Cost Modeling in the Integrated Supply Chain Strategic Decision Process

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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
and
Master of Science in Mechanical Engineering

In Conjunction with the Leaders for Manufacturing Program at the
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Abstract

This thesis is based on an internship at Honeywell Aerospace's Integrated Supply Chain (ISC) Leadership division. This work focuses on the role and use of analytical cost models in the strategy development process. The scope of ISC strategic decisions encompasses Honeywell Aerospace's global footprint of external and internal suppliers, and includes insourcing, outsourcing, transition and consolidation activities.

The current practice within Honeywell Aerospace is to construct a Transition, Migration, and Integration (TMI) model which calculates the net present benefit associated with a specific transition's spending and savings. This model is the primary tool for strategic plan development. This work looks at the use of the TMI model for strategic planning with the intent of addressing concerns related to the model's complexity and accuracy. This work also develops the framework for estimating a confidence range within the TMI model to provide better visibility to the potential range of financial outcome.

An additional tool used in the development of the strategic plan is the Landed Cost model. The Landed Cost model is used to calculate the steady state total cost associated with a particular supply chain. Historically within Honeywell Aerospace ISC planning, the Landed Cost model has been used to much less of a degree than the TMI model. This work develops the role of the Landed Cost model and establishes a framework for estimating labor, logistics, inventory, and tax costs associated with manufacturing products in a variety of global regions.

While this work focuses on developing analytical tools, developments and recommendations are provided in the context of the overall strategic decision process. Examples are provided to highlight the major cost drivers associated with a particular transitional activity or supply chain design. Improving the analytical component of the decision process allows ISC Leadership to more accurately and effectively identify tactics for improving operational efficiency and identify potential growth opportunities in emerging regions.

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Lastly, I would like to thank my family, especially my brother Michael, for their assistance and encouragement as I embarked on this journey.

Biographical Note

In 1993, Todd Robinson graduated from the University of California at Berkeley with a Bachelor of Science in Mechanical Engineering with Honors, and from the University of California at Santa Cruz with a Bachelor of Arts in Sociology. He has over 9 years of experience developing production processes for the manufacture of space, defense, and commercial electrical and mechanical hardware, including turn-key electrical enclosures for the IT industry. His most recent role was as the New Product Introduction Manufacturing Engineering Manager at Trend Technologies, Inc., a global contract manufacturer serving key Silicon Valley IT equipment manufacturers. In this capacity, he held primary engineering responsibility for deploying new products and manufacturing processes into seven production facilities worldwide, and has provided support both in the US and overseas on production launches for customers including Dell, Sun, Cisco, Apple, HP, and Toyota.

Currently, Todd Robinson is a Leaders for Manufacturing Fellow at MIT, class of 2006. He is interested in pursuing Operations Management opportunities in Asia upon graduation.

Note on Proprietary Information

In the interest of protecting Honeywell competitive and proprietary information, figures presented throughout this thesis have been disguised, are for the purpose of example only, and do not represent actual Honeywell data.

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1 Introduction

This thesis is based on an internship within Honeywell Aerospace's Integrated Supply Chain (ISC) Leadership group in Phoenix, Arizona. One of the functions of ISC Leadership is to identify opportunities to improve the Aerospace organization's global operating efficiency, and develop a strategic plan to realize those opportunities. Operating decisions influence how and where products are to be manufactured and serviced, and can entail insourcing or outsourcing, factory consolidation, or the transition to a Low Cost Region (LCR). The purpose of this internship is to assess analytical tools used by Honeywell Aerospace to make strategic decisions.

This thesis assesses and develops the analytical framework for two key cost models used for creating and implementing the Aerospace strategic plan: the Transition, Migration, and Integration (TMI) model, and the Landed Cost model. The work detailed here serves to address some concerns over the existing tools, such as precision vs. accuracy, ease of use, and the calculation of a confidence range. This thesis also considers the current strategic decision process and how these models fit into that process.

The work described herein is divided into the following chapters. Chapter 1 is an overview of Honeywell, the recent Aerospace reorganization, and the role of Strategy and Integration. Chapter 2 outlines the project, the problems to be addressed, and the approach. Chapter 3 looks into the organizational process for using analytical tools to develop strategic goals. Chapter 4 describes work on the TMI model, including the development of a new Level 1 transition cost model. Chapter 5 describes the development of a new Landed Cost model. Chapter 6 summarizes the integration and use of these tools within the current process. And finally, Chapter 7 summarizes lessons learned while working on this project.

1.1 Honeywell

Honeywell (NYSE: HON) is a diversified technology and manufacturing leader headquartered in Morris Township, NJ. They are a Fortune 100 company with sales of $25.6 Billion in year 2004. There are four major Honeywell business units: Automation and Control Solutions, Transportation Systems, Specialty Materials, and Aerospace. Aerospace makes up the largest segment with sales of $9.8 Billion in 2004.

Figure 1 – Honeywell 2004 Sales

Honeywell Aerospace is headquartered in Phoenix, Arizona. They employ 40,000 people worldwide, and offer a diverse set of products and services under three major categories: Aerospace Electronic Systems (AES), Engine Systems & Services (ES&S), and Aircraft Landing Systems (ALS). Their customer base contains a global spectrum of aerospace manufacturers, including Airbus, Boeing, Bombardier, Cessna, Hughes, Learjet, Lockheed Martin, Northrop Grumman, Raytheon, United Technologies, the U.S. Department of Defense, Department of Energy, and NASA, as well as leading airlines and airport authorities.

1.2 Aerospace Reorganization

Just prior to the start of this internship, Honeywell Aerospace began a major reorganization to combine the three business units (AES, ES&S, and ALS). During this time, the scope of the internship was expanded from an AES focus to include all of Aerospace operations. The purpose of this reorganization is to improve operational efficiency by taking advantage of the synergies that exist within the original business units. Within ISC, major strategic initiatives focused on reducing redundancies and aligning different approaches and activities within functional support, sourcing, and factory operations.

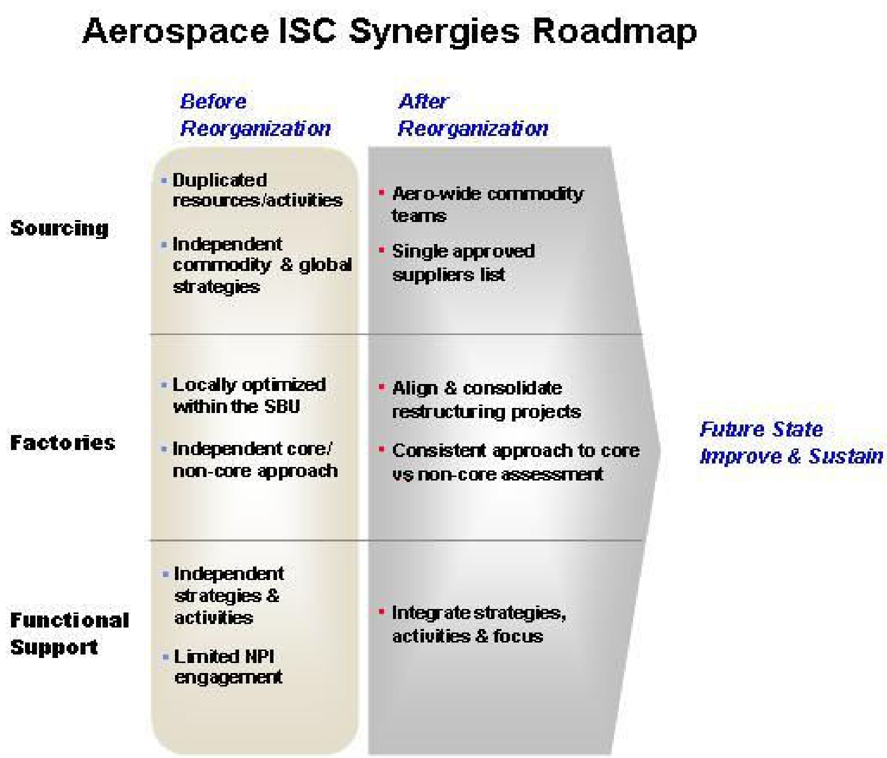

Figure 2 – Honeywell Aerospace ISC Synergies Roadmap

The separate electrical and mechanical strategic planning departments were combined into one, called Global Strategy and Integration, and located within the Tempe Arizona facility. It is within the Global Strategy and Integration group that this project takes place. The new organization has responsibility for completing analytical work on strategic projects generated prior to the reorganization, as well as identifying new opportunities as the result of the reorganization. Figure 3 below shows the new organizational structure.

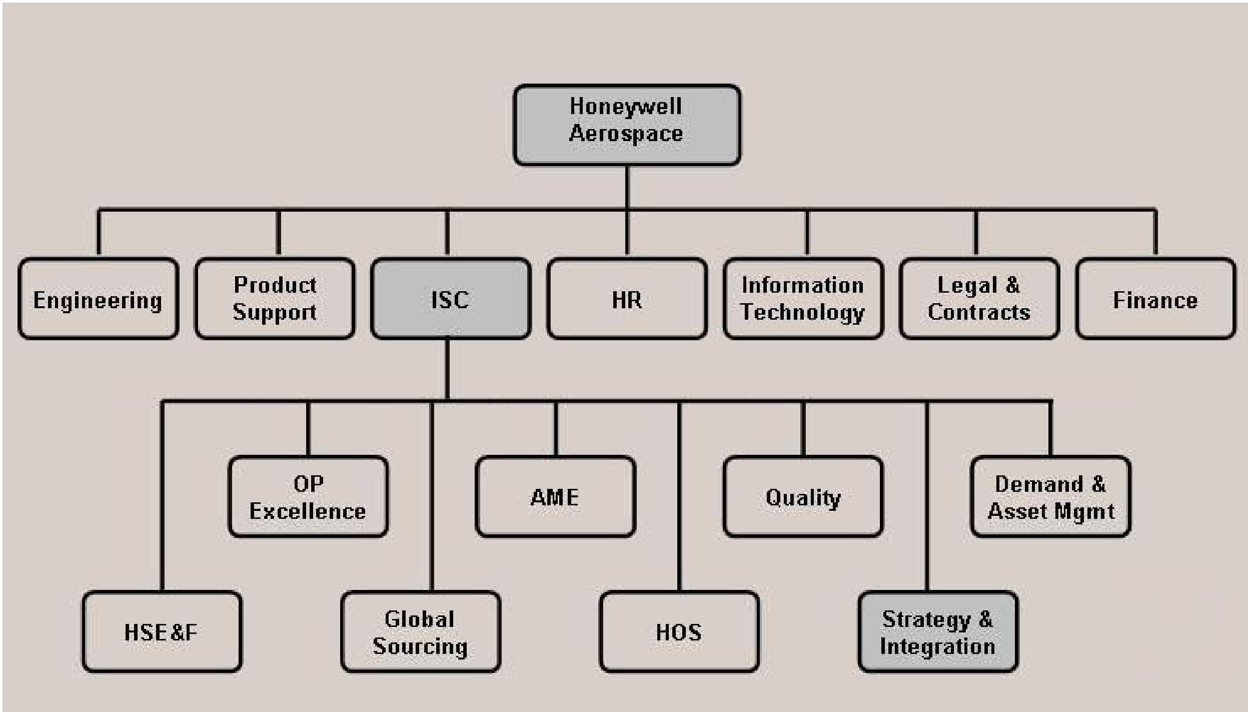

Figure 3 - Honeywell Organizational Structure

1.2.1 Strategy and Integration

Within Global Strategy and Integration, the term 'transition' refers to the process for changing the integrated supply chain manufacturing configuration or footprint, often involving significant restructuring of manufacturing assets. Figure 4 (below) lists the major transition categories and the associated benefits. For each transition type there is typically an investment requirement associated with different activities, which may include asset relocation, severance payments, and start-up costs. There should also be a long term benefit in operational savings. Analytic models are used to calculate the net present value of the investment and savings. The Strategy and Integration group uses this information and considers each transition against other operational constraints to determine the overall strategic plan. Such operational constraints can include, but are not limited to, customer or agency requirements, the minimum return on investment, the strategic development budget, and/or the maximum allowable yearly P&L impact.

Prior to the Aerospace reorganization, there were different departments using their own analytic models within AES and ES&S for strategic planning. In addition to using different models, the groups had different definitions for costs and what items were included in the overall analysis. At the time of the reorganization, it was decided that the AES TMI model would be the model used within the new organization. The AES TMI contained a greater level of detail in the analysis and also included the timing of various activities or events on a monthly basis within the transition. The previous ES&S model still allowed for a complete analysis, but cash flows were more aggregated and the model did not provide the level of detailed insight into the process that the AES version did.

The AES TMI model, from now on called the TMI model, is used to calculate a variety of scenarios for strategic planning with the Strategy and Integration group. This model is the primary tool used to decide which strategic projects go forward.

TYPE OF TRANSITION	SOURCES OF OPERATIONAL BENEFIT
Consolidation	When synergies exist between operations, combining indirect labor pools can reduce the total indirect labor requirement. If space is available within a single facility for both operations, the manufacturing space from the exited facility can be sold or used for another purpose, reducing overhead and generating cash from the sale of real assets.
Off-shoring	Moving a manufacturing or assembly operation to a low-cost region (LCR) reduces direct labor costs. If raw materials are available locally within the LCR, raw material costs may also be lower. Depending on how the new operation is managed, indirect labor and overhead may increase or decrease.
Outsourcing	Usually considered for only non-core operations, outsourcing allows certain operations to be performed by companies who specialize in this service and can provide it at an overall lower cost. The associated savings should be considered against the additional overhead needed for managing the new source.
Insourcing	Insourcing improves utilization of assets and operations when such operations fit within the product profile and/or need to be retained for core activities.

Figure 4 – Major Transition Categories

2 Aerospace Strategic Process

Given the sensitive nature of strategic transitions, confidentiality and rumor control are major concerns within the organization. There are three phase-gates that the TMI model must pass through before being approved and executed. The different phase-gates are used to strike a balance between the number of people who need to be aware of a proposal and the minimum data required to determine if the analysis and transition should proceed. Often, it is not possible to generate exact quotes for moving manufacturing equipment or to determine the market value of property without alerting the community to potential plans to change the business. Many different scenarios are carried out on paper, and only a few will make it into the official strategic development plan. Rumors concerning changes to the business are potentially disruptive and it is in ISC Leadership's interest to protect the different plans being considered from passing outside the Strategy and Integration organization.

As the TMI passes through the three phase-gates, cost and savings estimates are refined to the highest level of confidence possible without publicly disclosing the project. If a transition plan makes it through the three phase-gates and is approved, it is assigned to a transition team who becomes responsible for executing the transition within the defined budget. The transition budget is approved based on TMI estimates, and, after approval, gets rolled into the publicly disclosed general operating budget for the entire division. Therefore, once a project begins, it is difficult to revise the budget if additional funding is needed.

2.1 Problem Statement

The competitive landscape for Honeywell Aerospace is maturing with an increased level of price sensitivity. While still not a commodity market, operational efficiency is becoming increasingly important. Additionally, trends toward globalization drive new operational optimization challenges.

Honeywell's analytic modeling process is a key component in their overall strategic planning process. This project assesses current modeling practices within Aerospace Strategy and Integration with the intent of not only addressing existing concerns over the models, but also developing improvements to these analytic tools, as well as the overall decision process. Recommendations and analytic tools developed within this project are designed to create an enhanced level of confidence that the correct strategic actions are being implemented. It is hoped that through this effort, a more effective supply chain management process will result.

2.2 Deliverables

This thesis documents developments in three major areas. Two separate cost models are considered: the TMI Model and the Landed Cost Model. The analytical methodology for these tools is described here. Additionally, the operational process within Strategy and Integration for using these two tools is addressed. The actual modeling tools developed remain with Honeywell and are not included here in their entirety. Instead, examples using the models are included for demonstration purposes.

2.3 Approach

The analytic frameworks for the TMI and Landed Cost models were developed in the context of the overall ISC strategic decision and implementation process. This process evolved over the course of the internship as recommendations were implemented. While improvements to the models and process occurred in parallel, the strategic decision and implementation process will be addressed here first. By framing the process for using the analytical tools, developments to analytic methodologies will appear in context. Analytical tool methodologies are approached while considering the current process, existing resources, data availability, product demand profiles, and the existing operating environment.

2.3.1 Organizational Process

In order to develop appropriate modeling tools, the purpose and implementation of those tools in daily practice needs to be understood. During the discovery phase of this research, the way in which the analytic models are used is assessed. It is not enough to have analytic models that produce accurate results. It is equally important that the models are used in a way that ultimately benefits the company. While assessing the process for using these models, the question is asked: Does this process lead to the creation of a factory footprint that operates as a competitive advantage?[1] Making an incremental operational improvement is not always in the best interest of the company, especially when the improvement is from a single perspective. For example, moving to a low cost region to realize direct labor savings may actually increase the total value chain cost. Aspects of a factory footprint that can increase total cost include the distance and response time to the customer, sequence of core operations, and the location of the supply base.

Due to the reorganization, operational processes were evolving rapidly during this internship. This provided the unique opportunity to incorporate procedural recommendations as they were identified. Some of these recommendations were incorporated into Honeywell's modeling work instruction. Changes to the process and the underlying philosophy for generating both a strategic vision and incremental strategic goals are detailed in Chapter 3.

2.3.2 TMI Model

The TMI model is the primary tool used to determine the value of a strategic transition. It is used to calculate transition scenarios which may get incorporated into the strategic plan. One major transition, a consolidation between two electronic assembly facilities, was nearing completion at the start of this internship. This transition provided the opportunity to interview people involved in executing the transition to determine where errors in the estimation process occurred. Financial results from several other completed transitions were also reviewed. A series of improvements to the model developed from the findings of this investigation and initial concerns regarding the model from management.

[1] Mueller et al., Designing the Factory Footprint for Competitive Advantage, 2005.

This effort followed two paths. The existing TMI model was modified to incorporate the desired improvements and a new modeling tool, called the Level 1 model, was developed to allow rapid generation of scenario results for quick comparisons. The purpose of the new Level 1 model is to allow rapid changes to the underlying assumptions within an estimation so that several 'what if' scenarios can be generated quickly.

Incorporated into the new Level 1 model is the ability to estimate the effect of lean manufacturing practices on a scenario's NPV as if the sending site (the site manufacturing operations are moving from) was operating at an improved level of efficiency. This feature provides a better understanding of borderline cases where small improvements could change the final decision.

The results from the Level 1 tool are comparable to the existing TMI model. However, validating one estimation tool with another creates concerns over the real accuracy of new model, and the lack of consistency in historical data made historical comparisons difficult. Therefore, a system was implemented for retaining real transition performance data going forward for the purpose of verifying and making adjustments to both models in the future.

2.3.3 Landed Cost Model

The Landed Cost model, often referred to as the Total Landed Cost model, was not being consistently used for strategic planning. There were a few different versions of landed cost modeling tools available. However, the available models either required the user to define all of the costs or were generally too complicated for everyday use. A few of the existing landed cost and supply chain inventory models were assessed for suitability against reasonable use expectations and typical Aerospace product profiles. Ultimately, it was determined that a new model would be needed to meet the current analytic requirements.

A new Landed Cost model was developed that calculated the cost impact of four major categories: Direct Labor, Shipping, Inventory, and Taxes. The purpose of this tool is to allow quick comparisons between a variety of global regions for both individual parts and entire part families. While this tool does not calculate the total landed cost of a value chain, it does allow the direct comparison of these major cost drivers with minimal input data requirements.

Each of the four included cost drivers is considered within the model incrementally. In some cases, assumptions were made in order to maintain the model's ease-of-use expectation. Since the model is used for comparing alternate manufacturing regions, and not for calculating an exact landed cost, the assumptions made were determined to be acceptable as any error would be constant across all regions.

We hope that by creating a model that requires minimal input data and is easy to use, landed cost comparisons will become standard practice during the development of strategic goals and initiatives. As with the Level 1 model, real part data from emerging regions is scarce and validation of the model will occur as the model is used. Both the Level 1 and Landed Cost model have been created to allow changes to be made easily to the underlying cost assumptions, so that as more is known about real costs the models can be quickly updated.

3 Strategic Planning and Implementation

Over the course of this internship, the process for planning and executing a transition changed significantly, partly as a result of this internship effort and partly as a result of other improvement initiatives. The initial depiction below for modeling, approving, and carrying out a transition describes the process at the beginning of the internship. After an initial investigation, several recommendations were generated to improve the process. These recommendations are also described, along with the actual changes to the process.

3.1 Initial State

Before the Aerospace reorganization, AES and ES&S had different transition modeling processes. At the start of this internship, these systems were being combined. Even though the combination of these systems was underway at the start of the internship, it is important to note the differences as it impacts initial findings and the consistency of available historical data.

Direct comparisons between AES and ES&S project plans were difficult because each used different key metrics, assumptions, and approval criteria. The ES&S TMI model tended to have more aggregated cost entries over a broader timeframe than the AES model. For example, ES&S equipment relocation expenses might include a certain amount of facilities cleaning or fit-up expenses, where in the AES model they're entered as separate line items. When comparing relocation costs, it would be difficult to reconcile why ES&S might be estimating $15/sqft compared to $8/sqft from AES. Figure 5 below outlines the major differences in the two processes.

The existing AES methodology was selected as the modeling system to be used going forward. The AES TMI model had a higher degree of resolution, both in time and specific costs, as well as desirable error checking features that helped identify mistakes. The AES process allowed for three rounds, or phases, of model evaluation, each with an increasing level of analytical scrutiny.

At each of the three phase-gates, called 5%, 50%, and 95%, the financials in the model needed to pass certain hurdles in order to proceed. During each subsequent phase, more time is invested in identifying and refining estimates for probable costs and savings. If a project passes to the 95% stage and is approved, it is transferred to a transition team that re-evaluates the financials and signs off on a transition budget. The different level percentage labels loosely referred to the level of confidence in the results, and are explained further in Section 3.2.1. Once the project was approved at the 95% stage, the process entered Phase 0 (zero). After the financials were accepted and the transition budget set, the project entered Phase 1. A process diagram is shown in Figure 6 below.

AES TMI Model	ES&S TMI Model
• Develop 95% model for project approvals - Detailed sending business unit (SBU) involvement - Monthly cash breakdown • 2-3 year payback periods - Less capital intensive factories - Push for 18 month or less transition period - Generally no ex-pats • Partial capture of full transition costs - Includes partial transition team, hidden factory and overtime costs - Fails to capture full SBU transition involvement • Higher consistency within model - Some internal error check capabilities	• Develop 5% model for project approvals - No sending business unit involvement - Yearly cash flows • 4-6 year payback periods - Capital intensive factories - Overly conservative timelines for asset and census changes - Significant ex-pat costs - Acceleration of some costs • Key transition costs are excluded from the model - No transition team costs - No hidden factory costs - No overtime for inventory build and productivity loss • Low consistency within model - Key model inputs do not tie between Excel spreadsheet tabs

Figure 5 – AES and ES&S TMI Methodology Comparison

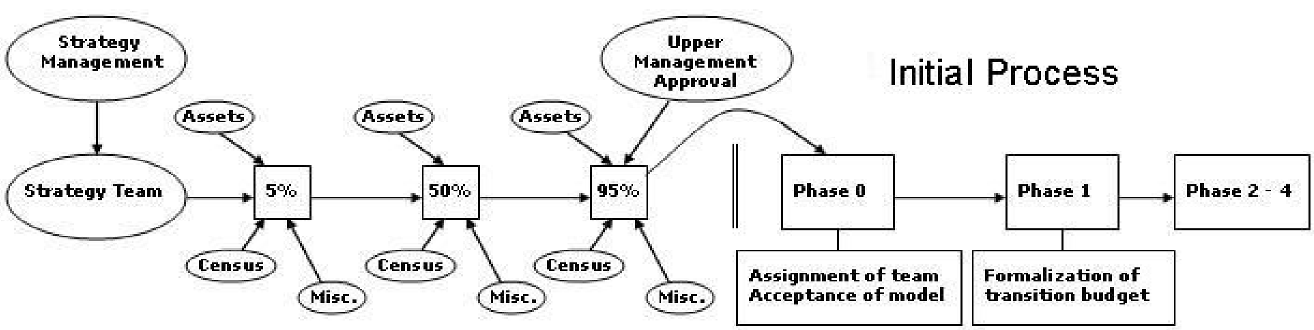

Figure 6 – Flow Diagram of Initial TMI Process[2]

[2] Assets, Census, and Misc. refer to the individual estimates for a transition's specific investment requirements.

3.2 TMI Process Improvement

Following an initial assessment of this process, the following recommendations for process improvements were generated. During the internship, while the TMI model and Landed cost model were under development, these recommendations were implemented and incorporated into the process work instruction.

3.2.1 TMI Model Phase Labeling

The 5%, 50%, and 95% labels for the three model stages were used to suggest a certain amount of confidence in the model's financial results. As the model proceeded to the next stage, more research was performed to justify the quoted financial cost and savings estimates. The final model approved might then be assumed to deliver financial results with a 95% confidence. These labels were found to be confusing and potentially misleading. The indicated confidence level label neither defined a traditional confidence interval for the expected results, nor declare how confident the team was that the results were exactly accurate.

Since the stage labels function more as a progress indicator, communicating how far along the team was in the analysis, they were changed to Level 1, Level 2, and Level 3[3]. This may seem like a trivial adjustment, but it becomes an important perceptual difference in how the results are viewed and shared with other departments or Honeywell leadership. The results from the final level model are used to define the project budget, which then becomes a constraint for the transition implementation team. Declaring a false confidence level for the expected outcome may inaccurately set management's expectations and generate conflict as contingencies arise.

3.2.2 TMI Model Level Requirements, Assumptions, and Definitions

The TMI model contains cash flow information on about 25 different worksheets, or tabs, within an Excel workbook. Previously, the individual cost definitions, assumptions, and minimum data requirements at each model level were not clearly specified and it was up to individual interpretation when enough work had been performed to declare a phase-gate review. For a Level 1 analysis, any information that was known about a project or could be estimated within a few hours was entered. As the model progressed to Level 2 and Level 3, data within all 25 worksheets was readdressed as the preliminary estimates were refined. Because the model was in a constant state of refinement, at any point in time it was hard to track changes and assumptions through the three levels and to know where enough work had been done or more work was needed. Also, because all estimates in the entire model were being refined through each level, there was some inefficiency in the process through repeat reviews.

The specific details of what gets included in each model entry need to be standardized. Without formal definitions for individual line items, it is difficult to interpret reports, pass ownership of a project to someone new, or perform a meaningful post-project analysis or data review. Also

[3] Wu, Total Supply Chain Cost Model, 2005.

needed is a specification of the minimum data requirements at each level, such as what assumptions are made and when those assumptions are refined with actual quotes. The assumptions should be used to calculate earlier level results and get updated with hard numbers as the model passes though the next levels. Organizing both the process and the model will improve its ease-of-use and the tracking of assumptions, estimation sources, concerns, and potential contingencies. A complete list of TMI Model entries and the associated final definitions is included in Appendix A. The following simplified example illustrates typical expectations at each level of the analysis.

> Moving equipment between two facilities might involve packing and crating, shipping, the supplying of power, water, and lighting in the new building, and removing the utility drops in the old building. The model's asset relocation entry would cover only the costs for packing, crating, and shipping. In a Level 1 analysis, the costs would be estimated from the size of the manufacturing area multiplied by a typical cost per square-foot. During the Level 2 analysis the sending site manager provides details about the manufacturing area that change the cost per square-foot assumption. Before the Level 3 analysis is completed, a quote to move the equipment might be generated.

3.2.3 Split vs. Continuous Process, and Cost Estimation Ownership

Possibly the largest issue with the previous process was that it was separated into two distinct steps. A model for each project is created by the strategy group and then passed 'over the wall' to an implementation team. It is interesting that Phase 0, which might signify the beginning of a project, occurred after the project was approved. At this point, the transition implementation team would do a bottoms-up calculation of what the actual transition costs will be and compare it to the approved estimation. The new result is based on what is actually happening on the manufacturing floor. There is a certain amount of renegotiation that takes place during this step before a budget is finalized and activity begins. In the past, the original model was not always updated and some opportunities to learn from the implementation were lost. If a lessons-learned review was performed, it occurred after the completion of the project.

The discontinuity that occurs between the two steps has several negative effects, one of which concerns the perception of ownership over the model and the analysis. The strategy team may do an accurate job estimating the project, but after Phase 1 they were no longer accountable for the financial outcome of the project. The transition team might take an adversarial stance in the process as they were inheriting a project with a constrained budget. There is the perception that some approved projects are positively biased in order to meet the minimum financial requirements. Given such a case, the project would be burdened from the beginning and the transition team would have a difficult time being successful.

The primary reason for this discontinuity concerns project confidentiality. Rumors about strategic plans are particularly disruptive to the organization. Should the manufacturing staff be alerted to potential plans to move the operation, whether the rumors are founded or not, the operational efficiency of the organization will decline as workers take the mindset that there is no future in the organization. In addition, key people may start looking for new jobs and leave when they are needed most. Because of the need for total confidentiality, there is a high level of secrecy for strategic development proposals. It is not possible to take an accurate audit of what is happening on the floor without people becoming suspicious. Simply visiting a plant once or twice is enough to start suspicions.

Currently within the organization, there are people who have been involved in implementing active transitions and have managed transition teams. Bringing these people onboard earlier in the process will help smooth the handoff between planning the project and executing it. Confidentiality can still be protected while creating an overlap between the two functions. In addition to involving the transition team earlier, the people responsible for modeling a project should be involved in any post-approval financial revision. Each function, planning and implementation, needs visibility into what the other side is doing.

Ultimately, a project begins when it's first conceived and a Level 1 analysis is performed. In the revised process, this is where the Phase 1 begins. At that point, a Project Lead gets assigned who has ownership over the financial model through to the completion of the project. The new process flow diagram is shown in Figure 7 below.

The TMI Project Lead drives the analysis through to approval, and then participates in the budget review process as the transition is being executed. The Project Lead owns the estimation model and is responsible for updating it throughout the project. By linking the two functions, estimation and implementation experiences can be shared and learning maximized. Also, keeping the Project Lead involved during the implementation reduces the incentive to bias the analysis and helps mitigate the adversarial stance adopted by the implementation team.

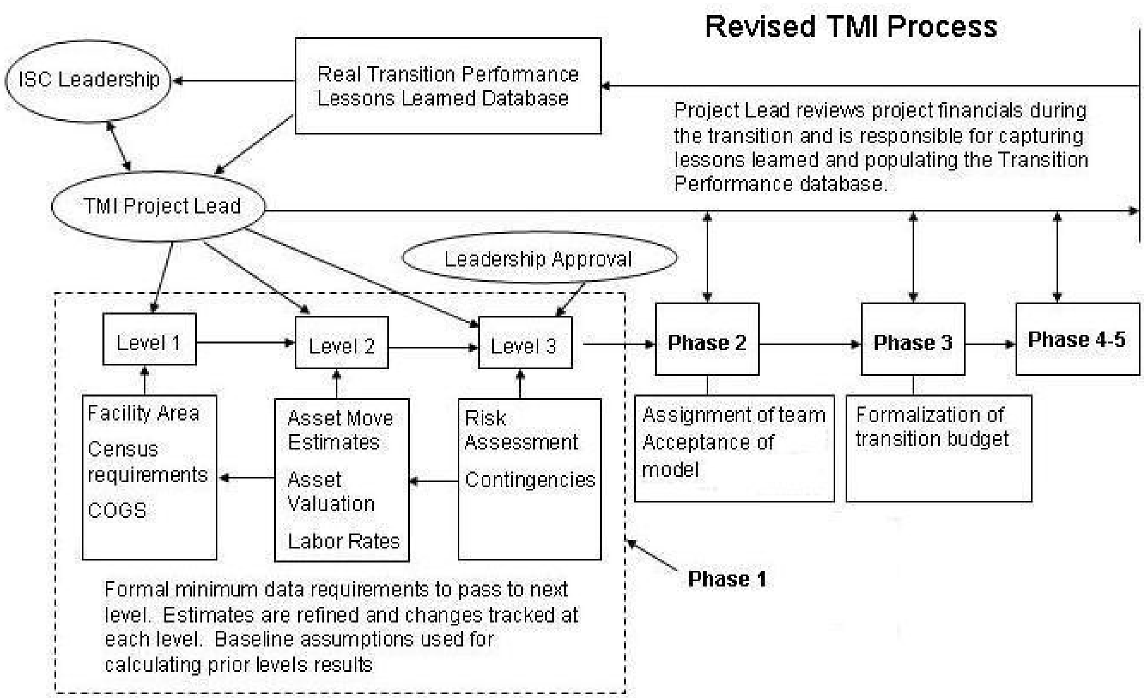

Figure 7 – Revised TMI Process

3.2.4 Departmental Reviews, and Knowledge Retention

In the past, strategic projects have been approved without being viewed by some of the more important internal organizations. A transition might be underway, only to find out there are enormous tax or legal consequences. Before final approval, each proposal should be reviewed by the following internal departments, regardless of any preconceptions: Site Finance and Sourcing Leads, Facilities, HR, Legal (Contracts Review and Export Compliance), Tax, Logistics, and Corporate Finance.

Again, there is the concern about confidentiality. In the revised process, these organizations are contacted just prior to final approval to see if any financial adjustments are needed or any potential contingencies should be highlighted. Regular discussions with these departments can also help to identify additional opportunities. For example, during one discussion with the Tax group, a unique R&D tax incentive within Mexico was identified. If R&D capabilities get incorporated into new Mexico greenfield projects then there are additional tax savings.

Changes to the TMI process are designed to help make the Project Leads as knowledgeable as possible. Retaining this knowledge and transferring it to new members of the organization is the final step in the revised process. A new Lessons Learned database was created that tracks initial estimates, final financial results, and any errors or missed contingencies along the way. The TMI Project Lead has responsibility for collecting and entering the final financial data. Hopefully, as this database gets populated, future estimates will grow increasingly accurate. Another function of this database is to allow the refinement and validation of the new Level 1 Modeling tool discussed in Chapter 4.

3.3 Incremental Improvement vs. Strategic Vision

Considering the financial analysis of the TMI model alone does not provide the needed insight into how the overall organization needs to develop. In fact, the TMI may financially justify a strategic move that is counter productive. The TMI model only looks at two manufacturing options or locations and determines the net savings associated with the switch. There are cases where the model could indicate a move is profitable when it actually will harm the business. One reason for this is the inability to capture all of the relevant costs or effects of the move, especially when some effects are more qualitative in nature.

For example, when comparing manufacturing in the US to China, the labor savings in China might be significant enough to show a net savings even in light of the added logistics and management costs. However, there are more issues to consider: Will the local labor force be talented enough to build the products in question? Are there regulations preventing the off-shoring of the technology? Is manufacturing in the region approved by the FAA? Will the new location create an outlier in the supply chain footprint, away from current suppliers and customers requiring additional management overhead?

Thinking along single lines of 'where should we go from here' can lead to making decisions that detract from the efficiency of the organization as a whole. This is classified in literature as incremental improvement. In order to prevent making mistakes associated with incremental improvement, a vision of the ideal final state of the entire value chain for the whole organization is needed[4]. Then, when considering strategic moves, ask the question 'Does this move us closer to the ideal state or away from it?'.

A major concern in aerospace and defense manufacturing is government regulatory constraints. Other factors that need to be considered include customer requirements, the supply base, region capabilities, and total landed cost. Within this research, the landed cost model that was developed (and documented in Chapter 5) was created to assist the Global Strategy and Integration group define the ideal ISC final state vision. Understanding the total cost of the value stream is vital to defining the optimal manufacturing footprint. Figure 8 below shows the revised strategic development process from a higher level.

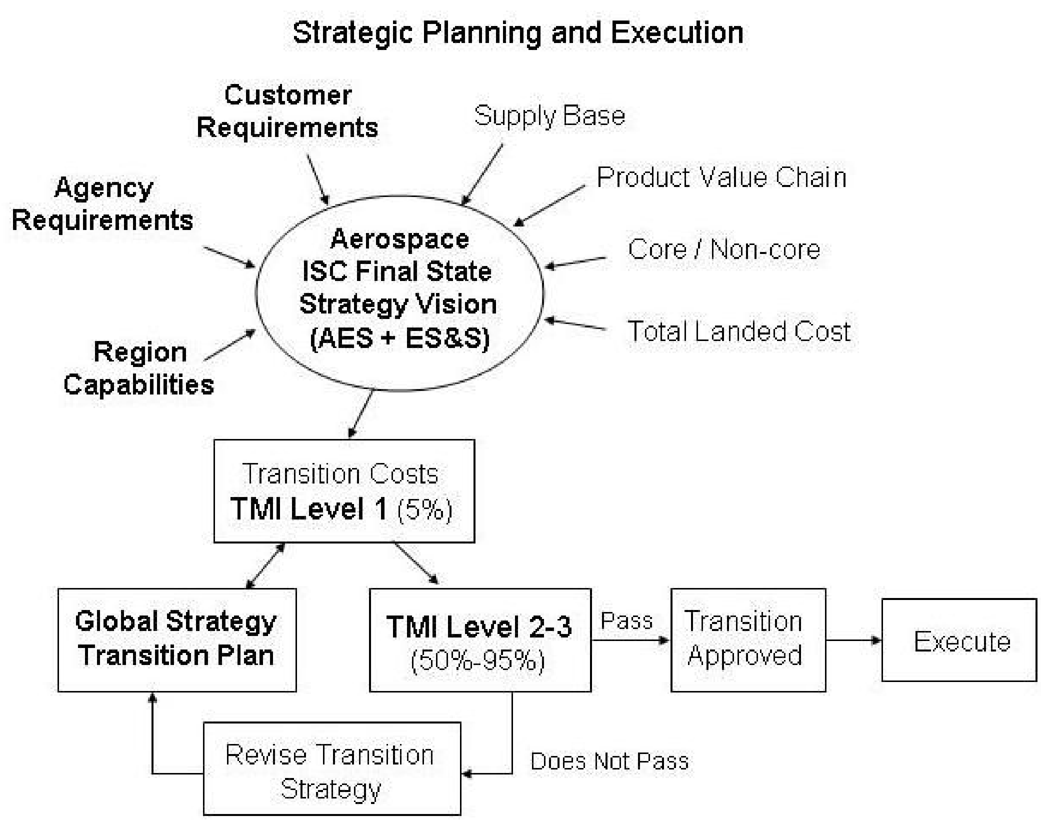

Figure 8 – Development of the Strategic Vision

[4] Cohen et al., Strategic Supply Chain Management – Strategy, Planning, and Operations, 2004

After the ideal final state is defined, the TMI model is used to consider specific scenarios related to achieving the final state. Given the initial investment requirement for a transition, the TMI model will define which strategic moves get incorporated into the Global Strategy Development Plan. There are currently more aerospace opportunities than implementation resources available, and the TMI is used to screen different scenarios to determine which scenarios to execute first.

As an example of another way to think about this, suppose that during the creation of the final state vision it is established that the company needs to develop certified manufacturing operations in Mexico. However, the startup costs associated with FAA regulatory and certification processes are high. The TMI analysis for a Mexico greenfield plant will be burdened by the start-up costs and may not pass the minimum requirement for a 5 year return on investment. If all new Mexico manufacturing operations cannot be approved because the start-up costs are high, then either the strategic vision needs to be changed or the investment needs to be considered outside of typical ROI standards. If Mexico operations are still desired, then a TMI analysis on all available scenarios will determine the best opportunity.

3.4 Implementation of Refined Strategic Process

The process outlined above is a change in the way of thinking about how a strategic plan is developed and executed. The two most important concepts outlined here are:

1) A vision of what the value chain footprint should look like in the future is required, and the strategic development plan should be moving the company toward that vision.

2) There are elusive elements to every strategic transition, both quantitative and qualitative, that can have a major impact on the performance of a project. It is important to consider a decision from alternative viewpoints and to get feedback from resident experts on issues such as logistics, inventory, taxes, and others.

This revised process was incorporated into Honeywell's Strategic Planning work instruction. An explanation of the sequential steps is documented along with some of the underlying philosophy for this process. The process flow diagrams (Figures 7 and 8) are also included. Continuous improvement is a desirable characteristic of any competitive company, and so this process will likely continue to evolve. Throughout this change process, it's important to consider not only what we do, but why we do it. The work described above is intended to create some of that philosophic foundation.

4 Transition, Migration, and Integration Model

The purpose of the TMI model is to estimate the net effect of changing the value stream. For a typical supply base and manufacturing configuration, potential strategic development plans might include insourcing, outsourcing, consolidation, and relocation of parts or all of operations and current products. In order to change the configuration of operations, a certain amount of investment is required. This investment may be in the form of purchasing new assets, relocating existing assets, hiring and training, or the severance of existing employees to name just a few. This investment will be referred to as the switching cost to realize the savings from improved operations.

Estimating the switching cost is a key part of making sound strategic decisions. Consider the following example.

> Moving a plant over the border might produce annual savings of $1million in labor and related expenses. The product line is believed to become obsolete in 10 years. The switching costs are $3.8million and it will take 1 year to implement the change. Should the plan go forward? Assume the internal rate of return is 9% and there would be 9 years of savings after implementation. The Net Present Value (NPV) of the savings is $5.5million. Therefore, the NPV of the project is $1.7million. If there were no risk in the project, it should go forward. However, there is always some risk in disrupting operations, and in some cases the risk is substantial. To account for risk, there may be a requirement that all operations improvement projects have a NPV of at least $2million before they are approved. In that case, the project will not be executed.

These concepts are rooted in the principles of finance[5]. The TMI model is performing this calculation at a much larger scale for transition projects that are typical in the aerospace industry. At the beginning of this research, there were some initial concerns within ISC Leadership about the performance of this modeling tool. This research aims to address those concerns as well as identify other improvement opportunities.

4.1 Initial TMI modeling concerns

Current Honeywell Aerospace strategic plans based on the TMI's financial results represent $100's of millions in development projects. There is significant interest in ensuring that the TMI model is providing a sound financial analysis. Strategic plans can be classified as non-routine operating decisions. When considering strategic scenarios, all relevant incremental cash flows should be accounted for[6]. The TMI is a comprehensive model that aggregates estimated cash flows from up to 33 different sources depending on the nature of the project. Typical projects can take 2-5 years to implement, and financial projections go out for years after the implementation is complete.

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[5] Brealey et al., Principles of Corporate Finance, 2003
[6] Eldenburg et al., Cost Management – Measuring, Monitoring, and Motivating Performance, 2005

4.1.1 Model Accuracy

The primary concern with the TMI model is over the accuracy of the financial projections. The model has evolved over the years from a single page tally of cash flows to the current 25 page Excel spreadsheet. As new relevant cash flows were identified, they were incorporated into the model. Most of the cash flows represented in the model for any specific project are based on estimates. Therefore, the result is the aggregation of many small estimates. There are two sources of error in the model.

1) Estimation error in an identified cash flow.

2) The omission, or overlooking, of a relevant cash flow.

Concerns over rumor control and project confidentiality add to the challenge of making accurate estimates. While some cash flows can be estimated accurately with quotes and financial operating statements, others may be entered as approximations based on experience.

4.1.2 Range of Results

Typical of any Excel-based spreadsheet, the final result can offer a precise projection out to multiple decimal places which grossly misrepresents the model's actual accuracy. Most people recognize that precision in the forecast doesn't represent accuracy. What is needed is an estimation of the potential range of expected outcome. The existing TMI model did not provide this visibility, which can lead to some very large surprises.

Consider the previous NPV example. The reason for the $2MM minimum return for new projects was to cover unknown risk associated with disrupting operations. This has the same effect as raising the required IRR to something that would represent a similarly risky investment. Let's assume that the project financials just pass at $2MM. Assuming a normal distribution for financial outcome, there is a 50% probability that the results realized will be above the projection and a 50% probability that the results will be below. However, we don't know how far above or below $2MM we will be, or if the project will actually realize a negative NPV.

4.1.3 Ease of Use

As newly identified cash flows have been added to the TMI model, the model has evolved to the point that makes it difficult to understand or use, especially for people who are unfamiliar with it. The model allows the estimation of up to 33 different cash flows on 25 different worksheets. The enhancements are driven by the need for accuracy. However, in some cases only a quick result is needed, such as when considering several different 'what if' scenarios. The complexity also makes it difficult to understand what a project's primary cost drivers are. This ultimately ties the model to its creator to answer all questions about the analysis and to make any changes.

4.2 TMI Model Assessment and Error Sources

An investigation into the TMI modeling process was conducted to identify sources of estimation error. One transition in particular, a consolidation between two facilities making similar products in Phoenix, was used as the basis for interviews with individuals on both the TMI modeling team and the transition implementation team. This transition was nearing completion and provided an excellent source for information on the current state of the process. Information from these interviews provided insight into how the model differed from the actual project, as well as into the TMI process altogether (these interviews provided some of the basis for the process recommendations outlined in Chapter 3). The interviewees were informed at the start of each interview that all interviews were completely confidential and that they could be as candid about the process as they wished. For this reason, details from each respondent are not included in this thesis.

Other historic projects from the AES and ES&S business units were also selected for investigation. These investigations entailed interviewing the primary project contact within Strategy and Integration and reviewing the original model against the recorded financial results. There is a general lack of continuity within historical data, as the modeling process along with the types of cash flows captured has changed over the years. While many of the error sources within the historical projects had already been fixed in the current process, these projects provided insight into how human effects can disrupt both the analysis and a project's implementation.

4.2.1 Relevant Incremental Cash Flows

When calculating the net effect of a strategic decision, the TMI model sums incremental cash flow changes that are caused by the decision as they would occur in time. Some of these cash flows are directly related to transition activity and are easy to predict, while some are more subtle and may involve effects like operating efficiency. In addition, the relevance of an included cash flow may depend on perspective, and can be the source of more philosophic discussions.

To illustrate this point, consider the following.

> The people who will execute the transition may already be on the payroll in another capacity. Should their labor be included as an expense? The site will see no additional payroll expense, but what about their productivity on what they were doing before being reassigned?
>
> When a manufacturing facility is being closed, there is a decline in the operating efficiency for the products made in the facility until the factory closes. The same labor and overhead expenses will be allocated to fewer finished products. This decline is caused by both the logistics of the process, as equipment is relocated and assembly areas

vacated, and the reduction in employee morale as people deal with uncertainty and the loss of their jobs. How should the associated additional cost be accounted for?

Once an assembly area is vacated, the area can be put to another use, leased, or sold. Should the expenses associated with retaining that area be included in the model as a savings once it is vacated? What if no other use for the space is found?

Two criteria were applied when considering which cash flows to include in the model. The first is how much the cash flow impacts the final result. The percentage of change depends on the ratio of the cash flow to the aggregate result. Since the TMI model is used for a range of transition types and sizes, if a cash flow could impact some of the smaller projects then it was included. A detail can always be omitted in the model if it is found to be inconsequential.

Secondly, if recording a cash flow affects the implementation team, then it was included. The TMI model is ultimately used for developing an execution timeline and budget, and constraints are created for people associated with the project based on the analysis. Even if a cash flow has a small effect on the final result, it was included in the analysis if it was felt that not including it might negatively impact some part of the downstream process.

Some cash flows are budgeted within a project model that may not appear within the operation as result of the project. This can be a source of discussion with people in finance, since these cash flows are not necessarily incremental to the business. Ultimately, this is a matter of how the boundary is drawn around a project and can change for different scenarios. When building a model, it is important to state the assumptions as they relate to these cash flows. For example, the headcount of the transition team is added as a cost to the model. The assumption is that these people were working on something before they were reassigned and there would need to be some backfill support, possibly in the form of temporary workers. Another example deals with fixed overhead. Usually, within the model there is a savings associated with fixed overhead reduction when product is removed from an assembly area. Unless the area is disposed of, the overhead charges are still there and get spread over the remaining products manufactured in the facility. The assumption is that the space will be used for something productive, which may not always be the case.

4.2.2 Cash Flow Assessment Results

The following factors were already captured by the TMI model at the beginning of this investigation. Each item was specifically accounted for within the model. A few of the included items do not directly enter into the cash flow calculations, such as book value and depreciation, but are used for determining the P&L effects of the project. Management may add additional constraints to a strategic plan relating to the maximum allowable P&L impact on the company's financial statements for a given period. As an example, the sale of a building creates a positive cash flow for the project increasing its value. If the sale amount is below book value then the asset sale will be recorded as a loss on the company's books. While cash flow is important for determining real value, P&L effects can influence public perception of performance.

TMI Estimation Factors*

- **Asset Move**
- **Building Cleanup**
- **Environmental Cleanup**
- **Hidden Factory**
- **Requalification/certification**
- **Overtime requirements**
- **Information Systems**
- **Tooling**
- **Facilities Fit Up**
- **Transition Core Team**
- **Transition Team Travel**
- **Census**
- **Transfers**
- **Severance**
- **Retention**
- **Relocation**
- **Hiring and Training**
- **Census overlap**
- **Variable Overhead**
- **Fixed Overhead**
- **Asset Sales**
- **Book Value**
- **Write-offs**
- **Depreciation add-back**
- **Depreciation**
- **Inventory Pre-build**
- **Inventory Pre-build Overtime requirement**
- **Material Add-back**
- **Outsourcing Costs**
- **Inventory Driven Costs**
- **Other operating expenses**
- **Discretionary spending costs**
- **Miscellaneous Spending**

* A list of definitions is included in Appendix A

This investigation highlighted sources of error in two categories, estimation error and the omission of a transition effect. From the list of captured values above, the following have estimation accuracy issues.

Hidden factory – Hidden factory represents the cost to document all of the undocumented processes with an operation. This depends on the age of the plant, the number of products and processes, and how well plant management has historically performed in ensuring processes get documented. For operations being exported to foreign countries, Hidden Factory will also include the cost of document translation. There have been studies in Hidden Factory cost estimation which improve estimation results. However, because of the complexity of the issue, rules-of-thumb are typically applied with the understanding that the real cost is undetermined.

Transition team cost – Transition team cost represents the personnel expense for the people required to implement a transition. An initial estimate is based on the type of manufacturing, type of project, and the product volume or COGS. Projections are based on experience, but requirements can change as the project progresses.

Hiring / Training cost – Typically, estimation errors relating to Hiring and Training involve operations in emerging regions, where there is little internal experience in a local marketplace. The rates charged by local employment contractors are estimated based on the published local labor rates. However, because of increasing hiring competition in emerging regions, the local hiring agencies may charge as much as in the US.

Current asset (inventory / real) estimation – Valuation of company assets to be sold is subject to changing market conditions as well as the condition of the asset. For outsourcing projects, where material is sold to a contractor, inventory value is easier to estimate. Differences in inventory value occur when the physical inventory is located and the condition assessed. For real, or property assets, sales price depends on the market and offers received. Unknowns about the property's condition impact the final sales price.

Required census / assets – A more thorough investigation into existing conditions will help improve estimations for census and asset requirements in a new location. Estimation errors in census arise from an abnormal labor utilization at the sending site. When a new operation is established, the labor requirements are defined as a percentage of full utilization without overtime. Assets such as equipment and fixtures at the sending site may need to be replaced or repaired before placed into service at the new location.

Pre-build requirements & cost (efficiencies) – A pre-build is specified when the transition is buffered by material. While the sending site is shut down and the receiving site has not yet begun production, customer requirements are satisfied with pre-built inventory. Depending on the labor utilization of the sending site, pre-build typically is created using overtime and extra shifts. If the sending site is already using overtime to meet current demand, then satisfying pre-build requirements may require additional resources. Once a transition is announced, production efficiency tends to decline as a result of both the transition logistics and morale erosion. This further impacts the ability to meet pre-build demand.

In addition to the TMI estimation factors listed above, some new factors were identified that influence the analysis and implementation of a project. These factors are described below.

Current census utilization – As described above, the sending site labor utilization can differ from what will be expected at the receiving site. New factory operations set labor utilization to the current standard, which does not include an allowance for overtime. Any difference in utilization between sites will mean that the census requirements at the receiving site will need to be adjusted. This factor is not directly incorporated into the TMI model, but is highlighted as something that should be determined prior to project approval.

Transition effect, factory efficiency reduction – As described above, transition activity causes a decline in factory productivity. This can be difficult to estimate. Like census utilization above, this effect is documented as something to be aware of when defining production requirements for the sending site.

Local labor source turnover rate – In some foreign countries, seasonal effects and long term labor churn can add to the overhead requirement for maintaining the labor pool. Local labor trends need to be considered when establishing operations in a new region.

Tax effects – Tax effects can have a dramatic impact on the results of a project. Taxes are also the most difficult to model, as some tax benefits are realized through negotiation with local governments. The tax department should be consulted prior to beginning activity on any project. Some tax credits may become more difficult to negotiate once an implementation is in process. Tax effects that should be considered include, but are not limited to:

- **Import tariffs –** Customs duties may be added to imports depending on the product in question. The rate applied to specific products is defined according to their Harmonized Tariff Schedule (HTS) category.
- **Intellectual Property tax penalties –** The US applies a special tax penalty to the offshore production of intellectual property.
- **Tax incentives –** Some governments issue tax holidays or credits to businesses associated with local investment.
- **Business exit tax –** When exiting a region, the local government may apply a tax on the value of the business that left.
- **Different regional tax rates –** Different global regions apply a different tax rates to profit created and retained in the region. For example, the US rate is approximately 40% while Singapore is about 20%. An arms-length standard is applied to internal transfer pricing to discourage tax abuse. This topic is covered more in Chapter 5.

Inbound / outbound logistics effects – Incremental logistics costs are included within the model's variable overhead section. Logistics costs should have a separate category within the model to highlight the potential significance of this cost driver. The logistics cost impact depends on the availability of local sources. For greenfield establishments in emerging regions, the material pipeline may extend for raw materials being imported to the region as well as for returning finished goods. Logistics costs are also covered within Chapter 5.

Additional investigative effort while estimating these factors will help to improve the accuracy of the model. However, understanding the potential range for each factor is enough to allow a proper analysis. If there is a question about the potential magnitude of a cash flow, the conservative end of the range can be used. In this way, any surprises will hopefully be pleasant. However, this may block a project with borderline results. Since there is a level of uncertainty with all estimates, the preferred method is to pass the expected range through the model to the final result to determine the potential effect of the uncertainty. Doing a sensitivity analysis on questionable inputs will identify whether or not the uncertainty is significant to the overall project. Knowing how the range associated with each factor effects the analysis will also help identify where to allocate investigative resources. The ability to pass uncertainty through the model, outlined in section 4.3, was developed and incorporated in the current model version.

4.2.3 Cash Flow Analysis

The TMI model starts at Level 1 with rough estimations for a few factors, typically the relocation of equipment and census changes. Projects that pass the minimum financial requirement for ROI progress to Level 2, where the assumptions used in Level 1 are refined. At Level 3, all relevant factors should be estimated and included in the model. The cash flow analysis performed by the model is fairly straight-forward. Costs and savings are recorded within the model according to the time they are expected to occur. The TMI model is broken down into monthly cash flows, which are then binned into yearly amounts. The monthly resolution allows the model to be used for planning implementation activities. The combined annual amounts are then summed for a total year-by-year expected cash flow. The remaining input to the model is the company's internal rate of return. The discounted cash flows, NPV, and IRR for the project are then calculated. A sample output from the final model version is included in Appendix B.

4.2.4 Cost Avoidance vs. Savings

Within the TMI model there may be entries for expenses that can be prevented by the transition, such as required building repairs, retrofits, or upgrades. As the transition is carried out, the costs avoided may not get included within the financials as operational savings. This can be a source of discrepancy between estimated and realized financial reports. If the expenses were already budgeted, then they can be associated with the project to show up as a gain. In any case, documenting and keeping track of cost avoidance factors throughout the project will help keep estimates inline with actual project performance.

4.2.5 Contingencies

There can be some incremental cash flows that may or may not occur. These factors behave like step functions, and the probability for their occurrence is often undetermined. Simply including or excluding them in the model will bias the results one way or the other. Also, recording an expected outcome based on the estimated probability will not provide the entire view of a project's risk to management. Some examples of contingencies include performing environmental remediation prior to an asset's sale, updating processes to new standards, being awarded tax incentives, or paying optional employee benefits. If the contingency is significant, a separate model result for each scenario can be generated for discussion. When dealing with contingencies, documenting all model assumptions and potential risk is critical. Often, taking proactive measures can mitigate the risk, and if a negative situation arises, then management will have already been alerted to its potential.

4.2.6 Dealing with Change vs. Estimation Error

Even if an exact financial projection was possible, in short time something will change. Strategic projects involving the relocation of manufacturing operations can take years to implement. Over the course of the implementation, demand, customer requirements, and labor and material costs can change. New products or projects might be introduced. During an implementation, it is important to understand when differences in project performance are caused by errors in the original financial projection or by the changing business landscape. Shortening the implementation duration can help mitigate some of the risk of change. However, focusing on projects that take only a year or two to implement may interfere with the company realizing its strategic vision.

Within the project review process, there needs to be a mechanism for identifying change and accommodating it. Holding the implementation team to the original financial projections or census levels will be counter-productive if product demand is escalating. Similarly, if the manufacturing site or products are rapidly becoming obsolete, management needs to know when and how to abandon the project. Difficulties can also arise when two projects overlap. For example, if two assembly areas are being moved into one building, there will be discussions about which budget is used to pay for improvements to the infrastructure. In this case, it may be best to combine the project financials.

4.2.7 Human Effect and Model Error

One potentially large source of error between the financial projections and actual results, either during the estimation process or after implementation has begun, is the human effect. The reality is that transitions disrupt people's lives, and they will behave in ways that protect their jobs or resist change. Bias in the model can occur when people providing estimates act to influence the result one way or another. If there is pressure to find a way to get a particular project approved, the financial estimates may be adjusted to present a better view. If site leaders realize their location may be closed, they may adjust estimates to make the financials look worse. Once a transition is approved and in process, people within the sending site may impede progress to protect their jobs as long as possible, or disrupt the process out of a sense of retribution for losing their job. In one particular case, an otherwise straight-forward project turned into a major problem when equipment and documentation at the sending sight were not delivered complete and on-time. Dealing with strong unions, as in the aerospace industry, is particularly challenging. Terminating a few positions within one facility can create a nationwide strike if the union objects. Much of the human effect can be mitigated through negotiation combined with strong and effective management, both during the data collection process and throughout project execution. Even so, there will be situations that arise that were not predicted.

4.3 Financial Results Confidence Range

Within Honeywell, one of the desired outputs from this internship is the ability to estimate a potential range for a financial result. This capability was incorporated into both the TMI model and the Level 1 model.

4.3.1 Cash Flow Estimates

In most cases, the estimated range for a particular cash flow value is created based on personal experience. That is, it is someone's guess as to how far off they could be from the projected target. The recorded historical financial data available does not currently allow a mathematical assessment into primary cost drivers and typical error levels. Ideally, there would be enough data to perform a regression in order to estimate future projects. However, most transitions are unique events. There is often only one previous occurrence of a type of manufacturing operation moving to a specific region. In fact, there may be no previous record of the particular type of project being estimated. To further complicate the usage of historic data, the actual items that were included in different recorded categories have changed over time, so like-kind comparisons cannot be made.

4.3.2 Assumptions

Even though the range provided for an estimate may not represent a true confidence interval and the actual cost or savings realized may not be normally distributed, it is assumed that the most likely result is the target estimate with a decreasing probability for occurrence out to the range endpoint. It is also assumed that the probability of the actual result being above an estimate is the same for it being below.

When combining estimate ranges, it would not be proper to add up all of the potential deviations since the chance of all the realized costs and savings being on the extreme high or low side is very small. Instead, estimates calculated within the TMI and Level 1 model use a square root approach.

Δi = Potential deviation from an estimated expected value (i = Estimate 1,2,3,…)

$$\text{Total Predicted Range} = \text{Nominal Total Estimate} \pm \sqrt{\sum (\Delta i)^2}$$

Looking at cash flows, and how they represent value to the company, we have to consider the difference between inflows and outflows. For a typical transition, there is an investment period after which some operational savings occurs. The maximum value to the company is when the smallest investment creates the largest return. Similarly, the smallest value to the company is when the largest investment creates the smallest return. This principle is incorporated into the model for year-over-year results. Results for maximum and minimum NPV reflect company value.

4.3.3 Model Usage for Range Prediction

Within the TMI model, the range estimation process occurs within the final results page. The final results page lists itemized cash flows for each year. An example is included in Appendix B. An overall tolerance, listed as a percentage, for each item can be adjusted. Since the TMI model has 25 different data input pages, this approach allows individual estimate ranges to be displayed and adjusted along with the overall result all in one window.

The Level 1 model calculates range estimates for each item, and aggregates the estimates into the final results. The Level 1 model also allows the entry of a lopsided range in case moving the nominal value off-center is desired. The Level 1 model is discussed further in Section 4.4 below.

4.4 Level 1 Estimation Model

The TMI model was retained as the primary tool for performing a complete cash flow analysis. Use of the TMI model is already established within the Strategy and Integration group, and the amount of detail and results provided by the model are suitable for the final level approval process. However, the TMI model has a level of complexity that makes it difficult to use for quickly comparing scenarios at a low level. The Level 1 tool was developed within this research to perform these low level calculations, allowing easy 'what-if' scenario generation.

Within the TMI modeling process, a Level 1 analysis is considered the first step. It is a screening step to determine if a proposed project has any potential. The expectations for accuracy of a Level 1 analysis are not as high as the final Level 3 analysis. Keeping this in mind, the Level 1 tool was designed to meet the following requirements:

- Model must be easy to use
- Data inputs and financial summary are in the same view
- Time spent for Level 1 data collection and reporting should be 2-4 hours
- Financials report minimum, expected, and maximum results for 5, 10, and 20 years
- Baseline assumptions are easily viewed and adjusted
- Tool must allow easy addition, deletion, and modification of items for calculated results
- Individual factor estimates can be quickly overridden for unique cases
- The final results will be also populated into the traditional TMI results format for quick comparison between models

4.4.1 Level 1 Cash Flow Estimation, Assumptions

During a Level 1 analysis, most cash flows are estimated from an easily identified project parameter multiplied by an associated scaling factor. If sufficient data were available to perform a regression, a detailed estimation equation for each cash flow could be identified. The cash flow estimates would look like the equations below.

$$\text{Asset Move Expense} = \beta_0 + (\beta_1 * \text{Factory Area}) + (\beta_2 * \text{COGS}) + (\beta_3 * \#\text{ SKUs}) + \ldots + \text{error}$$

or

$$\text{Hidden Factory Expense} = \beta_0 + (\beta_1 * \text{Factory Area}) + (\beta_2 * \text{COGS}) + (\beta_3 * \#\text{ SKUs}) + \ldots + \text{error}$$

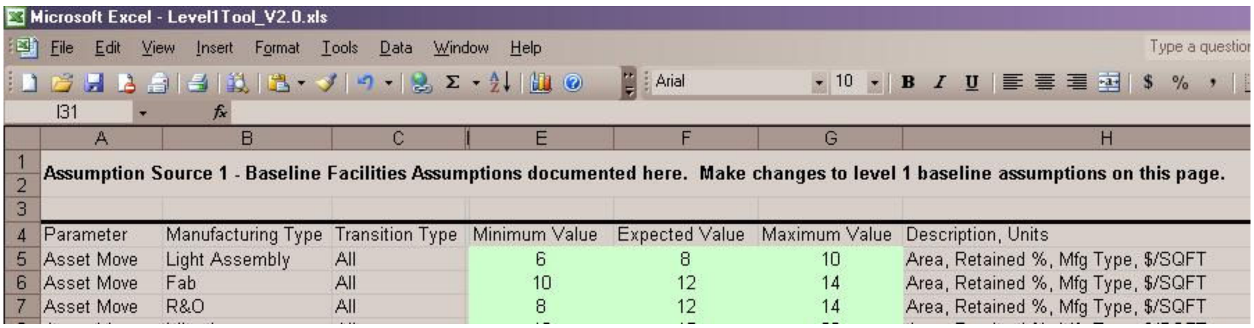
Within the Level 1 model, the significant parameters or primary cost drivers were identified for calculating an initial cash flow estimate. In order to keep the model simple, a small number of input parameters, listed below, were selected as significant cost drivers.

Level 1 Model Input Parameters

- **Manufacturing Type**
- **Transition Type**
- **Transition Distance**
- **Sending Site Region**
- **Receiving Site Region**
- **Production Floor Space**
- **COGS**
- **COGS – Labor %**
- **COGS – Material %**
- **COGS – Overhead %**
- **COGS Retained/Outsourced**
- **Outsource Region**
- **# of SKUs**
- **Transition Duration**
- **Census Training Overlap**
- **Asset Sale Value - Inventory**
- **Asset Sale Value - Property**
- **Census – Sending Site Direct**
- **Census – Sending Site Indirect**
- **Census – Receiving Site Direct**
- **Census – Receiving Site Indirect**

Individual cash flow estimates are based on one or more of these parameters. In addition to these parameters, the model also allows the direct entry of asset values, contingencies, and miscellaneous cash flows. An example of the Level 1 model input screen is included in Appendix C. The input fields are colored green (in B&W copy the fields show as darkened).

The baseline assumptions used to calculate cash flows are recorded in two lookup tables, one for transition costs and the other for regional census costs and labor rates. The lookup tables were created to allow records to be changed or added simply within a single page. In addition, if a cash flow becomes associated with a different set of input parameters or the basis for an estimate changes, the equations for estimating each cash flow can also be easily updated. The intent was to create a framework that can be updated as more is known about the primary cost drivers. The assumption source table allows the entry of minimum, expected, and maximum values. This format allows entries with asymmetric intervals. An example of the calculation process is shown in Figures 9 and 10. The input fields are colored light-green (in B&W copy the fields show as lightened). Once the baseline assumptions are established, capturing the potential range for a given activity, they can be used for a variety of scenarios without needing to be updated. Within the cash flow estimates screen, the model also allows the user to override any estimate if unique information is available.

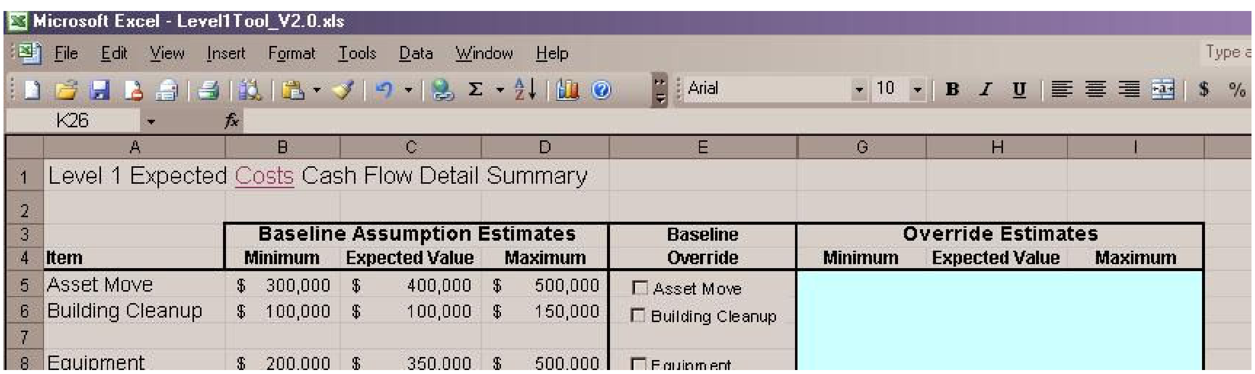

Microsoft Excel - Level1Tool_V2.0.xls

Assumption Source 1 - Baseline Facilities Assumptions documented here. Make changes to level 1 baseline assumptions on this page.

Parameter	Manufacturing Type	Transition Type	Minimum Value	Expected Value	Maximum Value	Description, Units
Asset Move	Light Assembly	All	6	8	10	Area, Retained %, Mfg Type, $/SQFT
Asset Move	Fab	All	10	12	14	Area, Retained %, Mfg Type, $/SQFT
Asset Move	R&O	All	8	12	14	Area, Retained %, Mfg Type, $/SQFT

Figure 9 – Level 1 Model Cash Flow Assumption Source

The primary cost driver for Asset Move costs is the retained facilities area in square-feet. The example below demonstrates a light-assembly process with 50,000sqft of retained manufacturing floor space. In Figure 9, the expected cost to move manufacturing assets for a light-assembly operation is shown as $8/sqft. The total expected cost, indicated in Figure 10, is $400,000 (or 50,000sqft * $8/sqft). Similar results are calculated for the maximum and minimum values.


Microsoft Excel - Level1Tool_V2.0.xls

Level 1 Expected Costs Cash Flow Detail Summary

	Baseline Assumption Estimates			Baseline	Override Estimates		
Item	Minimum	Expected Value	Maximum	Override	Minimum	Expected Value	Maximum
Asset Move	$ 300,000	$ 400,000	$ 500,000	Asset Move			
Building Cleanup	$ 100,000	$ 100,000	$ 150,000	Building Cleanup			
Equipment	$ 200,000	$ 350,000	$ 500,000	Equipment			

Figure 10 – Level 1 Model Cash Flow Estimates

4.4.2 *Timing of Cash Flows*

Similar to the TMI model, the Level 1 Model allocates cash flows on a monthly basis. The allocation process is automated within the model with the cash flows being spread evenly across the months in which they are likely to occur. This is performed by setting the likely start and stop points for an activity to happen during the implementation. The start and stop points are set as a fraction of the total transition duration. The model accommodates transition durations of up to 5 years, which covers most typical projects. Continuing with the Asset Move example from above, assume that assets are moved within a transition beginning at ¼, and ending at ¾, of the total implementation time. If the project transition duration is 24 months, then assets are moved starting in month 7 and ending in month 18. The total move takes 12 months so 1/12th of the total move expenses accrue each month.

Some cash flows extend beyond the transition duration, such as census savings. The model calculates financial performance indicators for 5, 10, and 20 year intervals. Therefore, it is assumed that all annual incremental savings as a result of the project continue out to 20 years.

4.4.3 Results

One of the original design requirements was to provide maximum, expected, and minimum IRR and NPV financial performance results for 5, 10 and 20 year periods. These results are summarized within the data entry window so the effect of the various input parameters on the results can be easily seen. Project results are displayed both before and after the impact of contingencies are included in the analysis. This output configuration provides a wide view of what can be expected from a project. A sample output is included in Appendix C, and summarized below in Figure 11.

The light-assembly project described earlier involves sending 50,000 sqft of manufacturing to Mexico. The transition duration is 24 months, and involves $1MM in COGS, 200 SKUs, and 50 direct heads. Some sample contingencies are included as well (see below).

Level 1 Financial Summary			
With Asset Sale	5 year	10 year	20 year
IRR - min	3%	26%	30%
IRR - Max	54%	69%	70%
NPV - Min ($MM)	($0.772)	$4.747	$10.666
NPV - Target ($MM)	$2.189	$10.247	$18.889
NPV - Max ($MM)	$5.162	$16.014	$27.651
Contingencies	Amount	Year	Ongoing
Eviron. Cleanup	$ -	0	N
Engineering OT	$ (125,000)	1	N
GRC Standards	$ -	0	N
Tax Impact	$ 150,000	2	Y
Discretionary Fund	$ -	2	Y
Incentives	$ (50,000)	1	Y
With Contingencies			
IRR - min	4%	27%	31%
IRR - max	54%	69%	69%
NPV - Min ($MM)	($0.635)	$5.137	$11.326
NPV - Target ($MM)	$2.326	$10.637	$19.549
NPV - Max ($MM)	$5.299	$16.404	$28.312

Figure 11 – Level 1 Model Financial Summary

In addition to this output, a copy of the TMI model results summary is populated within the Level 1 model allowing direct comparisons between the two models. The post-contingency 5 year NPV target represents the expected outcome within the TMI model results summary.

4.4.4 Model Validation

Project data was entered into both the TMI model and the Level 1 model and compared. The results from both models were found to be similar, which is the result of both models being based on the same cash flow assumptions. Comparing the two estimation processes only determines that the two models track for a Level 1 analysis, and does not validate the model against the real world. In order to validate that the model's financial projections match a real outcome, real project data is needed. One of the changes to the TMI process, described in Chapter 3, was to collect real project data into a single spreadsheet, referred to as the Lessons Learned database. This spreadsheet was designed to allow the validation of both the TMI model and the Level 1 model at a later date as the spreadsheet gets populated. The Level 1 model is designed to allow quick changes to cost assumptions and calculations, so that as this data is collected the model can be improved.

4.5 Lean Practices and the TMI Model

Factory transitions are a controversial topic. Changing the manufacturing footprint creates questions about the nature of the overall business. Other concerns deal with the emotional aspect surrounding the loss of jobs. In an effort to stay competitive into the future, jobs will continue to be exported to lower cost regions. US plant managers may be wondering if there is a way to prevent their plants from being closed. Over the past decade, Lean Manufacturing has been implemented widely within US manufacturing to improve operational efficiency and stay competitive. This research examines how improving operational efficiency, or implementing lean practices, will affect the financial projections of a transition analysis.

Whether or not a transition project gets selected for implementation depends on how it compares to other projects on the table and if the project passes the minimum threshold for expected return. Given that some implemented projects may just pass the minimum expected return, improving the efficiency of the sending site may change the financials enough to make it no longer economically viable to relocate the business in light of the required investment. Of course, efficiency improvements might also make it easier to move a factory.

Lean Manufacturing[7] is a fairly broad term that is used to describe a range of advantageous operational activities, such as reducing inventory, improving work flow, and eliminating unnecessary processes. The term may also be perceived negatively as it has become associated with reducing labor requirements and job elimination. Therefore, rather than use the term Lean Manufacturing to relate factory efficiency and transition financials, the relevant independent

[7] Womak et al., Lean Thinking – Banish Waste and Create Wealth in Your Organization, 2003

operational characteristics will be considered directly. Four potential areas of efficiency improvement within a factory will impact a transition analysis: census, inventory, space requirements, and standard work. The ability to adjust these four parameters independently and determine the net impact on a specific project has been included as an additional feature of the Level 1 model. The assumptions and basis for these calculations are described below.

4.5.1 Census

For outsourcing, consolidation, and relocation projects, long term labor savings is a highly significant, if not the most significant, positive cash flow contributor. Typical scenarios move both direct labor and any associated indirect labor from high-cost regions to either outside contractors or a low-cost region. The cash generated annually equals the number of heads multiplied by the labor differential. Since year-over-year labor savings is positively correlated to the number of positions being relocated, reducing the labor associated with a particular manufacturing process prior to performing a transition analysis will reduce the transition project's ROI.

Consider the previous Mexico relocation example from above. Within the Level 1 analysis, improving labor efficiency or reducing labor content by 10% lowers the projects NPV by $364,000, from $2.33MM to $1.96MM. A 20% reduction in labor creates a $728,000 reduction in project value. Given our original $2MM minimum NPV threshold for project approval, a 10-20% reduction in labor would make this project no longer viable. This example is summarized in section 4.5.5.

4.5.2 Inventory

Reduction of inventory levels primarily affects outsourcing decisions. When factory processes are outsourced, inventory held at the sending site gets sold to the contract manufacturer creating a cash inflow which helps offset the transition investment requirements. Reducing inventory levels within the factory prior to performing a transition analysis will have the same effect; however, the cash inflow will be associated with operational improvements within the plant rather than an outsourcing decision.

For other types of transitions, inventory reduction has the small effect of reducing the cost of any inventory pre-build requirement, lowering initial investment requirements. In our example, a 10% reduction in inventory raises the project NPV from $2.33MM to $2.37MM.

4.5.3 Space Requirements

Elimination of unnecessary manufacturing steps, processes, inventory, equipment, and fixtures will reduce the space requirements for a given product. Ideally, the space recovered is put to a productive use generating income for the plant. Improvements in operations that reduce space requirements also lower the cost to move the operations to another location. In our example, a 10% improvement in space efficiency increases project NPV from $2.33MM to $2.43MM.

4.5.4 Standard Work

Creating standard work and documenting processes will reduce hidden factory levels within the plant. Recall that hidden factory costs represent the activity required to document undocumented processes. Improvements in standard work will reduce the initial investment requirements for a transition. For the Mexico example, a 10% improvement in standard work represents an increase in value of $22,000.

4.5.5 Level 1 Model, Example

Section 4.4.3 describes the results for the Mexico light-assembly example. The Level 1 model has, within the data entry window, pull-down menus for selecting pre-transition efficiency gains for census, inventory, floor space, and standard work. These gains are assumed to be produced prior to the transition assessment. Figures 12 and 13 below describe how incremental improvements in these four areas change the project's projected 5 year financial performance.

Project NPV with 10% Efficiency Gains

5 Year Expected NPV - $MM	Census: 0%	Census: 10%	Census: 0%	Census: 10%	
Inventory: 0%	2.33	1.96	2.35	1.98	Production Area: 0%
Inventory: 10%	2.37	2.00	2.39	2.03	
Inventory: 0%	2.43	2.06	2.45	2.09	Production Area: 10%
Inventory: 10%	2.47	2.11	2.49	2.13	
	Standard Work: 0%		Standard Work: 10%		

Figure 12 – Expected Project 5 year NPV

Project NPV with 20% Efficiency Gains

5 Year Expected NPV - $MM	Census: 0%	Census: 20%	Census: 0%	Census: 20%	
Inventory: 0%	2.33	1.60	2.37	1.64	Production Area: 0%
Inventory: 20%	2.41	1.68	2.45	1.73	
Inventory: 0%	2.53	1.80	2.58	1.85	Production Area: 20%
Inventory: 20%	2.62	1.89	2.66	1.93	
	Standard Work: 0%		Standard Work: 20%		

Figure 13 – Expected Project 5 year NPV

If gains are achieved equally in each area the overall value for the transition declines. Some of the loss in NPV from census reductions is regained by improvements in inventory, standard work, and floor space; however, the net impact is still negative. This demonstrates that improvements to operational efficiency within a plant can help make the case for not moving that facility, as least currently, to a low-cost region. This can be viewed from the perspective of how and where savings generated by operational improvements are linked. Savings generated by activity within a plant is associated to that plant's management, whereas improvements from a transition project become attributed to the project.

4.5.6 Final Note on Efficiency

Within the context of this analysis, those responsible for implementing certain operational improvements may perceive their work as making the eventual transfer of their jobs more likely. Thus, when undertaking such improvements, this apparent disincentive needs to be handled with effective communication and management. Ultimately, being both efficient and competitive is the only way to survive in the current global manufacturing environment. While regulation of the aerospace industry creates significant barriers to entry, there are currently enough players that products are becoming more differentiated by price. Allowing inefficiencies to remain within operations will only improve the opportunities for other manufacturers to compete for business, which ultimately presents a greater overall threat to job security.

5 Landed Cost Model

Within the strategic planning process, a tool was needed for calculating the entire value chain cost. A limitation of the TMI model is that each model considers a single scenario and doesn't incorporate the part-specific data required to determine if the receiving location is the ideal location. As described in Chapter 3, the strategic development process entails defining a final-state vision and then using the TMI model to plan toward achieving that vision. When defining what the factory footprint should look like, some concept of the total cost to produce in different regions is needed. The Landed Cost model was developed to provide insight into how four major cost drivers impact the total value chain cost for various global regions.

Total landed cost models attempt to estimate all of the cost effects of individual value chain configurations, and thus estimate the total operating cost. However, the number of factors needed to determine total cost is seemingly endless; there is always something else that can be included within the model. Total landed cost models have not been widely used within Strategy and Integration because the previous models available were either too complicated for everyday use, required the direct estimation of each cost effect, or too simplistic to be trusted. What was needed is a model that strikes a balance between estimation complexity and ease-of-use. The present Landed Cost model was developed to suit this purpose. This Landed Cost model is more of a rule-of-thumb model, in that it estimates, and compares across different regions, four major cost drivers: labor, logistics, inventory, and taxes. The results of the model do not indicate the real costs to manufacture in a specific area, but rather allow comparisons of the incremental effects associated with these four factors. The model is used to highlight the differences between regions and the analysis should be used as a starting point for investigating regional opportunities.

Before proceeding with development of the Landed Cost model, other modeling tools available were assessed for usability. One of the available modeling packages would perform fairly sophisticated inventory optimizations. With this software, in order to understand cross regional inventory differences, individual models would need to be constructed. For the demand profiles typical of the aerospace industry, with low volumes and high production variability, the required level of support and resultant benefit made this tool impractical for everyday use. Another modeling package used a database of regional trade laws to determine which regions and manufacturing sequences minimized tariffs. While the models considered were useful for their specific purposes, they did not cleanly provide the kind of visibility across different cost drivers that is needed.

The original specification for the Landed Cost model includes the following:

- Simple user interface with input data and results on the same screen
- Minimal input data requirements for desired accuracy
- Allows simple adjustments to cost structure and region data
- Calculates cost effects of labor, logistics, inventory, and taxes
- Analysis compares between different regions
- Allows modeling of individual parts as well as entire part families

5.1 Labor Costs

Labor cost calculations are straight-forward, requiring both the labor content in hours and the hourly labor rate applied. Even though part specific data on labor content is not easily accessible within the Strategy and Integration group, labor content was defined as a required input to the model. In order to calculate regional effects on costs, some minimum knowledge about the product being produced is required.

Labor Cost = Labor Content * Labor Rate

Global labor rates were collected from the US department of Labor Bureau of Labor Statistics[8]. Hourly labor rates in US dollars for manufacturing workers were used as the model baseline. Using labor statistics from a single source helps ensure like-kind comparisons within the model. When adjusting labor rates to account for skill level, fringe, or burden, it’s important to make

[8] <ftp://ftp.bls.gov/pub/special.requests/ForeignLabor/ichccsuppt02.txt>

similar adjustments to all regions being considered. A comprehensive source for employee fringe data is not available, and internal estimates are not available for all regions. Overhead burden estimates can also be misleading depending on how different sites are managed. Maquiladora factories may appear to have a low associated overhead, but if facility operations are being supported by a sister plant in the US then the true management costs may not be captured. For this reason, fringe and burden were not included in the initial labor rates used. This can be seen as underestimating the true cost of labor. However, since US benefit costs are some of the highest, the associated error will be on the conservative side. When making adjustments to labor rates from the baseline, care should be taken to not bias the results toward a particular region.

5.2 Logistics Costs

Freight, duties, and customs clearance fees are included as the sources of incremental logistics cost. In order to calculate freight, the part's weight and shipping configuration are needed. Honeywell's internal shipping rate data tables were available for two different global shipping modes, economy and express. The model also allows the input of shipping carton size, which is not used for cost estimation but rather to check if oversized package charges will be assessed by the shipping company. The per-piece shipping cost is calculated as follows.

Box Weight = Part Weight * # of Parts per Carton * Packaging Weight Factor

Total shipping cost is determined from a regional rate lookup table.

Per-piece Shipping Cost = Total Shipping Cost / # of Parts per Carton

When considering moving production to an emerging region, the availability of a local supply base needs to be taken into account. Within the model, both the shipping mode and availability of a local supply base can be selected for each region. Finished goods are assumed to return to a US facility before being delivered to the customer. The model also assumes that if a local supply base is not present, then raw materials will be shipped from the US effectively doubling the incremental shipping cost.

Customs duties and clearance fees are assessed as importation charges and are levied independently of the origin of manufacture. Import tariffs are calculated based on the products Harmonized Tariff Schedule (HTS) category and the clearance fees are charged on a per-container basis. Most tariffs are charged as a percentage of the product's value. A database of HTS categories is available online with the associated import charges[9]. Care should to be exercised when selecting a category, as actual category declarations will need to be documented and justified. Fortunately, no duties are currently levied on most aircraft components. Clearance fees are typically $25-$50 per carton. The model takes as an input the global duties and fees to be assessed, and allocates incremental charges to imported parts as follows.

Customs Charges = (Part Cost * Tariff Rate) + (Clearance Fee / # of Parts per Carton)

[9] <http://www.usitc.gov/tata/index.htm>

5.2.1 Shipping Configurations

Since material returns to a US facility before being delivered to the customer, a fair amount of inbound shipping flexibility should be available. The model allows the user to change shipping configurations by adjusting the number of parts shipped per container. Changing the shipping configuration to improve shipping efficiency has a dramatic effect on logistics cost. Shipments are typically charged a base fee plus an incremental cost for weight. Spreading the shipping base fee and any customs clearance fees over multiple parts will greatly reduce the impact of those fees. Figure 14 below shows the annual cost results for a family of 10 sample Machined Housings. The costs are estimated for manufacturing in Singapore, China and Mexico. Keep in mind that the model calculates incremental costs and the results should be viewed comparatively. The baseline cost for US production is $1.18MM. This example includes inventory and tax effects and assumes no local supply base.

Figure 14 – Shipping Effects on Sample Landed Cost Data

5.2.2 Simplified Labor vs. Logistics Model

Looking at just the first two cost drivers, labor and logistics, some generalizations or rules-of-thumb can be generated regarding where parts should be manufactured. Consider sourcing in China, which is currently a hot topic. When does it make sense to go to China over Mexico? Labor is cheaper in China, but the shipping costs are higher. The Landed Cost model can be used to determine the sourcing threshold between these two regions depending on the labor content and product weight. An example of this kind of analysis is included below (the actual cost structure has been concealed to protect confidentiality).

* Values shown are per Shipping Carton (Hours/Carton, Lbs/Carton)

Figure 15 – China vs. Mexico

Based on this example, a shipping carton that weighs 8 lbs and contains products that require 20 hours of labor should be sourced in China. Similarly, a carton that weighs 50 lbs and contains products that require 40 hours of labor should be sourced in Mexico. Obviously, this is a simplification, but it demonstrates how product characteristics influence total cost.

5.3 Inventory Costs

The Landed Cost model does not attempt to optimize inventory levels within the plants. The model assumes that product demand and inbound material availability will be constant across all regions. Given the absence of a local supply base, inbound material is assumed to ship from the US. Outbound material is assumed to return to a US facility before shipping to the customer. If demand and supply profiles are constant, then inventory levels within plants are assumed to be constant as well. This may not always be the case, but it is possible given proper management within the regional facilities. When comparing plants with similar characteristics across regions, the incremental difference in material levels is associated with the shipping pipeline, both inbound to the assembly plant and outbound returning to the US. The Landed Cost Model determines the additional material and value associated with the transit time and adds the material holding cost to regional part costs.

Additional material requirements within the system come from two areas: material in the pipeline and additional safety stock requirements created by shipping time and variability. The boundary is defined around the system at a high level so that all additional material is captured within the system regardless of who owns the material. We assume that additional costs get passed along, ultimately increasing costs downstream.

The input requirements for this calculation are defined as:

- Unit Cost (USD)
- Annual Demand (Units)
- Desired Customer Service Level (%)
- Inventory Holding Cost of Capital (%)
- COGS Average Raw Material Component (%)
- Shipping Time (Days)
- Shipping Variability (%)
- Weekly Demand Variability (%)

Both Unit Cost and Annual Demand are part specific while the other parameters are defined once and applied universally. The COGS Average Raw Material Component is used to value material inbound to the factory should a local supply base not exist. Since actual variability may be difficult to determine, a generally expected percentage of error is used. Most people will describe a difference of approximately two standard deviations when stating potential error, so variability is defined within the model as two sigma.

The process for calculating inventory costs is described below[10,11]:

$$Es = \text{Expected Shipping Time in Weeks}$$
$$\mu = \text{Weekly Demand}$$
$$\sigma_d = \text{Weekly Demand} * \text{Demand Variability} / 2$$
$$\sigma_s = \text{Shipping Time} * \text{Shipping Variability} / 2$$
$$\beta = Es * \sigma_d^2 \quad , \quad \eta = \mu^2 * \sigma_s^2$$

$$\text{Pipeline Inventory} = \mu * Es$$
$$\text{Additional Safety Stock Inventory} = z(\text{Customer Service Level}) * \sqrt{\beta + \eta}$$
$$\text{Incremental Inventory} = \text{Pipeline Inventory} + \text{Additional Safety Stock Inventory}$$

[10] Simchi-Levi et al., Designing and Managing the Supply Chain – Concepts, Strategies, and Case Studies, 2003
[11] Chopra et al., Supply Chain Management – Strategy, Planning, and Operations, 2004

Using the above method, incremental inventory requirements are calculated separately for outbound inventory (OI) and for inbound inventory (II) when raw materials are being supplied from the US. The material holding cost associated with these two sources is defined as follows.

CC = Inventory Holding Cost of Capital
MC = COGS Average Raw Material Component (%)
II = Incremental Inbound Inventory (Used when no local supply base exists)
OI = Incremental Outbound Inventory (Returning to the US)

Inventory Cost per Part = ((II*Unit Cost*MC*CC) + (OI*Unit Cost*CC)) / Annual Demand

For Aerospace products, the contribution from incremental inventory to the overall pre-tax regional cost result ranges from 2 - 30%, depending on the unit cost and shipping mode. Aerospace parts tend to be fairly expensive, and long shipping channels can add a significant inventory contribution to the landed cost. Using one of the Machined Housings as an example, labor to produce the part in China is estimated at ~$13.60 and the incremental inventory holding cost for economy shipping is ~$11.00.

5.3.1 Use of Expedited Shipping

The use of expedited shipping is common within the Aerospace industry. There is a pervasive expectation for moving shipments quickly. The demand profile of certain products can explain some of this behavior, with demands for some engine or service parts ranging between 20-50 pieces/year. This section looks at whether this expediting is justified and how much might be saved through better planning.

Marshall Fisher proposes two categories, Functional and Innovative, for product classification when determining if a supply chain should be efficient or market responsive[12]. The use of expedited shipping is more of a characteristic of market responsive supply chains. In his work, What is The Right Supply Chain for Your Product?, he describes demand profile differences between the two categories. The aspects of a demand profile that would classify a product as Functional or Innovative are shown below in Figure 16 along with an assessment of the typical products produced by Honeywell Aerospace.

According to the given thresholds, Honeywell Aerospace's products are not completely Functional or Innovative. Product life cycles and the demand for service parts can span decades which suggests a Functional property. However, the other aspects of their demand profile suggest that there is more of an Innovative than Functional aspect to their product line. In this case, expediting shipments may make the most sense for the organization.

[12] Fisher, What is the Right Supply Chain for Your Product, 2000

Aspect of Demand	**Functional**	**Innovative**	**Honeywell Aerospace**
Product Life Cycle	More than 2 Years	.25 – 1 Year	More than 2 Years
Contribution Margin	5 - 20%	20 – 60%	20 – 60%
Product Variety	Low (10 - 20 variants per category)	High (often millions of variants)	High
Average Margin of Error in Forecast	10%	40 – 100%	~ 10 – 40 %
Average Stockout Rate	1 – 2%	10 – 40%	~ 10%
Average end-of-season markdown percentage	0%	10 – 25%	N/A
Make-to-order Lead time	6 Months to 1 Year	1 Day to 2 Weeks	2 weeks to 6 months

Figure 16 – Functional vs. Innovative

Incorporated into the Landed Cost model are two shipping rate tables, Express and Economy. The model considers both the shipping time and demand profile when estimating inventory costs. Both modes of shipping were compared using the Machined Housing product family data to determine the total annual cost difference. The same model assumptions from before apply, and the parts ship 32 to a carton. The result is shown in Figure 17.

Annual Cost	**Singapore**	**China**	**Mexico**
Express	$790,000	$660,000	$610,000
Economy	$780,000	$610,000	$630,000

Figure 17 – Express vs. Economy Shipping

The results are mixed. Interestingly, in the case of Mexico the total cost goes up when economy shipping is chosen. This suggests that, given the Aerospace product demand profile, the use of expedited shipping can be justified.

5.4 Tax Effects

Tax effects are the last landed cost driver incorporated into the model. Tax effects refer to the taxation of revenue and not import duties, which are included under logistics. Different corporate tax rates apply depending on which region revenue is earned in. For example, the US corporate rate is about 40%, whereas in Singapore it is only 20%.

For the regional rate to apply, the revenue generated from associated operations must remain in that region. This is generally not a problem. However, there are US tax rules that specify how revenue gets allocated between different manufacturing regions. Revenue is transferred between facilities through the use of internal transfer prices. US tax law states that the establishment of internal transfer prices must be an arms-length transaction. That means that the price a facility receives for a part must be similar to what a local contractor would receive for the same part.

In order to perform this analysis, the following additional inputs are required:

- Region Tax Rates (%)
- Average Margin (%)
- Internal Transfer Pricing Margin (%)

The model estimates the transfer price based on the original unit cost, the calculated regional savings, and an internal transfer pricing margin. From the transfer price, the amount of revenue allocated to the US and the regional facility is determined. Shipping cost is paid by the receiving facility, so if no local supply base exists, the incremental inbound shipping is included in the producing facilities costs.

The process for calculating tax effects is described below:

$$\Delta_L = \text{Regional Labor Cost} - \text{US Labor Cost}$$
$$IS = \text{Inbound Shipping Cost (To the Plant)}$$
$$OS = \text{Outbound Shipping Cost + Duties + Fees (Returning to the US)}$$
$$UC = \text{Unit Cost (Original cost to produce part in the US)}$$
$$AM = \text{Average US Margin}$$
$$TPM = \text{Transfer Pricing Margin}$$

$$\text{Old US Tax} = UC * AM * \text{US tax Rate}$$
$$\text{Transfer Price} = (UC + \Delta_L + IS) * (1 + TPM)$$
$$\text{New Region Tax} = (UC + \Delta_L + IS) * TPM * \text{Regional Tax Rate}$$
$$\text{New US Tax} = ((UC * (1 + AM)) - \text{Transfer Price} - OS) * \text{US Tax Rate}$$

$$\Delta_{TAX} = (\text{New Region Tax} + \text{New US Tax}) - \text{Old US Tax}$$

For mechanical assemblies, the internal transfer pricing margin is set to ~10%, which represents the amount that might be negotiated with an external contractor. The average US margin is set to Honeywell Aerospace's typical product margin. We assume that the original price the customer pays will stay the same, although over time there may be price erosion. The resulting net impact of tax effects is that all costs are pulled toward the baseline. If producing in a different region reduces cost then more taxes will be paid. Similarly, if costs are increased then less tax will be paid. The magnitude of the difference depends on the individual tax rates for each region and the transfer price. The model provides the benefit of being able to see the net effect of different regional tax rates on the overall result.

The model is estimating a steady-state environment. Not included in the analysis are any tax credits or penalties. Local governments may award tax holidays to promote regional investment. Similarly, additional tax penalties may be levied, such as the US intellectual property tax. The effects of any tax incentive programs need to be considered outside of the model analysis.

5.5 Landed Cost Model

The user interface of the Landed Cost model allows quick comparisons of different scenarios. A sample screen-shot with data is included in Appendix D. Pull down menus are used to select up to three different regions to compare. Region data is contained in a look-up table which can be easily modified. Information on labor rates, shipping zones, shipping times, and regional tax rates are included in the table. The initial version of the model contains information for the following 11 regions, although the model accommodates inserting new records as needed.

Manufacturing Regions

- **Canada**
- **China**
- **Czech Republic**
- **Indonesia**
- **Israel**
- **Japan**
- **Malaysia**
- **Mexico**
- **Singapore**
- **Taiwan**
- **UK**
- **US - Phoenix**

Given three regions selected for a particular analysis, the model will identify the lowest cost origin for each part entered. While individual parts might be sourced optimally in a particular region, parts often need to be sourced together. The model also calculates the total annual cost for the entire part family based on individual part demand. The products with higher demands have more influence on the annual estimate and are thus weighted more in the sourcing decision. Sample annual results for the Machined Housing example are shown below in Figures 18 and 19. These results are based on the original assumptions from above, include inventory, and are shown both without and with tax effects.

Machined Housing Results Without Tax Effects

MH Example, Baseline Cost: US ~ $1.2MM	**Express Shipping Current Supply Base**	**Express Shipping Local Supply Base Exists**	**Economy Shipping Current Supply Base**
1 Part per Shipping Carton	Singapore~ $1.4MM Mexico ~ $1.1MM Czech R ~ $1.6MM	Singapore~ $1.1MM Mexico ~ $.84MM Czech R ~ $1.1MM	Singapore~ $1.3MM Mexico ~ $.95MM Czech R ~ $1.4MM
4 Parts per Shipping Carton	Singapore~ $.80MM Mexico ~ $.48MM Czech R ~ $.83MM	Singapore~ $.65MM Mexico ~ $.37MM Czech R ~ $.60MM	Singapore~ $.71MM Mexico ~ $.42MM Czech R ~ $.73MM
20 Parts per Shipping Carton	Singapore~ $.61MM Mexico ~ $.27MM Czech R ~ $.59MM	Singapore~ $.51MM Mexico ~ $.21MM Czech R ~ $.43MM	Singapore~ $.55MM Mexico ~ $.26MM Czech R ~ $.49MM

Figure 18 – Annual Landed Cost Results Excluding Taxes

Machined Housing Results With Tax Effects

MH Example, Baseline Cost: US ~ $1.2MM	Express Shipping Current Supply Base	Express Shipping Local Supply Base Exists	Economy Shipping Current Supply Base
1 Part per Shipping Carton	Singapore~ $1.3MM Mexico ~ $1.1MM Czech R ~ $1.4MM	Singapore~ $1.1MM Mexico ~ $.96MM Czech R ~ $1.1MM	Singapore~ $1.2MM Mexico ~ $1.0MM Czech R ~ $1.3MM
4 Parts per Shipping Carton	Singapore~ $.90MM Mexico ~ $.75MM Czech R ~ $.94MM	Singapore~ $.83MM Mexico ~ $.68MM Czech R ~ $.81MM	Singapore~ $.89MM Mexico ~ $.72MM Czech R ~ $.89MM
20 Parts per Shipping Carton	Singapore~ $.80MM Mexico ~ $.62MM Czech R ~ $.80MM	Singapore~ $.74MM Mexico ~ $.59MM Czech R ~ $.71MM	Singapore~ $.78MM Mexico ~ $.63MM Czech R ~ $.75MM

Figure 19 – Annual Landed Cost Results Including Taxes

These results indicate that, among the three regions considered, Mexico would be the lowest cost origin for the Machined Housings. Of these three regions, Mexico's tax rate is the highest at 30%, compared to 20% and 24% for Singapore and the Czech Republic, so the tax impact for Mexico is greater. Economy shipping would actually raise Mexico's post-tax Landed Cost results, and establishing a local supply base for raw material would create an additional $30,000 in savings for these parts annually.

The results presented within the model represent hypothetical scenarios, and historical cost data for these situations is not available. Without actual part-specific shipping, inventory, and tax data, validation of the model is impossible. Typically, these costs are not captured and recorded in one accessible location within the organization. In fact, different individual departments are responsible for managing these aspects of operations. Should this data become available in the future, the model can be validated at that time. During the construction of this model, the incorporated methodology was produced using details provided from each responsible department and should provide reasonably accurate estimates.

The Landed Cost model is intended to be the first step in performing a sourcing analysis. It functions as a rule-of-thumb tool and can be used to efficiently compare various manufacturing sources. Assumptions made within the model were intended to maintain the desirable level of usability, and the results will reflect these generalizations. Still, the model is useful for providing insight into how the four major cost drivers combined with various regional effects will impact landed cost.

5.6 Additional Sourcing Risks

When comparing different regions for sourcing opportunities, there are additional risks that should be considered which are not represented within the models. Constraining candidate locations to established trading regions will help mitigate some risks. Some sources of financial risk include regional government instability, currency, and labor force issues. Increasing the length of the value chain to foreign countries can also create quality and customer service problems, as well as slow down the company's ability to respond to those problems. Before moving ahead with a transition project, a regional risk assessment should be performed. A requirement for completing risk assessments has been added to the TMI modeling process and is included in the work instruction under the minimum requirements for project approval.

6 Integration

The Landed Cost model calculates steady-state operating costs for different potential manufacturing origins. The Landed Cost model does not calculate total cost and should be used comparatively, looking at the cost differential between regions. Even though the same assumptions are applied to all regions, there will be error associated with both the estimation process and not capturing all costs. Therefore, the results should be viewed in terms of the order-of-magnitude in cost difference between regions. Along with results from the Landed Cost model, customer and agency requirements, the supply base, and desirable factory footprint also need to be considered. The model is the first step in identifying suitable manufacturing locations and should be used to support the generation of a strategic vision.

Once the final-state vision for a manufacturing value-chain is identified, the TMI model is used to develop a plan for moving toward that vision. The TMI model calculates the net benefit of moving operations while considering the initial investment requirements for the transition. The TMI model captures incremental cash flows associated with transition activity including cash flows associated with cost drivers used in the Landed Cost model. The methodologies for the two models overlap in some areas; however, each approaches the cost analysis from a different perspective. The Landed Cost model uses individual part data to determine the associated value-chain cost, while the TMI model uses operational level data associated with changes to the operations to define the switching cost and benefit. Together, the Landed Cost and TMI models provide a detailed assessment of the operational landscape, with the Landed Cost model calculating operational cost effects traditionally overlooked within the TMI.

The procedure for using these models has been incorporated into Honeywell's strategic planning and transition process documentation as described in Chapter 3. Specific modeling technicalities and requirements are defined along with the underlying philosophy of the process. The application of both models together will improve the efficiency and effectiveness of the strategic planning and implementation process.

7 Conclusion

In the increasingly competitive environment of the aerospace industry, analytical approaches for supply chain and operations design are becoming indispensable. The techniques outlined in this thesis are not the only available methods for answering cost-related strategic questions. The approach taken with the Level 1 and Landed Cost model was to provide reasonable resolution into the major cost drivers while minimizing data collection requirements and simplifying the user interface. In order to simplify the models, some accuracy was sacrificed. There are always more details that can be incorporated into a model. However, the additional effort required to operate a complex and precise model is not always justified. Being able to quickly gain a sense for how major cost drivers will impact a project allows the efficient allocation of project management resources. In a sense, the models were designed to provide the largest informational return for the time invested in collecting project data.

Some strategic insights derived from preliminary use of these modeling tools include:

- Efficient census utilization improves the financial case for retaining existing manufacturing facilities in the US.
- Shipping efficiencies can have a dramatic effect on annual landed costs.
- Express shipping is justifiable for typical aerospace demand profiles.
- The case for off-shoring manufacturing to China cannot be made universally, and depends largely on what is being produced.

7.1 Management Feedback

The response from Honeywell managers and other key stake holders on the models and revised business process has been very positive. The specifications for model development were defined in response to their original needs and interests for model enhancements. While some of the improvements were analytical, such as the ability to output a range for the expected result, other benefits were in the form of a simplified user interface. For example, having the project input data and the financial result on the same screen allows the effect of adjustments to the input data to be seen directly. This is helpful in establishing a cause-and-effect relationship between specific project parameters and financial performance; within the Level 1 model, the effect of shortening the transition implementation duration can be quickly defined, helping management decide if the additional resources required to expedite a project can be financially justified.

One of the more pressing issues facing ISC leadership is how much and what type of manufacturing to pursue in China. There is a concern that delaying the establishment of operations in China will become a competitive disadvantage. Understanding how China performs from a landed cost perspective is a key part of any China operations strategy, and the Landed Cost model helps frame this discussion for different aerospace products. The result shown in Figure 15 is an example of how the model can be used to screen products for a specific region. In this case, the likely candidates for Chinese sourcing are lighter products with high labor content, such as wiring harnesses. In the machined housing example, Mexico was identified as the optimal sourcing location when compared to China.

Revisions to the process, which have been incorporated into the TMI modeling work instructions, not only establish a boundary around the problem of determining the optimal strategic solution, but also help define an ideology for developing ISC strategy. Formalizing the process method, definitions, deliverables, and approval requirements will allow the people within Strategy and Integration to more effectively identify and assess relevant cost drivers for a particular decision. Simply identifying taxes as a major factor for total organizational efficiency has opened up discussions with Honeywell's tax group that have been useful in defining negative tax implications for certain transitions as well as identifying potential opportunities for tax related savings. While the effects of particular cost drivers are incorporated into the TMI analysis, defining the cause/effect relationships is particularly useful at the high level, where management is developing the long term strategic vision. Finally, a critical part of the new process is the documentation of lessons learned. Management fully appreciates that the knowledge from previous and current projects needs to be retained and used to drive future improvements to the strategic planning process.

7.2 Practical Considerations

During this project, one of the challenges was developing an estimation methodology with limited data. Concerns over confidentiality prevent the direct appraisal of each transition project. Currently, much of the initial estimation process for transition projects is based on the personal experience of a few key individuals within the strategy group. During the development of the Level 1 model, this experience was captured where possible and formed the basis for the model's analytic methodology and baseline assumptions. Historical data for a few projects is available, however differences in how cash flows were accounted for make direct comparisons between these projects difficult. In addition, there is not enough project data to perform a statistical trend analysis. In a way, each project has unique features that highlight potential areas of variation and complicate the estimation of an expected result. As far as the TMI process is concerned, these data availability issues are likely to continue into the near future. With the incorporation of the Lessons Learned database, new data will be collected in a meaningful fashion. However, transitions are long events, and the transitions that begin today may not reach completion for 2-4 years. Therefore, it is important to understand how the major cost drivers impact the result along with potential sources of variation and to not simply rely on the project's bottom line. When presenting an analysis, assumptions and potential contingencies need to be communicated.

Similarly, with the Landed Cost model, specific part data availability was problematic. The current process for determining part cost is based largely on quoting to part drawings. Information about part weight and time-based labor content is not currently captured in an accessible database or in one location. In fact, the initial data used to test the model was provided by an internal supplier with a high degree of suspicion. As described earlier, when making landed cost calculations, some knowledge about the part is required. Estimates for weight and labor content can be used, but the accuracy of the estimate will influence results.

Initially, it will be harder to use the landed cost model as the group determines the best way to collect part data. Thinking in terms of landed cost represents a culture shift for the organization, and developing the internal processes to readily support this kind of supply chain analysis will take some time.

7.3 Lessons Learned

This internship and research project was selected with the intent of learning about and gaining practical experience with many of the concerns relating to supply chain globalization. This experience offered the opportunity to explore a wide spectrum of concepts relating to globalization costs and benefits. Some of the specific topics where personal knowledge was realized are summarized below. However, these examples in no way comprise the full extent of learning or value achieved as a result of this project.

7.3.1 Relevant Incremental Cash Flows

Calculating the net present value of a cash flow stream is fairly straight-forward process. The difficulty lies in determining which incremental cash flows are generated as the result of a strategic transition decision. The sources of cash flow defined in Appendix A represent a comprehensive assessment of what might be expected within the major transition categories: insourcing, outsourcing, consolidation, and relocation. Estimating the exact magnitude of each cash flow can be a complicated process. However, knowing the scope of concerns needing an estimate defines a boundary around the problem and allows resources to be deployed so that the right questions get answered. In order to define which cash flows should be included in the analysis, knowledge of the implementation requirements and process is needed. This internship provided the opportunity to interface with and learn directly from the people responsible for creating these estimates as well as the individuals involved in executing or implementing the transitions. Having direct contact with these individuals provided the opportunity to develop a comprehensive understanding of the total planning and implementation process.

7.3.2 NPV Effects vs. P&L Effects

Managers of public companies need to be aware of how investment decisions and activities will impact the company's financial reports in light of performance projections and expectations. Transition projects may be additionally constrained by how the project affects the company's P&L statements. Unfortunately, as projects are selected for implementation, some otherwise financially sound projects can be indefinitely postponed due to the nature or level of activity involved. An example of a P&L concern is the sale of inventory to a contract manufacturer during an outsourcing decision. The sale of assets creates a positive cash flow increasing project NPV. If the book value of the inventory is more than the sale amount, the transaction will be recorded on the financial statements as a net loss. Similarly, sales of Plant, Property, and Equipment (PPE) can have a significant P&L impact depending on how much depreciation has been recorded and the current book value. In principle, all projects that meet minimum NPV hurdle requirements should be executed. Since there are usually implementation resource limitations, a subset of available projects will be selected for approval. Typically, the projects that will create the highest return and cumulatively have a lowest level of negative P&L impact are chosen. A valuable part of this internship was not only learning how transition activity creates incremental cash flows, but also how those cash flows will be recorded into financial records.

7.3.3 Leaning Effects on Transition Cash Flows

The results of modeling work outlined in section 4.5, Lean Practices and the TMI Model, offer a unique perspective for what is typically a binary decision. The implementation of lean manufacturing practices has been considered throughout the 90's as a way to maintain US competitiveness in the global market. With current trends toward moving manufacturing out of the US, it is helpful to know how improvements in the efficiency of a particular operation change the financial case for relocating it. In borderline cases, this helps define additional strategic options, especially for operations with a finite and defined lifespan. Since most of the value of relocating operations outside of the US is generated from the labor rate differential, reducing labor content has the direct effect of decreasing the expected return on transition investment. While this is a generally understood principle, incorporating the ability to pre-select plant efficiency in the Level 1 model allowed the impact of lean activities to be quantified. The results shown in Figures 12 & 13 highlight the importance of implementing and maintaining continuous improvement processes that focus on labor reduction.

7.3.4 Tariffs and Duties

Depending on the product specification, or HTS category, tariffs can represent a significant contribution to total landed cost. In order to define the analytic methodology incorporated into the Landed Cost model for tariffs, the process for assessing and collecting tariffs needed to be understood. This process is commonly thought of as a black box, with whole departments devoted to internalizing import laws and maintaining import compliance. One of the benefits of investigating this process is a heightened sense for how import charges are levied and where potential opportunities for decreasing fees may exist. Manufacturing postponement is a typical strategy for aggregating component demand and smoothing overseas manufacturing operations. However, depending on how sub-components are classified for importation, postponement may also be useful for exploiting the arbitrary HTS classification index to reduce import charges. It is important to note that import laws and the fees assessed are dynamic in that they change as trade policies evolve. The current trend is toward free trade, so conceivably this will be less of an issue in the future. However, this trend may change as more manufacturing moves to low-cost regions. Having an appreciation of import rules and processes also helps develop a better understanding of the potential sources of financial risk associated with global operations.

7.3.5 P&L Tax Effects

Similar to tariffs and duties, differences in regional corporate taxation rates and rules create opportunities to reduce costs by structuring the manufacturing footprint to take advantage of favorable policies. In addition to the different tax rates assessed on profit retained within each region, market entry incentives and exit penalties can have a major impact on total landed cost and transition financials. Understanding the potential impact of policy on total operating cost is critical when defining the strategic development plan. This project provided the opportunity to develop a better understanding of the global corporate tax process. Exclusive of unique incentives and penalties, this process was incorporated into the Landed Cost model. The calculation for an arms-length transfer price is an example of how the analytic process is dictated by US tax law.

7.3.6 Pipeline Inventory Effects & Expedited Shipping

Considering the machined housing example quoted in section 5.3.1, it was surprising to find that switching to economy shipping had only a small, and in one case a negative, effect. Inventory holding costs often get overlooked as a contributor to the total value chain cost. This example showed how, depending on the product cost and demand profile, inventory holding cost savings might exceed the incremental costs of expedited shipping. This example highlights the importance of controlling inventory levels to only what is required to provide the desired service level. While performing an inventory optimization is beyond the scope of this paper, it should be recognized as a useful tool for reducing overall operating expense. In higher volume or commodity markets, optimizing inventory levels should be viewed as a competitive necessity.

7.4 Criticisms

The methodologies used in the two models developed during this project are based on historical data and the personal experience of individuals directly involved in each process. The lack of current compatible sourcing and transition data, and the unique nature of transition and sourcing decisions, makes the validation of these models during this internship impossible. Systems were implemented within Strategy and Integration to collect meaningful data which can be used to validate these tools in the future. At present, the tools should be used for performing preliminary estimations and for deciding how to focus investigative resources for a thorough sourcing analysis.

In an effort to simplify the models and reduce the input data requirements, some analytical generalizations were made. A balance was sought between user input requirements and the model's accuracy. The generalizations made are not thought to significantly degrade the quality of the results. However, users need to be aware of how the assumptions influence their analysis. For example, inbound raw material values in the Landed Cost model are assumed to be the average material component of COGS multiplied by the finished part cost. This simplification allows the analysis to proceed without requiring the user to define raw material value, which might be a difficult if not impossible task. Another example is the exclusion of overhead and fringe from the regional labor rate database. Unless the exact overhead and fringe rate for each region is known, all values should be excluded to prevent biasing the model.

Lastly, the analytical process is not automated and the user is expected to have some knowledge about the models and how they should be used. The models rely on data inputs from the user, and thus can be manipulated should the user wish to bias the results. The results from these or any analytical tools should not be blindly accepted, but should serve as the basis of discussion. Some sophistication is required when interpreting the results to relate the model inputs and major cost drivers of the process to the analytical conclusion.

7.5 Recommended Future Work

The work described within this thesis represents a shift within Honeywell Aerospace's Strategy and Integration group toward using a higher level of analysis for making strategic decisions. There was a consensus within the group that more sophistication is needed within the strategic planning process. As this trend toward using analytical methods to answer strategic questions continues, people will become more aware of the importance of collecting and storing relevant data. Currently, generating data to perform and support an analysis is a difficult process. Potential future projects might consider how to coordinate data collection between the various departments in a way that that can be useful for these models or similar types of analysis. Honeywell is in the process of implementing SAP, which should enhance their ability to perform landed cost calculations or inventory optimizations. Supply chain efficiency will become increasingly relevant as the aerospace industry becomes more cost competitive. Future projects might determine the best way to use SAP, or interface it with other modeling tools, to simplify the modeling process and provide a more comprehensive view into their supply base performance.

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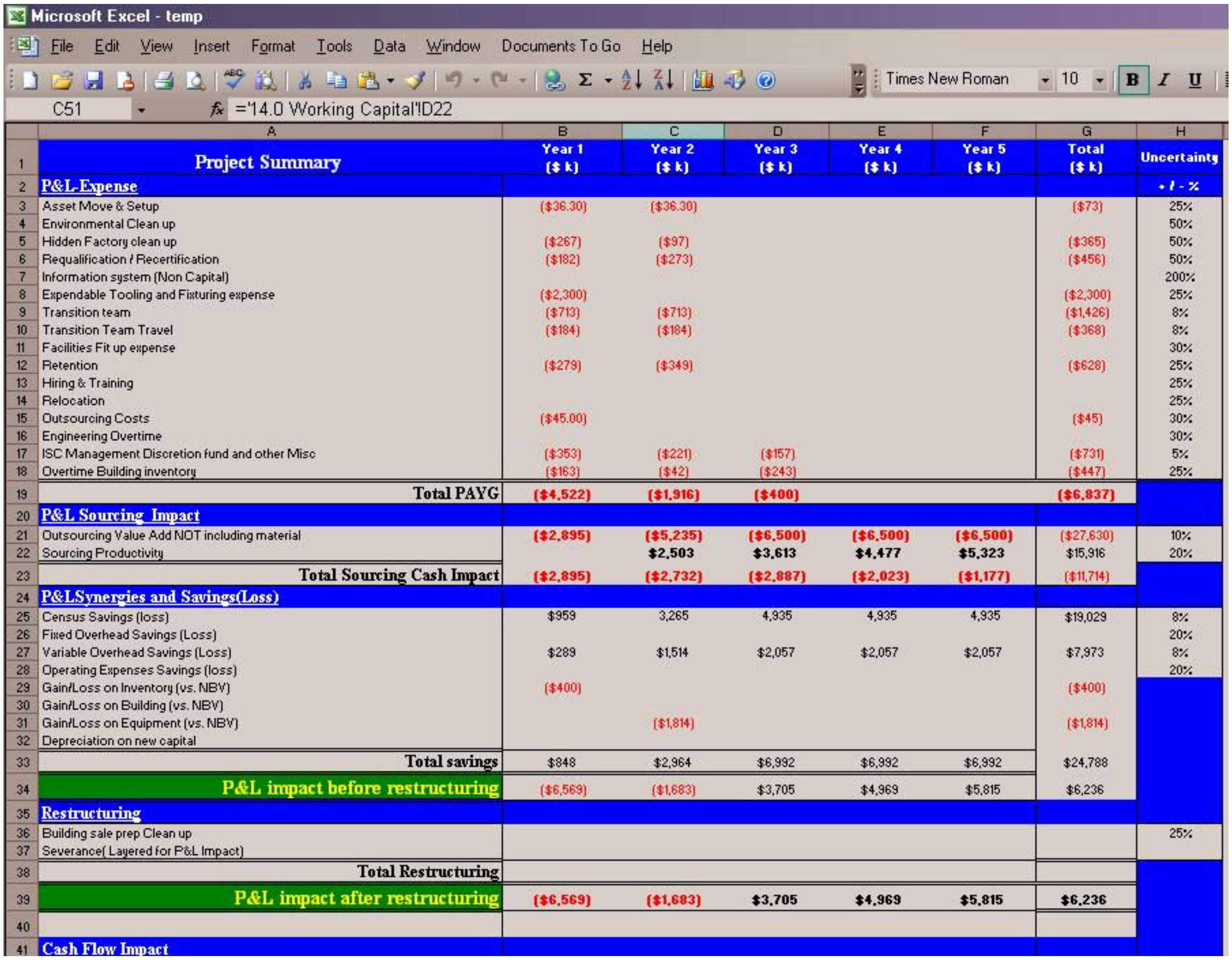
Appendix A – Cash Flow Definitions

Asset Move	Cost of preparing assets for relocation, (site preparation is in Fit-ups), and relocation.
Building Cleanup	Cost of cleaning vacated building and capping off utilities.
Environmental Cleanup	Cost of any environmental surveys + remediation
Hidden Factory	Cost of knowledge transfer/retention. Includes updating/translating old product documentation and creating new documentation for undocumented processes.
Requalification / Certification	Cost of having new production site qualified for specific products. Includes final assembly approval, as well as any process approval. FAA and customer certifications. GR&R
Overtime requirements	Transition Engineering OT (rarely used)
Information Systems	Cost of creating IT infrastructure at new facility, and data migration / transfer of IT services to new facility.
Tooling	New tooling requirements or duplicate tooling capital expenses at receiving site.
Facilities Fit Up	Receiving site facilities layout, construction, supporting infrastructure, and required upgrades. (Utility drops for new or relocated assets)
Transition Core Team	Cost of transition team salaries and benefits
Transition Team Travel	Transition team travel expenses during transition.
Census	Sending and Receiving site head count (costs as salary + benefits w/o overhead (Unburdened)).
Transfers	Census relocations.
Severance	Cost of potential loss of productivity, severance pay (US: 1month + 1 week per year service) + benefits, and outplacement services.
Retention	Bonuses paid to retain key individuals slated for termination during the transition process (bonus weeks of salary).
Relocation	Cost of relocating transfers
Hiring and Training	Recruiting and training costs per head increase at receiving site.
Census Overlap	Census model should include census overlap for training at receiving site, or TMI model should include inventory prebuild buffer to supply FG during transition shutdown for training.
Asset Sales	Sales revenue estimate for sale of building, inventory, and equipment.
Book Value	Net book value including improvements, of building, inventory and equipment.
Write-offs	Building and lease improvement write-offs (Sales minus book value).

Depreciation add-back	Depreciation recapture for asset depreciation.
Depreciation	Current depreciation of receiving site building improvements.
Inventory Pre-build	Asset value of transition inventory buffer build and burn.
Inventory Pre-build OT requirement	OT paid during the creation of the transition inventory buffer, Production only
Material Add-back	Increase in material costs due to outsourcing activities, Old material cost – (new raw material cost + direct labor + margin (Purchase price of outsourced material: supplier quoted value)).
Outsourcing Costs	Temporary transition team cost associated with outsourcing activities.
Inventory Driven Costs	Before and after inventory levels (WIP, SS, RO, FG), Include risks (obsolescence, shrinkage).
Variable Overhead	Sending site and receiving site variable overhead costs.
Fixed Overhead	Sending site and receiving site fixed overhead costs.
Other operating expenses	Sending site and receiving site operating expense delta (various).
Discretionary spending costs	Discretionary spending associated with Census change, awards, training, office supplies, computer expenses, etc. Can be included under Misc. or in variable overhead.
Misc. Spending	Place for one time transition costs not covered elsewhere.

Appendix B – TMI Model, Sample Results Screen



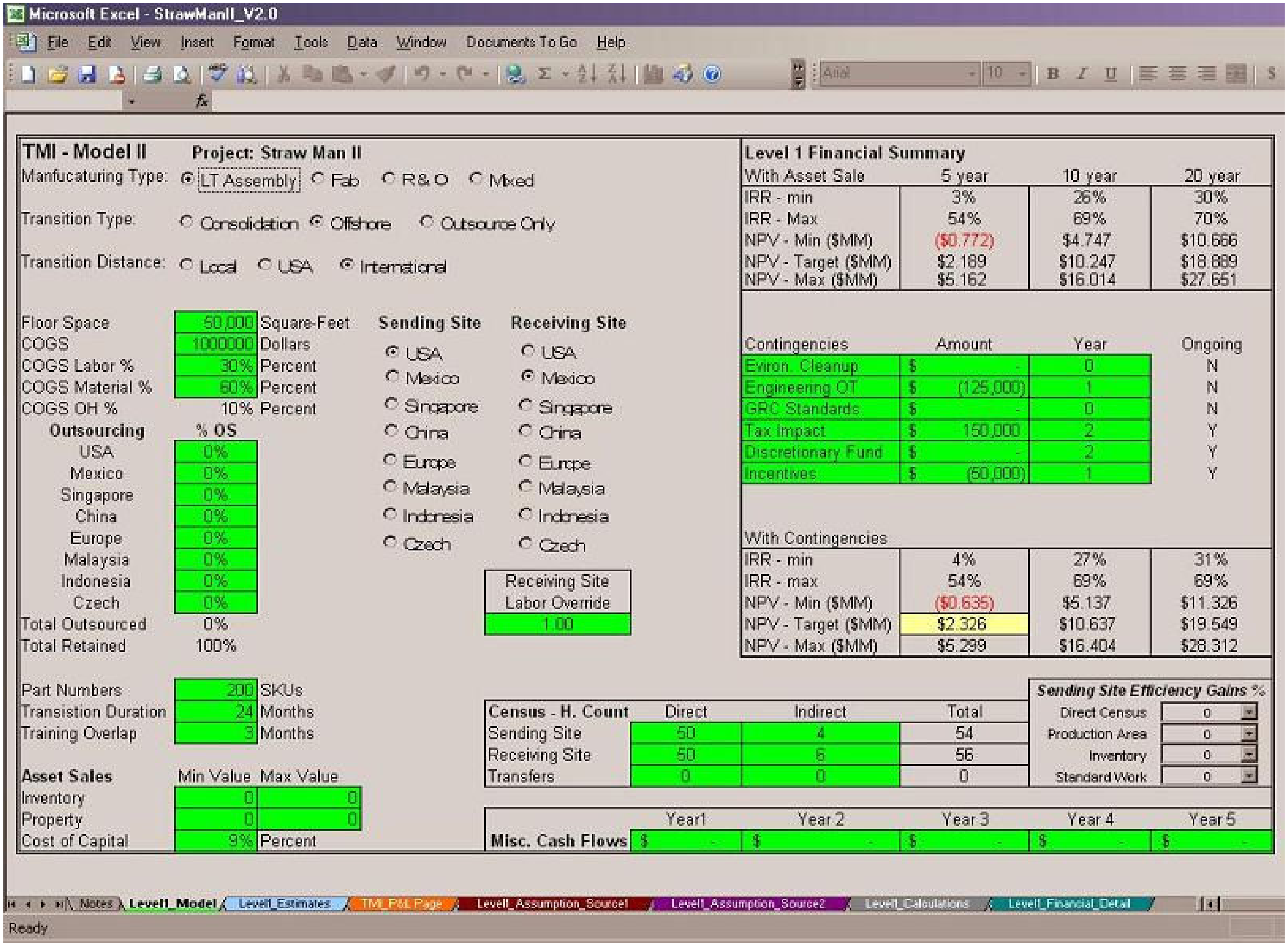
	A	B	C	D	E	F	G	H
1	Project Summary	Year 1 ($ k)	Year 2 ($ k)	Year 3 ($ k)	Year 4 ($ k)	Year 5 ($ k)	Total ($ k)	Uncertainty
2	P&L-Expense							+/- %
3	Asset Move & Setup	($36.30)	($36.30)				($73)	25%
4	Environmental Clean up							50%
5	Hidden Factory clean up	($267)	($97)				($365)	50%
6	Requalification / Recertification	($182)	($273)				($456)	50%
7	Information system (Non Capital)							200%
8	Expendable Tooling and Fixturing expense	($2,300)					($2,300)	25%
9	Transition team	($713)	($713)				($1,426)	8%
10	Transition Team Travel	($184)	($184)				($368)	8%
11	Facilities Fit up expense							30%
12	Retention	($279)	($349)				($628)	25%
13	Hiring & Training							25%
14	Relocation							25%
15	Outsourcing Costs	($45.00)					($45)	30%
16	Engineering Overtime							30%
17	ISC Management Discretion fund and other Misc	($353)	($221)	($157)			($731)	5%
18	Overtime Building inventory	($163)	($42)	($243)			($447)	25%
19	Total PAYG	($4,522)	($1,916)	($400)			($6,837)	
20	P&L Sourcing Impact							
21	Outsourcing Value Add NOT including material	($2,895)	($5,235)	($6,500)	($6,500)	($6,500)	($27,630)	10%
22	Sourcing Productivity		$2,503	$3,613	$4,477	$5,323	$15,916	20%
23	Total Sourcing Cash Impact	($2,895)	($2,732)	($2,887)	($2,023)	($1,177)	($11,714)	
24	P&LSynergies and Savings(Loss)							
25	Census Savings (loss)	$959	3,265	4,935	4,935	4,935	$19,029	8%
26	Fixed Overhead Savings (Loss)							20%
27	Variable Overhead Savings (Loss)	$289	$1,514	$2,057	$2,057	$2,057	$7,973	8%
28	Operating Expenses Savings (loss)							20%
29	Gain/Loss on Inventory (vs. NBV)	($400)					($400)	
30	Gain/Loss on Building (vs. NBV)							
31	Gain/Loss on Equipment (vs. NBV)		($1,814)				($1,814)	
32	Depreciation on new capital							
33	Total savings	$848	$2,964	$6,992	$6,992	$6,992	$24,788	
34	P&L impact before restructuring	($6,569)	($1,683)	$3,705	$4,969	$5,815	$6,236	
35	Restructuring							
36	Building sale prep Clean up							25%
37	Severance(Layered for P&L Impact)							
38	Total Restructuring							
39	P&L impact after restructuring	($6,569)	($1,683)	$3,705	$4,969	$5,815	$6,236	
40								
41	Cash Flow Impact							

41	**Cash Flow Impact**							
42	**Capital**							
43	Information system Capital							50%
44	Tooling & Equipment capital							25%
45	Facilities Capital							25%
46	**Total Capital**							
47	**Other Items that Impact Cash**							
48	Change in Accounts payable/accounts receivable	$1,565	$782					10%
49	Inventory build ahead	($9,000)	($3,000)				($12,000)	1%
50	Inventory burn	$5,400	$3,600				$9,000	1%
51	Inventory sale - one time	**$10,600**					$10,600	20%
52	Equipment/Building Sale - one time		**$202**					20%
53	less already accounted for P&L impact: equipment, inv, bldg sale (gain/loss)	**$400**	**$1,814**					
54	Depreciation add back (New Capital)							
55	Severance P&L timing impact adjustment (reversal)							
56	Severance Cash Impact							20%
57	**Total other items that impact cash**							
58	**Pre tax Cash Flows**	($6,569)	($1,683)	$3,705	$4,969	$5,815	$6,236	
59	**Uncertainty**	$2,233	$806	$1,064	$1,186	$1,319		
60	**Maximum Value Potential**	($4,336)	($877)	$4,769	$6,155	$7,133		
61	**Minimum Value Potential**	($8,802)	($2,490)	$2,641	$3,783	$4,496		
62								
63	Pay back	3.75	Years		Max	Min		
64	IRR (5 Yrs)	21%			55%	-1%		
65	NPV (5 Yrs)-DCF-9%	$2,717			$7,963	($2,529)		
66								
67	Pay back		Years		Max	Min		
68	IRR (10 Yrs)	42%			70%	24%		
69	NPV (10 Yrs)-DCF-9%	$17,417			$25,996	$8,837		
70								
71	IRR (20 Yrs)	45%						
72	NPV (20 Yrs)-DCF-9%	$33,180						
191								

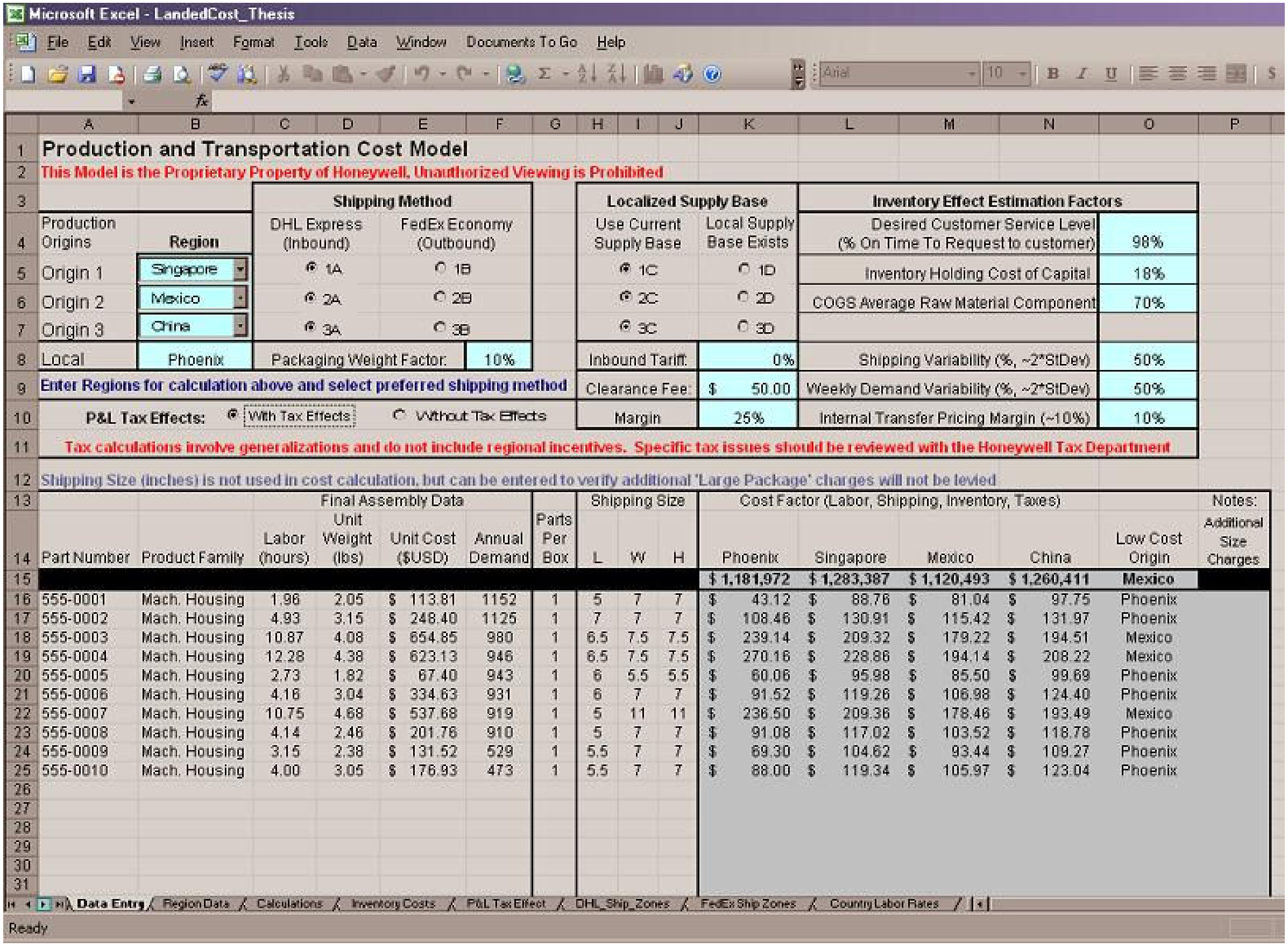
26.0 Results- IRR-NPV | start file | 27.0 COGS comparison | 27.0 Monthly Spend | 28.0 Presentation summary | 29.0 Exec Summary-Employee

Ready

Appendix C – Level 1 Model, Sample Input Screen



Appendix D – Landed Cost Model, Sample Input Screen



Microsoft Excel - LandedCost_Thesis

Production and Transportation Cost Model

This Model is the Proprietary Property of Honeywell, Unauthorized Viewing is Prohibited

Production Origins	Region	Shipping Method: DHL Express (Inbound)	Shipping Method: FedEx Economy (Outbound)	Localized Supply Base: Use Current Supply Base	Localized Supply Base: Local Supply Base Exists	Inventory Effect Estimation Factors	
Origin 1	Singapore	1A	1B	1C	1D	Desired Customer Service Level (% On Time To Request to customer)	98%
Origin 2	Mexico	2A	2B	2C	2D	Inventory Holding Cost of Capital	18%
Origin 3	China	3A	3B	3C	3D	COGS Average Raw Material Component	70%
Local	Phoenix	Packaging Weight Factor:	10%	Inbound Tariff:	0%	Shipping Variability (%, ~2*StDev)	50%
Enter Regions for calculation above and select preferred shipping method				Clearance Fee:	$ 50.00	Weekly Demand Variability (%, ~2*StDev)	50%
P&L Tax Effects:	With Tax Effects	Without Tax Effects		Margin	25%	Internal Transfer Pricing Margin (~10%)	10%

Tax calculations involve generalizations and do not include regional incentives. Specific tax issues should be reviewed with the Honeywell Tax Department

Shipping Size (inches) is not used in cost calculation, but can be entered to verify additional 'Large Package' charges will not be levied

Part Number	Product Family	Labor (hours)	Unit Weight (lbs)	Unit Cost ($USD)	Annual Demand	Parts Per Box	L	W	H	Phoenix	Singapore	Mexico	China	Low Cost Origin	Notes: Additional Size Charges
										$ 1,181,972	$ 1,283,387	$ 1,120,493	$ 1,260,411	Mexico	
555-0001	Mach. Housing	1.96	2.05	$ 113.81	1152	1	5	7	7	$ 43.12	$ 88.76	$ 81.04	$ 97.75	Phoenix	
555-0002	Mach. Housing	4.93	3.15	$ 248.40	1125	1	7	7	7	$ 108.46	$ 130.91	$ 115.42	$ 131.97	Phoenix	
555-0003	Mach. Housing	10.87	4.08	$ 654.85	980	1	6.5	7.5	7.5	$ 239.14	$ 209.32	$ 179.22	$ 194.51	Mexico	
555-0004	Mach. Housing	12.28	4.38	$ 623.13	946	1	6.5	7.5	7.5	$ 270.16	$ 228.86	$ 194.14	$ 208.22	Mexico	
555-0005	Mach. Housing	2.73	1.82	$ 67.40	943	1	6	5.5	5.5	$ 60.06	$ 95.98	$ 85.50	$ 99.69	Phoenix	
555-0006	Mach. Housing	4.16	3.04	$ 334.63	931	1	6	7	7	$ 91.52	$ 119.26	$ 106.98	$ 124.40	Phoenix	
555-0007	Mach. Housing	10.75	4.68	$ 537.68	919	1	5	11	11	$ 236.50	$ 209.36	$ 178.46	$ 193.49	Mexico	
555-0008	Mach. Housing	4.14	2.46	$ 201.76	910	1	5	7	7	$ 91.08	$ 117.02	$ 103.52	$ 118.78	Phoenix	
555-0009	Mach. Housing	3.15	2.38	$ 131.52	529	1	5.5	7	7	$ 69.30	$ 104.62	$ 93.44	$ 109.27	Phoenix	
555-0010	Mach. Housing	4.00	3.05	$ 176.93	473	1	5.5	7	7	$ 88.00	$ 119.34	$ 105.97	$ 123.04	Phoenix	

Data Entry / RegionData / Calculations / Inventory Costs / P&L Tax Effect / DHL_Ship_Zones / FedEx Ship Zones / Country Labor Rates

Ready