goals. This way, employees can be empowered to contribute directly to bottom-line improvements, and thus be better motivated and deliver stronger results.

However, among these common lessons, the key lesson necessary to create and sustain positive results involves in the organization's people, whom through collaboration and a desire for continuous improvement are the true source of innovation. Thus it is crucial that organizations move away from the reactionary form of solving problems and move towards a preventive mindset in avoiding problems from the outset. The author believes that this was the most readily observable lesson that he gained during his projects, as the execution of these projects became simpler as time progressed and individuals became more receptive to continuous improvement initiatives. Indeed, as organizations move more towards this philosophy of preventive problem solving, so do they get closer to achieving world-class operational performance.

APPENDIX

9 Exhibit 1- Business Development Guide

9.1 High-Level Process Guide



9.2 BDG Process Owners

Receiving Business Unit	Local SLP Process Owners
SLP BD Process Owner	• SLP Operations Manager (Jorge Alberto García)
ESMOM Controller	• Hector Alvarado
Supply Chain Manager	• Francisco Zarazua
Facilities/ Operations Manager / SLPBD Process Owner	• SLP Operations Manager (Jorge Alberto García), or Receiving BU Plant Manager
IT Director	• Antonio Jimenez
HR Process Owner, Transferring Process Owner	• Martha Nigenda / Graciela Zendejas
SLP BD Process Owner	• Receiving BU Plant Manager
Operations Manager	• SLP Operations Manager (Jorge Alberto García)
Operations Manager	• SLP Operations Manager (Jorge Alberto García)

- Mexico Overview
  - Transportation & Logistics Costs (vs. non-North American locations)
  - Travel Costs (vs. non-North American locations)
- SLP Overview
  - Supplier availability (local transnational companies, regional transnational companies, current suppliers to ABB)
  - Logistics (to and from the U.S. border)
  - RFE (definition, advantages, and status of application to ABB SLP)

Mexico /SLP Overview Presentation

- *ADDITIONAL CONTACT INFORMATION (Secretaría de Desarrollo Económico SLP):*

  Director of Industrial Development and Promotion:
  Ing. Gylmar Mariel,
  gmariel@slp.gob.mx,
  +52 (444) 834 – 3600 ext. 3604

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9.4 Business Case (if Applicable)

- Business Plan to make a case for initiating operations in SLP
- All the financial calculations and justifications necessary for CIMT approval go through this phase – transferring Business Unit has already gone through this phase, then not applicable

CIMT Documentation

Headcount Planning

Operations, Project Mgt Cost Forecast

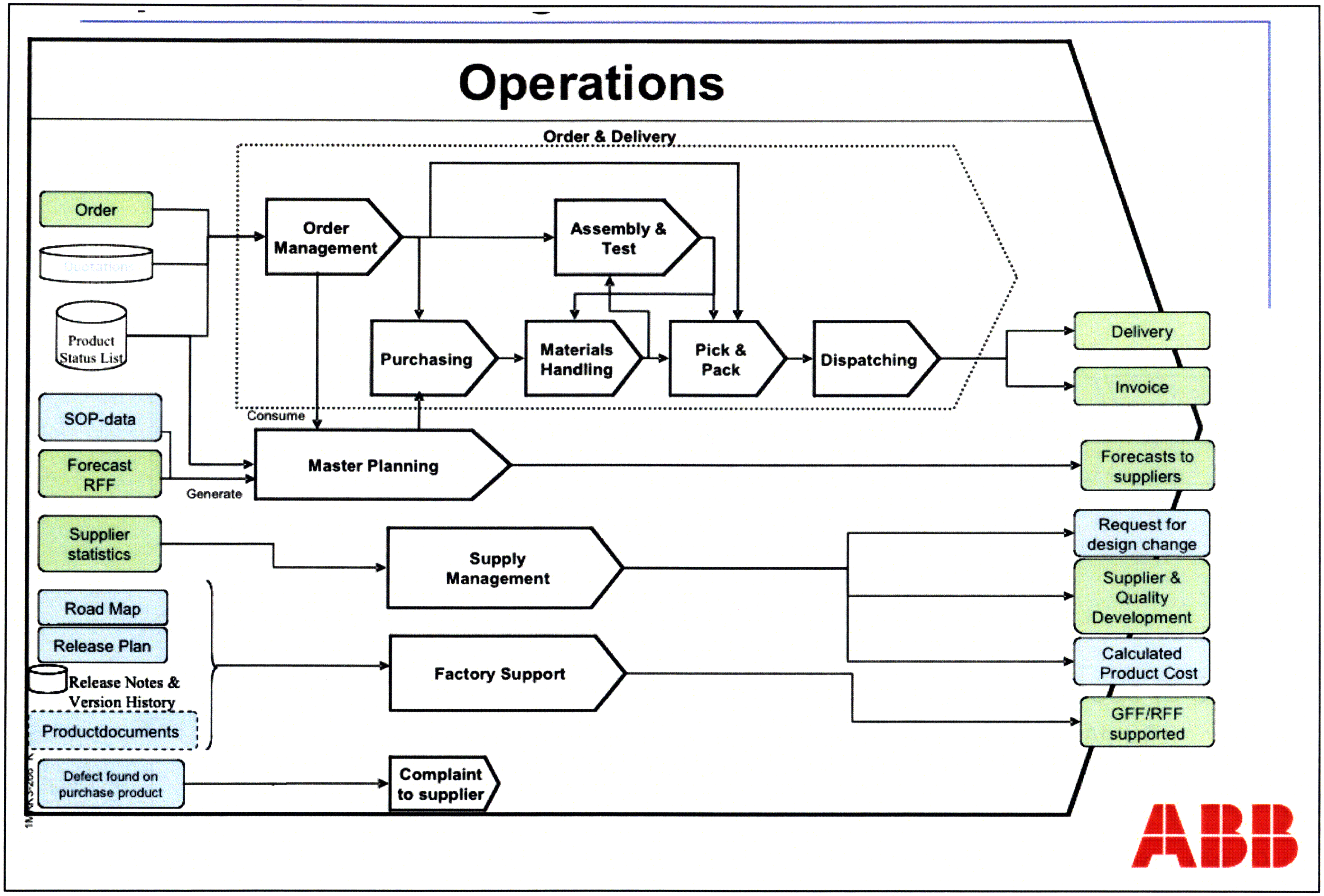
Order, Revenue Forecast, EBIT

Real Estate Costs

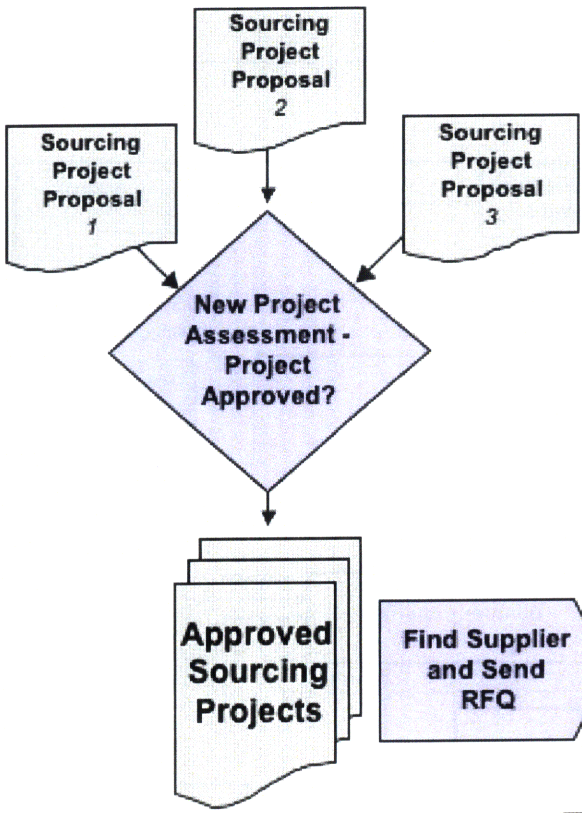
Total Investment Costs

- Key people in Project Team
  - Steering Committe (STECO)
  - Core project team / task owners, in transferring BU and local owners

9.4.1 Operations Management



- Setting up of the procurement, logistics and transportation system is done by receiving Business Unit (BU_I), supported by the technology transferring unit (BU_T)
- To reduce risk of using new local suppliers, dedicated personnel to sourcing activities (quality, delivery times, audit etc.) needs to act well in advance.



Potential ABB Supplier Qualification Questionnaire

ABB Supplier Audit Questionnaire

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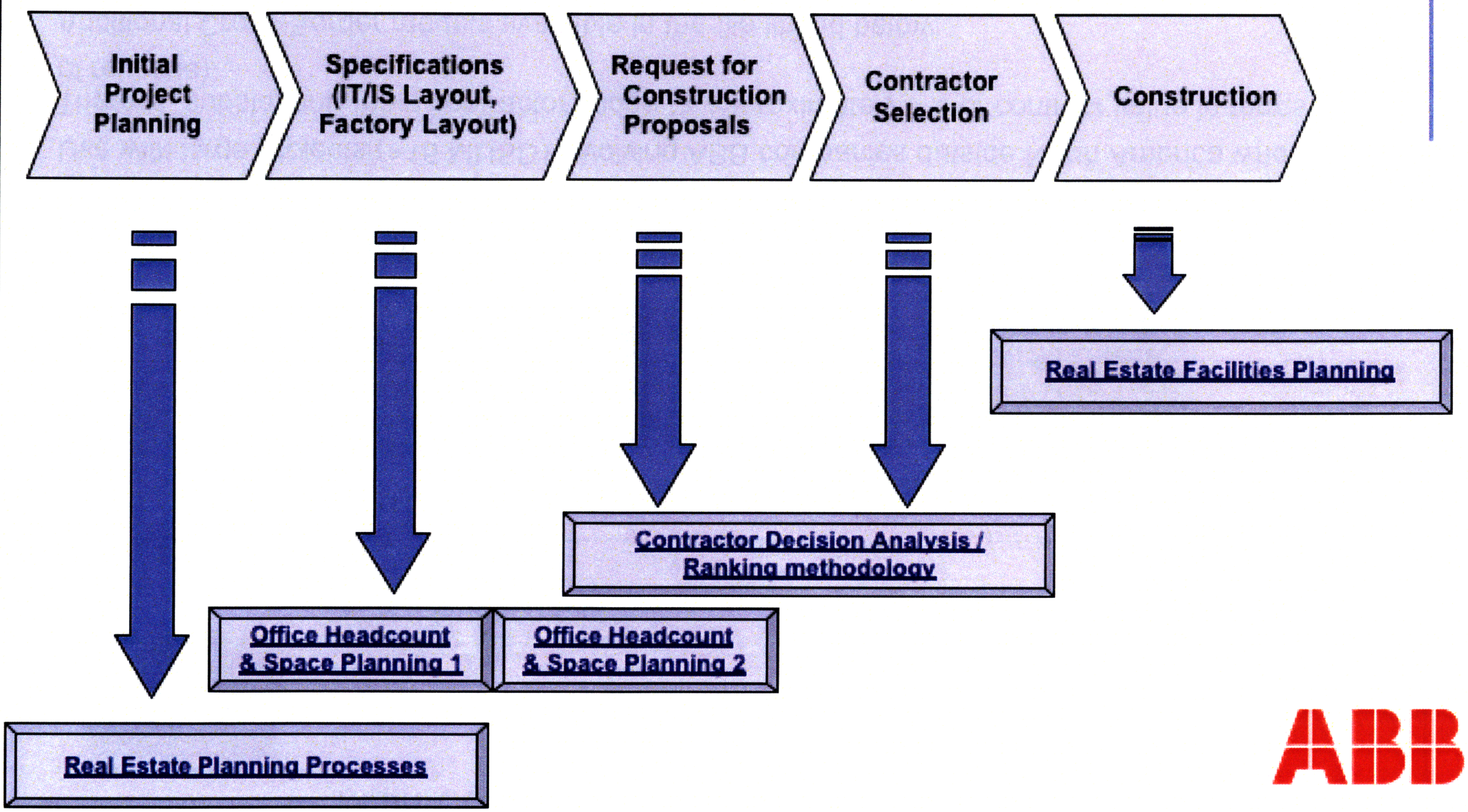
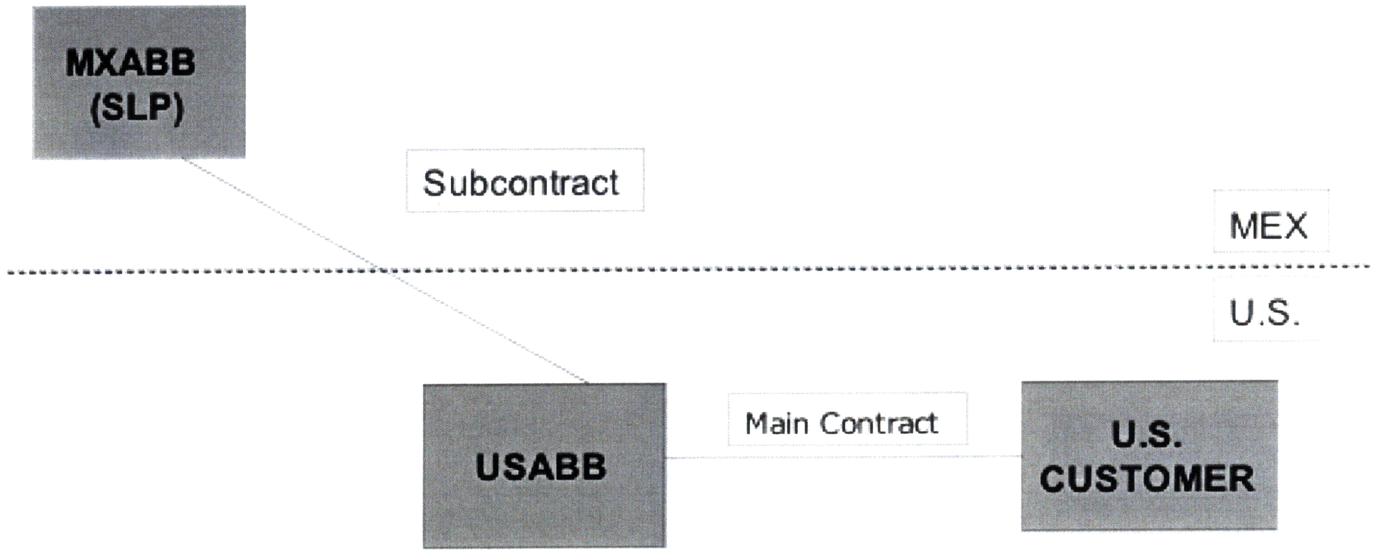
9.6 Facilities Development

- The following steps are necessary to ensure a smooth and successful construction project



9.7 Cross-Border Business Agreements

Preferred and Recommended Model: Main Contractor / Subcontractor Model



- Use with all projects within North America.
- Use with non-large projects (<15 MUSD) involving ABB companies outside North America.
- Use with large projects (>15 MUSD) involving ABB companies outside North America where
- There is "substantial" main contractor scope (> approximately 5% of contract value in terms of revenue).
- Additional Cross-Border models available in the file linked below:

Principal Cross-Border Business Model

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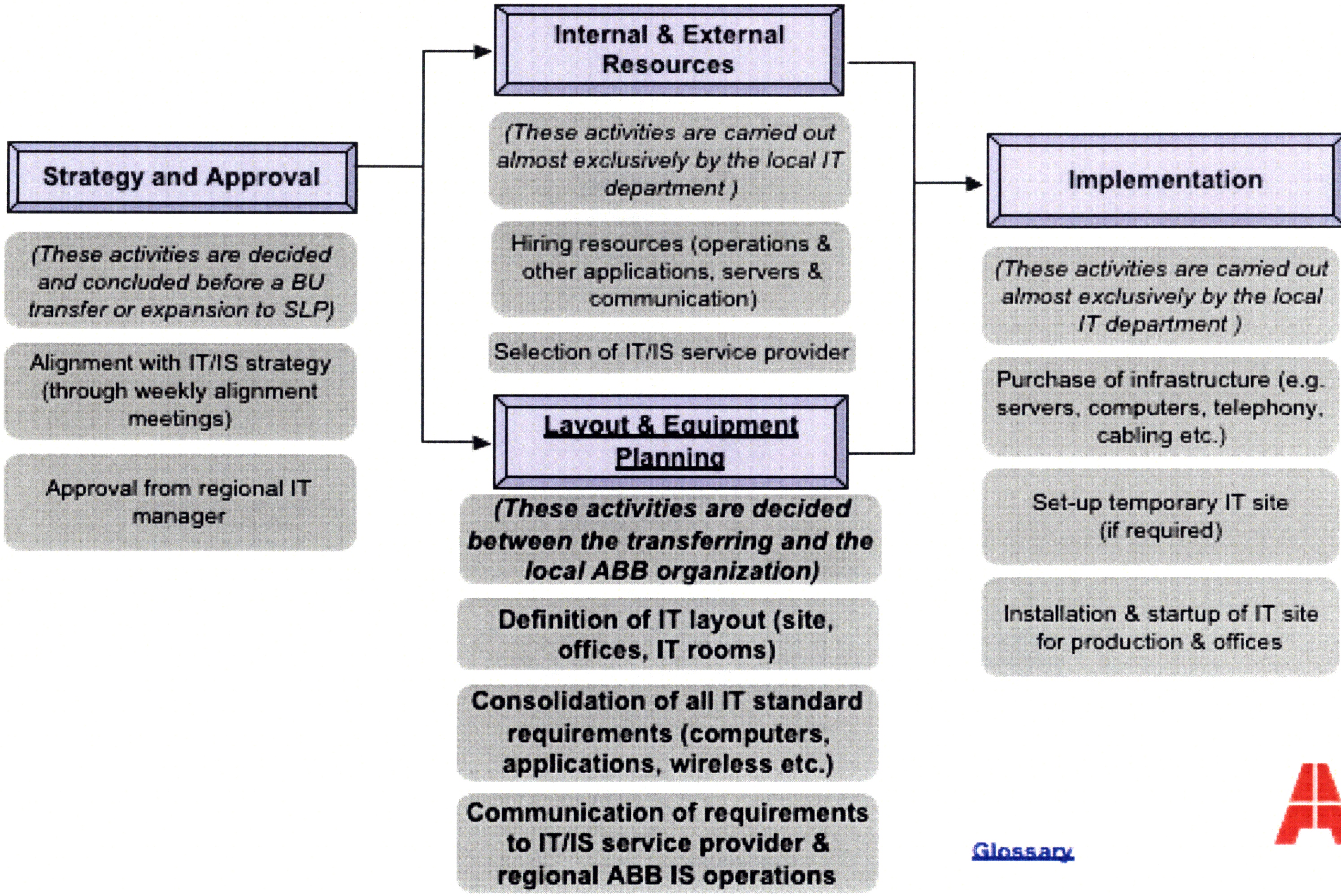
9.8 IT / IS (HW, SW, & Service)

- The planning and implementation of information and communication systems is principally supported by the local ABB country organization
- Activities of the IT/IS plan (in bold are activities performed mutually by transferring and local business units):



Glossary

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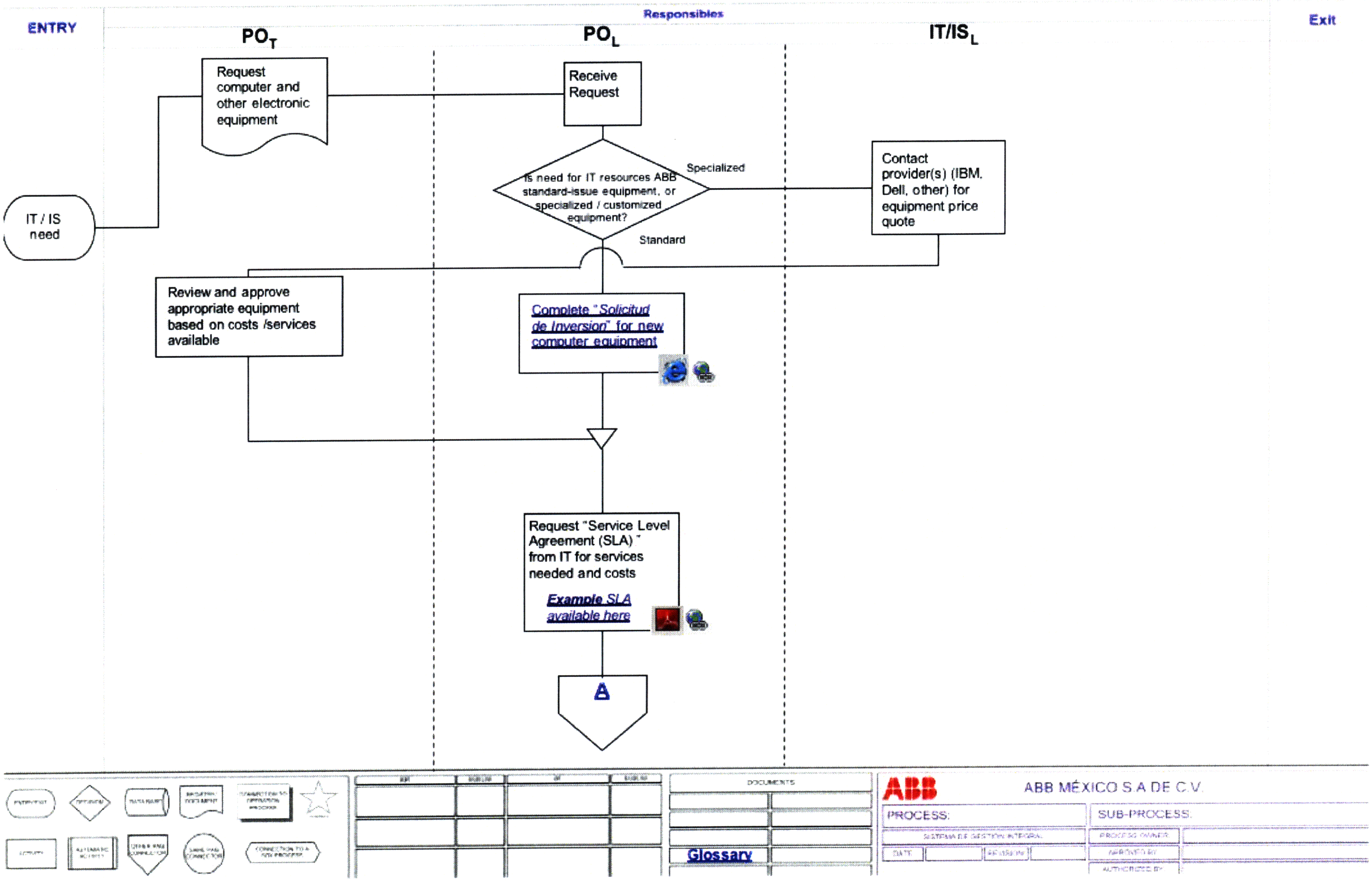
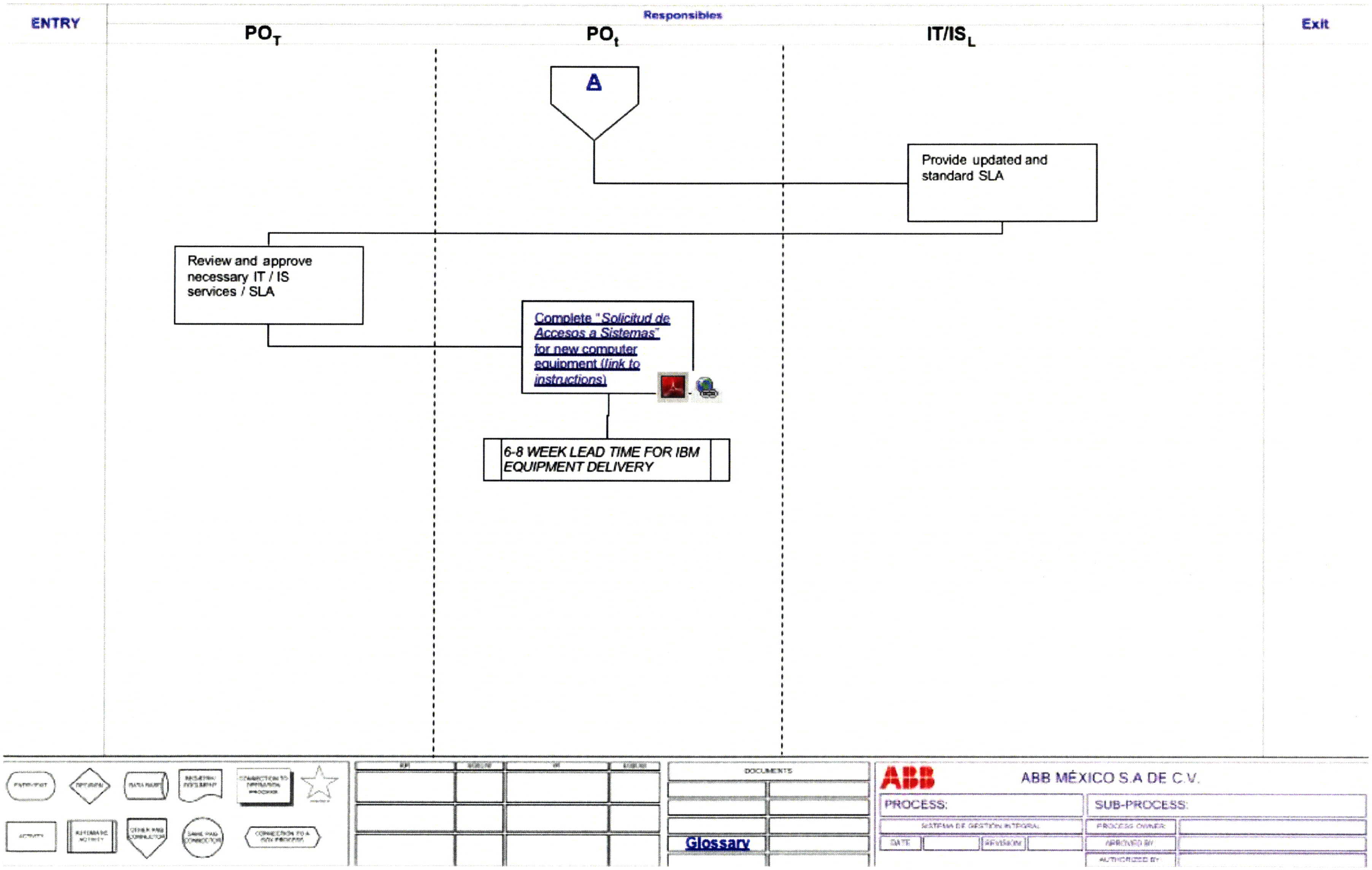
9.8.1 Layout & Equipment Planning

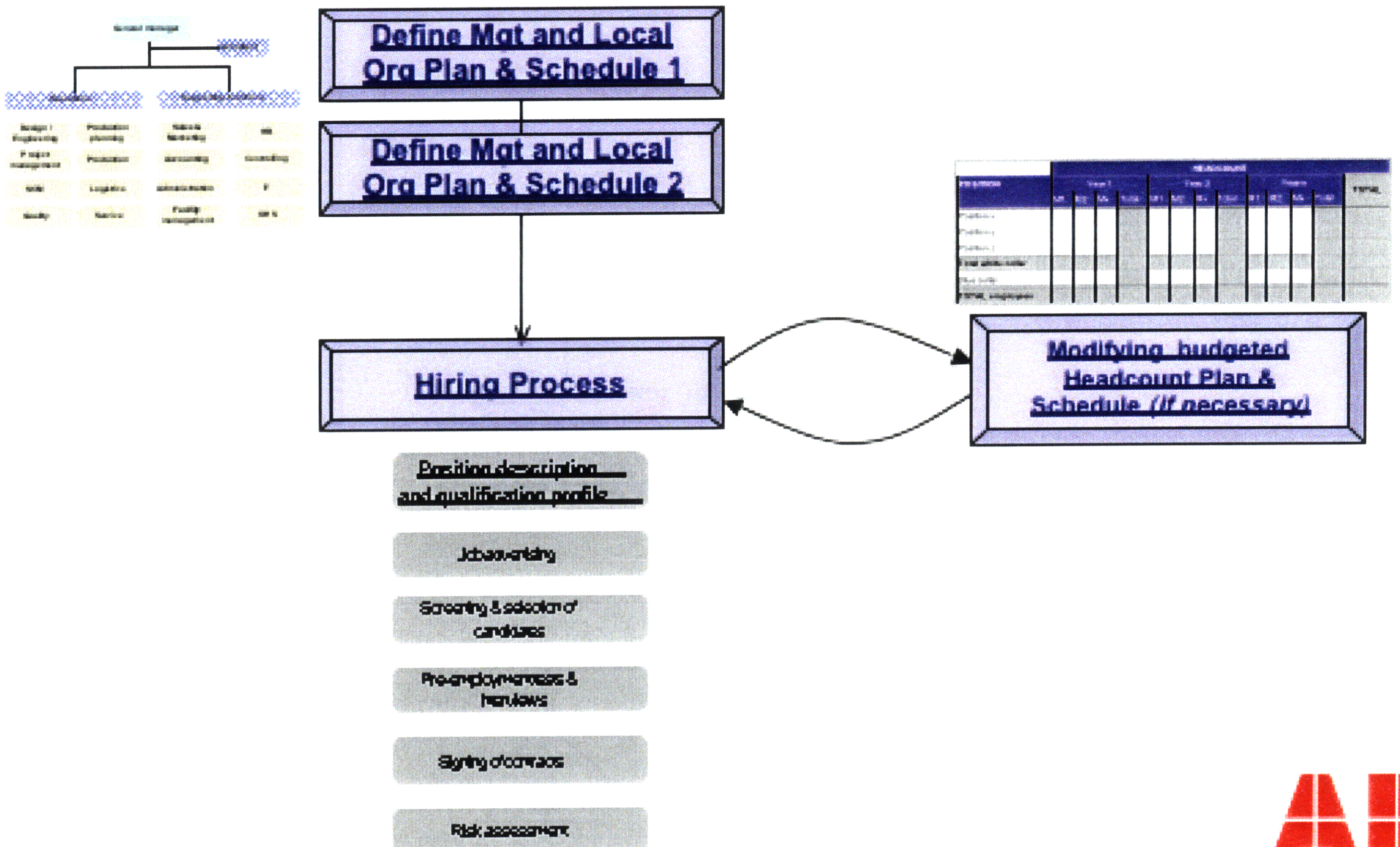


9.8.2 Layout & Equipment Planning (B)

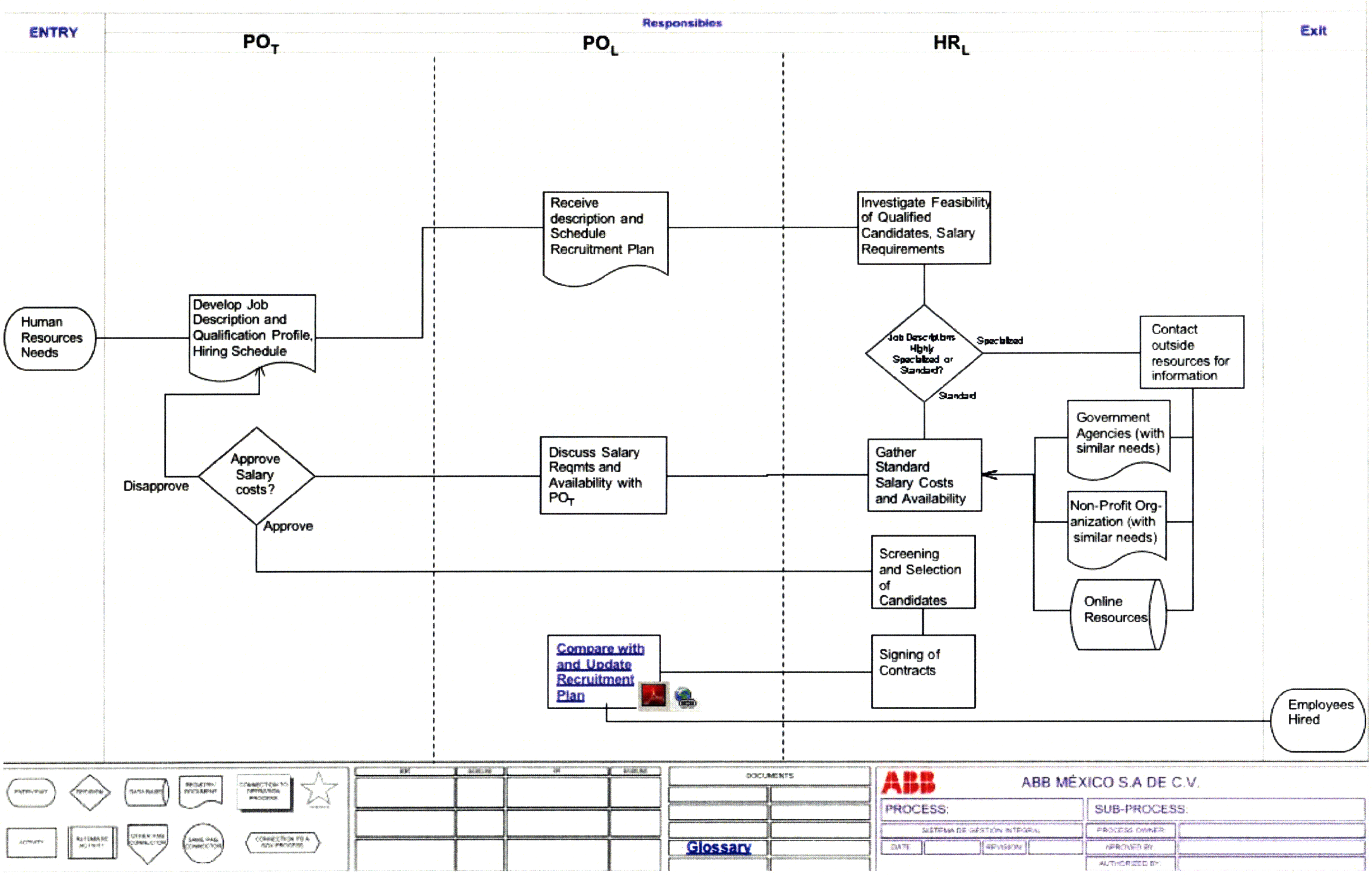


9.9 Human Resource Process

- High-level headcount planning is carried out during CIMT approval phase by global division/BU team. Detailed headcount planning and planning of recruitment and training are completed and executed by the local business management and local HR function with support from division/BU.



9.9.1 Hiring Process (Human Resource Process)



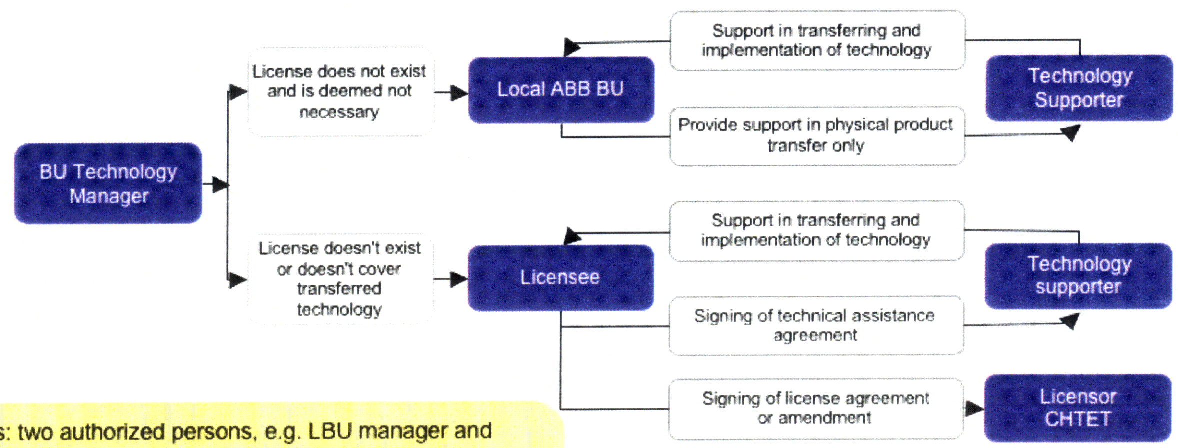
- CHTET is legal owner of ABB Technology (currently approx. 75% of ABB technology portfolio is covered).
- Legal transfer of technology is done by signing license agreement between CHTET and licensee (see documents linked below for example of a license agreement).
- Some Business Transfer processes to SLP may not involve a Technology Licensing Agreement

Technical Assistance Agreement

Tech Assistance Agreement (one page instruction)

Technology License Agreement

Questionnaire on Transfer of Technology



- **"Technology License Agreement"**: Licensor grants to Licensee a non-exclusive, non-transferable license under the unde the Licensed Technology to manufacture, sell, or otherwise supply Licensed products.
- **"Technical Assistance Agreement"**:: Licensor shall make available to Licensee such further know how, technical assistance, training and services relating to the Licensed Technology which is not covered by the License Agreement.

- **Licensee**: ABB unit that receives technology; Signers: two authorized persons, e.g. LBU manager and LBU controller (can vary from case to case)
- **Technology supporter**: ABB unit that mainly developed transferred technology; Signers: two authorized persons, e.g. LBU manager and LBU controller (can vary from case to case)
- **Licensor**: CHTET, owner of ABB technology; Signers: BU Manager and Jürgen Germann or Rene Cotting

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9.11 Physical Product Transfer

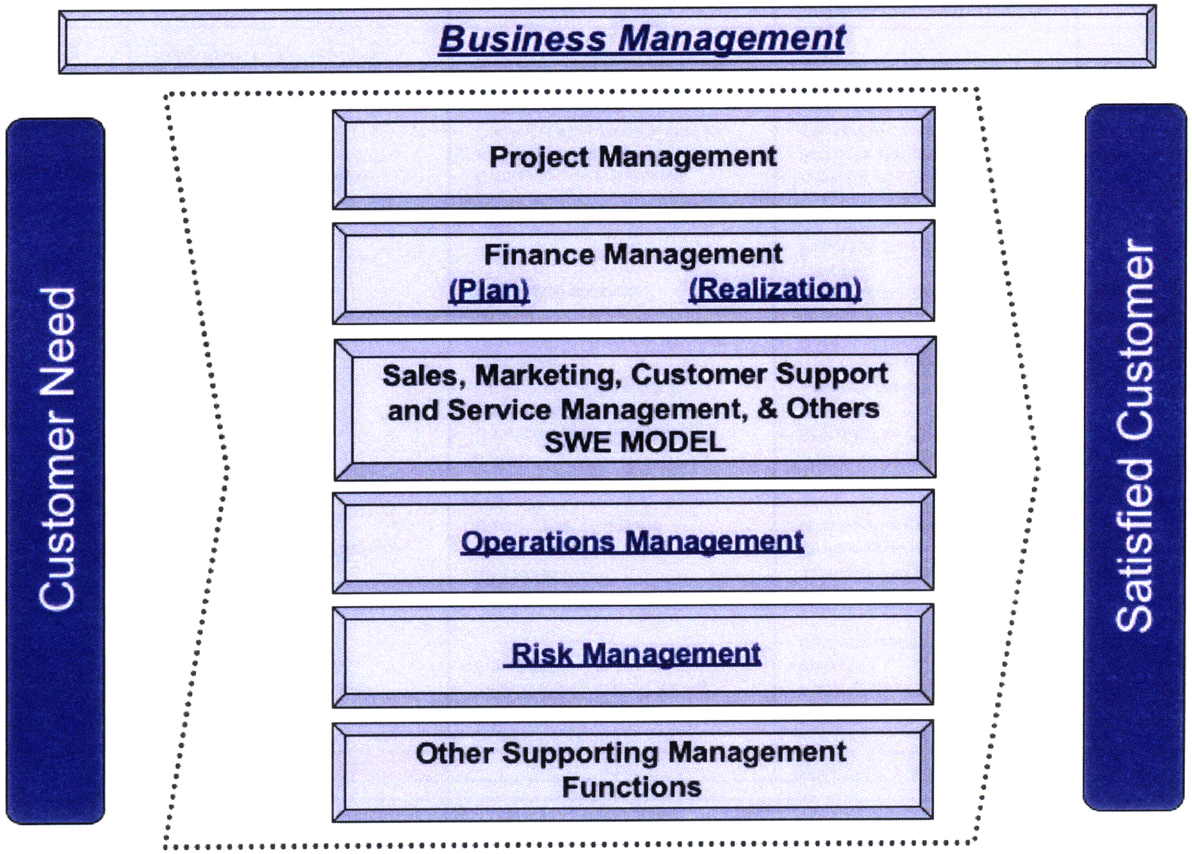
- Physical transfer of technology is managed by technical assistance agreement between licensee and transferring ABB

Product and Component Transfer -- High Level Process Map

	TR0	TR1	TR2/3	TR4
Objectives	• Define Program Objectives: Cost, Quality, Schedule • Cross Functional Resources Committed to Core Team	• Scope/Strategy of Transfer finalized • Team Commits to Cost, Quality, Schedule	• Catcher's Process Capability Evaluated • Performance of evaluation units Verified • Catcher ready to ship pilots	• Catcher's Process Capability Proven • Pilot prod'n Issues Resolved • Quality/Cost Goals Achieved • Catcher ready for full prod'n
Key Deliverables	• Risk Assessment and risk retirment plans defined • Manufacturing / Sourcing Strategy defined • Resource costs/savings estimated • Catcher identified • Program Scope defined • Core Team & extended core team defined	• Risk assessment complete, major risks retired • Manufacturing/Technology/ Sourcing Plans Complete • Resource costs/savings fully defined • Commitments for Schedule/ Cost/Quality goals • Pitcher/Catcher Scorecards established • Drawings/Specifications/ Structure updated • Service plan complete	• Evaluation units Verified to drawings/specifications • Phase-in/phase-out plan updated/old suppliers notified • Catcher's Suppliers selected and contracts signed • Schedule/Cost/Quality goals on track • Catcher's readiness for pilot production confirmed • Drawings/Specifications released for pilot production • Importation requirements complete • Regulatory Requirements Met	• Verification/Validation of Pilot units complete • Phase-in/out plan finalized • Cost/Quality goals achieved: Catcher's Zst >= Pitcher's • Catcher's facility/equipment/ tooling/procedures complete • Drawings/Specifications released • OTR/Importation/Exportation requirements complete • Service plan in-place
Actions Authorized by Milestone Approval	• Resources assigned to Retire major risks • Complete Zst Baselines • Complete detailed definition of Resource costs / savings • Execution of TR1 Deliverables	• Catcher to tool-up & procure evaluation & pilot materials • Catcher builds evaluation units for verification/validation • Pitcher executes Verification plan when parts/assemblies available	• Authorize Pilot Shipments to Pitcher for integration and/or shipment to customers • Begin phase-out of old parts • Place production ramp-up demands on Catcher	• Full production ramp-up • Final phase-out of parts from old suppliers • Final phase-out of production at Pitcher's site
	Product Transfer Program Established	**Program Commitments Defined**	**Catcher Pitcher Ready for Pilot Production**	**Full Production Quality Monitoring**

Product Transfer Process Guide | **Product Transfer Process Map** | **Product Transfer Scorecard**

- In addition to the operations processes, the technology transferring unit needs to transfer following business management processes:



9.12.1 Project Management

- Monitor and evaluate the processes and results against objectives
- Report the outcome

Project Plan

Project Organization

Project Budget Tracking

Project Task Capturing

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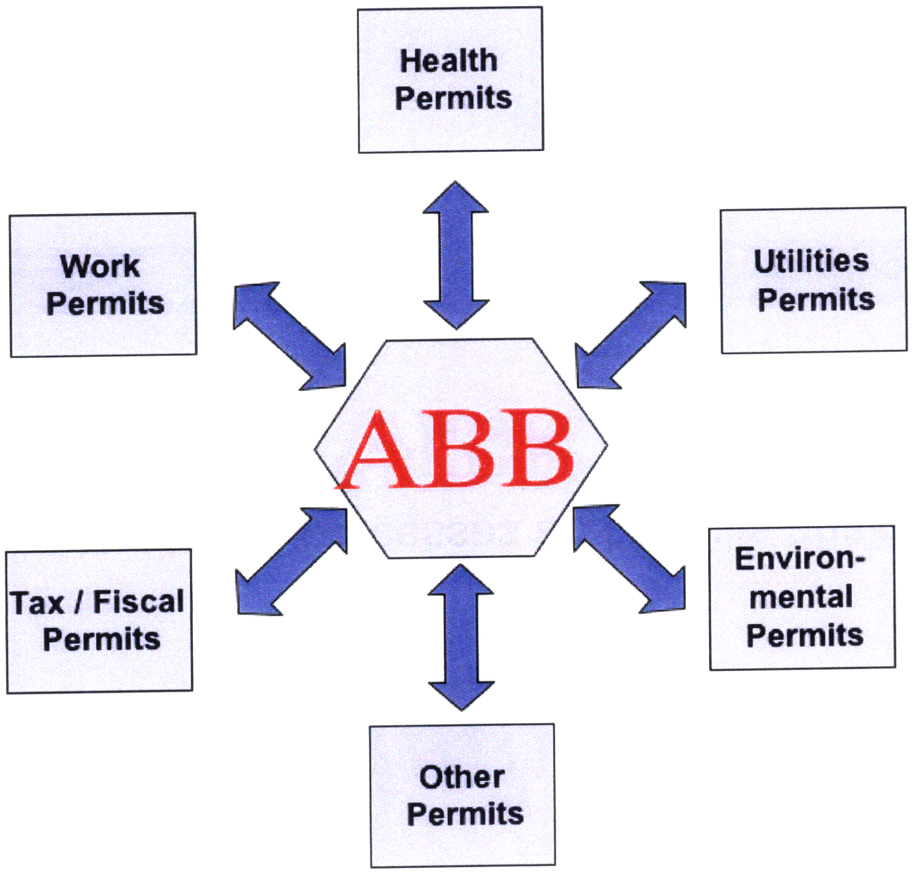
9.13 Operational Permits



- Below is a checklist for all necessary permits for initiating business in SLP:

Facilities Permits Worksheet

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