Evaluating End-of-Life Strategies for Decommissioned Semiconductor Facilities

by

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ABSTRACT

This thesis studies the life-cycle of semiconductor facilities and the potential roles that they may play once they reach the end of their life. Specifically, the author's findings are based on studies associated with the decommissioning of a semiconductor manufacturing facility ("fab") at the Intel Corporation's Aloha Campus in Portland, Oregon.

With increasing demands for its products, Intel is constructing newer and more modern facilities to support large-scale manufacturing efforts. As newer product lines and facilities come on line, older product lines are being eliminated and older semiconductor facilities that produced them are consequently being shut down largely without regard for what their use will be afterwards. As such, this study starts by first looking at the concept of facility life-cycle with respect to semiconductor manufacturing facilities. After discussing potential pre-shutdown planning requirements, the author presents an empirical framework for evaluating possible roles that these fabrication facilities could play after they are taken out of service. In brief, the framework consists of five general steps - (1) establish reference state; (2) develop list of alternatives; (3) establish decision factors; (4) generate measures for comparison; and (5) compare and contrast to draw conclusions - and is based upon a thorough consideration of all relevant technical, strategic, and financial issues.

The paper then applies the framework to a current semiconductor manufacturing facility that was the focus of this research. The example developed for Intel's Fab 4 demonstrates that a combination of a short-term role (utilizing the building as a manufacturing support platform) and a long-term strategy (combining the resources of Fab 4 and Fab 5) appears to be the "most feasible" set of alternatives. In addition, the methodology is then applied to other examples of past and potential future wafer fabrication facility decommissioning projects.

Conclusions from this research indicate that a process-oriented (rather than outcome-oriented) framework best captures the iterative and dynamic nature of the problem. As such, the major contribution of this methodology is that it presents a framework for how to think about the problem rather than how to immediately solve it. As such, the author believes that the research results presented herein are not intended to be a panacea for what remains to be a difficult problem. However, since companies will no longer be able to walk away from existing facilities, the author concludes that incremental investment and planning for adaptive re-use during the facility's lifetime would appear to offer numerous advantages over waiting until after it is shut down.

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Chapter 1: Introduction and Problem Statement

Throughout the history of industrial activity, production facility closure and/or realignment is usually only considered either in a time of crisis or when production ceases. Usually brought upon by such factors as poor financial performance, competition, or technological innovation, facilities in most industries enter the economic equation as an "afterthought." However, with continuing environmental legislation forcing companies to re-think leaving the problem for someone else to deal with, as well as the dwindling amount of greenfield sites to construct new facilities at reasonable costs, the proper use and disposal of manufacturing facilities has become a prime agenda item for many modern corporations.

1.1 The Semiconductor Industry

The semiconductor industry, for example, is an area where many of these decisions are only now coming under review. While a relatively young industry, the semiconductor market has been recently marked by great strides in technological innovation and process improvement. At the same time, there has been a thrust to reduce prices and costs and increase volume so that companies can remain competitive against each other.

Semiconductor manufacturing has grown steadily from the introduction of the first transistor and integrated circuit. Today, with the expansive growth of silicon-based technology driven by short product lifetimes and high capital investments, the semiconductor industry remains an extremely competitive and volatile market. For many companies, future profitability lies not only in their ability to best utilize their existing manufacturing facilities but also in how they plan ahead for creating more modern facilities in the future.

"Intel Corporation, as the technological leader in microprocessor development and the market leader in world-wide microprocessor sales with approximately 80% - 90% of the personal computer market share," (Kirkpatrick, 1997) is arguably one of the best companies that has successfully meshed current manufacturing requirements with future manufacturing strategy. By committing large financial resources to research and development to develop new technology as well as financing the construction of modern facilities to manufacture them, Intel positions itself to stimulate market demand for its products (through the continual introduction of better products produced through research and development) and then supply that demand for its products through its manufacturing facilities. This "investment for the future" policy has become the cornerstone of continuing to maintain its leadership position in the highly competitive microprocessor market.

With the construction of these modern-day semiconductor fabrication facilities to support new technology, Intel attempts to remain ahead of its competitors by reaping the economies of scale associated with large-scale production. However, as technology continues to grow, older technologies continue to be phased out of production. Market demand dwindles, production costs rise (as the volume decreases), and the products become phased out and replaced by successors. With a corporate strategic vision centered on producing leading-edge technology, many of Intel's older products find themselves outside of the corporate strategic umbrella and are subject to discontinuation. As such, when production ceases, the fixed assets or facilities that support them are left without a clearly identified future role.

1.2 Facilities as an Element of Strategy

While committed to constructing newer and larger semiconductor fabrication facilities and shutting down smaller so-called "fabs", the future of Intel's (and other companies') older and smaller fabs remains uncertain. With potential alternative uses ranging from complete demolition to renovation for future manufacturing, the fact remains that more and more of these older fabs will come off line in the near future. However, while still considered to be "fixed capital assets", only when these facilities are able to be utilized to reap future benefits will they truly be considered "assets."

As such, the thrust of this thesis is to investigate the host of issues as well as the potential options for these fabs as they are being decommissioned. From this, the study attempts to highlight how Intel and potentially other companies in the same industry (as well as outside of the industry), can position themselves to deal with this future reality today. As a means to accomplish this, the author will present the facility life-cycle model and discuss its application to the semiconductor industry. Next, the author develops a general framework for allowing evaluation of end-of-life strategies for semiconductor facilities which consists of five general steps and applies those steps along three critical dimensions (technical, strategic, and financial). After introducing the framework, the author tests its validity by applying it to a specific semiconductor manufacturing facility (in this case, Intel's Fab 4). Afterwards. the paper applies this framework to past facilities which have already been shut down (Intel's Fab 1A and Fab 3) and to facilities which potentially will be shut down in the future (Intel's Fab 5 and Fab 6).

1.3 Objective of the Research

The purpose of this research was originally intended to provide an analysis of specific alternative roles for a specific decommissioned semiconductor manufacturing facility. However, after researching the topic, the author found that little basic research on end-of-life strategies for semiconductor manufacturing facilities had been performed. As such, the final purpose of this research was not necessarily to look at one facility but rather to develop a general methodology that could provide high-level managerial decision-making insight into the facility decommissioning process.

The research results presented herein is not intended to be a panacea for all decommissioning activities; rather, it is designed to be an example of an application in one industry (semiconductor manufacturing) and to one company's currently decommissioned facility (Intel). However, the hope is that the general nature of the methodology will find application in other similar situations, both within and outside of the specific industry investigated.

The organization of the research is intended to address the problem from a high level and work down to a lower level of detail by using Intel's Fab 4 as a "case study." The author thought that this type of type of organization would offer more value to the reader since it would describe much of the background and decision-making process before the actual recommendations. In Chapter 1, the concept of facilities as assets and as elements of strategy is introduced. As an introductory chapter, the intent is to provide a brief managerial perspective of facilities during their life-cycle and introduce the three phases of facilities applicable to decommissioning -- the decision to close a plant, pre-planning requirements for decommissioning, and development of alternative uses of facilities.

Chapter 2 begins the discussion of facilities in the semiconductor industry by providing background on the semiconductor industry itself. The chapter offers a brief introduction into the products, processes, and technological challenges that face the semiconductor industry. In particular, the chapter investigates the historical role that facility assets have played in the semiconductor industry and highlights trends that are indicating that their strategic and financial importance will continue to rise. Following this discussion, the concept of adaptive reuse (or re-using facility assets for roles after its useful life) is introduced and its applicability to the semiconductor industry briefly discussed. Chapter 2 is included in the research because the author wanted to address a more universal audience rather than those only familiar with the semiconductor industry and its unique characteristics.

Chapter 3 discusses specific strategic and technical elements that face semiconductor facilities once they are planned to be closed. The intent of this chapter is to provide a background on why facilities close, the decisions and issues which should be addressed before actually shutting down a semiconductor facility, and strategies for dispositioning semiconductor manufacturing equipment. The chapter briefly introduces pre-planning strategies as applied to the semiconductor industry but does not provide a comprehensive review of all potential decommissioning issues facing facilities in other industries.

Chapter 4 begins the presentation of the general methodology that grew out of the research of the project. The chapter describes the sources of information that applied to the author's on-site research effort. The chapter also describes the relevance and sensitivity of the research (for example, can conclusions brought forth by this research be applied across other industries?). As such, Chapter 4 is not intended to be a universal tool of potential sources for information when decommissioning a semiconductor facility but rather offer potential sources that other companies could exploit.

Chapter 5 presents a general methodology for evaluating potential roles for existing semiconductor facility assets after they have served their useful lives. While its application is rooted in a specific investigation of the semiconductor industry, Chapter 5 provides a high-level perspective of a methodology that could potentially be applied to other companies in the semiconductor industry and to other industries. The chapter presents a five step methodology for evaluating end-of-life strategies that is intended to be both thorough and rational: (1) establish reference state; (2) develop list of alternatives; (3) establish decision factors; (4) generate measures for comparison; and (5) compare and contrast alternatives. In addition, Chapter 5 describes many of the technical, financial, and strategic measures that form the backbone of the methodology and might be applicable to other individual semiconductor manufacturing facilities or other manufacturing facilities in general. As mentioned previously, Chapter 5 is intended to provide a general framework that was designed for a specific industry (semiconductor manufacturing) and addressed the specific facility problem at hand.

Having established a general methodology in Chapter 5, Chapter 6 applies the framework to a current semiconductor manufacturing facility. The example developed for Intel's Fab 4 is the major thrust of the chapter, although other examples of past and potential future wafer fabrication facility decommissioning projects are also discussed. By discussing the particular technical, strategic, and financial measures in extensive detail, the author hopes to demonstrate the application of the framework in detail and provide a basis to test its validity.

Finally, Chapter 7 presents a summary of the framework developed as part of this research, as well as potential conclusions that resulted for its application. Chapter 7 also identifies potential future avenues for research into the areas of adaptive re-use and end-of-life strategies for facilities across other industries.

Chapter 2: Background of Semiconductor Facilities and Adaptive Re-Use

The decision to close any facility is one that will have both short term effects as well as long term ramifications. As such, there are a number of implications associated with the decision that must be thought through and analyzed before the final decision is made. With this in mind, the point of this chapter is to two-fold: first, to briefly introduce the concept of semiconductor operations and the factors that drive their unique facility aspects and secondly, to present the theoretical groundwork for viewing facilities as an asset and introduce the concept of facility re-use as an element in the decision-making process

2.1 Semiconductor Manufacturing

The semiconductor manufacturing process, by virtue of its nature, dictates facility requirements that tend to be different from many other types of manufacturing operations. For instance, in sharp contrast to automotive assembly plants where distinct and sequential operations build up the product, semiconductor operations are not sequenced but are more repetitive. Characterized as "re-entry flow", various steps in the process are repeated and the product is passed through the same piece of equipment numerous times to achieve the desired results. Hence, before one can begin to analyze potential uses of facilities, one should first have a foundation of the process itself.

As detailed in Figure 2-1, the semiconductor manufacturing process consists of various fundamental processing steps. Structures are essentially fabricated through the repeated application of a number of basic processing steps - oxidation, photolithography, etching, diffusion, evaporation or sputtering, chemical vapor deposition, ion implantation, and epitaxial layer formation. In general, each of these steps generally either deposits materials or removes materials that were deposited earlier. Similarly, typical "front-end" processes are performed before the first metal layer is deposited while "back-end" processes occur after the addition of the first metal layer.

While the point here is to only briefly introduce the process, one should understand that by implanting various dopants into the silicon itself and placing metal layers between connector points and "insulating" them from one another, one is able to create elementary electrical devices. These structures -- transistors, diodes, capacitors, resistors, etc. -- form the elemental logical basis of such electrical devices are integrated circuits, memory products, and microprocessors.

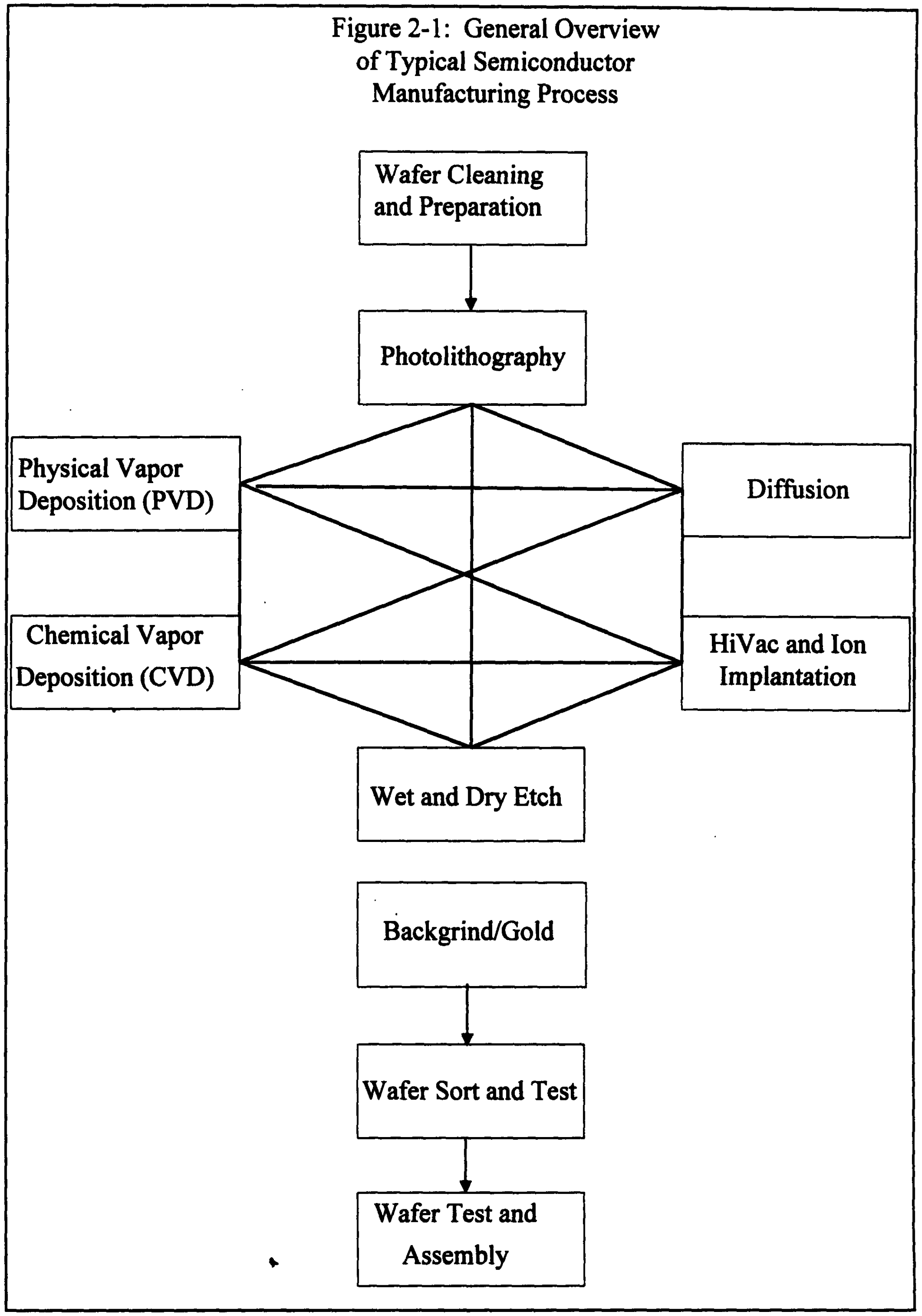


Figure 2-1: Semiconductor Manufacturing Process

There are a number of key implications with the semiconductor process. First, while early fabrication techniques used silicon wafers that were 4-inch to 5-inch in diameter, current processes generally use 6-inch and 8-inch wafers, with 12-inch being the next generation silicon product on the horizon. Essentially, the larger the diameter of the wafer, the more integrated circuits "die" that can be produced at any one time. Hence, since many wafers are processed at the same time, one can begin to understand the advantages of utilizing larger and larger wafer sizes (assuming that the "yield" or proportion of "good" products remain comparable across wafer sizes). Secondly, the cost implications associated with processing various wafer sizes makes larger sizes more cost-effective. That is, processing costs per wafer are relatively independent of wafer size, so the cost per die is lower for larger wafer sizes. "As such, there are strong economic forces driving the integrated circuit industry to continually move to larger and larger wafer sizes." (Jaeger, 1988). Finally, the facilities act as a shell for housing this intricate operations. While they are not necessarily responsible for actually operating on the product itself, the facilities are responsible for providing the multitude of process liquids and gases, support utilities, and high-quality clean room environment to support these operations. Consequently, if the facility functions cannot be maintained at stringent levels, the process suffers and product yields are sacrificed. Thus, one can see the important role that facilities play in the semiconductor manufacturing process.

2.2 Background on Semiconductor Facilities

"In 1995, it was estimated that approximately 700 wafer fabrication facilities (or "fabs") and 450 dedicated research and development fabs were operating around the world under the umbrella of "semiconductor manufacturing." (Singer and Hars, 1995) In addition, as capacity becomes more fully utilized and demand for silicon-based products continues to rise, planned construction of another 80 to 140 wafer fabs are expected through the year 2000" (Burggraaf, 1995). Naturally, because of the wide cyclical swings in the semiconductor industry, both product demand and facility construction requirements change as the industry continues to develop.

In the past twenty years, the costs of constructing wafer facilities have increased by an order of magnitude. As depicted in Figure 2-2, costs for new fabs have increased dramatically from 1970 to 1990 as product sizes have decreased and product performance have increased. Consequently, the "average" wafer fabrication facility either planned or under construction today consists of approximately 65,000 SF of Class 1 or better (sub-Class 1) clean room space.

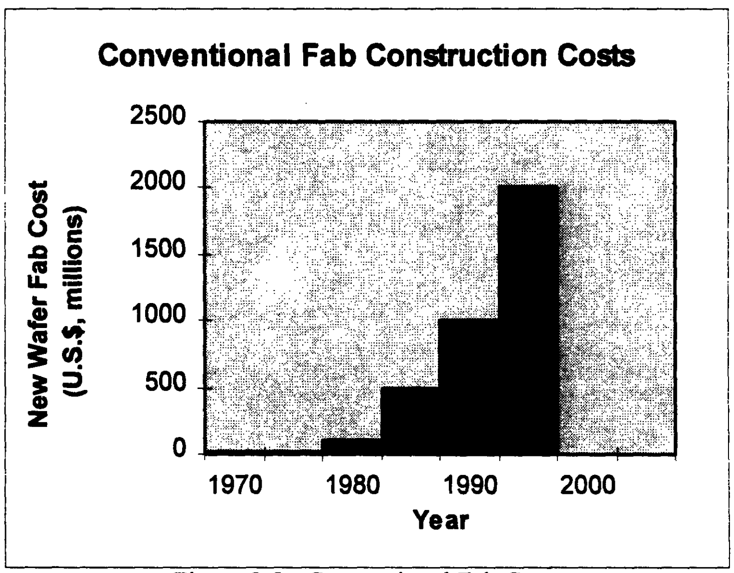


Figure 2-2: Conventional Fab Costs
Source: Burggraaf, 1995

Similarly, as depicted in Figure 2-3, the proportion of equipment costs in new fab budgeting has also changed dramatically. For example, while originally only an average of 30% of total facility cost (including facility construction and equipment outfitting), trends in equipment costs have increased that proportion to a point today where almost 65% of total facility cost will be constituted by the cost of semiconductor manufacturing equipment.

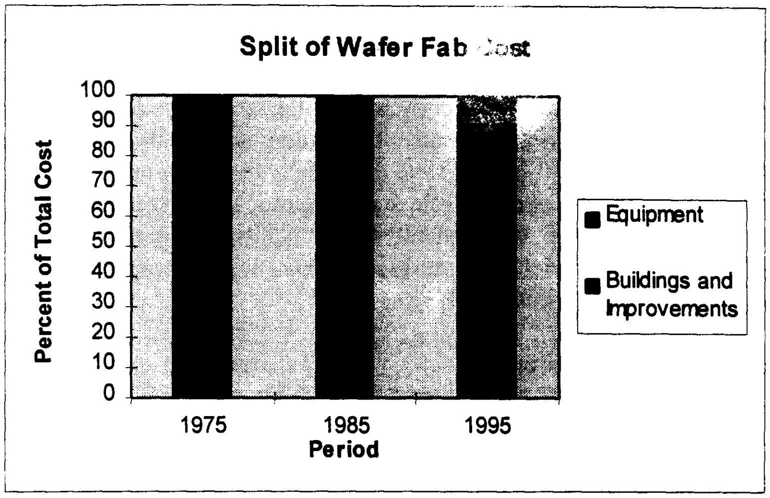


Figure 2-3 Split of New Wafer Fabrication Facility Costs
Source: Burggraaf, 1995

In light of these trends, it has become noted that two paths are possible. First, companies will have to continue to budget large amounts to support newer and better facilities. This fact, by itself, may create higher and higher barriers to entry as "deeper" corporate pockets are required for companies to maintain their market share and market position. "At a new facility cost which could rise to an estimated fifty-percent (50%) of revenues during the facility's lifetime, building a world-class fab with all new state-of-the-art equipment might only be an option that only the most successful companies can pursue." (Burgraaf, 1995) Hence, it is quite possible that only those highly vertically integrated companies will be able to remain competitive.

Secondly, companies will have to begin to seriously consider improving their existing facility assets to meet their future requirements. In fact, it is possible to upgrade almost anything within the fab itself -- the clean room area (ceiling filters, air handlers, ductwork, raised flooring, etc.), utilities (process gases, water, electrical services, etc.), and even the equipment. Yet, the question that these companies are wrestling with is whether this investment in upgrading is actually worthwhile. That is, first can it actually be done and will the investment be worth it in the end and secondly, how can one begin to think about comparing these vastly different approaches.

2.3 Facilities as an Asset -- an Analogy:

Perhaps the best way to begin to think of the concept of facilities as an asset is to use an example. While the average American has been driving an automobile since the age of sixteen, one of the biggest decisions we make in our lifetime has to do with the asset that we use in this case - the automobile itself.

Generally, an automobile (like a facility) is designed to last a finite period of time and essentially serve a specific set of purposes for that period of time. However, at some point in its lifetime, the owner has to make a decision or a series of decisions which determine the length which they will hold onto the fixed asset. Hence, the owner is faced with a number of possible scenarios. For example, the owner can sell the automobile after a time (for a profit or a loss), depending on the car's service history and the market value of the product. However, by doing so, the owner also has made a decision that another automobile will have to purchased in the near future to fulfill their requirements (provided that the need for a car still exists or that another means of transportation will be used.)

Similarly, the owner may make the decision to sell or dispose of the automobile based on its condition. That is, despite its inherent value as a means of transportation, the anticipated or expected future costs associated with restoring the asset to a condition which would make it useful once again are perceived to be higher than the costs of selling the car and purchasing a new one. As such, depending on its condition, the owner might have to suffer a loss to sell the car or might even have to pay a third party to dispose of the automobile.

Finally, perhaps changes in the owner's needs have dictated that the automobile is out of date. For instance, if the automobile is a two-seat vehicle and the owner's family consists of two adults and three children, the value of the car to the family is less than perhaps a minivan which can accommodate all passengers at once.

The point here and the analogy to facility assets is intended to be simple. The case for a corporation evaluating what to do with a fixed asset like a facility is not necessarily that much different from the decisions we make when evaluating what to do with an asset like an automobile. The asset must be evaluated on the basis of a new, defined need and the ability of the asset to meet that new need (as well as potential future needs). As described above, there are three potential extensions of this statement. First, while potential needs may not change, the ability of the asset to meet that need is diminished. Secondly, while the ability of the asset has not necessarily changed, the needs or requirements for the asset have changed. Finally, given that the needs have changed as well as the ability of the asset to meet those changes has diminished, the asset must be re-evaluated.

Given these conditions, three possible outcomes are feasible. First, the asset can be disposed of or sold at a salvage value; secondly, the asset can be fixed up or renovated to meet the need; and finally, nothing could be done. That is, one could keep the asset and do nothing until the need is more clearly defined. As expected, decisions might be different based on changing market conditions (for instance, interest rates on new vehicles, the price for new vehicles, how much extra money one can afford to spend, etc.), the costs associated with "fixing the old asset" versus "disposing and buying new", and the foreseeable requirements for future needs. As such, the timing of the decision and the potential environmental changes anticipated in the future must also be considered in the process.

2.4 The Facility Life Cycle and the Concept of Adaptive Re-Use

Much like the automobile described above, a facility is an asset whose costs and benefits vary over time. For example, one might think of the facility's life cycle in a very similar manner to the product life-cycle (Porter, 1980):

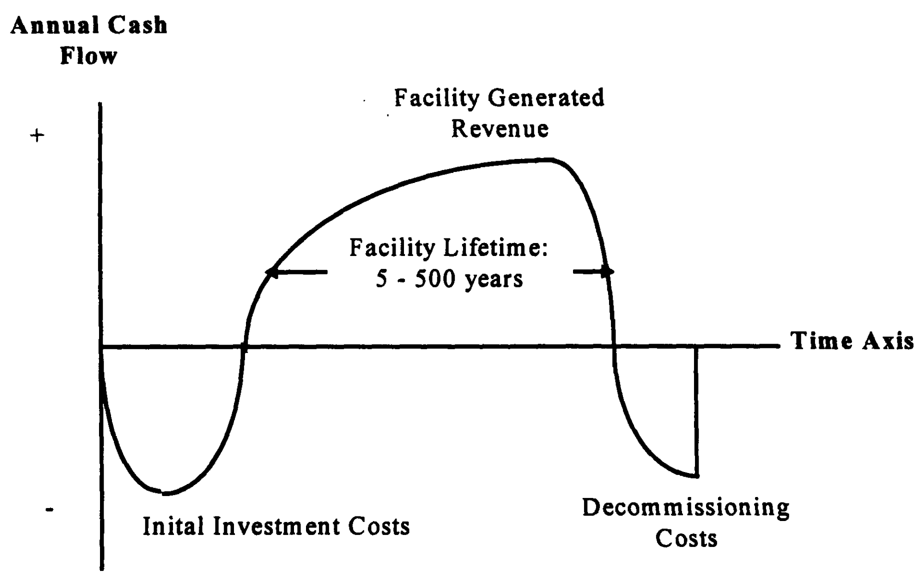


Figure 2-4: Facility Life Cycle

Over its lifetime, the facility goes through many different periods where its role changes. For example, during the first phase of its life, the facility is a large investment where it is a significant cost to the owner. The owner takes this action with the intent of recovering their investment by utilizing the asset to generate revenue. Hence, during the course of its lifetime, the facility produces revenue which generates the curve as seen above. At times during its lifetime, the owner may reinvest in the facility (at a cost), with the intention of making additional revenue. However, at some point, the owner must make a decision about what to do with the facility. Normally occurring at the facility's end-of-life, the owner is faced with many choices. Should the owner decide to decommission the facility, there is usually a large cost associated with that. Yet, this brings the element of time into the equation. Since the decision has been made at the facility's end of life, could any costs have been avoided if the owner had taken various steps to prepare the facility for decommissioning earlier? While not necessarily the focus of this research, one could begin to evaluate the feasibility of this argument.

In essence, this is the basis for viewing facilities undergoing decommissioning as "assets." However, the concept of redefining new roles for facilities has found its application in many industries today. Adaptive re-use, or the re-utilization of facilities for additional purposes after they reach the end of their useful life, has become a topic of much debate recently. "In fact, the concept of adaptive re-use is "... applying a potential fitness for purpose test toward facilities, with an eye for identifying feasible alternatives after they have reached the end of their useful lives." With the closure of single-purpose manufacturing facilities, as well as other buildings which were once thought only able to support one role, the question of "adaptive re-use" has come to the forefront of urban planners, construction engineers, real estate developers, and business persons." (Poskanzer, 1996)

Adaptive re-use has found roots in major areas. For example, old clothing mills have been transformed into housing units, office spaces, and warehouses. "Similarly, excessive urban office space has been converted into habitable housing units to meet shortcomings in the housing supply market." (Gann and Barlow, 1996) However, most buildings are designed to satisfy the needs of existing forms of use; that is, they are rarely designed to meet future needs. Hence, the quality of a building and its capacity for change depends on a number of factors. For example, for offices, many of those issues would include location, its surroundings, and local infrastructure (parking, amenities, waste disposal, shops, and recreation activities).

Since many of these same issues face decommissioned semiconductor facilities, one can draw an analogy that might explain how adaptive re-use might find applications in the semiconductor field. While the theory finds its application in many areas, the question remains how applicable this would be to semiconductor facilities. By looking at the issues associated with shutdown, as well as analyzing the technical, strategic, and financial implications of various alternatives, one begin to draw conclusions about the viability of certain alternative uses for semiconductor facilities and the role that adaptive re-use may play in their future.

Chapter 3: Elements of Facility Closure

The decision to close a semiconductor facility is a decision which is usually reviewed at the highest levels of the corporation. Across many different industries, including the semiconductor industry, most of these decisions are based on financial considerations as well as a host of other intangibles that are not always obvious to characterize. However, on more than one occasion, corporations have elected to operate facilities and/or production lines "unprofitably" because of "other considerations." These considerations, coupled with the financial implications, essentially create a threshold beyond which the corporation is not willing to accept unprofitable operations. As one might expect, this threshold will vary depending on the corporation itself, the financial cost of capital to the corporation, and the industry and environment in which the corporation competes.

Thus, the point of this chapter is to highlight two aspects of plant closure. First, the author hopes to bring forth some of the internal and external factors that cause facilities (and semiconductor facilities in particular) to be shut down. Similarly, this chapter will also attempt to highlight some of the issues which must be faced once the decision is made and hence, should be considered when deciding whether to shut down or close a semiconductor facility.

3.1 Internal and External Factors

As alluded to in the automobile analogy, more than financial considerations are generally responsible for deciding to close a plant. These factors may be generally grouped into those internal to the corporation and those of the external environment and market.

Internal factors include high fixed costs, low utilization, age of facilities, corporate strategy, and labor strategy to name a few. For example, high fixed costs (when compared against industry benchmarks or even internal plants) sometimes make older facilities less desirable to support operations. Such fixed costs as inefficient energy utilization, infrastructure support costs, or even property taxes may be a factor in the decision. Similarly, low capacity utilization is also a reason for closure consideration. Particularly in the semiconductor industry where low costs are achieved through high volumes, a plant which produces at a lower volume is not able to compete with similar plants because it is largely unable to spread the fixed and variable costs profitably among the low volume of products. Thirdly, the age of the process and/or the equipment and facility itself may be another reason for considering closure. As the equipment becomes fully depreciated, the costs of modernizing the process and the facility may be considered "excessive" when compared against merely constructing a new facility and/or moving the process elsewhere to a greenfield or undeveloped site. In general, the costs to modernize may be greater than the value placed on the facility itself because of the complexities dealing with existing structures, interference, inflexible floor layouts, etc. Fourthly, corporate mandate may also be another driver for facility closure. That is, despite economic analyses which may show viability, strategic decision-makers at the corporate level may have already decided that the benefits of closure will outweigh any potential seen in maintaining operations. Finally, as an example of a driver for closure, worker productivity and/or relations with the work force is also a reason for consideration. Numerous plant closings have been delayed by virtue of the willingness of a work force to make concessions and attempt to improve their productivity. However, on the other hand, if a corporation is faced with a difficult union environment or potentially closing the plant and outsourcing the materials, many corporations will take the latter.

In addition, external factors can also responsible for plant closure. First, changes in the marketplace, as a result of low demand, a sagging economy, rising interest rates, etc. are generally seen as major external drivers. At the same time, however, increased level of competition is also seen in the same light. For instance, if there is increased competition within the industry as a result of process improvements or cost saving measures or even global competition, companies may decide to re-focus their production and leave the segment in which they are currently competing. Similarly, some other examples of external factors include lack of community support, government regulation or deregulation, and environmental compliance. In the past few years, environmental issues have received much more attention than in previous decades. No longer can a corporation leave a contaminated site without a plan in place or remediation efforts underway to restore the site to an acceptable condition.

3.2 Pre-Planning Issues

With an understanding of the factors which sometimes drive plant closures, the next section will discuss issues which semiconductor corporations in particular (and manufacturing corporations in general) wrestle with when weighing the decision itself. Planning without these issues or without fully understanding the significant issues and hidden costs of potential closure, could change one's views of the perceived advantages/disadvantages of closure. As such, it appears entirely feasible that companies could lower their shutdown costs if they consider all issues and plan explicitly.

Utilizing semiconductor manufacturing as an example, there are a number of areas which should be considered beforehand. As a means to consolidate and investigate these issues, they have been grouped together into four basic categories (Corporate Assets and Resources, Market, Corporate Relations, and Corporate Strategy) related to their focus area.

Corporate Assets and Resources	Market	Corporate Relations	Corporate Strategy
Workforce and Manning Decisions	Product Decisions	Legal Issues	Risks
Manufacturing and Production Planning Decisions	Customer and Marketing Issues	Contractual Issues	Organizational Issues
Equipment Decontamination and Dispositioning		Environmental Issues	Timing
Facility Decommissioning and Dispositioning		Political Issues	Financial Considerations
Inventory Issues		Communication Issues	

Table 3-1: Pre-Shutdown Planning Areas

Within each of these area, there are decisions and issues which should be considered during the pre-planning phase. While the purpose of this section is not necessarily to investigate these in detail, Table 3-2 on the following three pages does present a framework of specific decisions and questions which could be applied. The framework lists issues and specific decisions (as applied in the semiconductor manufacturing industry) that are requisites for consideration during the pre-planning phase. While this list is not necessarily exhaustive, it does serve to provide a background on the complexity of issues, as well as their intertwined nature, as they apply to facility shutdown requirements.

Table 3-2: Decision Factors

	Decision Category	Issue Definition	Potential Decisions
1	Workforce and Manning	Employee separations and/or relocations	Expected or anticipated annual turnover effects on headcount planning requirements
			Intra-company movement -- matching personnel to other positions within the corporation
			Reduction in forces (RIFs) or corporate sponsored early retirement packages
		Employee contracts approaching shutdown	Utilizing contract (temporary) labor to supplant relocated/separated employees
			Maintaining all or a proportion of company employees until shutdown date
		Indirect Labor Requirements	Maintaining or reducing indirect labor as shutdown approaches
		Employee empowerment	Encouraging employee empowerment to solve problems
		Workforce knowledge	Maintaining an experienced employee base to ensure the stability of the production process as closure approaches
		Morale	Maintaining high morale throughout the closure process
		Re-training and integration	Adequate planning for future training requirements for relocated employees and tools for easing their transition into their new organization
2	Product	Product Cycle Decisions	End of Life (EOL) strategy -- discontinue production
			Technology and process transfer to other manufacturing facilities
			"Bridge builds" or inventory build up to satisfy anticipated future demands
			Licensing products or processes to outside firms to continue supplying customers
			Transferring customers to new technology (identification of migration paths to new products)
		Product Pricing Strategies	Increase purchase price of older technology products being phased out to stop new orders
			Reduce purchase price of newer technology products to promote customer movement
		Competition Assessment	Identification of alternate sources of supply for customers of discontinued products
			Identification of company as a sole-source producer
3	Legal	Product	Obligations to support end-of-life (EOL) products for a pre-determined length of time (by government or contractual requirements)
		Personnel	Obligations to promote personnel relocation (versus RIFs and early retirement programs) without bias for age, skills, etc.
		Public	Time and avenue to provide notification to the public of shutdown decision

4 Manufacturing and Production Planning	Production Planning	Level production until closure
		"Ramped-Down" or steadily decreasing production levels until closure
	Forecasting	Accurate forecast of future demand (versus capacity analysis) to account for all "build-aheads" before shutdown
	Process transfer	Equipment transfer to other facilities
		Transfer of photolithographic masks or cost budgeting for new masks to be used at other facilities
		Adequate knowledge transfer to other facilities
		Allowing an adequate period for "learning curve" effects at new facility
	Warehousing and storing	Store at sort and test area prior to assembly and test operations or after assembly and test operations are complete
	Process control	Potential impediments to maintaining "expected" yields and keeping the process in control
	Production batch sizes	Small versus large batch sizes prior to shutdown -- potential concerns about cost implications of a higher number of set-ups versus running small batches to meet demand as the forecast becomes more accurate over time
	Product production decisions	Potential early elimination of complex processing steps before losing experienced technicians (for example, highest technology product using the most process steps)
		Potential to decommission equipment concurrently as process steps are eliminated
5 Financial	Equipment valuation	"Write-down" value; "write-off" value; salvage value
		Potential impacts of sale (capital gain effects), scrap ("write-off"), internal transfer, or donation of equipment
	Equipment decommissioning and dispositioning	Levels of costs associated with "contaminated" and "uncontaminated" equipment
	Facility valuation	"Write-down" value; "write-off" value; salvage value
	Employee incentives	Identification of retention bonuses, re-deployment costs, relocation costs, separation pay
	Profit and loss effects	Local reporting effects
		Corporate reporting effects
	Product	Identification of product transfer costs
	Inventory	Inventory carrying costs and inventory valuation
6 Customer and Marketing	Product	Differentiation between internal and external customer bases for each product line
		Identification
		Adequate time frame of notification to customers of product decisions

		Identification of migration paths for customers to new products or other suppliers
7 Contractual	Material Supply Contracts	Suspension and/or negotiation of long-term material delivery contracts (for example, silicon wafers, chemicals, etc.)
	Transportation Contracts Labor Contracts Equipment Support Contracts	Suspension and/or negotiation of long-term transportation contracts Negotiation of external labor contracts Suspension and/or negotiation of long-term equipment support contracts
8 Risk Identification	Market Risk Corporate Personnel Risk Process Risk Temporary Labor Pool Risk Environmental Risk	Accuracy of market demand and market forecasts Potential loss of highly-experienced workforce base Potential inability to maintain process control and/or yields prior to closure Potential inability to achieve anticipated process yields after process transfer Availability of experienced temporary employees Known and unknown environmental contamination Level of desire to pursue accounting for all environmental contamination
9 Organization	Morale Change Leadership	Ability to maintain organizational health throughout the period Ability of employees to embrace change Ability of organization to make rapid decisions with less people
10 Equipment	Decommissioning Dispositioning	Assessment of potential chemical residues associated with each piece of equipment and the method of cleaning Sell, scrap, transfer, or donation of "non-contaminated" equipment Disposal of "contaminated" equipment
11 Timing	Shutdown Date Planning	"Flexible" or "firm" shutdown date -- potential effects of always changing the date as demand for products becomes more refined When to establish a timeline of major/key events
12 Facilities	Decommissioning Dispositioning	In-house labor versus contract labor Identifying future uses for the facility prior to shutdown
13 Environmental	Contamination	Potential short-term and long-term remediation requirements Level of efforts to check all potential sources of present and future contamination

	Permitting	When to suspend (if at all) environmental discharge permits
14 Communication	Open Channels	What, why, and when to tell employees of major/minor decisions
		What forum to communicate with employees (for example, email, "word-of-mouth", large meetings, small meetings, etc.)
15 Inventory	Valuation Levels	Maintaining adequate cost-of-good sold on accounting records versus actual potential cost at which products could be sold on outside markets (i.e.,, avoiding an "over-valued" inventory) Allowing adequate levels for customers
16 Political	Local Community	Maintaining open communication with community Maintaining business tax incentives despite closure

3.3 Equipment Decommissioning

Nearly all manufacturing processes involve specialized equipment that presents a potential for environmental contamination. For example, in the automotive assembly process, the paint shop area houses ovens and booths which over time become contaminated with chemical residues from the paints they keep inside. Similarly, semiconductor manufacturing by its very nature, depends on toxic chemicals and gases that are essential to the process itself. As such, when considering shutting down a semiconductor facility, one is faced with the considerable challenge of ensuring that environmental contamination within the equipment has been mitigated before it has been dispositioned. That is, while the equipment protects the personnel working in the fabrication area from the hazards of the process, the equipment itself usually becomes contaminated. The types of hazardous chemicals that may exist within these pieces of equipment range from fluorine, hydrogen, silane, sulfuric acid, hydrofluoric acid, arsenic, etc. The point here is simply that in the semiconductor process, equipment decommissioning is an essential part of the facility shutdown process. As such, the purpose of this section is to provide a flow chart detailing the decision-making process for equipment disposal based on such things as value, level of residual contamination, contamination sources, and potential uses.

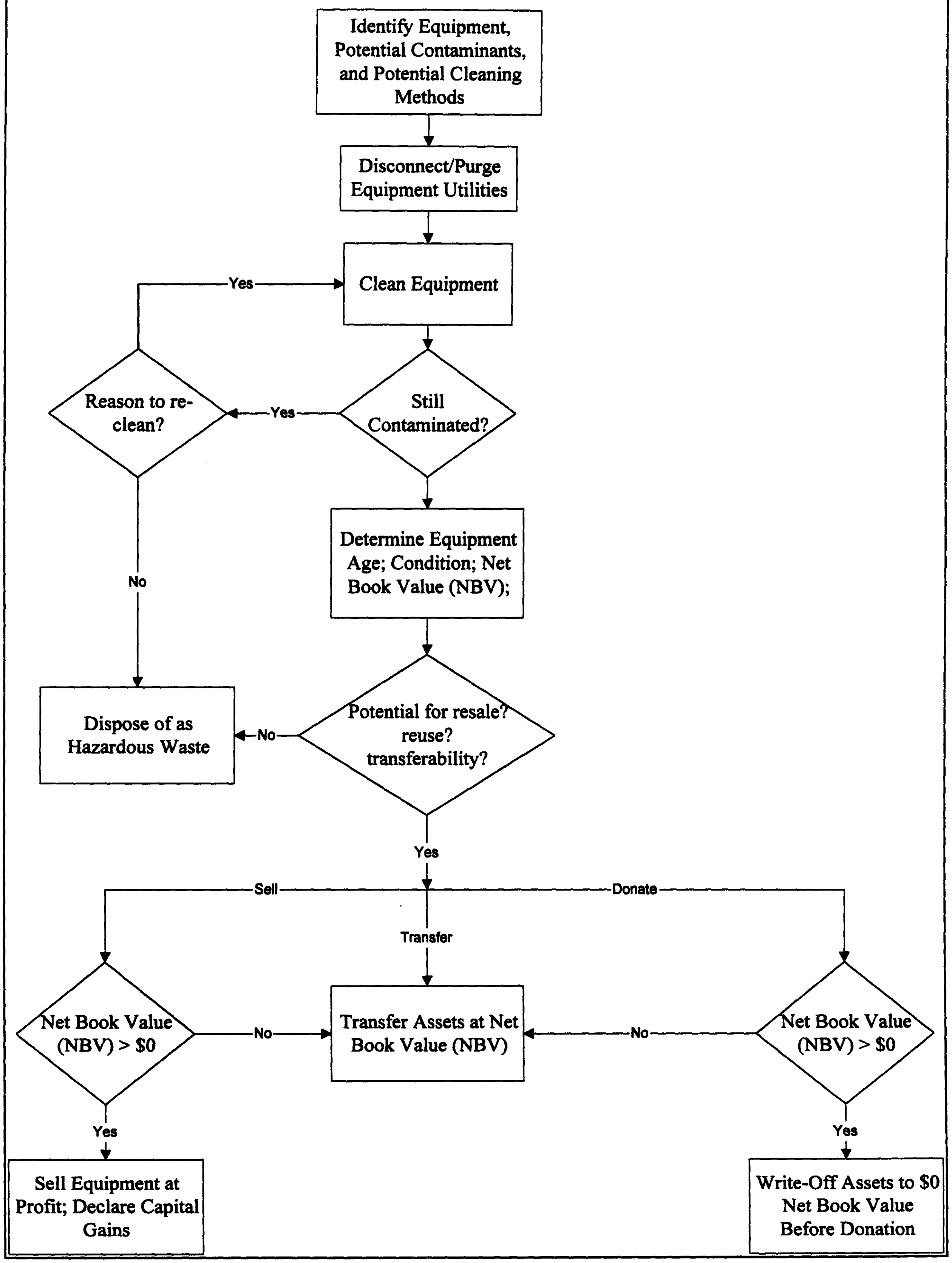
As discussed previously, semiconductor manufacturing equipment constitutes a large capital asset. Costs of major pieces of equipment can range from tens of thousands of dollars to tens of millions of dollars. However, with the short depreciation life cycles for the equipment (ranging from four to eight years), semiconductor companies usually must expense a portion of the cost of acquiring the equipment over individual product costs (thereby reducing margins or increasing the total product cost). At the same time, though, they are able to reap the full rewards of the depreciation tax shields that the equipment provides.

When shutting down a semiconductor facility, the equipment represents a critical role in identifying potential future uses for the facility. That is, until equipment is decontaminated and/or dispositioned, the facility does not have many other alternative purpose for use. As such, Figure 3-3 in this section is dedicated to presenting a general decision-making framework that can be used for dispositioning equipment.

Generally, semiconductor manufacturing equipment can be dispositioned in four general ways. First, the equipment can be internally transferred to other facilities requiring the equipment. Since this is essentially an "asset transfer", the costs associated with this action are generally shipping and handling costs. Secondly, if a secondary market exists for the equipment, it can be sold to other parties. Because of the relatively short depreciation schedule (yielding a residual value equal to $0 or the anticipated salvage value at the time the depreciation schedule was computed), most sales of equipment in secondary markets result in a capital gain for the corporation. Thirdly, the equipment can also be disposed of (or scrapped) in different types of landfills, depending on its environmental condition. For instance, if the equipment is contaminated, then it will have to be disposed of differently than equipment which is non-contaminated. As such, the costs associated with disposing of equipment are shipping and handling, as well as landfill fees. Fourthly, the equipment can also be donated to academic institutions, local schools, etc. While some equipment that is donated may have a secondary market value, all donations require that the equipment be "written off" at zero salvage value and do not result in any revenue generation for the company. In return, most institutions pay for the shipping and handling costs.

With this background in mind, Figure 3-3 presents a general decision-tree for equipment dispositioning decisions.

Figure 3.3 Equipment Dispositioning Flowchart



3.4 Conclusions

The purpose of this chapter has been to bring forward some of the pre-planning issues and decisions which could be well thought-out and addressed before shutting down a manufacturing facility. The general groundwork presented (as well as the lists and issues proposed within this chapter) are not intended to be comprehensive. Rather, they are intended to acquaint management with as many issues as possible to make the decommissioning process less difficult.

Having provided a general background on the semiconductor industry, the pre-planning decisions associated with facility decommissioning, and an example of the sensitivity of one area of decommissioning (equipment), Chapter 5 will present a framework to evaluate end-of-life strategies for the facility. Hence, assuming that a facility is being shut down and has been decommissioned, the next logical step is the explore the possibilities for adaptive re-use of these facilities. After the following chapter, Chapter 5 applies the framework to evaluate the feasible alternatives for Intel's Fab 4 (which is currently being decommissioned), as well as to two past decommissioned facilities (Fab 1A and Fab 3) and two potential future decommissioning activities (Fab 5 and Fab 6).

Chapter 4: Methodology

The purpose of this chapter is to acknowledge the sources of data that provides the basis for the framework presented in Chapter 5. As an on-site intern from 10 June 1996 to 10 December 1996 at Intel's Aloha campus in Aloha, Oregon, the author was given access to all sources of information relevant to this research topic.

4.1 Data Collection

In essence, the data presented in this framework can be broken out into three major categories: (a) technical, (b) financial, and (c) strategic. From the technical perspective, most specific facility information for on-site facilities (Fab 4 and Fab 5) was provided by reviewing existing "as-built" drawings provided by Intel's General Site Services (GSS) function. The following drawing sets were of particular help in providing information and should be referenced accordingly: (1) "Fab 4 Original Drawings" (May, 1974) by Simpson, Strata, and Associates; (2) "Fab 4 Remodel (February, 1981)" by Peterson Associated Engineers; (3) "Fab 4 AME Installation/Facility Upgrade" (1993) by CRS Sirine; and (4) "Fab 4 System Drawings" (1996), currently maintained by the Oregon GSS organization. Similarly, walk-through inspections with Intel personnel within the GSS organization, the Environmental Health and Safety (EHS) organization, and the Fab 4 Manufacturing and Engineering departments also helped verify much of the information. In addition to these employees, numerous conversations were held with Intel personnel from many different departments. For example, GSS facilities engineers, long-range facility strategic planners, process and integration engineers, industrial engineers, and managers of those departments from Fab 4, Fab 5, Fab 15, and the Aloha Campus Sort and Test Area provided a wealth of insight that was used to collect and verify much of the information. With respect to documentation, most reference books (including the 1994 Uniform Building Code, the 1996 National Electric Code, and the 1993 Uniform Fire Code) that were found within the Intel Employee Resource Center (ERC) were also useful for making many technical evaluations and judgments. Technical articles and publications included in the bibliography were used as background for analysis.

Similarly, financial information for construction costing purposes was provided by self-generated cost estimates derived from the 1992 edition of R.S. Means' Construction Cost Estimating Guide and adjusted for approximate changes in the Consumer Price Index (CPI). Limited facility cost information (not product cost data) was also provided by the Intel Aloha Campus Finance Department personnel, but I have purposely tried to minimize the use of non-public information in my analyses. Depreciation schedules, weighted average costs of capital, hurdle rates, and other accounting information were also provided by Intel's Finance Department. Specific financial analyses were provided by Intel Finance Department members, as well as centralized Materials and Resource Planning financial analysts. In addition, any revenue information or miscellaneous information is largely based on data obtained from public sources (for example, this includes the 1995 Intel Annual Report).

All strategic information utilized in this paper's context is based on the author's personal interpretation of Intel's past policies and future direction. The author's opinions are his own and represent his interpretation of public and non-public information. With respect to non-public information, the author's conclusions were the result of conversations with Intel managers and Intel employees who were willing to share and discuss their views. The author has specifically attempted not to include any confidential Intel information in his analysis. However, in the few instances where production and related data and/or sensitive facility or product cost data has been used, the author has purposely disguised the information.

Finally, all relevant material presented about Fab 1A, Fab 3, and Fab 6 were provided through conversations with Intel management personnel who had either worked at the aforementioned facilities prior to shut down (Fab 1A and Fab 3) or were familiar with the current layout (Fab 6). In addition, internal documentation provided by Intel sources also provided information about the facilities in question. Similarly, all information presented about International Business Machines' (IBM) and Digital Equipment Corporation's (DEC) decommissioning efforts were the results of conversations with facility management personnel at both organizations.

4.2 Relevance

Because of the sensitivity of this problem to the semiconductor community (as well as the potential insights that it might offer to other industries), the author finds the resulting discussion to be extremely relevant. The choices that the author presents are real-world decisions that cannot be made without considering all factors. While the examples used to present the framework are limited, the author's intent is to present a general framework that can be applied outside of the specific boundaries of this paper.

4.3 Analysis Methods

The analysis methods presented in the following chapters are based on technical and managerial insights. Technical insights are the result of looking at the problem from an engineering perspective. Financial and strategic insights build upon current analysis methods used in management science.

Although the methodology and conclusions presented forth are only applicable to the facilities under examination, the author feels that the intent of providing a general tool has been met. As such, the methodology presented is not intended to be rigid and firm. The tools could easily be expanded to include other aspects not necessarily covered but considered particularly relevant for certain situations. Similarly, they can also be diluted to remove factors that are not necessarily applicable from the equation as well.

With respect to questions about objectivity and subjectivity, the author believes that the resulting methodology presents a significant amount of objective information. As such, while the results set forth are his own, the author considers them to be valid and rationale conclusions.

Chapter 5: Hierarchical Presentation of Framework

5.1 Introduction

The purpose of this section is to develop the bases for comparing the potential end-of-life strategies for facilities. The intent here is to present a high level perspective of the methodology and develop it further as different activities and tasks are assigned to each element. After explanation, the following chapter then utilizes the framework to apply it to an existing facility (Intel's Fab 4 facility) to review past closures (Intel's Fab 1A and Fab 3) and to theorize about potential near future closures (Intel's Fab 5 and Fab 6).

5.2 Level One Framework

As described earlier, the analysis of alternative uses for facilities could be viewed two-dimensionally. That is, evaluating potential alternative uses should not only address identifying and considering current and known needs against the facility's ability to meet those needs but also anticipating future and/or potentially unknown needs and evaluating the facility's worthiness against those needs. As such, if we vary the fixed point in time (or reference frame) when we analyze facilities, one may arrive at entirely different conclusions. Consequently, one of the challenges is to present a framework that incorporates enough flexibility to take this into account.

In Figure 5-1, the author presents a general framework for looking at the potential alternative. From a list of alternatives, one applies various decision factors to assess the current capabilities and/or worthiness or flexibility of the facility against each alternative. By applying a set of "tools" and methods of comparison, the original list is reduced to a more manageable set of alternatives. From this list of alternatives which present themselves as the "most feasible potential solutions," management can look further into them and consider all aspects of them before arriving at a final solution.

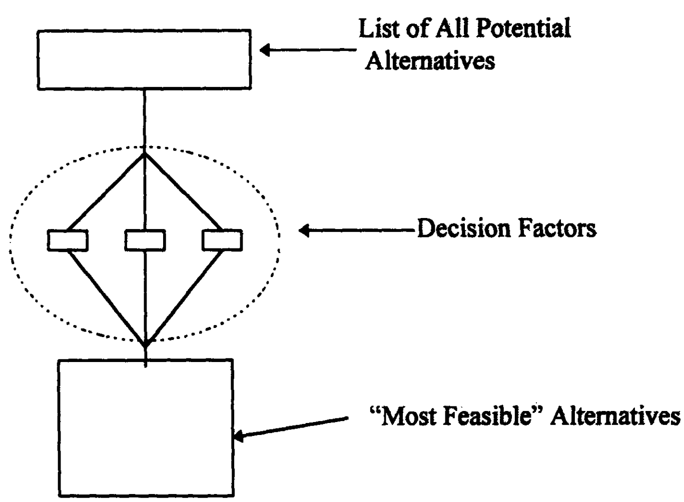


Figure 5-1: Level One Framework

Depending on individual interpretation or assessment of the situation, establishing the decision factors can be limited or quite extensive. Similarly, depending on the type of data that can be collected and the level of its accuracy, the final analysis methodology employed may be qualitative, quantitative, or a combination of them both.

5.3 Level Two Framework

With this overview in mind, one can begin to remove another layer of abstraction and develop the methodology further. As such, by establishing a potential flow of steps that are necessary for the Level One framework, one can derive a series of activities and tasks.

As indicated below in Figure 5-2, a general description of the process flow may be depicted as follows:

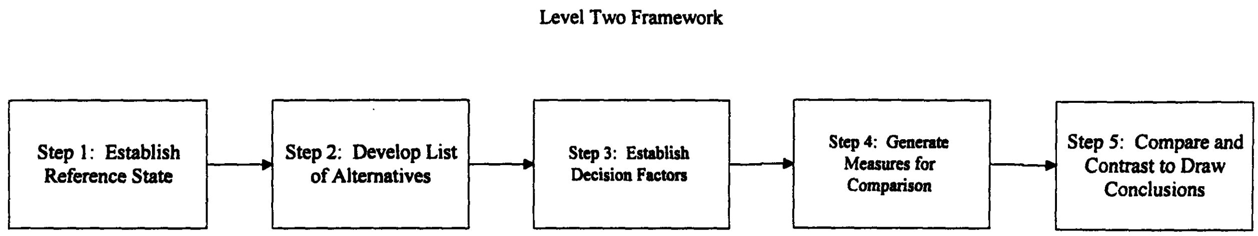


Figure 5-2: Level Two Framework

Within each of these steps, we can further refine those tasks necessary for the methodology:

<u>Step 1: Establish reference values</u>

<u>Key Tasks:</u>

(a) Establish current state
(b) Review facility history and establish time reference
- <u>Original</u>: Year built; demand requirements (load requirements, capacity, capabilities, function and operations); original design and construction; original layout
- <u>Modifications</u>: Year of renovations and/or modifications (up to present); new demand requirements; new design and construction; new layout
- Time Reference: determine when the role of the facility is expected to change

(c) Identify removable elements (equipment, furnishings, temporary partitions, etc.)
(d) Perform preliminary site assessment
- Interactions, independencies, adjacencies

(e) Evaluate current externally defined requirements (code and regulations) -- perform a complete building code review
- Uniform Building Code and/or applicable local building codes
- Uniform Fire Code
- National Electric Code and Uniform Plumbing Code
- Environmental assessment
- Other applicable codes

<u>Step 2: Develop List of Alternatives</u>

<u>Key Tasks:</u>

(a) Define potential general categories of use
- Do nothing
- Renovate
- Demolish
- Lease or Sell

(b) "Brainstorm" all current needs and potential future needs within each category of use
  - Assess known current requirements
  - Assess potential future requirements
(c) Create an "alternative/requirements" matrix (if necessary) to understand requirements further
  - List of "needs"
(d) Benchmark against exercised alternatives
  - Internal organizations
  - Industry competitors

<u>Step 3: Establish decision factors</u>

<u>Key Tasks:</u>

(a) List potential major decision factors for judging alternatives:
  - Technical factors
  - Strategic factors
  - Financial factors
  - Other (current and potential future factors)
(b) List decision factor assumptions

<u>Step 4: Generate measures for comparison by decision factor</u>

<u>Key Tasks:</u>

(a) Building Code Review -- perform a complete code review for future potential occupancies
(b) Perform a building assessment -- establish current capabilities
  - Plan, elevation, and schematics
  - Salvageable equipment lists
  - Capacities and condition of systems (structural systems, enclosure systems, mechanical systems, electrical systems, communication and control systems, architectural components, etc.)
(c) Create a "balance sheet" or "thought document"
  - Identify a comprehensive list of potential measures (issues and/or constraints) associated with each decision factor for each alternative
(d) Identify and consolidate the most "constraining" measures from the complete list of measures (quantitative and qualitative)
  - Existing requirements
  - Present need
  - Future need
    1. Consolidate Technical Measures
        - Externally Defined Requirements
        - Structural Requirements
        - Mechanical Requirements
        - Electrical Requirements
        - Architectural/Facility Requirements
        - Miscellaneous Requirements
    2. Consolidate Strategic Measures
        - Fit with corporate strategy
        - Fit with long-term and short-term facility strategies
        - Fit with corporate guidelines
    3. Consolidate Financial Measures
        - Cost of Capital (Risk and Duration)
        - Investment and Annual Costs
        - Opportunity Costs and Revenues

Step 5: Compare and contrast data to draw conclusions

Key Tasks:

(a) Perform "coarse" elimination of potential alternatives
(b) Perform more thorough elimination of potential alternatives
- Contrast and compare to identify most feasible alternatives
  1. Current needs
  2. Potential future needs

(c) Perform sensitivity analyses

While all of the steps in this methodology are important, steps (3) and steps (4) are particularly important because they attempt to create the foundation for the framework of comparison presented in step (5).

In general, the methodology can be summarized as the following five statements. First, "Understand what you have"; this can be done by assessing the facility's current state. Second, "Identify potential alternatives"; this step requires understanding the unique requirements of each alternative. Third, "Determine decision factors"; essentially, these factors are the bases upon which alternatives can be compared. Fourth, "Evaluate the specific needs of each alternative against the current capabilities of the facility"; identify all potential measures for these needs and identify those variables that are considered potential constraints or higher valued items that should be considered. The point here is not to use the extensive list of measures brought forth but rather to reduce that list to the most important and potentially constraining issues. Finally, "Eliminate alternatives"; this comparison can be done in two levels -- a relatively easy elimination step and a second more thorough elimination step. The result of this exercise should be a list of the "most feasible" alternatives.

5.4 Level Three Framework: Quantitative and Qualitative Measures

When trying to outline the measures for comparison, it soon becomes apparent that certain elements of the analysis lend themselves to be "quantified" while other measures are more accurately defined when they are qualitatively examined. That is, certain measures (like building load capacity, building square footage, utility capacities, and even cost estimates) are based on or best defined by numerical values. As such, if all measures of the methodology could be quantified, then one could essentially create an "apples to apples" comparison by comparing those values against required values.

However, additional measures cannot necessarily be quantified in this same manner. For instance, corporate strategy and direction, potential environmental risks, and financial assessment factors lend themselves to be more accurately depicted in qualitative terms. As such, these descriptive elements cannot always be usefully converted into a common numeric scale that would allow the same type of direct comparison that quantified elements would.

Hence, one of the major initial difficulties of developing a methodology is trying to maintain continuity and to create a robust mechanism that allows for appropriate consideration and comparison of both quantified and qualified elements. Yet, there is inherent value in maintaining the differences and juxtaposing their results during comparison. That is, instead of requiring that all measures be equated on the same scale, the author believes that one can still adequately evaluate alternatives by utilizing both types of data (quantitative and qualitative) together.

As such, with respect to quantitative measures, one could employ a simple methodology. First, one identifies reasonable current values for those quantifiable measures in the methodology. Next, one identifies an expected range of values (from a potential minimum up to a potential maximum) that could be expected in the near future. Finally, given that this data is quantifiable, one could perform sensitivity analysis to determine the responsiveness to certain changes in the environment, including market share, revised load requirements, or size of new equipment.

With respect to qualitative measures, one can also develop a similar mechanism. For instance, one first identifies current status with respect to a stated objective and/or industry standard. Qualitative terms such as "poor", "good", or "excellent", "high", "medium", or "low" not only relate the qualitative nature of the measures but also give one a sense of the potential quantifiable differences between alternatives. Next, one identifies near and short term goals and then evaluates the strategies and level of effort that would allow it to more from the current state to the future. By compiling this data in a common framework, one is then able to juxtapose the results to maintain the "apples to apples" comparison.

5.4.1 Quantitative Methodology

As an example below, the author first developed a framework which attempted to evaluate all elements of alternatives quantitatively and then compare then to find the most feasible set of alternatives. As pointed out above, ultimately, the purely quantitative methodology was altered to include both quantitative and qualitative elements because of the value in maintaining both types of data. However, because the author feels that this methodology might find application in some instances, it has been presented below. Similarly, it is hoped that by presenting this first attempt at creating a general methodology , the audience might begin to understand the difficulties of quantifying inherently qualitative information.

Generally, the intent of the quantitative framework was to create matrices which allowed one to compare alternatives along defined decision factors. As indicated in Figure 5-3 below, the template created an "alternative/measures" evaluative matrix.

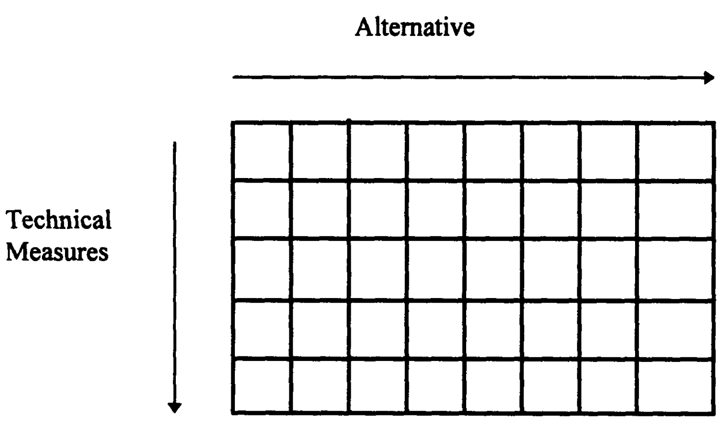


Figure 5-3: Decision Factor -- Technical

For each decision factor, a list of "measures" was identified for the alternatives. These measures formed the left-hand column in the matrix. Similarly, the alternatives themselves formed the first horizontal row of the matrix. By assigning any range of values within the cells of the matrix (for instance, the author thought that a -10 to +10 range was best suited), one "equated" the "positive" or "negative" impacts of a measure associated with an alternative. (It should be noted that although each alternative might not have a value assigned for every measure, the data would be "normalized" later to allow better comparison.)

After assigning values to those cells of the matrix that corresponded to measures which were related to the alternative, one could then compute the sum of the column for each alternative. The total was then entered below the corresponding column. Next, the data was "normalized" since each alternative was not necessarily judged on the same number of "measures." As such, the next step was to count the number of entries (or "measures") in the corresponding column where the alternative was evaluated on. This number (n) would vary for each alternative. To "normalize" the data, one then divided the total sum of the column by n (or any derivation of n) to maintain an "apples to apples" comparison.

The result of this can be quantified as the following equation:

$$\text{Score}_{\text{Technical Measures, Alternative A}} = (1/n_{\text{Alternative A}}) \times \sum (\text{Technical Measures})_{\text{Alternative A}}$$

For each decision factor, one repeated the same procedure and created an "alternative/measures" matrix for each. After doing so, the final step was to combine the results of each matrix by summing the total "score" for each alternative over the decision factors, given that the "weighting" assigned to each decision factor may be different. For example, if three measures were included in the analysis (technical, financial, and strategic), the sum would be as follows:

$$\text{Total Score}_{\text{Alternative A}} = (W_{TM} * \text{Score}_{\text{TM, Alt A}}) + (W_{FM} * \text{Score}_{\text{FM, Alt A}}) + (W_{SM} * \text{Score}_{\text{SM, Alt A}})$$

Finally, given the score for each alternative, one would choose the alternative with the highest weighted score as the most feasible alternative.

As such, a summary of the matrix operations essential to the comparison of alternatives was as follows:

(1) Create an "alternative and measure" matrix for each decision factor (technical, strategic, and financial)
(2) Determine a "weight" for each decision factor such that the total sum of the weights equals 100 ($\Sigma\ W_{TM} + W_{FM} + W_{SM} = 100$)
(3) For each decision factor matrix, assign a "score" for each relevant measure and alternative based on a pre-determined range
(4) For each alternative, sum the column corresponding to that alternative
(5) "Normalize" the data for each alternative by dividing the total by the number of measures that had recorded values entered in the cells
(6) For each alternative, multiply the "normalized sum" for each decision factor by the corresponding weight and sum the total for each alternative
(7) Choose the most "positive" alternatives for consideration

An example of the spreadsheet and scores created for one of the decision factors, Figure 5-4 is provided on the following two pages to demonstrate the results.

Alternative #		Technical Criteria # 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		Subtotal	# Criteria	Adjusted SUBTOTAL
Alternative #1:	Maintain as Class 100 fab	(10)	5	(5)	(10)	10	(5)	(5)	(10)	(5)	(10)	0	(5)	(2)	(5)	(5)	0	5	(5)	0		(62)	19	-3.26
Alternative #2:	Renovate for > Class 100 semiconductor wafer fabricatior Class 1, Class 10, etc)	(10)	5	(10)	(10)	10		(10)	(10)	(10)	(10)	10	(10)	(2)	(10)	(10)	(5)	5	(10)	(5)		(92)	18	-5.11
Alternative #3:	Single function -- maintain as C 100 facility and move planar	5	3	5	0	10	(5)	(5)	(10)	0	0	0	(8)	(10)	(10)		0	1	(7)	(3)		(34)	18	-1.89
Alternative #4:	Multiple function -- renovate fo Class 100 manufacturing and m multiple direct manufacturing fu (including annelva) from F5 to I	(10)	5	(10)	(10)	10		(10)	(10)	(10)	(10)	10	(10)	(10)	(2)	(5)	(5)	5	(5)	(5)		(82)	18	-4.56
Alternative #5:	Maintain as Class 100 wafer fab support facility (ie, parts clean,	5	3	5	0	10	(5)	(5)	(10)	0	0	0	(5)	0			(2)	1	(7)	(3)		(13)	18	-0.72
Alternative #6:	Maintain as < Class 100 sort flo	10	(10)	10	(2)	5		5	(10)	0	0		(3)	(2)					5	(5)		3	13	0.23
Alternative #7:	Renovate for allowing F15 manufacturing clean room expa by relocating cafeteria	(5)	5	5		(50)																(45)	4	-11.25
Alternative #8:	Do Nothing ("mothball" facility) until fate of F5 is decided		(10)	0													1		5			(4)	4	-1.00
Alternative #9:	Lease/sell facility		10	0	(10)												(2)	(10)	0			(12)	5	-2.40
Alternative #10:	Demolish facility and retain lanc future use		(5)	0									(10)			5			5	(10)		(15)	5	-3.00

Alternative #	Alternative #11:	Alternative #12:	Alternative #13:	Alternative #14:	Alternative #15:	Alternative #16:	Alternative #17:	Alternative #18:
	Demolish facility and convert to parking garage or parking deck	Renovate facility and convert to functions (cubicles, conference r etc.)	Renovate facility and convert to administrative functions (Intel University, Employee Resource etc)	Maintain as "pseudo" Class 100 semiconductor fabrication trainir facility (clean room, non-cleanrc instruction area, classroom area) support Fab 5, Fab 15, and Intel Oregon	Maintain as Class 100 facility an perform internal reclaim	Vertical Integration -- convert bu to pull silicon ingots and cut waf (backward integrate)	Renovate for non-manufacturing administrative space (gymnasiun care center, etc.)	Renovate for warehousing facilit
Technical Criteria #								
1		0	0	5	5	(5)	5	5
2	(10)	(5)	(10)	(10)	0	(5)	(8)	(5)
3	0	(2)	(2)	5	5	(5)	5	5
4				3				
5	(5)	(10)	(10)	5	10	10	(5)	2
6								
7		(2)	(2)		5	(5)		
8		(5)	(5)	(5)	(10)	(10)	(5)	5
9						(8)		
10								
11								
12	(10)	(2)	(2)	0	(2)	(5)	(4)	(2)
13		(2)	(2)		1	1	(3)	(3)
14							(3)	
15	0	(5)	(5)		(2)	(2)		(2)
16				(3)				
17				(3)	2	3		
18	5	5	5	5	(3)	0	5	5
19	(10)	(5)	(5)	(1)	(2)	(2)	(2)	(2)
Subtotal	(30)	(33)	(38)	1	9	(33)	(15)	8
# Criteria	6	11	11	9	12	12	10	10
Adjusted SUBTOTAL	-5.00	-3.00	-3.45	0.11	0.75	-2.75	-1.50	0.80

5-4: Quantitative Framework Example (continued)

After considerable discussion and reflection, the author decided that the proposed purely quantitative framework was not robust for a number of reasons. First, it relied heavily on a number of assumptions. For instance, it assumed that the list was inclusive and detailed all potential alternatives and measures. It also assumed that each issue/measure had equal weight in the analysis. In addition, it assumed that the anticipated variance (particularly, over time) is the same for all issues.

Second, the methodology also was highly subjective and was difficult to replicate. That is, it would appear that many values were somewhat arbitrary and depended on individual interpretation. Along those same lines, the analysis did not appear to capture the dynamics of the framework presented earlier. That is, as needs and requirements changed, the analysis would have to be completely re-done.

For these reasons, the author adopted the mixture of both quantitative and qualitative measures presented earlier.

5.5 Development of Quantitative-Qualitative Framework

<u>Step 1: Establish reference and building state</u>

(a) Establish Current State:

The intent of this first step is simply to establish a reference of the facility's location (country, region, state, community, etc.), its geographic proximity to other facilities within the corporation, and the role that it plays within the larger corporate picture.

Similarly, a second element or activity is to evaluate the facility's existing infrastructure. For example, one might start by considering both the utility network (sanitary sewers, storm water, water, natural gas and electricity, and waste disposal), accessibility issues (traffic, transportation network, and parking), and a host of non-utility infrastructure issues (local education systems, public transportation, and installed corporate base). For instance, the transportation networks available (sea, land, and/or air) are particularly important for manufacturing facilities since the products will eventually have to be shipped either to market or for further manufacturing steps to be performed.

In addition, understanding the production location in relation to the distance to the market, distance from sources of supply, and the education level of the available labor pool helps to "ground" the methodology. As such, a thorough understanding of the product's supply chain (for the facility under examination) and the role that it plays in the value added process may prove quite fruitful.

(b) Review Facility History and Establish Time Reference:

The author was once told, "how can you assess what a facility can do for you in the future when you first don't understand how it has evolved from the past?" As such, the author feels it is imperative that one attempt to understand the evolution of a facility over time. Not only can this lend insight into the changing requirements that the facility was designed to meet at various points in its lifetime but also it can allow one to learn about how original facility shortcomings were worked around.

Perhaps the best source to use for this research is actually walking through the facility with engineers and/or designers who can describe the various systems, reviewing "as-builts" of the original construction drawings as well as those of building modifications, or talking with individuals who have extensive knowledge of the facility and its systems.

(c) Identify Removable Elements:

One of the distinguishing features about semiconductor manufacturing facilities is their inherent need for flexibility. Consequently, most modern facilities employ removable elements (bay and chase walls, raised floors and grated floors, drop ceilings, equipment, process piping and utility connections, etc.) to allow them to meet this need. As such, the purpose of this step is to understand the fixed elements of the facility versus those elements which may be removed without impacting future roles.

(d) Perform Preliminary Site Assessment:

Understanding the specific facility under question is only one step in trying to develop a methodology. Knowing the facility's role in the site, the potential advantages that the site has to offer, as well as the interactions between the facility and other facilities on the site is almost as important as understanding the facility itself.

For example, some issues which one might consider when evaluating this are:

(1) How large is the site (acres)? -- how much is developed; how much is undeveloped? (i.e., implications for site expansion)
(2) Where is the facility positioned on the site (i.e., is it between facilities, is it alone on the site, does it have any adjacencies with existing facilities)?
(3) Location of existing utilities that run throughout the site (i.e., if one is thinking about demolishing a facility, one might want to be sure of where things are "supposed" to be located)
(4) Interconnecting utilities between facilities and/or shared utilities (i.e., if a building is fed from a utility that is located within a facility one is considering demolishing or remodeling, one probably should be aware of it)

(e) Evaluate Current Externally Defined Requirements:

Many important facts that can be revealed through reviewing existing applicable regulations as they pertain to the existing facility. For example, this step would include reviewing the standard Uniform Building Code (UBC) or the applicable state and/or local building codes for the area in which the facility is site. For example, by knowing the type of construction (steel frame, masonry brick, concrete, wood frame, etc.), one can determine the "type" of facility one has (Type I, Type II, Type III, Type IV, and Type V) and the type of construction (non-combustible, one-hour rating, two-hour rating, etc.).

In addition, building codes lend insight into the requirements for fire rated occupancy separations. For example, according to the 1994 Uniform Building Code, if one or more occupancies are located within the same space, fire-rated walls, ceilings, corridors, etc. may be required to provide for up to 4 hour separation ratings (or may not even allowed at all). One should realize when applying these concepts that occupancy separation needs to be considered in all directions; that is, horizontal separation, floor separation, and vertical or ceiling separation.

Building codes also provide guidelines for life and safety for each occupancy. These include the number of exits that are required, minimum separation between exits, maximum travel distances, fire separation ratings, ventilation requirements, and what (if any) type of emergency power is required. For instance, in Section 307 to the 1994 Uniform Building Code (which addresses Group H occupancy ratings), emergency power is required for H6 and H7 occupancies while standby power is required in H1, H2, and H3 occupancies.

The Uniform Fire Code (UFC) should also be reviewed as a supplement to local building codes to ensure that fire code requirements are being met or what new requirements (should the occupancy change) would be required. Conforming to the fire code has implications beyond meeting the printed word; that is, including financial implications (i.e., insurance underwriters will not necessarily insure or even provide liability protection against injuries or damage occurring in a facility that didn't meet code). In general, the Uniform Fire Code provides insight into requirements for sprinkler coverage, types of sprinkler systems allowed, required fire system pressure at the point of release, fire detection systems, etc.

The Uniform Plumbing Code (UPC) and the National Electric Code (NEC) provide guidance with respect to electrical and piping systems.

Step 2: Develop Alternatives

(a) Develop general categories of use and (b) "Brainstorm" current needs:

After actually reviewing the state of the facility, the next step should be an initial "brainstorming" of potential needs for the facility. Potential alternatives should not necessarily be specific in scope but should delineate potential uses that should be considered now, as well as for the future (time concept). The purpose is to first create a generic list which includes potential categories of use and then "break down" those categories into specific needs and alternatives.

In general, most potential uses can be classified into four major categories: (1) Do Nothing, (2) Renovate or Rehabilitate, (3) Demolish, and (4) Lease/Sell. Within each of these categories, one can identify potential alternatives by looking internally and externally at (manufacturing) processes and sub-processes currently performed at the facility or other on-site facilities, elsewhere throughout the corporation or by competitors and suppliers. Similarly, one could also evaluate the potential of emerging processes (such as research and development or other test platforms) and potential new business areas by consulting internal sources with insight into he company's strategic plans. In addition, one could also evaluate the potential of support operations (such as non-direct manufacturing, administrative, warehousing, etc.) by also investigating their feasibility.

(c) Alternative/Requirements matrix:

Particularly when considering processes or potential uses which require numerous process utilities, it may be worthwhile to create an "alternative/requirements matrix" to ensure that all known requirements are considered. For example, as depicted below in Figure 5-5, the vertical columns consist of the potential alternatives while the horizontal rows constitute the process and utility requirements for the alternatives. If the requirements are specifically known, actual requirements (and their units) may be placed in the applicable box while if only qualitative facts are known (for example, "yes" or "no"), a check may be placed in the box when the utility is required.

Requirements	Alternative	# 1	# 2	# 3	# 4	# 5	***	# n
HVAC	Air Quality							
	Heating							
	Cooling							
Exhaust	Scrubbed Exhaust							
	Solvent Exhaust							
	Heat Exhaust							
Water	Fire and Sprinkler Water							
	Domestic Water							
	Industrial Water							
Bulk Chemical Distribution	Solvents							
	Corrosives							
Drainage	Acid Waste							
	Solvent Waste							
	Sanitary							
	Storm							
	Hydrogen Fluoride							
Cooling Water	Process Chilled Water							
	Chilled Water							
Ultra-Pure Water	Dionized Water							
Process Gases	Nitrogen							
	Bulk Gases							
	Specialty Gases							
Compressed Air	Oil-Free Air							
	Instrument Air							
	Breathing Air							
Vacuum	Process Vacuum							
	House Vacuum							
Electrical	High Voltage							
	Medium Voltage							
	Low Voltage							
Power Distribution	Normal							
	Emergency							
	Back-Up							
	Uninterruptible Power Supply (UPS)							

Figure 5-5: Alternatives-Requirements Matrix

(d) Benchmarking:

Benchmarking, or "the establishment of operating targets based on best practices" (Camp, 1989) is becoming increasingly commonplace among all types of businesses. Although the major driver of most of these companies has been the promise of improved competitive positioning and enhanced productivity (and not necessarily how other companies use decommissioned facility assets), there still is value to be gained by reviewing both internal and external past practices. As such, attempting to understand how other companies have dealt with similar situations may provide insight that would otherwise be overlooked.

Step 3: Establish Decision Factors

(a) List Potential Major Decision Factors and (b) List Decision Factor Assumptions

The purpose of establishing decision factors is to determine upon which specific aspects each of the alternatives should be evaluated. These factors, as previously mentioned, can vary with time and even with changes in the internal corporate and external business environment. As such, the intent is not to provide a short list or, conversely, a comprehensive list of potential decision factors. Rather, the purpose is to identify those dimensions (and their assumptions) that are considered valuable for the company. For example, some decision categories may be technical, political, socio-economic, strategic, financial, environmental, etc. Hence, depending on "what is important to the company", these factors may be different depending on the company's objectives.

However, for decommissioning facilities, many of the aforementioned factors can be encompassed in three major decision categories: (1) technical, (2) strategic, and (3) financial. Socio-economic and political factors can be taken into account under strategic and financial factors. Similarly, environmental factors can also be reasonably approximated under technical, strategic, and financial factors (depending on the situation). As such, one can "reasonably" approximate most issues under the umbrella of technical, strategic, and financial factors.

Ultimately, within each of these decision factors, there are also interactions between the factors. For example, financial and strategic factors may be interrelated if a company has a lot of liquid assets on hand and is investigating whether vertical integration or manufacturing expansion or even acquisitions are alternatives. Similarly, with respect to manufacturing requirements, the gap between current and near-term technical requirements will also require financial resources to close. Hence, although these decision factors are broken out, it should be understood that many relationships still exist between them.

Step 4: Generate Measures for Comparison by Decision Factor

(a) Building Code Review:

For many of the same reasons detailed in Step 1, a thorough building code review for potential future occupancies can offer insight into any potential requirements that different occupancies may offer. These requirements can range from exit widths, number of exit doors, toilet fixtures, etc. and can sometimes be difficult to overcome with an existing facility. As such, a comprehensive review with new occupancies in mind is instrumental to assessing the adaptive capabilities of an existing facility.

(b) Perform a Building Assessment:

Understanding the suitability of a facility for adaptive re-use depends on evaluating its capabilities against the specific needs of potential alternatives. As described in the referenced article (Poskanzer, 1996) this step is intended to establish and evaluate such technical measures as:

1. Structural integrity of the facility
2. Adequacy of existing infrastructure
3. Environmental issues
4. Site work improvements
5. Construction constraints
6. Roofing integrity

While this list is not intended to be comprehensive, the intent here is to understand the current capabilities of the facility and compare those to the potential requirements of future roles.

(c) Create "Balance Sheets":

While the exercise may take time, the author found it extremely beneficial to "brainstorm" potential problems (liabilities) and/or potential positive aspects (assets) associated with each alternative. That is, given an alternative (as indicated above), think about potential issues that might have to be overcome and those issues that make the alternative more or less attractive, based on each decision factor annotated above.

As an example, consider Alternative #1 (indicated below), "Demolish facility and construct new facility." A short result from applying this exercise may be as follows:

1. DEMOLITION -- Demolish and build new facility

(a) Technical Decision Factor: (Technical Feasibility (TF) and Technical Challenges (TC)):

(TC) - Demolition would have to not affect the "normal" production processes of the other fabs (i.e., no wrecking ball)
(TC) - Construction (similar to demolition) could not affect the production process (whether through vibrations or whatever)
(TC) - Additional parking requirement for displaced workers - can the site accommodate?
(TC) - Potential increases in site wastewater disposal permits
(TC) - No specific role for a new building has been identified -- don't want to just build a facility for the sake of building one

(b) Financial Decision Factor: (Efficiencies Gained (EG) and Efficiencies Lost (EL)):

(EL) - Key financial point: the incremental value of additional space that is not needed (i.e., if the site isn't space constrained and Intel would only be using the facility for creating "more" elbow room) is ZERO
EG - The incremental value of additional space that MAY be needed in the future is greater than zero
(EL) - High cost of demolition
EG/(EL) - New facility could be constructed to accommodate specific mission (versus retrofitting) -- downside; small footprint of building would limit the size of a facility that could be put in its place

(c) Strategic Decision Factor: (Positive Corporate Support and Negative Corporate Support (CS)):

(CS) - Would construct only if it could not be accommodated in Ronler Acres' plan and the mission needed to support F5/F15
(CS) - Would consider only if new land acquisition costs and "loss of proximity to other functions" were higher than complete demo

The intent of this exercise if two-fold: first, to comprehensively identify all technical, strategic, and financial measures that are unique to individual alternatives; and secondly, to reduce the comprehensive list of potential measures to a list of "common" or "constraining" measures that are associated with each alternative.

(d) Consolidate Constraining Measures for each Decision Factor:

Having "brainstormed" each alternative, the next step is to delineate common and usually constraining measures upon which the alternatives can be judged. For each decision factor, the objective is to create a set of measures against which the alternatives can be compared. In particular, the measure should identify the nature of the function versus the existing condition, the present need, the future need of generations, and any actions/costs associated with meeting the requirements.

1. Consolidate Technical Measures:

One way of looking at a facility from a technical perspective is to examine it on more than one level - "independently" and "interdependently." First, "... what are the specific building technical constraints versus needs for each alternative?" Second, "... when viewed in a larger picture, what are the specific site constraints that need to be considered?" The point here is to avoid being "short-sighted" and to try to encompass thinking of the facility in a larger picture. That is, evaluating some of the technical issues associated with the facility not only includes building constraints (mentioned above) but also site constraints. The intent of this methodology is to develop the framework for creating general technical measures for the alternatives.

(a) Externally Defined Requirements:

A thorough comparison of applicable codes at the time of facility construction and their modern day counterparts will lend valuable insight into possible requirements and changes that are necessitated for a number of potential roles. The first element is to analyze the facility for various occupancy ratings (as described by the various alternatives) and determine whether the facility can support them.

As described in Step 1, a thorough understanding of the implications of potential alternatives with respect to applicable codes lends much insight into occupancy requirements. If one is considering re-zoning the occupancy ratings, one can get an idea of how to apply various scenarios to see if the existing construction would meet all requirements. Similarly, understanding applicable requirements could also lend insight into what changes would be necessary, or even if an occupancy is allowed for certain type of construction. For example, in a multi-occupancy facility, one would need to apply to "sum less than 1" rule to ensure that the sum of the total allowed square footage divided by the total available square footage for each occupancy does not exceed one. That is, one can see whether potential occupancies together in a multi-occupancy arrangement need to have limitations on their space.

Similarly, renovations and alterations are also addressed in the building code and provide guidelines for potential exceptions or "grandfathered" clauses. The code even lends insight into how the rules are enforced and exceptions that can be made by the local Building Official. All in all, the purpose of reviewing the local building codes should be to essentially "get a feel" for how the facility exceeds or doesn't meet requirements for structural soundness, life-safety, or overall integrity.

Similarly, depending on these ratings, one also needs to consider other life-safety issues brought forth by the building code. Depending on the combustibility of products, the toxicity of chemicals used during the process, and the type of occupancy, life/safety requirements (including exit width and ventilation requirements) will also dictate whether potential occupancies are feasible. Since this element lend itself to binary support, "yes" and "no" factors may be used as valid figures.

(b) Structural Requirements:

In part, the structural design of decommissioned facilities dictates both the types of loads that can be supported as well as the integrity of the building to support different requirements.

With respect to loading requirements, understanding both dead loads and live loads are important measures for assessing the worthiness of a facility for adaptive re-use. For example, the heaviest piece of equipment for prior process generations may have weighed 8,000 pounds and been adequately supported by a concrete waffle slab floor. However, if another role is being investigated which includes next-generation equipment which requires a two-foot raised floor to support a point load of 10,000 pounds, the flooring system may not be adequate.

"Anticipated reasonable values for live loads required to support semiconductor processing is 250 pounds per square foot (on a raised floor) while a reasonable value for live loads required to support personnel is 100 pounds per square foot. Similarly, an approximate value of a concentrated point load for semiconductor processing (on a raised floor) is 1,200 pounds." (Intel Fab Design Criteria, 1994)

Similarly, the building's load bearing and structural systems will also determine the ability to support seismic and vibration movements. Depending on the foundation system (for example, pile-supported versus concrete footings), the interior and exterior structure (masonry brick versus steel framing), and the accompanying soil conditions (clay versus sand), the ability to support alternatives requiring seismic and vibration movements may or may not be met.

For example, with respect to vibration movements, one would need to approximate a reasonable estimation of the maximum floor deflection that is allowed (at the third harmonic) to support the most delicate piece of processing equipment for the process. Similarly, the maximum deflection for less-sensitive equipment (when measured at the third harmonic) would also have to be estimated. Hence, depending on the equipment selected, the existing building structure may or may not be able to support various equipment needs.

Similarly, sensitivity to vibration can also translate into how the building can meet seismic requirements. Depending on the facility's structure, the depth of its foundation and the construction, and the types of restraining devices in place, seismic (as well as vibration) concerns may be an element for examination. In particular, one should pay attention to this point since most semiconductor manufacturing companies (and many of their manufacturing facilities) are located within California's Silicon Valley.

(c) Mechanical Requirements:

Depending on the nature of the alternatives, mechanical systems could play an important role in the evaluation of alternatives and the ability of the facility to meet them. In addition, this type of analysis will indicate whether existing systems are best designed to meet those needs or whether additional changes may be required.

First, one needs to understand the environment in which they are operating. Depending on the wet bulb and dry bulb requirements of the particular region, the number of heating and cooling days, and the facility's location and orientation with respect to the sun's movement across the sky, HVAC requirements can be different. With respect to HVAC requirements, the nature of the heating loads (and conversely cooling loads) -- the sources (personnel, equipment, etc.), the types of loads (concentrated or point loads versus uniform or evenly distributed loads) -- can be evaluated by understanding the requirements for each alternative and then comparing it against existing systems. For example, typical heating loads within an equipment intensive environment will require more cooling capability than an administrative facility where lights and people generate much of the heat. Similarly, locating functions which generate a considerable concentrated heat load in an area where little cooling capability exists will require considerable rearrangement.

Similarly, one also needs to evaluate internal climate requirements and the ability of existing systems to meet them. "For example, within semiconductor manufacturing operations, typical temperature requirements (72 degrees F, +/- 0.3 degrees F) and humidity requirements (39.2 percent, +/- 1 percent) are stringent and even more restrictive in certain functional areas (i.e., lithography operations)." (Intel Fab Design Criteria, 1994) In contrast, most administrative functions require an adjustable temperature with fewer restrictions on temperature and humidity swings.

Finally, utility capacities must also be evaluated for each alternative. As depicted in creating an "alternatives/requirements" matrix, one can use this tool to compare existing capabilities versus the requirements of specific alternatives.

(d) Electrical Requirements:

The capabilities of an existing facility to supply adequate types of power to support various roles should be considered. If a facility has more than adequate power, then potential consolidation may be considered an alternative. However, unless one first identifies the types of loads, the location of loads, and any special needs (i.e., emergency power, back up power, uninterruptable power requirements, etc.), understanding the nature of alternatives cannot be understood.

(e) Architectural/Facility Requirements:

Architectural and facility requirements generally are taken into account during the design process. Depending on the characteristics of the function that the building is intended to support, various elements can be arranged to do so. With this in mind, such factors as clear span (the distance between one structural column and the next), location of shear walls (interior structural elements which usually cannot be removed), floor to ceiling heights, and even equipment size must be considered when determining the feasibility of adaptive re-use. Generally, these factors can affect open and clear space availability, rearrangement potential, and the potential to accommodate future requirements.

Typically, most semiconductor facility designs attempt to limit the amount of interference that shear walls, floor to ceiling height restrictions, and column locations can impose on future rearrangement possibilities. Hence, typical floor-to-ceiling heights can range from twelve feet (12') to twenty five feet (25') and clear spans can range from fifty feet (55') to seventy-five feet (75').

(f) Miscellaneous:

Although not explicitly covered elsewhere, technical factors including potential effects on process or product flow, integration and coordination issues, material handling requirements, and environmental restrictions must be also be considered.

2. Strategic Measures:

Understanding strategic policy and direction is also an essential element of considering potential uses for decommissioned facilities. Since facilities are considered corporate assets (depending on interpretation, until they are sold or their net book value (NBV) is equal to zero), they provide the basis from which a manufacturing company can provide products and/or services that generate revenue for the corporation. As such, facilities play an important role in the strategy process.

(a) Fit with corporate strategy:

Understanding and identifying the corporation's overall strategy and its relationship with the corporation's specific manufacturing strategy is the first step toward understanding the potential value of decommissioned facilities. For example, if the company foresees growth in demand for its products and cannot meet projected requirements with its existing facilities base, then additional manufacturing space might be required. Similarly, if the company expects to enter a phase of cost-cutting and consolidation at the same time, then use of the facilities for administrative use may not be justified.

As background, one also needs to understand the different facility decisions in the strategy process. For example, depending on the alternative under consideration, elements such as space needs (size), geographic distribution issues (flow of materials from raw materials to customers), focus issues (product, process, volume, or market focus), scale and scope issues (economics), and competitive dimensions (quality, cost, service, etc.) need to be considered to evaluate the "fit" of potential uses. For example, with respect to the last element, if the company is competing on cost, then scale and size become significant issues; large throughput capabilities and hence large facilities are required. Similarly, if the company is competing on product innovation and competing in a niche market, then the size of a facility becomes less significant. Hence, identifying how a company creates "value" in its products and how it competes, as well as identifying its current strategy for the future, can lend insight into the value that various roles for decommissioned facilities can play.

As such, one needs to evaluate whether the strategic goals of the corporation are aligned with potential uses facing the facility. However, since these values lend themselves to more qualitative measures, they can be judged as "high", "medium", or "low" fits for the alternatives under question.

(b) Fit with long-term and short-term facility strategies:

Facility strategy should be considered on a number of levels. First, the potential role of the facility needs to be viewed not only from a local standpoint but from a state, regional, and even global standpoint. Depending on the context, the role that the facility currently plays or could play in the entire corporate picture needs to be considered.

The second basis for evaluating facilities strategically should take into account current facility strategies and future strategies. That is, the strategic decisions about current facilities as well as potential plans for constructing future facilities. By evaluating how the company is currently using its facility assets, as well as planning to use facility assets in the future, one can gain insights into the potential strategic "fit" that various roles for the facility may have.

Similarly, since these values lend themselves to more qualitative measures, they too can be evaluated as "high", "medium", or "low" fits for the alternatives under question.

(c) Fit with corporate guidelines:

Besides interpretation of corporate strategy, one needs to also consider corporate policies. That is, corporate standards that are internally published or adhered to which govern corporate operations. For example, if a company mandates that each employee only receive 100 square feet of cubicle space, then a policy of converting an adjoining building to accommodate spaces of 200 square feet would be violated.

Since this type of measure also lends itself to qualitative measurements, rankings based on "high", "medium", or "low" are considered more valuable than quantitative measures.

3. Financial Measures:

As with most major decisions, financial evaluations provide a tool for both financial and non-financial planners to evaluate the worthiness of potential investments. Whether demonstrated through Net Present Value (NPV) analysis or through a project's Internal Rate of Return (IRR), financial tools lend much insight into the estimation of costs and revenues and their underlying assumptions. As such, the author believes that understanding the financial measures is also an essential part of the decision-making process.

When creating a list of financial measures for evaluating alternatives for decommissioned facilities, one needs to consider three general measures: (a) the implications and derivation of a weighted average cost of capital (WACC), (b) costs and the different types associated with each alternative, and (c) potential revenues and opportunity costs.

(a) Cost of Capital:

The first step in this process is to understand the company's financial management techniques. At the heart of this element is establishing a hurdle rate, discount rate, or weighted average cost of capital (WACC) for the alternatives. Since this hurdle rate is very important in determining the worthiness of a project, one should take the time to understand its meaning and implications of the input variables in its derivation.

According to modern finance theory (Brealey and Meyers, 1991), the weighted average cost of capital (WACC) or hurdle rate for a project is a function of the firm's cost of equity, its cost of debt, its financial leverage, and the risk of the investment (as perceived by either public capital markets, private investors, and/or the corporation, depending on the source of investment).

The cost of debt can be described as the cost that banks and other lending institutions would judge the risk associated with lending the firm capital (as depicted in the interest rates that they would charge the corporation). Similarly, the cost of equity is a function of the expected return of potential investors (as judged by the capital marketplace) for a firm or similarly a specific project proposed by the firm.

Finally, the risk of the project (measured by the level of investment, the range of anticipated returns, the duration of the project, and even the health of the corporation) must also be taken into account. For example, a project with a higher risk would be expected to return a higher rate of return than a project of lower risk. For projects of equal risk within a firm, the hurdle rate should be the same for both. Hence, when setting a project's hurdle rate, one must need to consider what an "acceptable" rate would be, for whom the rate is "acceptable" (i.e., the corporation or capital investors), and the duration of the project.

For most facility investment projects, the hurdle rate will generally be lower than other short-term investments. This stems largely from the fact that facility investments are considered long-term investments (rather than, for example, a short-term investment in a highly risky research and development project). As such, since financial return is directly related to the level of financial risk, the risk and hence, hurdle rate of facility investment projects tends to be lower. However, since investments in semiconductor operations tends to be more risky than other similar facility investments, one would also expect the industry's average hurdle rate to be higher than other "less-risky" industries.

A range of generally acceptable hurdle rates for semiconductor manufacturing facilities can extend from a low of five percent (5%) to a high of twenty percent (20%), depending on the firm and the project.

(b) Costs:

In the second step, one needs to collect information about the potential costs associated with each alternative. These costs may include initial investment costs (potential construction and rearrangement costs), annual operating costs (fixed and variable) under operating and non-operating conditions (i.e., facility holding costs), annual property taxes, annual headcount or salary costs, and other undefined costs.

Sources for this type of information can range from internal sources (for example, departments specializing in renovation and construction), historical information from similar investment projects, annual budgets for operating costs (usually within the corporation's finance or accounting departments), common reference materials (for example, construction estimating tools), or even outside sources (for example, estimates provided by contractors).

When evaluating potential alternatives at such a high level, one should be most concerned with estimating a proper magnitude of values and not necessarily be as concerned with the accuracy of those values. Without a specific design in hand, preliminary estimates of construction costs can prove difficult and highly inaccurate. Hence, one needs to be aware of the high level of uncertainty that will characterize some estimates and be primarily concerned with trying to generate an order of magnitude estimate.

(1) Annual Costs:

Estimating annual costs should include such operating expenditures as energy costs (electricity, natural gas, oil, etc.), sewer and wastewater disposal costs, water usage rates, raw material and input costs, direct and indirect labor costs, depreciation costs, etc. If an internal department specializes in tracking these costs, they should be more easily obtainable than if they need to be derived.

It should be noted that the values of each of these categories should (if possible) be tailored for the specific alternatives under consideration. Although it might be difficult to estimate in more detail than a "cost per square foot" basis, higher energy costs associated with operating a wafer fabrication facility should be differentiated from the energy costs associated with operating an administrative facility.

While an order of magnitude estimate is reasonable, these costs should have more certainty than other potential costs.

(2) Initial Investment Costs:

Estimating investment costs will require some diligence and potentially research into more than one source. Investment costs should include construction and rearrangement costs, equipment investment costs, demolition costs, permitting costs, etc. If the company has a function specializing in estimating these costs or even tracking historical cost expenditures, it could provide very useful.

As mentioned earlier, because of the high level of uncertainty associated with these costs, the objective is to create an order of magnitude estimate. For example, unknown future economic conditions in the construction industry could drive prices up or down. Similarly, depending on how the project is designed by an Architect-Engineering firm, construction costs could also vary significantly. As such, since more cost details will be available during the design process, one can only expect to create a "reasonable" value of cost ranges. With this argument in mind, one can expect costs to vary as much as fifty percent (50%) from the estimates presented.

Similarly, for comparing similar alternatives against each other, one needs to create a common baseline. For example, when comparing the costs of renovation versus constructing a new facility, the actual equipment costs should be the same. As such, one should compare the costs of creating the same level clean room environment. One cannot compare the costs of creating a clean room environment in one alternative against the costs of constructing a new facility which includes all processing equipment costs. All direct comparisons need to have the same basis for comparison to be considered accurate.

Finally, the cost of demolition can serve as the baseline for comparing all alternatives. Since demolition costs can vary as much by as one hundred percent (100%), an estimate of the cost of demolition can vary significantly from actual costs. However, since there are usually a number of demolition contractors in most metropolitan areas, potentially the best method for creating this baseline is to request a bid from one or more of them. With this figure firmly in mind, one can also create better judgments about other potential alternatives.

(c) Opportunity Costs and Revenues:

As the third component of the financial analysis, one needs to estimate the potential revenues, opportunity costs, and savings associated with each alternative. In this instance, revenues can be estimated based on existing product data obtained from non-internal sources or even from the consolidation of marketing or sales information. However, projecting revenues based on future demands introduces some uncertainty into the equation.

While sometimes difficult to define, opportunity costs represent potential avoided costs or savings incurred by taking an action. However, estimating costs savings resulting from lower input variables (i.e., energy, labor content, materials) need to be taken into account for an accurate comparison. Materials management functions, as well as facility engineering functions and accounting departments, may be able to provide reasonably good estimates of these values.

As estimates, future projected revenues (and costs for that matter) are sensitive to a number of market perceptions and economic changes and as such should be recognized. For example, depending on the type of product produced, margins can vary significantly. Microprocessors, for instance, earn significantly higher profits that microcontrollers or other commodity-like semiconductor products where customers can easily move from firm to firm. At the same time, increasing competition in the marketplace can drive down product margins and bring lower prices to the consumer as a result as well. Similarly, external market factors can also cause the costs of input variables to rise as well, driving down product margins. As such, one needs to recognize the sensitivity and potentially large variances that are built into estimating both costs and revenues.

(d) Appendix: Evaluating Capital Expenditures through Options Pricing:

During development of this methodology, research into financial evaluation tools revealed that one potentially valuable approach for evaluating capital expenditures involves utilizing an options pricing approach. While the author found it difficult to apply this tool in this particular case (since only a limited number of scenarios truly generated enough revenues to cover costs), the approach appears well-suited for a number of other potential situations where revenue sources are more defined.

As described in the reference, "options pricing differs from purely net present value (NPV) pricing by allowing one to "buy" additional information that can lend further insight into the decision-making process. Under the NPV model, all cash flows are discounted back to today (t=0). However, under options pricing, one is able to evaluate cash flows based on different times (t=1, t=2, etc.) and consider the implications of paying for additional information before committing to a certain decision." (Dixit and Pindyck, 1994)

For example, consider the following:

Currently, XYZ Corporation is deciding what to do with their decommissioned semiconductor manufacturing facility (current date is considered time t=0). Designing for a future function will entail a year of design effort and cost \$90 million dollars. At time t=1, construction will begin and last until time t=2. While the costs are not specifically known at this time (t=0), it is expected that they could be \$1.5 billion dollars, \$900 million dollars, or \$600 million dollars (each with equal probability (p) equal to 1/3). Similarly, at time t=2, current information from the marketing department indicates that XYZ Corporation will be able to sell the widgets that they will make at the facility. Projected lifetime revenues (assuming from t=2 to t=3) from widgets produced at the facility are anticipated to be either \$1.8 billion dollars or \$300 million dollars (with equal probability, p=1/2). The discount or hurdle rate of the XYZ Corporation is 10%. Should XYZ invest in the project?

According to the Net Present Value (NPV) rule, the expected value of the project to the corporation would be evaluated as follows:

$$NPV = -\$90M\$ - \frac{(1/3)*(\$1,500M)}{(1.10)} - \frac{(1/3)*(\$900M)}{(1.10)} - \frac{(1/3)*(\$600M)}{(1.10)} + \frac{(1/2)*(\$1,800M)}{(1.10)^2} + \frac{(1/2)*(\$300M)}{(1.10)^2}$$

NPV = -\$130M

Consequently, one would conclude that XYZ Corporation should not invest in the project.

However., by employing options theory, one can re-evaluate the same situation by varying the time that investment decisions are made. That is, under the NPV, it assumes that the decision at t=0 is the only decision that could be made. However, according to options theory, there is another decision which must be factored into the equation (at t=1). Consequently, if we assume that the initial investment of \$90 million dollars for the design has already been approved, the expected net present value (NPV) to the corporation would be evaluated as follows:

At t=2, the expected revenue return is (1/2)*(\$1,800M) + (1/2)*(\$300M) = \$1,050M

At t=1, three potential scenarios could present themselves:

Scenario #1: Cost = \$1,500M

Under this situation, one would never invest in the manufacturing plant because the expected revenue in the future (\$1,050M) is less than the cost of the facility (\$1,500M). Hence, the expected NPV of this scenario is NPV = -\$90M (the initial design investment) * (1/3) = -\$30M

Scenario #2: Cost = \$900M

Under this situation, one would invest in the facility (because the expected revenue is greater than the facility cost). Hence, the expected NPV of this scenario is as follows:

$$NPV = (1/3)*\{(-\$90M) - \frac{(\$900M)}{(1.10)} + \frac{(\$1,050M)}{(1.10)^2}\} = -\$13M$$

Scenario #3: Cost = $600M

Under this situation, one would also invest in the facility. Hence, the expected value of this scenario

$$NPV = (1/3)*\{(-\$90M) - \frac{(\$600M)}{(1.10)} + \frac{(\$1,050M)}{(1.10)^2}\} = +\$77M$$

Summarizing these results, the expected NPV of the project (by applying options theory rather than purely a NPV rule) is:

E(NPV) = -$30M - $13M + $77M
= +$34M

The major difference between the approaches is that under the options approach, one is "paying" $90M for the value of future information. Unfortunately, this approach did not necessarily work under Fab 4's framework (because many of its potential alternatives did not have an projected revenue source). However, options theory still remains a valuable tool for evaluating future capital expenditures, given potential costs and revenues. Since this framework is intended to have general applications (within or even outside of Intel), the author decided that making others aware of this tool was a valuable part of the methodology presentation.

Step 5: Conclusions

(a) Perform "coarse" elimination:

With all the information in hand, the next step is to determine the feasibility of alternatives. The first step in this process is intended to remove alternatives which are not feasible or cannot be included further because of their technical requirements. For example, if the alternative requires 50,000 square feet and the total size of the available facility is 20,000 square feet, then the alternative should be removed from consideration.

(b) Perform more thorough elimination:

In contrast to step (a), this step relies more on subjective (but rationalized) evaluation of issues and constraints resulting from the analysis in Step 4. The objective is to determine the "most feasible alternatives" from the remaining, given the information and combination of decision factors.

(c) Perform Sensitivity Analyses (if necessary):

With the "most feasible" alternatives in hand, sensitivity analyses could (if exercised) show how different variable affect each alternative. For example, if the hurdle rate is changed, the resulting impact may show one alternative is less susceptible than others.

Overall, the major intent of Step 5 is to draw conclusions from all the information collected. With information in hand, this section should focus on recommendations drawn from the data and provide reflection and justification for the most feasible alternatives.

5.6 Summary

The overall intent of Chapter 5 has been to introduce the general framework and describe the elements which compose it. Using this methodology, the following chapter will attempt to use an existing facility as an example and demonstrate the validity (as well as point out some of the shortcomings) of this model.

Chapter 6: Application of Framework

As a means to validate and explore the methodology presented, the author will present three case studies in this chapter. First, the framework developed in Chapter 5 will be applied to a current facility (Intel's Fab 4) that was the research basis for this thesis. The culmination of this application will be the presentation of the alternatives deemed most feasible by the methodology.

Next, the author will demonstrate the applicability of this methodology by reviewing past facility shutdowns and potential future shutdowns. In the first section, the framework will be applied to the two past facility shutdowns within Intel's recent history. Based on available historical information, the author will discuss the major decision factors and measures which dictated their future roles. Secondly, the methodology will be used to examine the future potential roles for two additional facilities within Intel's fixed asset base.

6.1 Application of Framework to Fab 4

Step 1: Establish reference values

(a) Current State:

Situated on Intel's Aloha campus, Fab 4 is located on the border of the towns of Aloha and Hillsboro in the state of Oregon and within the boundaries of Washington County. Aloha, Oregon is a suburban area located approximately fifteen miles southwest of the metropolitan city of Portland in the Pacific Northwest. Despite its small size, the town of Aloha is strategically located in the Portland Development Zone and is served by most infrastructure elements common to a large city.

The site sits next to one of the major four lane east-west highways in the area and represents one of two semiconductor manufacturing campuses that Intel operates in the area. The Aloha campus consists of five facilities -- three semiconductor manufacturing facilities and two administrative/support facilities. Approximately five miles away, the Ronler Acres campus consists of four facilities to date (one research and development manufacturing facility), with previously announced construction plans underway to expand the site further. Four other large campuses in the area (Jones Farms, Hawthorne Farms, Elam Young, and Cornell Oaks) provide administrative support, component assembly operations, and technology development areas for Intel-Oregon while one small campus (Amber Glen) mainly provides off-site support facilities. "Approximately 10,000 of Intel's 48,500 worldwide employees are located in the general Portland area." (Interview with Intel General Site Services Financial Planner, 1996)

Locally, the infrastructure supporting the site is relatively modern. Most utilities (sewer, storm, water, electricity, natural gas, etc.) border the campus and are easily accessible for connection. Similarly, the local area is generally filled with a well-educated and technically-oriented labor supply. Portland Community College (PCC) provides an associates degree program with a concentration in semiconductor manufacturing. Similarly, Oregon State University is located approximately ninety miles south of Portland in the town of Corvallis and provides a local source for technical undergraduate and graduate engineering students in the area.

With respect to transportation modes, Portland has an international airport, a well-known water port located on the Willamette River, and access to interstate highways running north-south (Interstate 5) as well as east-west (Interstate 84). Most semiconductor products produced in Oregon are shipped out of state (to Chandler, Arizona) or out of country (Penang, Malaysia) for assembly and test operations and packaging.

Intel as a whole operates numerous facilities in the western part of the United States as well as overseas. Headquartered in California's Silicon Valley, Intel operates domestic semiconductor manufacturing facilities in Santa Clara, California (Fab D-2); Phoenix, Arizona (Fab 6 and Fab 12); Rio Rancho, New Mexico (Fab 7, Fab 9, and Fab 11); and Portland, Oregon (Fab 5 and Fab 15) as well as overseas operations in Israel (Fab 8) and Ireland (Fab 10). Similarly, the company operates assembly and test areas and components manufacturing areas in DuPont, Washington; Penang, Malaysia; and Phoenix, Arizona. In addition, Intel recently announced plans to open a new wafer fabrication facility in Fort Worth, Texas as well as a new test and assembly facility in the republic of Costa Rica.

(b) Review Building History and Establish Time Reference:

"Fab 4 was designed in 1974 according to the 1973 Uniform Building Code (UBC)." (As-Built Drawings, 1974) It was originally designed with a large mechanical room, general administrative offices, and a cafeteria on the first floor; offices, bathrooms, wafer sort and quality assessment, and manufacturing areas on the second floor.

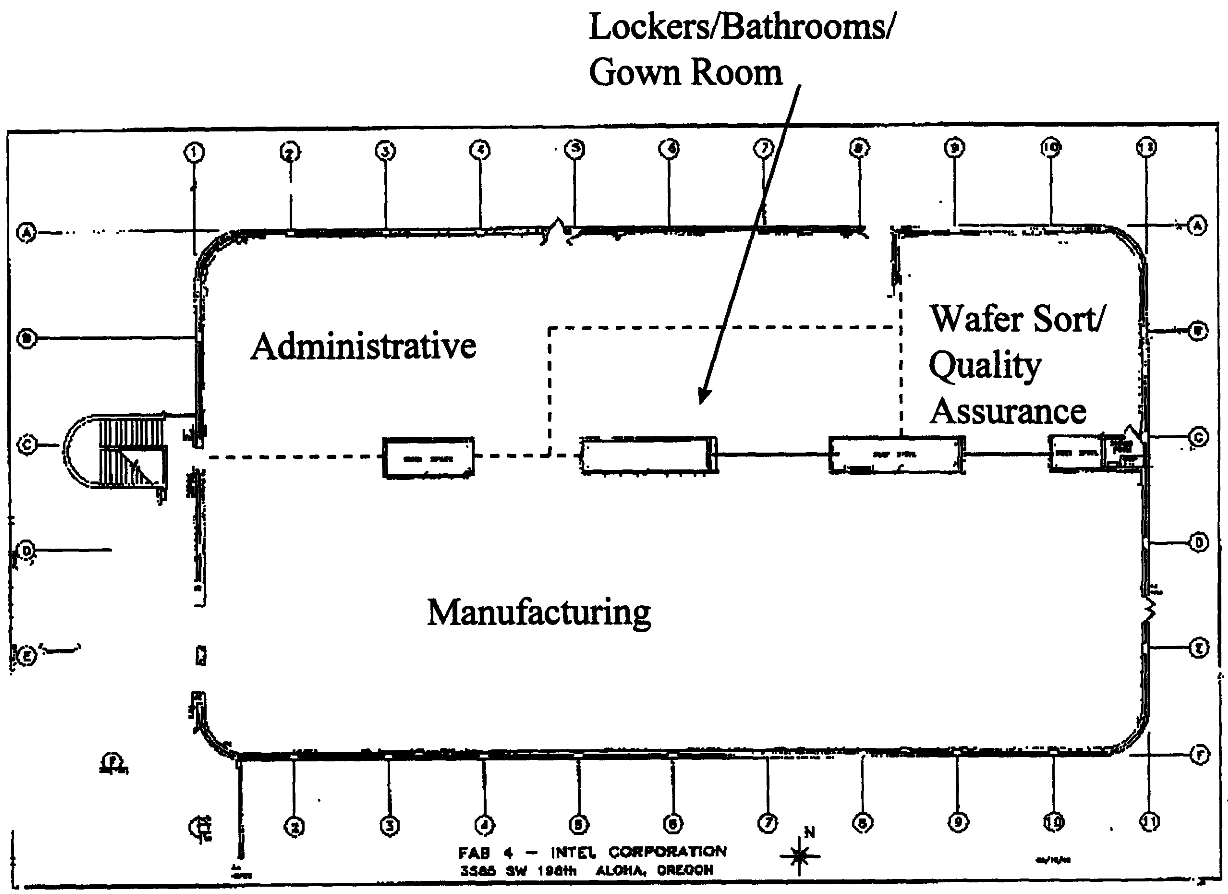


Figure 6-1: Fab 4 - Original Second Floor Functional Layout, May 1974
Source: Intel Corporation

From its original construction, the facility has undergone a number of renovations. Most consisted of rearranging the available floor space to allow for more manufacturing area on the second floor while the most recent major renovation included the construction of an annex (located at the bottom left hand corner of Figure 6-2). At the time of its closure, the facility supported approximately 20,000 SF of manufacturing on the second floor while the first floor had largely become a process piping and mechanical and electrical room.

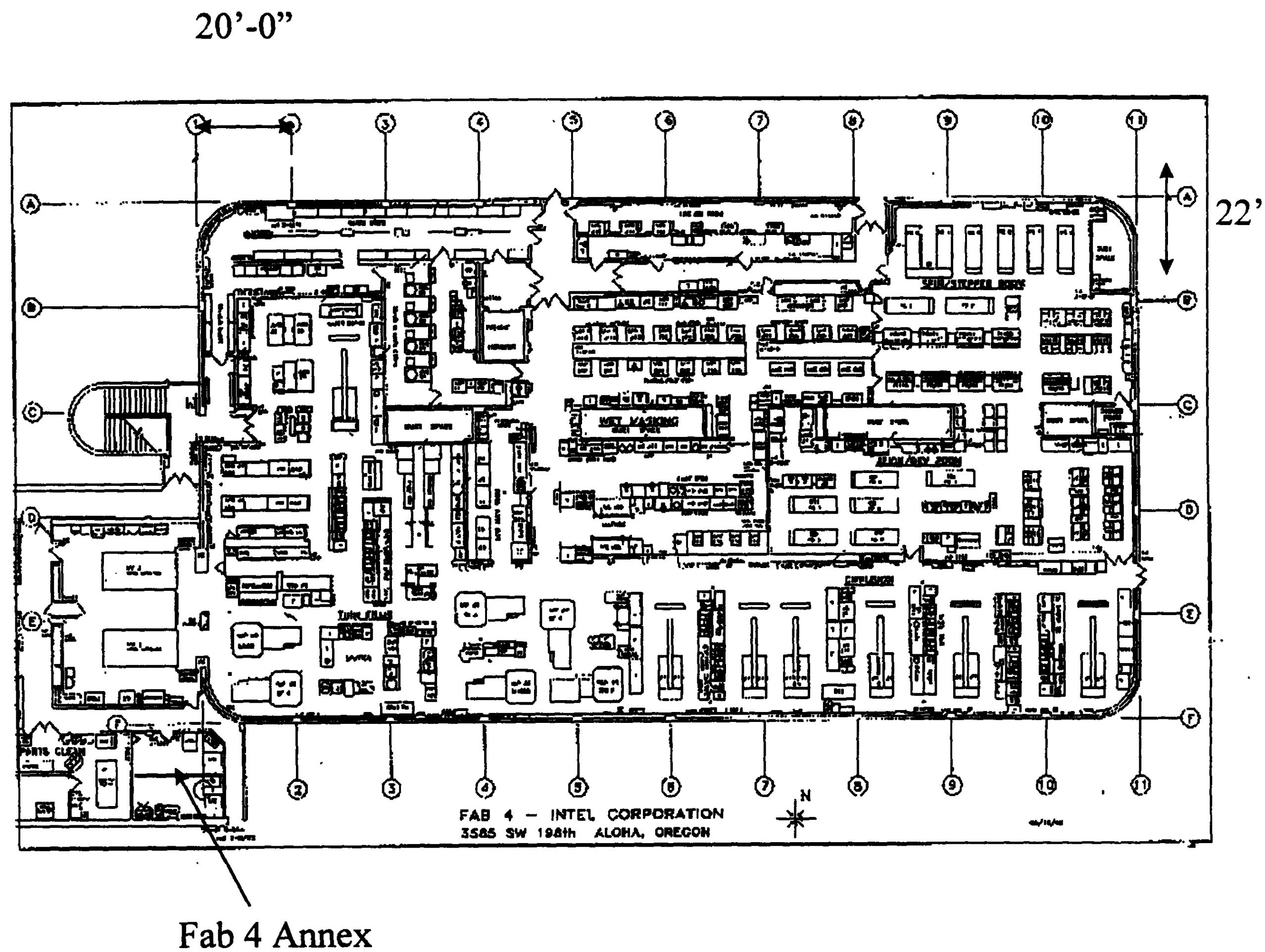


Figure 6-2: Fab 4 - Second Floor Fabrication Area Layout, June 1996
Source: Intel Corporation

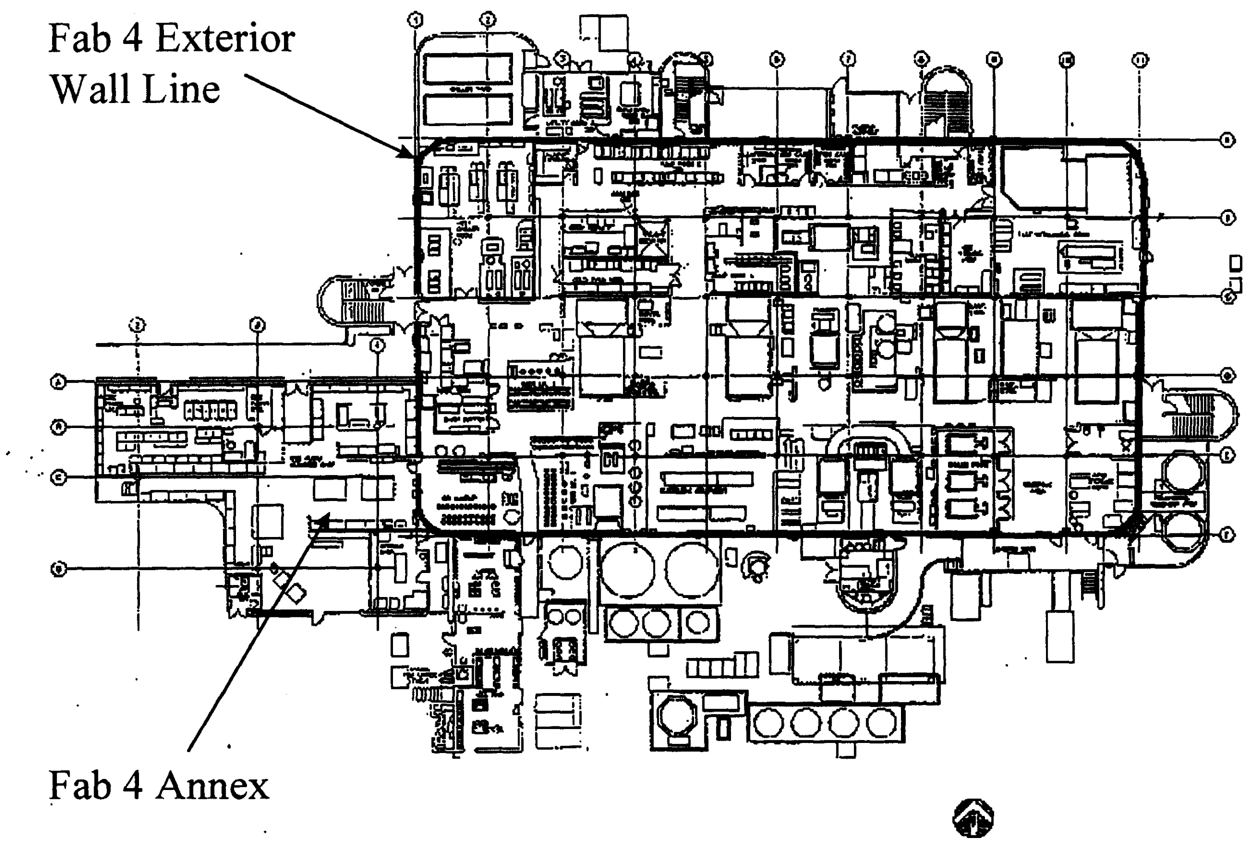


Figure 6-3: Fab 4 - First Floor (Subfab) Area Layout, June 1996
Source: Intel Corporation

With respect to the products that it supported, most of its production was focused on embedded control chips or semiconductor devices that are programmed to control specific functions in products. All of the products manufactured had relatively "high" line widths (when compared to today's standards of 0.6µ and 0.35µ). The wide range of discrete processes (estimated at approximately 100 at closure) and the large number of products (estimated at greater than 800 at closure) allowed Fab 4 to continue operating even as competitors shut down their existing product lines in favor of new process lines.

Strategically, the fab was positioned as a "cash cow" (Porter, 1980) -- that is, producing relatively small number of products at a relatively high margin.

At the time of this study, the building was planned for manufacturing shutdown in January, 1997 with a stated change of six months earlier or six months later than that date.

(c) Identify Removable Elements:

Unlike many of its sister fabrication facilities in Intel's inventory, the clean room walls and partitions are not removable. As such, only Fab 4's manufacturing equipment is generally considered to be removable.
The vertical laminar flow hoods, if considered separate from the plaster ceiling structure that they are integrated into, could also be considered removable but would leave large areas of open space for replacement.

(d) Preliminary Site Assessment:

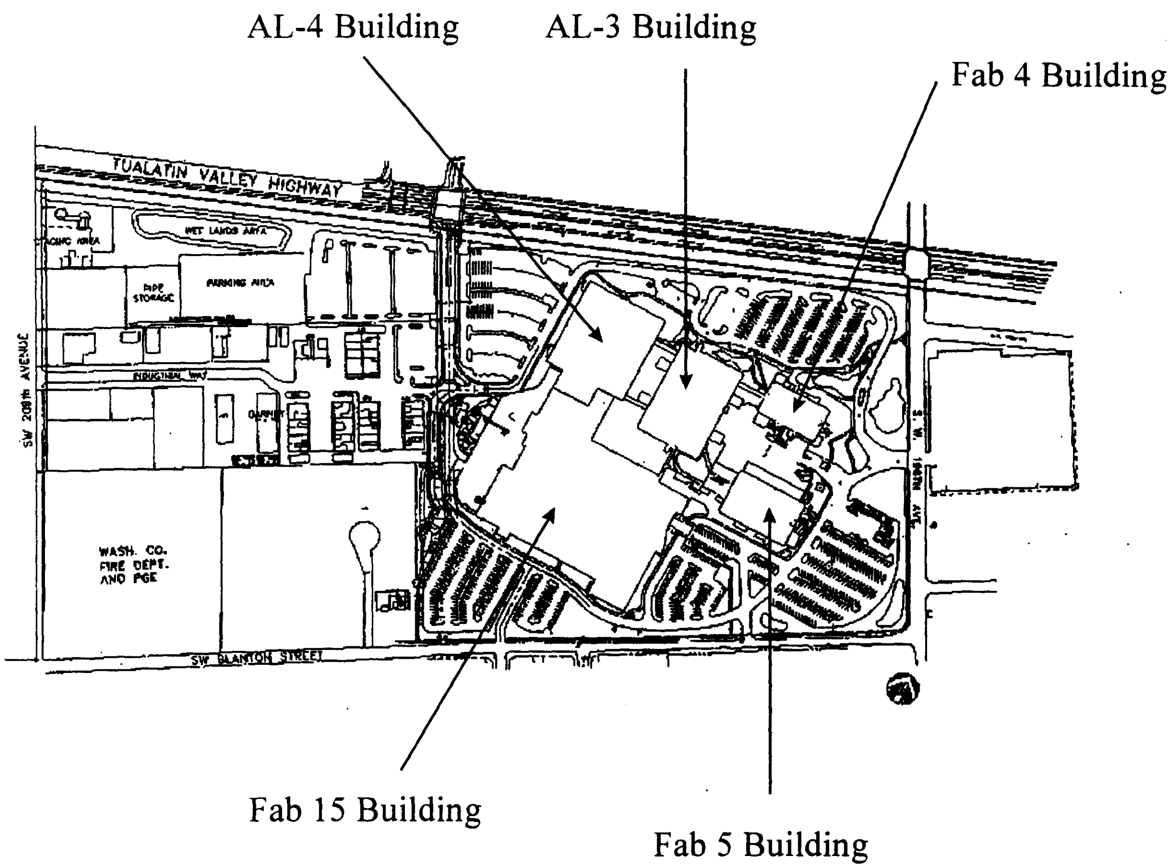


Figure 6-4: Plan View, Intel Aloha Site Campus, June 1996
Source: Intel Corporation

"As shown in the attached map in Figure 6-4, Fab 4 was originally constructed on a site comprised approximately 22 acres (the current site boundaries consist of approximated 50 acres)." (As-Built Drawings, 1974) The original facility was constructed in 1975-1976 while other facilities were constructed later. Two administration buildings (respectively known as AL-3 and AL-4), each largely composed of non-manufacturing support functions (i.e., Health Services, Computer Room areas, Wafer Test and Sort Area, etc.), are two-floor facilities. AL-3, constructed in 1979, is approximately 60,000 SF per floor with conference rooms and administration areas. AL-4, constructed in 1989, is approximately 90,000 SF per floor and used to house much of the PTD (Portland Technology and Development Group) before their recent move to the Ronler Acres site. Currently, it too houses many of the administration functions on site, as well as the Sort and Test area and other dedicated laboratory facilities.

In addition to Fab 4, two other semiconductor manufacturing facilities are located on site. Fab 5, with a footprint approximately 36,000 SF, was constructed soon after Fab 4 in 1979. With two major recent upgrades in the last ten years (one to the original development lab D-1 and the second to convert that lab to a Class 10 manufacturing facility), Fab 5 now produces 0.6µ technology products (i.e., P652 Pentiums® 75-100 MHz, and P653 chip sets, which are computer motherboard devices that perform logic functions in computers based on Intel processors) on

6-inch wafer technology. With an anticipated throughput of approximately 60 wafer starts per week (WSPW), it is generally regarded throughout the semiconductor industry that chipsets are "lower" margin products than microprocessors (which are able to reap gross margins of approximately 60%) (Kirkpatrick, 1997).

Fab 15 (recently renamed from development lab D1-B) encompasses approximately 75,000 SF of Class 1 clean room space that is producing 0.35μ technology products (i.e., P854 Pentiums® and Pentium Pros® and P55 MMX™ multimedia chips) on 8-inch wafer technology. Because of its larger size, throughput is "higher" but not proportionally higher because of the increased number of processing steps. Its current anticipated throughput is approximately 70 wafer starts per week (WSPW) while its larger sister plants (in particular, Fab 11) produce approximately 85 wafer starts per week.

Among the other points of interest to note are the site's property lines. The north end of the site extends to the nearby main road (TV Highway) and is bordered by railroad tracks. To the east, the site is bordered by SW 198th Avenue. On the south end, the property runs along SW Blanton Street until it meets property owned by Aloha Garbage Company and Washington Country Fire Department and Portland Gas and Electric (PGE).

Some potential notes of interest. First, Intel has mitigated wetlands in the northwest portion of the property, allowing it to use that space as it deems necessary. Note, however, that the railroad tracks are in that vicinity. Secondly, parking spaces for employees and contractors comprise a large portion of Intel's Aloha campus. Approximately 2,000 total parking spaces are annotated on site, and numerous warehouse facilities are located on site to provide storage capabilities for contractors.

The interdependencies between the facilities can be understood by talking with engineers and consulting other available resources. Revisiting Figure 6-4, it should be noted that Fab 4, Fab 5, and AL-3 share a common service yard that is a controlled entry point. Many of both Fab 4 and Fab 5's manufacturing resources as well as utilities are located in this area. For example, the yard houses a 4-inch storm drain line, 4-inch and 8-inch sanitary sewer line, 8-inch fire water line, 4-inch natural gas main, 6-inch domestic water line, numerous underground high voltage (HV) duct banks, acid waste neutralization (AWN) main lines, and a number of abandoned lines (for instance, hydrogen lines).

(e) Current Building Code Review:

Designed in 1974, Fab 4's construction was based largely on the requirements of the <u>1973 Uniform Building Code</u> and the Oregon Amendments to the edition. The building is classified as a Type III facility with an "N" or non-combustible rating (based on its concrete columns and reinforced masonry walls). The entire facility is 100 % sprinklered at three levels (the first floor subfab, the second floor fabrication area, and the interstitial space above the second floor and below the roof deck).

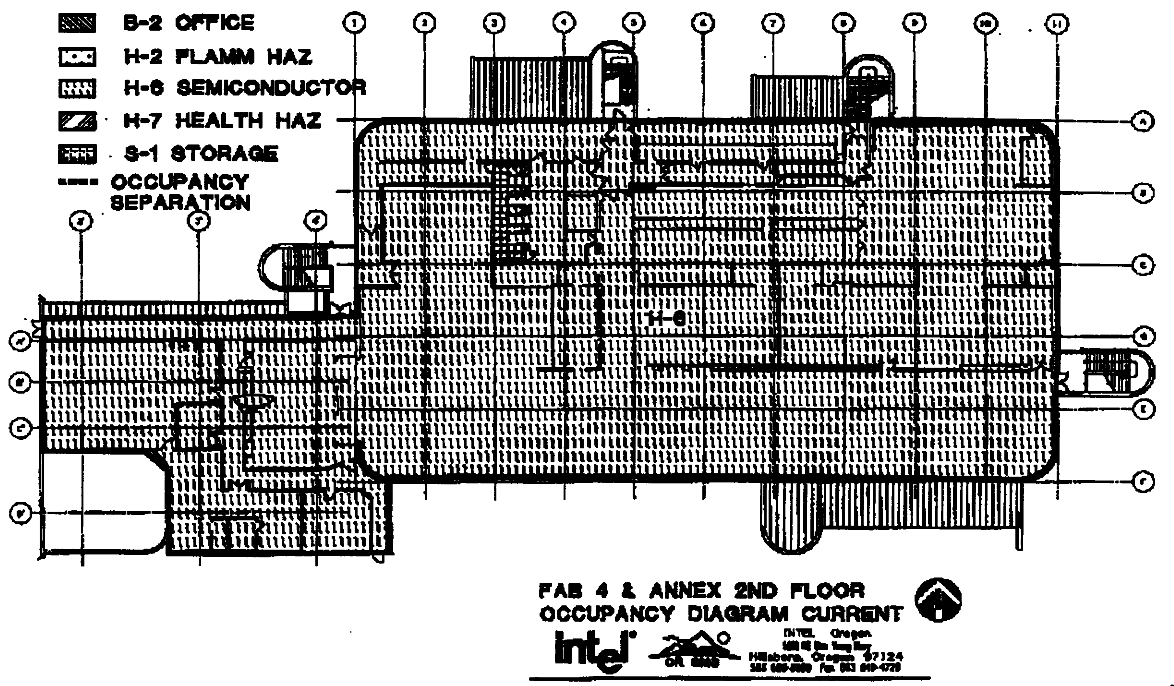


Figure 6-5: Fab 4 - Second Floor Occupancy Diagram, June 1996
Source: Intel Corporation

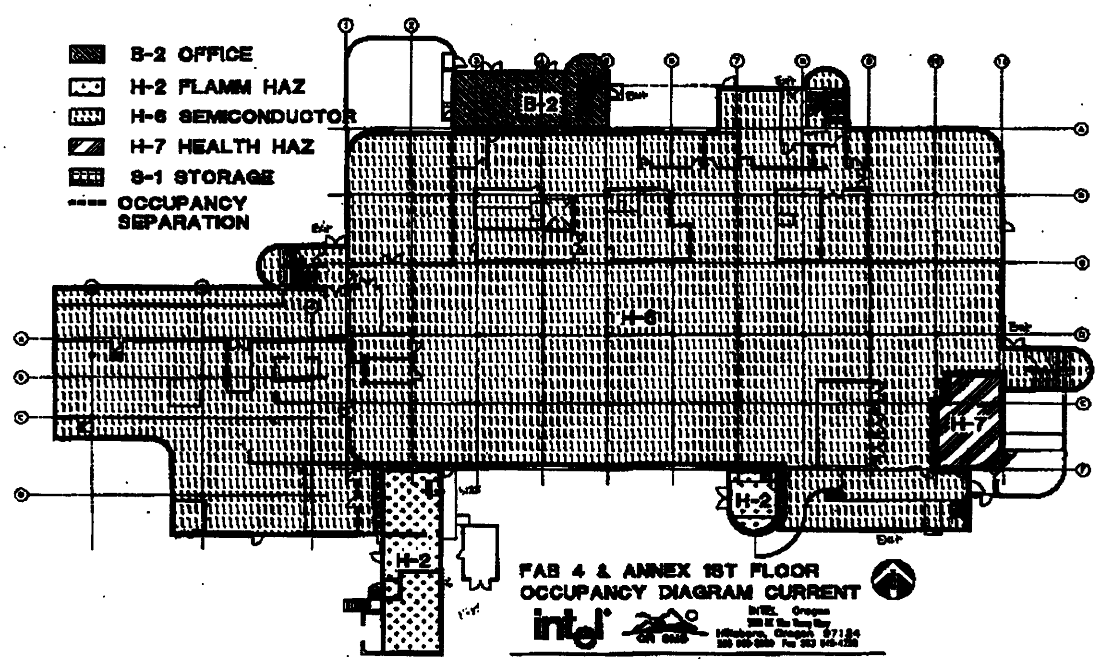


Figure 6-6: Fab 4 - First Floor Occupancy Diagram, June 1996
Source: Intel Corporation

Currently, the building is considered a multi-occupancy facility and consists of occupancy codes including H6 (semiconductor manufacturing operations), H2 (moderate explosion hazard), H7 (moderate health hazard), and B2 (office area). As detailed above, the first floor is largely H6 with the following exceptions: H2 (gas pad and bulk chemical solvent storage area); H7 (acid storage area); and B2 (North utility room and electrical utility room). The second floor is entirely H6 and the interstitial space (located between the second floor ceiling and the roof) is also zoned H6.

As previously mentioned, Fab 4 is considered a multi-occupancy facility with the annex and the building considered together. Since the building meets certain standards for unobstructed distances from the structure, Fab 4 is allowed a "sideyard increase" for the amount of clear space that surrounds it. Hence, any evaluation of the facility meeting applicable standards also requires taking the occupancy classifications within the annex area into consideration as well. The total facility height (based on UBC standards and definitions) is 43'; the building is considered multi-storied and is fully sprinklered.

As it exists today, Fab 4 consists largely of an H6 occupancy rating with zones of H2, H6, and B2. Based on Table 5-B within the UBC and allowable increases in Section 500, we can establish the following bases for Fab 4 today and applying those calculations to other potential occupancy ratings.

As such, the maximum allowances for occupancies within Fab 4 today are as follows in Table 6-7

Occupancy Codes	Table 5-B Allowable Floor Area	Multi-Occupancy Facility (2 Flrs)	Subtotal (1)	Sideyard Increase (57.5%)	Subtotal (2)	Sprinkler Increase (Double)	Total Allowable SF
B2	12,000 SF	2	24,000 SF	13,800 SF	37,800 SF	37,800 SF	75,600 SF
H2	3,700 SF	2	7,400 SF	4,255 SF	11,655 SF	N/A	11,655 SF
H6	12,000 SF	2	24,000 SF	13,800 SF	37,800 SF	37,800 SF	75,600 SF
H7	12,000 SF	2	24,000 SF	13,800 SF	37,800 SF	37,800 SF	75,600 SF

Table 6-7: Occupancy Allowance Calculations for Fab 4
Source: Based on 1994 Uniform Building Code, Table 5-B

Next, existing areas and their approximate square footage calculations are as follows:

First Floor:

(a) Total H7 (Acid Storage Room): 570 SF
(b) Total H2: 1,400 SF
    Upper and Lower Gas Pads: 1,110 SF
    Solvent Storage Room: 290 SF
(c) Total B2 (Utility Room A and Electrical Utility Room B): 1,500 SF
(d) Total Fab 4 H6: 21,540 SF
(e) Total Fab 4 Annex H6 (not including gas pad): 6,460 SF
== Sum of All Occupancy Codes (First Floor) = 31,470 SF

Second Floor:

(a) Total Fab 4 H6: 21,900 SF
(b) Total Fab 4 Annex H6: 6,460 SF
== Sum of All Occupancy Codes (Second Floor) = 28,360 SF

Consequently, the total H6 square footage for Fab 4 according to the calculations above equals:

28,000 SF + 28,360 = 56,360 SF

As a means to verify this information, one finds that it compares "closely" with the total documented H6 square footage of 56,630 SF.

The major point of this exercise is, as described in Section 504.3 of the 1994 Uniform Building Code, "... for a multi-story occupancy, the sum of the ratios of the actual square footage for an occupancy divided by the allowed square footage for an occupancy, totaled over all of the occupancy ratings must be less than one." In other words,

B2 ratio + H2 ratio + H6 ratio + H7 ratio <= 1 to meet UBC code requirements.

Similarly, as contained within Section 506 of the 1994 Uniform Building Code (referenced to Section 904.2.6), the maximum allowable height for a multi-occupancy facility can also be restricted (as in the case of single occupancy facilities). For example, as described in Section 904.2.6, the maximum height of any facility containing an H6 occupancy rating cannot exceed 3 floors or 55 feet (vertically). Hence, if one was considering vertical expansion, this would also limit the height that the facility can reach. However, it should be noted that there apparently is flexibility in this requirement; particularly, since Fab 15 does not meet this maximum stated requirement.

The layout of exits and exit corridors and travel distances appears to meet the 100' maximum travel distances (UBC standard for maintaining an H6 occupancy rating) for the required areas of the facility. "On the first floor, there are approximately 2 single-door exits, 1 horizontal exit, and 4 double-door exits to reach the outside (not including those of other areas which require additional exits) for Fab 4 and the annex." (As-Built Drawings, 1996) Based on its size (square footage) and accompanying occupant load (for its occupancy classification), the 1994 Uniform Building Code (according to Section 1018) requires that the first floor have at least two exits for each Group H occupancy having a floor area of 200 square feet or more. Similarly, all portions of any room classified as H1, H2, or H3 shall be within 75 feet of an exit door. These requirements, too, appear to have been satisfied. For example, the total exit door area required for the H6 occupancy code is 0.3 per occupant or a total of 42 total exit inches (total H6 = 28,000 SF; divided by 200 SF/occupant = 140 occupants). The maximum area (inches) for a single door is considered to be 36" while a double-door alone cannot be considered 72" unless the minimum number of exits are met. Similarly, the total required exit widths must be approximately even between all exits.

"Similarly, the second floor and annex have 2 single-door exits, 1 horizontal exit (that is, exits which lead to adjacent facilities), and 3 double-door exits." (As-Built Drawings, 1996) Based on its occupant load, the UBC requires that the second floor have at least two exits and a total exit door area of 42.5 inches. Here, too, the requirement for a maximum travel distance of 100' has governed the design of the facility.

With an occupancy separation on the first floor between H6, H7, H2, and B2 , Table 3-B of the 1994 Uniform Building Code displays the latest requirements for occupancy fire separation That is, a two-hour separation between H6 and H2 and a one-hour separation between H6 and B2. It should be noted that there is no requirement for separation between adjacent H6 occupancies and adjacent H6/H7 occupancies.

For facilities like Fab 4 which have undergone many changes since their original design, it is important to understand the arrangement of the exits and, in particular, the exit corridors leading to them. Within the facility, exit corridors are constructed to provide unobstructed access to exits. Corridors are protected by two-hour fire rated walls and two hour ceilings. Wall partitions between adjacent functional areas and exit corridors (for example, Align/Develop Room and Diffusion area) are also fire-rated to protect occupants from fire originating on one side of the wall spreading to another.

However, the requirement for providing exit corridors and safe passageways for employees to exits has created a floor plan which appears "less" than ideal. Two-hour fire rated walls and ceiling generally protect the exits and stairways, providing adequate separation from other areas of the second floor manufacturing.

Beyond emphasizing occupancy, egress, and fire code requirements, the Uniform Building Code also sets guidelines for building construction and the structural standards set for proper construction. For example, as displayed in Figure 16-2 (Seismic Zone Map of the United States), the general Portland area is classified under Seismic Zone 3 according to the 1994 Uniform Building Code. When designed in 1974, however, the building was designed under (presumably) Seismic Zone 2B requirements. Hence, any changes to the occupancy code of the facility (i.e., changing from say an H6 to an A2.1) "might" (unclear statement because it would be based on the Building Official's interpretation and recommendations) require structural upgrades to meet Zone 3 requirements depending on whether or not the hazardous condition and/or the number of occupants increases with the change.

Similarly, the availability of different types of power (i.e., the differences between emergency power and stand-by power) may be required to support operations depending on the Uniform Building Code's occupancy certificates (i.e., H6, B2, A2.1, etc.). In Fab 4's case, emergency power is required to maintain ventilation in hazardous areas even during a power loss.

With respect to the Uniform Plumbing Code (UPC) and the National Electric Code (NEC), many of the requirements that were known were reinforced. That is, as described in the NEC for instance, conduit and wire installations within H2 occupancy classifications falling under Class 1, Division 1 and Division 2 installations and require the use of explosion-proof wiring components. Similarly, all penetrations outside of the zone are also required to be fire-proofed to protect against the spread of combustion agents. Similarly, a review of the UPC pointed out the need for double-walled piping and leak detection systems in some of the utilities providing service to the fab, particular pressurized supply lines of solvents, acids, and other materials while usually, single-containment on gravity-drain lines.

Yet, the major point of a review of these documents was the potential inadequacy of the installation of heating and electrical equipment on the first floor. "That is, the boilers and electrical equipment (specifically, interior dry-type transformers with ratings above 112.5kVA) are now required to be installed in utility vaults/rooms which are separate from other areas and have at least a one-hour fire rating separation." (1996 National Electric Code, 1996) In particular, transformers above 112.5kVA cannot be installed in open areas but must be separated from other areas; in fact, this type of arrangement is common within Fab 5 and Fab 15. Consequently, this type of arrangement would have to be changed if Fab 4 underwent any major renovation or change in occupancy.

Step 2: Develop List of Alternatives

After actually reviewing the state of the facility and understanding its capabilities and the implications of changes in occupancy from the Uniform Building Code (UBC), the next step should be an initial "brainstorming" of potential needs for the facility. Potential alternatives should not necessarily be specific in scope but should delineate potential uses that should be considered now, as well as for the future (time concept). The purpose is to create a generic list which can have alternatives deleted as further criteria are evaluated against them.

(a) Potential Categories of Use:

Basically, there are five major alternative uses facing the facility: (a) complete demolition, (b) do nothing, (c) sell or lease "as is", (d) renovate for manufacturing function, and (e) renovate for non-manufacturing function. While rather generic, these categories form the basis for identifying specific functions.

The purpose of demolition is self-explanatory; the "value" of the building in another role is not considered viable. Some factors range from attempting to mitigate a potential future environmental liability (i.e., assuming something leaked into the ground over the past twenty years and wanting to fix it), restoring the land back to its full market value (i.e., some people might consider property with an existing facility on it to be worth less than a piece of property with no facilities on it), or even clearing the land for constructing another facility in its place.

Similarly, "doing nothing" remains an option if one feels that sometime in the future, a better role (or potentially a role at all) would be identified for the facility. That is, no alternative at present justifies the costs associated with fulfilling a need while the uncertainty of the future may present another role that the building could adequately support. The major basis of this argument is that the cost of doing something today and then converting it back to a condition where a future identified need takes precedence over the first could be more expensive then just waiting and only having to pay for renovation costs the first time.

The sale or lease of a facility remains an option if one believes that the revenue generated by allowing another party to use that asset outweighs an potential current or future uses of that facility. Generally, this option only remains attractive if the facility is not integrated into a site but potentially could still be used as such if proper contractual arrangements were made.

Finally, with respect to renovation, two paths are possible. First, renovation for a manufacturing function would maintain the facility's role as a semiconductor wafer manufacturing plant or as a clean room manufacturing support facility. Potential upgrades could include retrofitting the existing clean room environment to today's standards as well as constructing a more flexible equipment layout. Generally, the costs of renovation would have to be weighed against the costs of constructing new clean room space.

Secondly, renovation for a non-manufacturing functions would include converting the available building space to administrative or warehouse type space. While the anticipated renovation costs for non-manufacturing functions would be less than those for manufacturing functions, these costs would not necessarily be offset by potential revenue generated. As such, this option remains attractive only if it offers savings from existing arrangements or makes use of existing available space.

(b) "Brainstorm" Current Needs and Potential Future Needs within Categories:

With respect to finding additional roles for the facility, the scope must be considered at three levels. That is, locally (i.e., does the site require space for any mission or does the group within Oregon require any additional space) and globally (does Intel, in general, require additional space for assembly and test, etc.). Since microprocessor, logic, and flash memory manufacturing is the basis for most of Intel's products, semiconductor manufacturing would be a possibility. Similarly, other businesses which Intel has recently taken initiatives to enter (i.e., circuit board manufacturing, Internet technology, etc.) could also be considered possibilities as well as other potential manufacturing areas where Intel is considering entering the marketplace (for example, custom chip building (ASIC) or low-volume batch processing).

Basically, within the manufacturing function, there are three options and two types of roles. With respect to the manufacturing roles, the two potentials are: (a) direct manufacturing (wafer processing) and (b) manufacturing support (lab analysis, parts clean, etc.). Within these sub-categories, first, we can look at the facility as "stand alone" and evaluate filling the space with an existing or new manufacturing function that would be entirely fulfilled by Fab 4. That is, "custom designed" chips and processes (vs. large scale manufacturing) or other semiconductor products. Secondly, we can look at creating a parallel manufacturing facility -- that is, a facility which would include all the equipment of one of the on-site facilities and essentially multiply the site throughput by some factor. For example, if one duplicated all of Fab 5's equipment and technology, Fab 4 could potentially double Fab 5's throughput. Thirdly, we can also look at "breaking up" the existing manufacturing functions on site. Within this spectrum, one could utilize Fab 4 as a "constraint" manufacturing facility (a facility which essentially only performs those manufacturing functions which are considered bottlenecks, thereby creating better throughput) or "non-constraint" manufacturing (utilizing Fab 4's space as a means of creating additional manufacturing space by removing tools from the primary manufacturing facility).

As such, two main possibilities exist. The first possibility is to "off-load" a non-critical manufacturing or manufacturing support steps and place it outside of the newer fabs (Fab 5 and Fab 15), freeing up valuable manufacturing floor space. Many of these steps would fall under the categories of so-called "front-end" or "back-end" processes depending on whether the step was before or after the first metal layer has been applied.

The second possibility is to move an entire phase of the manufacturing process into Fab 4. The difficulty with this approach tends to be that semiconductor manufacturing is not a sequenced operation and personnel perform more than one function (thereby, necessitating them to move around). That is, unlike an assembly line in automobile manufacturing, semiconductor manufacturing uses many of the same steps to build up layers and patterns on top of and within the silicon wafer over and over again. For example, ion implantation not only builds up dopants within the silicon layer itself but it also builds up dopants in the polysilicon layers to enhance their "semiconductive" capabilities during later processing.

Different products can also be produced by changing the number, type, sequence, etc. of steps within the process. Different products can also be produced using the same process but different steps. As such, the semiconductor manufacturing process lends itself to keeping process tools in close proximity to one another and producing in large batch processes to reduce complexity and changeover.

Non-manufacturing roles could also constitute another group of alternatives. Those could range from renovating the area to support administrative space (i.e., offices, conferencing areas, etc.) to supporting high-end research and development (R&D) activities to even utilizing the space for new functions (training areas). Similarly, other non-manufacturing roles could include warehouse space, and storage space.

An example of a list of potential alternatives is considered below in Table 6-8:

Table 6-8: Potential Alternative Roles

Roles		Tentative List of Potential Options * *Note: Some of these could be combined together for multi-occupancies*
		Building Options:
Demolition	1	Demolish and build new facility
	2	Demolish and convert to parking spaces (parking deck)
	3	Demolish and retain land for future (or to-be-identified later) use
Do Nothing	4	Status Quo -- "mothball" facility (and retain for future undefined use)
Sell	5	Lease (sell) facility (property) to outside client
Direct Manufacturing	6	Semiconductor manufacturing facility for existing on-site manufacturing processes -- move out of Fab 5/Fab 15 or augment
		(a) Constraint processing -- photolithography (typical bottleneck), annelva (sputter), ion implantation, chemical vapor deposition (CVD), etc.
		(b) Non-constraint processing -- wet etch (wet processing stations), planarization, etc.
	7	Semiconductor manufacturing facility for tenant outside of on-site manufacturing
		(a) Current Intel supported technology (microprocessors, chip sets, logic, memory, etc.)
		(b) Non-Intel supported technology (ASIC or "custom" chipmaking)
	8	Non-semiconductor manufacturing (for example, circuit boards assembly, computer assembly, etc.)
	9	Combine Fab 4 and Fab 5 roles together
		(a) Potential construction to combine operations
Manufacturing	10	Semiconductor manufacturing support -- front end processing
		(a) Wafer cutting (from ingots)
		(b) Epitaxial layering
	11	Semiconductor manufacturing support done in-house -- back end processing and "semi-clean" support functions -- Relocate from Fab 5 and/or Fab 15
		(a) Wafer sort and electrical test floor
		(b) Goldgrind and/or Backgrind operations

		(c) Current Test and Assembly operations done internally (d) Future Test and Assembly operations ("flip chip" processing, C4 processing, etc.) (e) Planarization (f) Arsenic Parts Clean, Quartz Clean rooms, etc. (g) Analytical labs
	12	Vertical integration -- Perform outsourced semiconductor manufacturing support functions in-house (a) Pull own silicon ingots on site (b) Current Wafer sort, Electrical test, and Assembly operations outsourced (for instance, Intel currently subcontracts many of these operations for "older" products) (c) Internally reclaim wafers
Non-Manufacturing	13	Research and development facility
	14	Administrative space (offices, conference rooms, etc.) to bring off-site functions in-house
	15	Warehouse space (a) Controlled atmosphere (b) Unregulated atmosphere
	16	Fab Training facility (site specific versus Oregon specific)
	17	Relocate non-manufacturing space from Fab 5 and/or Fab 15 to create additional manufacturing space (a) Gymnasium (Fab 15 and 1FL) (b) Cafeteria/kitchen (Fab 15 and 1FL) (c) Administrative offices (Fab 15 and 2FL) (d) Training rooms (Fab 15 and 1FL)
	18	Employee Resource Center and Intel University

(c) Alternative/Requirements matrix:

Upon identifying potential functions, it is important to attempt to understand the requirements of various functions. After excluding potential alternatives that may not have any identifiable requirements (for example, administrative, warehousing, lease/sell, demolition, etc.), one can complete a matrix that can help translate requirements into needs. As such, Figure 6-9 shown on the following two pages delineates some of the known needs for various potential functions:

		Semiconductor manufacturing facility	Constraint processing (ion implantation - based on one 6" Varian implanter)	Constraint processing (annelva - based on one 6" annelva machine, dry pump, cryo compressor, RGA pump and head, and Neslab chiller)	Non-constraint processing (wet etch)	Combine Fab 4 and Fab 5 roles together	Semiconductor manufacturing support - front-end processing
Requirements (gpm per machine)							
HVAC	Air Quality	Class 1					
	Heating	x					
	Cooling	x					
Exhaust	Scrubbed Exhaust	x		112 CFM	x		
	Solvent Exhaust	x					
	Heat Exhaust	x	x				
Bulk Chemical Distribution	Solvents	x					
	Corrosives	x			x		
	Slurry	x					
Drainage	Acid Waste	x			x		
	Solvent Waste	x					
	Sanitary	x					
	Storm	x					
	Hydrogen Fluoride	x			x		
Cooling Water	Process Chilled Water	x	15 gpm	25.3 gpm			
	Chilled Water	x					
Ultra-Pure Water	Dionized Water	x	8 gpm	17.5 gpm	x		
Process Gases	Nitrogen	x	15 SCFM	2.1 SCFM			
	Bulk Gases	x					
	Specialty Gases	x		O2, He, Ar			
Compressed Air	Oil-Free Air	x	25 SCFM	0.17 SCFM			
	Instrument Air	x					
	Breathing Air	x					
Vacuum	Process Vacuum	x	2000 SCFM	x			
	House Vacuum	x					
Electrical	High Voltage						
	Emergency	x					
	Uninterruptible Power Supply (UPS)	x					

Table 6-9: Template for Alternative/Requirements Matrix

		Wafer sort and electrical test floor	Planarization (based on one Westech polisher, wetstation, planar scrubber, and Neslab chiller)	Arsenic Parts Clean, Quartz Clean rooms, etc.	Vertical integration - internally reclaim wafers	Fab training facility
Requirements (gpm per machine)						
HVAC	Air Quality	Class 10,000				
	Heating					
	Cooling	x				
Exhaust	Scrubbed Exhaust		100 SCFM	x		
	Solvent Exhaust					
	Heat Exhaust					
Bulk Chemical Distribution	Solvents					
	Corrosives					
	Slurry		0.25 gpm			
Drainage	Acid Waste		9.5 gpm	x	H2SO4, Nitric	
	Solvent Waste					
	Sanitary					
	Storm					
	Hydrogen Fluoride				x	
Cooling Water	Process Chilled Water	x	9.5 gpm			
	Chilled Water	x				
Ultra-Pure Water	Dionized Water		20.5 gpm	x	x	
Process Gases	Nitrogen					x
	Bulk Gases					
	Specialty Gases		GN2, GPN2			
Compressed Air	Oil-Free Air		1 SCFM			x
	Instrument Air					
	Breathing Air					
Vacuum	Process Vacuum	x				
	House Vacuum					
Electrical	High Voltage					
	Emergency					
	Uninterruptible Power Supply (UPS)	x				

Table 6-9: Template for Alternative/Requirements Matrix (continued)

(d) Benchmarking:

Within the semiconductor industry, there have been relatively few documented cases of facility dispositioning of semiconductor fabrication facilities. In large part, this appears to be due to the relatively recent nature of this problem.

However, within Intel's short history, there have been at least three cases of facility closure. Intel's Fab 1, located in Mountainview, California; Fab 1A located in Santa Clara, California; Fab 2 located in Santa Clara, California; and Fab 3, located in Livermore, California were shut down during the 1990's. While one can take some internal lessons learned from these experiences, those same lessons have found limited applicability to Fab 4's situation.

Externally, there are only a relatively few number of large semiconductor companies that have the same scale of facilities as Intel. Research and conversations with representatives of two of these companies (IBM and Digital Equipment Corporation) revealed similar problems with figuring out what to do with decommissioned facilities. "For example, in the past, DEC has decommissioned five fabrication facilities of various sizes (Fab 1, Fab 2, Fab 3, and Fab 5). Digital's Fab 1 and Fab 2 were eventually decommissioned together and resurrected as Fab 4 (consisting of approximately 26,000 SF) in the late 1980's. However, with the recent construction of 70,000 SF of sub-Class 1 clean room space in DEC's new 8-inch wafer facility (Fab 6) producing high-end Alpha processors, the need for production from the 6-inch wafer facility (Fab 4) has dropped substantially. As such, DEC organizations are already struggling to figure out what to do with Fab 4, though early indications are that a back-end process ("flip chip") was being seriously considered at the time of the conversation. Fab 3, on the other hand, has been mothballed since its recent closure and Fab 5 was decommissioned and sold to Motorola (since it was located off-site). One of the major factors determining DEC's decisions for potential roles is the fact that Digital does not have any low-end products. That is, its semiconductor operations are focused on producing high-margin, high-technology microprocessors." (Telephone conversation with DEC Industrial Engineer, 1996)

Similarly, IBM faced a similar situation with its downturn a number of years ago. "Conversations with employees from IBM's East Fishkill site indicated that whole fabrication facilities, as well as parts of some of the support buildings on this rather integrated site, were completely mothballed (with equipment inside), awaiting a potential mission." (Telephone conversation with IBM Facilities Manager, 1996) Obviously, this problem of finding potential roles for old facilities has not been any easy process for any company.

Step 3: Establish Decision Factors

(a) Potential Major Decision Factors:

Guided in part by discussions, theory, and relevant literature, three decision factors have been identified as relevant categories to consider for Fab 4. In short, they are: (1) technical measures, (2) strategic measures, and (3) financial measures. While all are important, it is conceivable that one decision factor could be judged as "more important" than the others.

(b) Decision Factor Assumptions (Technical, Strategic, and Financial):

As detailed on the accompanying page in Table 6-10, there are a number of financial assumptions associated with this evaluation. Similarly, by referring to the balance sheets performed for each alternative, one can also generalize some of the major technical assumptions associated with each alternative (although specific technical assumptions for each alternative can be referenced within the balance sheets in Appendix 1).

	List of General Financial Assumptions:
	Financial Facts:
1	Intel's Weighted Average Cost of Capital (WACC) used for scenario analysis = 15%
2	Intel's average corporate tax rate is based on 36.5% found in 1995 Annual Report
3	All Net Present Value (NPV) calculations are based on real dollars (in other words, inflation is not taken into account)
4	Annual increases above the average inflation rate as included as follows: (a) headcount salaries - + 2% (b) construction costs - + 2%
5	Depreciation and expense tax shields are included in all analyses; expense tax shields result from the fact that if the money was not used, it would be taxed as additional revenue
6	Fab 4 Net Book Value (NBV) during 1Q97 based on $900,000. Remaining NBV is depreciated straight-line over five (5) years with a salvage value equal to zero
	Depreciation Facts:
1	New semiconductor wafer fabrication facility construction is based on a 39-year straight-line capital depreciation schedule with a zero residual value
2	New non-wafer fabrication building construction is based on a 20-year capital straight-line depreciation schedule with a zero residual value
3	Existing building capital improvements are depreciated on a 10-year straight line basis with zero residual value
4	New semiconductor equipment is depreciated on a 4 or 5-year straight line basis with zero residual value
5	Depreciation tax shields are included against all capital expenditures
	Annual Costs ($/SF):
1	Annual Operating Costs ($/SF) are based on the following : (a) Do Nothing (Status Quo) - $10/SF for all space (b) Warehouse - $3/SF for all space (c) Class 1 - Class 10 cleanroom space - $175/SF based on cleanroom space (d) Class 100 cleanroom space - $50/SF based on cleanroom space (e) Class 1,000 - Class 10,000 cleanroom space - $10-$15/SF based on cleanroom space (f) Administrative - $5/SF based on all space
2	Annual Property Tax Costs and Traffic Impact Costs in Aloha based on the following: (a) Warehouse - $76,000 per year (b) Administrative - $100,000 per year (c) Property with no building present - $25,000 per year (d) New wafer fabrication facility - $800,000 per year (e) Renovated wafer fabrication facility - $500,000 per year
	Labor Costs:
1	Fully burdened personnel costs are based on the following: (a) Direct labor - $45 per hour (based on 40 hours per week and 50 weeks per year) (b) Indirect labor - $55 per hour (based on 40 hours per week and 50 weeks per year)
2	The estimated number of direct labor personnel to indirect labor personnel is based on 2:1 ratio
	Construction Costs ($/SF):
1	Estimated New Construction costs ($/SF) are based on the following: (a) Class 1 cleanroom space - $3,750 per SF of cleanroom space (includes all other space requirements) (b) Administrative space - $100 per SF
2	Seismic upgrade costs are based on the following estimates: (a) VLF hood retrofit - $500,000 (b) Exterior column attachment - $1,000,000

Table 6-10: Major Financial Assumptions for Alternatives

	List of General Technical Assumptions:
	Demolition:
1	Demolition process cannot interfere with continuing manufacturing in Fab 5 and Fab 15 (limits types of tools, demolition procedures used (for example, wrecking ball and dynamite), etc.)
2	Equipment necessary to support demolition will not significantly impact the available parking spaces for employees
3	Service yard access will not be inhibited during demolition
4	Whole scale demolition of Fab 4 and Fab 5 together couold potentially utilize demolition procedures without affecting production processes in Fab 15
	Lease/Sell:
1	Limited existing facility infrastructure connections to common utility systems cannot be easily altered.
	Administrative:
1	Existing parking lots will be able to accommodate additional personnel
2	Existing facility exits adequate to support administrative function
3	Required bathrooms could be easily retrofit into facility approximately where they used to exist
4	Office furniture would have to be relocated from existing facilities or purchased new
	Manufacturing and Manufacturing Support:
1	Existing ultra-pure water system can only support limited manufacturing operations with significantly affecting the process
2	Existing site ultra-pure water system has enough capacity to support new manufacturing requirements
3	H2 occupancy space can only be increased by approximately 1,500 additional square feet
4	Existing air quality under VLF hoods is Class 100
5	Roof line could be raised above the UBC limitations (similar to Fab 15)
6	Peneetrations in waffle slab on second floor do not pose structural problems that cannot be easily repaired
7	Seismic upgrade requirements would consist of: (a) strenthening the VLF hood hanging rod connections and (b) reinforcing connection of structural steel roof beams to exterior columns
8	Existing waste neutralization systems is adequate to support additional manufacturing functions
9	Existing loading dock, elevator, and H2 areas will be able to support hazardous processing material (HPM) requirements
10	Adequate parking to support existing personnel requirements

Table 6-11: Major Technical Assumptions for Alternatives

Step 4: Generate Measures for Comparison

(a) Building Code Review for Future Occupancies:

(1) Example of Evaluation of Potential Single Occupancy Uses:

By evaluating this table for Type III, Classification N, one can see that some "A" or "assembly" occupancy codes (A-1, A-2, and A-2.1) and some "I" or "nurseries or health care centers" (I-1.1, I-1.2, and I-2) are not permitted (with limited exception) in this type of construction. Hence, based on this one evaluative measure, we can already begin to rule out certain potential uses. For instance, if current occupancy ratings on site were considered for movement to Fab 4, one could summarize them as follows:

Fab 15 is zoned as follows:
(a) Auditorium: A-2.1
(b) Cafeteria (Eating area): A-2.1
(c) Gymnasium: A-3
(d) Cafeteria (Presentation and Kitchen area): B2
(e) Bathrooms/Gymnasium Locker Rooms/Training Rooms: B2
(f) Semiconductor Manufacturing Areas: H2/H6/H7

Similarly, Fab 5 is zoned as follows:
(a) Semiconductor Manufacturing Areas: H2/H6/H7
(b) Utility Annex/Gown Room: B2

Finally, AL-3and AL-4 are zoned as follows:
(a) Administrative and Office Space: B2
(b) Wafer Sort and Test floor: B2

Hence, based on the above information and UBC criteria, we can see that since the cafeteria (eating area) is a "high" occupancy area and would not be possible (i.e., definition of A-2.1 states, "occupancy of 300 or more without a legitimate stage.") Similarly, if Fab 4 was converted to a gymnasium (to accommodate more people because of the existing area's small size - 3,616 SF), the UBC implies that if the occupancy changes from "less than 300 persons" to "more than 300 persons" (assumption would have to based on reasonable evidence suggesting more than 300 people would use the facility at one time), the UBC would require this area to be re-zoned A2.1. Hence, cafeteria and/or auditorium are not permitted and gymnasium expansion would have to be further investigated.

All potential other occupancy classifications appear to be are allowed in this facility (including "B" (office or professional), "E" (educational/day-care), "S" (storage), and "H" (hazardous)).

However, based on the same table, square footage and height limitations are also imposed on such dedicated facilities. Before evaluating these facilities at face value, it should be noted that, as described in Section 501, there will be factors which will increase this figure (for instance, sprinkler systems, portion of building that is surrounded by public yards, etc.).

Based solely on the 1994 Uniform Building Code, for example:

Occupancy Classification:	Description	Max # of Floors	Max # of SF per floor
A-3	Assembly area , <300 persons	1	9,100 SF
B-x	Office, Professional	2	12,000 SF
S-x	Storage, Warehouse	2	12,000 SF
E-x	Educational/Day-Care	1	13,500 SF
H-2	Moderate explosion hazard	1	3,700 SF
H-6 and H-7	Semiconductor manufacturing (H6); Health hazard (H7)	2	12,000 SF

Table 6-12: Occupancy Code Calculations
Source: 1994 Uniform Building Code, Table 5-B

Hence, if one were considering utilizing Fab 4 as a single-occupancy facility, the only eligible occupancies would be B-x, S-x, and H6/H7 while the ineligible occupancies would be A-x, E-x, and H-2.

Based on these numbers, we can compute the following maximum total SF allowed for each of these:

(a) 12,000 SF x 2 floors = 24,000 SF x 1.575 (57.5% sideyard increase) = 37,800 SF x 2 (100% sprinkler increase) = = 75,600 SF (maximum allowable single occupancy space for B-x, S-x, and H6/H7 based on Type III, N combustible rating). Hence, one can conclude that with a total SF (Fab 4 and Fab 4 annex) totaling 59,830 SF (i.e., sum of 31,470 SF (1FL) and 28,360 SF (2FL)), any single occupancy B-x, S-x, and H6/H7 can be accommodated.

(2) Example of Potential Multi-Occupancy Uses and Calculation:

Now, with this information in hand, one should follow a similar exercise to evaluate potential multi-occupancies. For instance, one could evaluate (as an example) the use of the facility area as a gymnasium and H6 occupancies or gymnasium, administrative space, and H6 occupancies. In this example, assume that one maintains the first floor "as is", the annex "as is", the gas pad "as is", and we just want to renovate the second floor.

Based on the information above (including doubling for sprinklers and sideyard increases), we should attempt to figure out how large can the gymnasium be on the second floor to accommodate the occupancy:

(a) Max H6 = 75,600 SF
(b) Max H7 = 75,600 SF
(c) Max H2 = 11,655 SF
(d) Max B2 = 75,600 SF
(e) Max A.3 = 9,100 SF x 2 floor facility = 18,200 SF x 1.575 (57.5% sideyard increase) = 28,660 SF x 2 (100% sprinkler increase) = 57,300 SF

Hence, let us evaluate for the 2nd Floor (given x <=57,300 SF -- the constraint above):

$$\frac{56{,}360 - x}{75{,}600\text{ SF}}\,(H6) + \frac{570\text{ SF}}{75{,}600\text{ SF}}\,(H7) + \frac{1{,}400\text{ SF}}{11{,}655\text{ SF}}\,(H2) + \frac{1{,}500\text{ SF}}{75{,}600\text{ SF}}\,(B2) + \frac{x}{57{,}300\text{ SF}}\,(A3) \le 1.0$$

Based on this equation, we can conclude that A3 area cannot exceed approximately 24,700 SF without violating the UBC (this is an order of magnitude greater than the existing space of 3,600 SF). Obviously, we can play with these numbers a bit more (for example, what if one rezoned H7, H2, and B2 space) but the analysis method is clear.

Secondly, let us evaluate for considering the 2nd Floor for all additional B2 space:

$$\frac{56{,}360 - x}{75{,}600\ SF}\ (H6) + \frac{570\ SF}{75{,}600\ SF}\ (H7) + \frac{1{,}400\ SF}{11{,}655\ SF}\ (H2) + \frac{1{,}500\ SF + x}{75{,}600\ SF}\ (B2) <= 1.0$$

Based on this equation, we can conclude that the B2 area is not limited by virtue of the fact that whatever is deducted from H6 is added to B2. Given the same denominators, the equation does not change (the same is true for H7).

The only limiting factor in the equation is an H2 occupancy. Based on similar analyses, the maximum H2 space that could be allotted in Fab 4 (given existing zoning conditions) is solved as follows:

$$\frac{56{,}360\ SF\ (H6) + 570\ SF\ (H7) + 1{,}500\ SF\ (B2) - x}{75{,}600\ SF} + \frac{1{,}400\ SF + x\ (H2)}{11{,}655\ SF} <= 1.0$$

From this, one can conclude that the H2 occupancy cannot exceed an additional 1,477 SF (essentially a doubling of the existing space). Hence, if one were considering re-zoning for additional manufacturing space, this would need to be taken into account, particularly if a much larger amount of explosive hazards are required in the process.

For example, one scenario under potential consideration is relocating many of the functions from the South wall of Fab 15. At the subfab level, approximately one-half of the area under question is rated H2/H7 and the remainder part of the area is rated H6. Under the H2/H7 zoning, there are generally three (3) areas totaling approximately 8,240 SF: (a) Bulk Chemical Storage Room, (b) Solvent Storage Rooms and Pumping, and (c) Corrosive Storage Rooms and Pumping. Similarly, under the H6 zoning, there are generally three additional areas on the first floor: (a) Electrical Room South, (b) Wet and Dry Etch Rooms, and (c) PA Laboratory. On the second floor (fab level), all areas are zoned H6 and consist of "Parts Clean" areas -- that is, Etch Parts Clean, Litho Parts Clean, Arsenic Ion Implant (Bead Blast) Parts Clean, and Quartz Clean Room.

Hence, one could not remove the H2/H7 areas and "transplant" them to Fab 4 because the "allowable" increase of H2 space is only 1,500 SF. Therefore, only H6 functions on the south wall that require less than 1,500 SF of H2 support space can be considered for relocation.

(3) Review of Fire Separations

Another step should be a review of fire separations. That is, what are the required fire occupancy separation ratings (as described in Table 3-B). One should also remember the requirement for fire rating above, below, and horizontally to different occupancies. The following examples illustrate the immediate facts:

S-x and A-3:	1 hour (S2) (based on S-1/S-2 maximum requirement; S2>S1)
S-x and B-x:	1 hour (S2)
S-x and E-x:	1 hour
S-x and H-2:	2 hour
S-x and H6/H7:	1 hour
H6/H7 and A-3:	3 hours
H6/H7 and B-x:	1 hour
H6/H7 and E-x:	3 hours
H6/H7 and H-2:	2 hours
H-2 and A-3:	4 hours
H-2 and B-x:	2 hours
H-2 and E-x:	4 hours

E-x and A-3:	No requirement
E-x and B-x:	1 hour
B-x and A-3:	No requirement

Before evaluating, one should investigate the maximum fire resistance provided by the existing second floor suspended concrete slab, the exterior structure, and even the columns. According to the 1994 Uniform Building Code, Volume 3, calculating the fire resistance of concrete construction in compliance with the requirements of Table 7-7-C-C and the diagram on page 3-99, it becomes clear that there is a range of potential resistances. That is, depending on the type of concrete used during construction, the maximum fire resistance can be estimated between a minimum of 1 1/4 hours and 2 1/2 hours. However, it should be noted that this estimate is based on a floor which hasn't had penetrations cored through it entirely. The assumption is that the floor could be "retrofitted" to gain its full fire rating again but that it cannot exceed its original value. Similarly, based on an 8" brick wall that is 71% solid, the UBC states that the fire resistance rating is 3 hours. Finally, the concrete columns themselves, are judged to have a fire resistance of 4 hours since their dimensions exceed 16" (as depicted in Table 7-7-C-H).

Based on these facts and the potential occupancies under consideration, we can draw the following conclusions:

(a) B-x occupancies can basically support any other occupancy (i.e., maximum for anything is 2 hrs)
(b) Semiconductor manufacturing or H6/H7 occupancies are "most feasible" to be located next to mixed occupancies of H2, B-x, and S-x (i.e., potentially "cost prohibitive" next to A-3 and E-x operations and because it cannot meet the requirements, given that the floor can only have a maximum fire resistance of 2 1/2 hours)
(c) Any A3 occupancy can "best" exist next to occupancies of S-x, B-x, and E-x
(d) S-x occupancies can basically support any other occupancy (i.e., maximum for anything is 2 hrs)
(e) E-x occupancies can only exist next to S-x and B-2 occupancies

Some examples of potential problem occupancies (because of the 1st floor and 2nd floor concrete slab separation). Although one potentially might be able to increase this value by virtue of new suspended or gypsum board ceiling, the maximum occupancy that could be supported would exist with any occupancy that required less than a two-hour separation. For example, if one maintain the first floor as largely H6/H7, one could not have A-3 or E-x above it. Similarly, if the Gas Pad remains H2 (for potential future use), one could not put A-3 or E-x on the first floor because of the fire rating of the building's exterior wall construction.

In conclusion, the purpose of this exercise two-fold: first, to create awareness about the restrictions; and secondly, to question any preliminary alternatives that were under consideration that do not meet both the maximum square footage requirement and the minimum fire resistance requirements.

(b) Perform a Building Assessment:

Built in the 1975-1976 time frame, Fab 4 is a two story facility, approximately 200 feet wide by 110 feet long. As calculated from the above dimensions, the square footage footprint of the facility is approximately 22,000 SF per floor, yielding approximately 44,000 SF of "habitable" space. This figure, however, does not include existing structures for stairwells, utility rooms, loading dock, etc. or the additional space provided by the annex addition.

"Architecturally, the building is a masonry structure approximately 36' tall. Distance from 0' AFF (above finished floor) to roof line is approximately 32' while a 4' parapet structure extends above the roof line at its exterior walls. Along the roof ridge line (located approximately midway along the building longitudinal side), the roof height reaches its highest point (approximately 40') and slopes down to the sides. The distance from the slab on grade (SOG) to the bottom of the suspended waffle slab on the second floor is 16'. The distance from the waffle slab to the bottom of the steel roofing deck is approximately 16' as well. Within the second floor, the distance from the waffle slab to the bottom of the ceiling varies from approximately 9'- 0" to 10'- 2". (As-Built Drawings, 1974) The building's exterior construction matches the exterior construction of at least two other facilities on site, creating a sense of "architectural compatibility". Windows are generally at a minimum (limited to one existing row of windows remaining on one side); most were removed during one of the facility's many renovation projects .

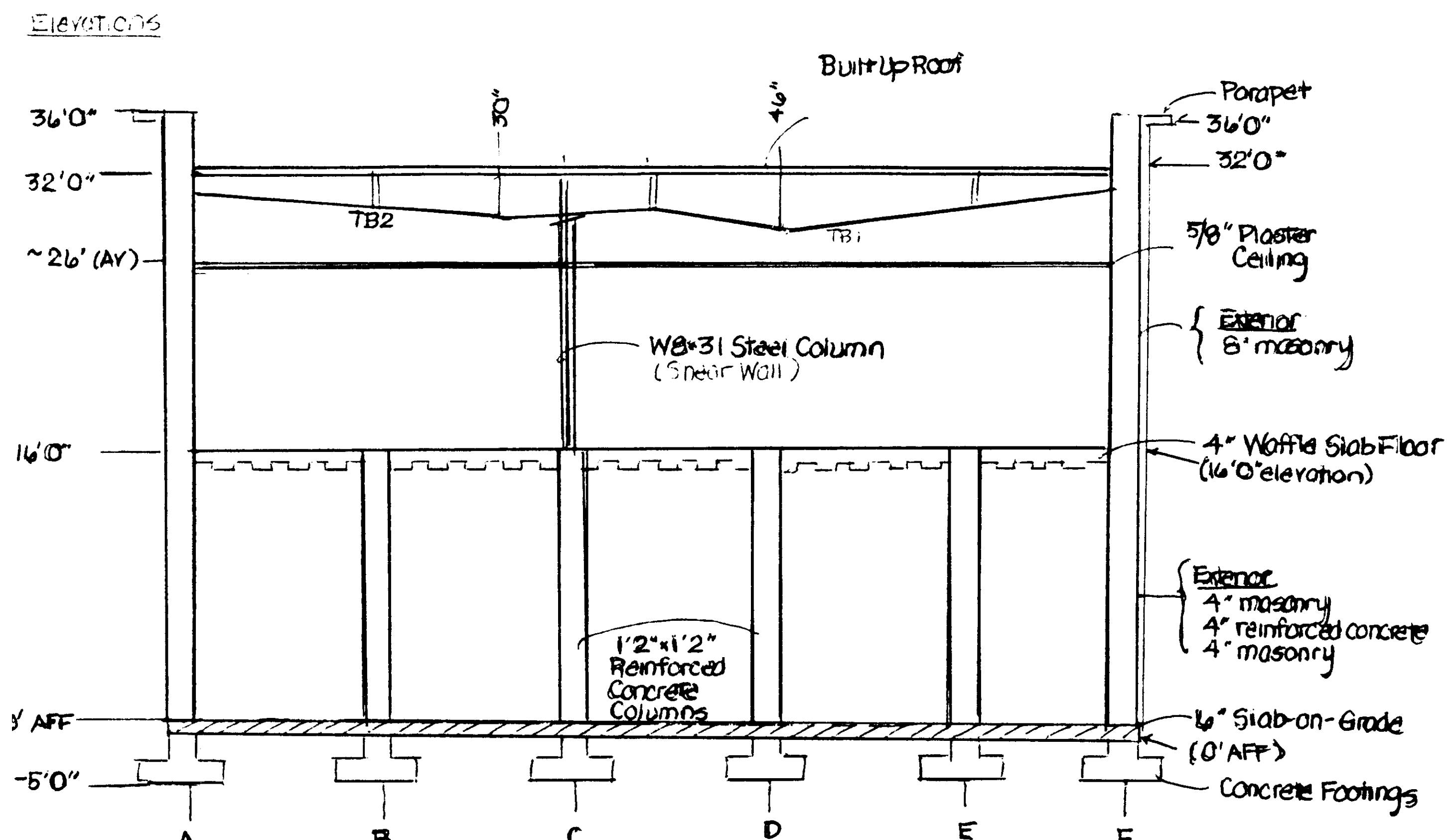


Figure 6-13: Existing Fab 4 Elevations
Source: Intel Corporation

Inside, the second floor interior consists of a number of fire-rated walls and exit corridors formed by gypsum board that were created by renovations to meet current life-safety code standards. The second floor is vinyl composition flooring on top of a suspended concrete floor. Many of the walls are furred out studded wall construction (mostly metal studs) with gypsum board acting as the sheathing. Similarly, the ceiling structure consists of a plaster ceiling with "cutouts" for the numerous vertical laminar flow (VLF) hoods that hang down from the open web ceiling joists.

"Structurally, the building is constructed on a series of below-grade strip foundations and spread footings and a six-inch reinforced slab on grade at 0' AFF. On the first floor, the exterior load-bearing 12" grouted masonry walls consist of a 4" exterior fascia brick, 4" of reinforced concrete, and 4" of interior masonry unit. Interior 20" x 22" columns are located approximately 20' from one another on a column grid system with exterior columns varying in size, location, and structure according to the foundation requirements. On the second floor, the exterior load-bearing 8" grouted masonry wall consists of one 8"x 8" hollow masonry brick reinforced by concrete and rebar and supported on a cast-in-place suspended waffle slab (4" thickness at minimum point and approximately 18" at thickest points) located approximately 16' AFF. Exterior wall columns on the second floor consist of a second row of staggered 8" reinforced bricks, creating an exterior column structure approximately 16" wide by 24" long. One row of steel columns located along the building ridge line acts as the second floor's only interior load bearing wall." (As-Built Drawings, 1974)

"The roof structure is supported on the columns by two tapered structural steel beams, one approximately 50' in length and the other approximately 60' in length." (As-Built Drawings, 1974) This design allows for relatively long spans supported by only one interior column, yielding large open space areas averaging 1,100 SF (55' x 20' between columns). Similarly, the built-up roof's metal decking is supported by open web joists and various steel joists (or girts) supporting on-roof structures, particularly on the building's west side and at the building's center.

Mechanically, the building consists of a number of heating, ventilation, and air conditioning (HVAC) systems, process piping, and other utilities. Because of the large amount of air that is exhausted from the building (as well as the requirements for new air to be supplied to the area to meet Building Code standards), the demand for outside supply air (and consequently, the need to cool and heat this air) is particularly great in a cleanroom environment. This need is fed through a complex HVAC system. From an HVAC perspective, many of the building's air handling units are located on the first floor with outside air and exhaust air ductwork running vertically through the second floor (along the load bearing column line) to the roof and the interstitial space located above the second floor ceiling. The main area for this ductwork chase is created by a partition wall constructed along the column line formed by the load bearing wall on the second floor, as well as a chase created in the building's northeast corner. A number of air handling units are also located on the roof but the majority of air handling equipment on the roof are exhaust fans for processing tools.

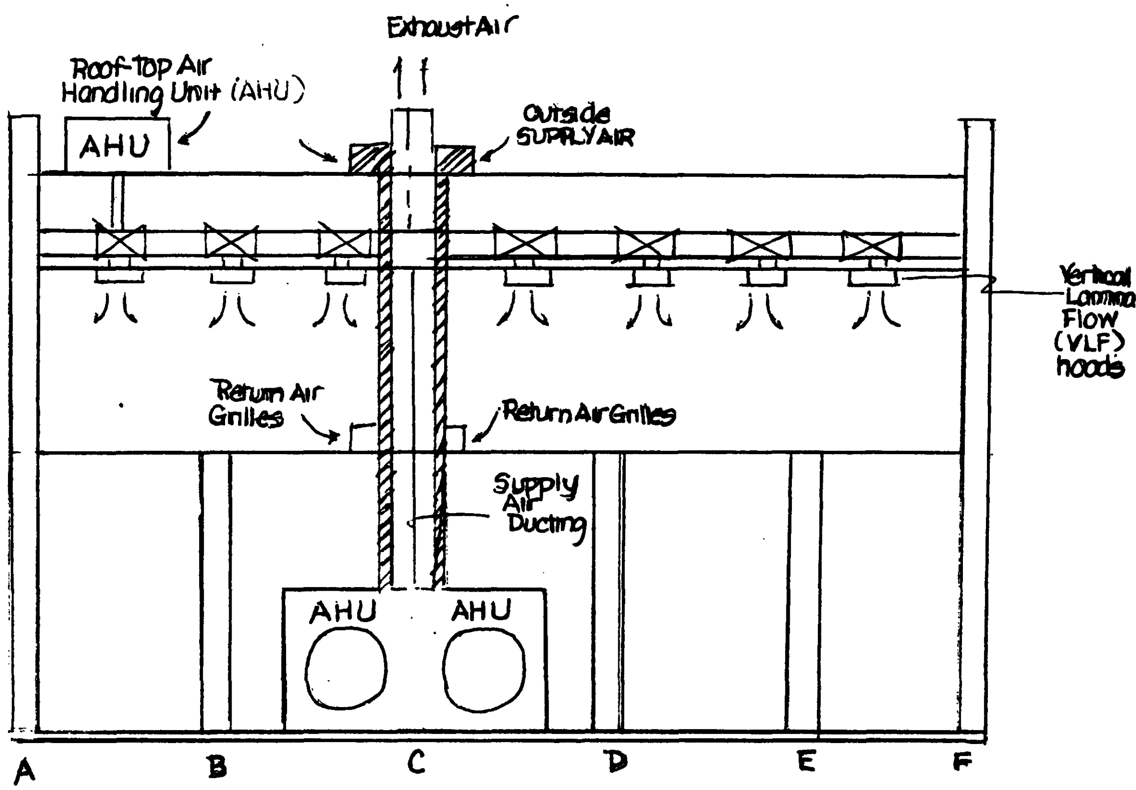


Figure 6-14: Fab 4 Heating, Ventilation, and Air Conditioning Perspective
Source: Intel Corporation

"Process piping within the facility (consisting of process gases, deionized water systems, acid waste neutralization systems, etc.) are generally arranged with the mains running around the perimeter of the facility and the branches connecting off the mains at the column lines. Consequently, the process piping is similar to a grid network and allowed connection to most requirements within a few feet of the floor penetration." (As-Built Drawings, 1996) However, this system arrangement is not necessarily correctly sized throughout or arranged ideally. That is, one main running down the center of the building may have served the purpose better than the network running around the perimeter of the facility. "Similarly, when facility systems were added to the existing network, system capacities were not necessarily realized because the piping was not correctly sized or rehabilitated." (Personal Interview with Intel Oregon General Site Services Mechanical Engineer, 1996)

Similarly, the infrastructure of the building was designed to support a large cooling load during all seasons. This large heating load is from the many pieces of equipment that were within the clean room itself (furnaces, ashers, etc.), personnel working within the fab, and the natural radiant heating effects of the sun on the building itself. "As such, the facility has a total cooling capacity of approximately 1350 water-cooled tons served by one three-bay cooling tower (450 tons per bay) as well as 440 air-cooled tons (served by a network of two air cooled condensers). Air conditioning capability is provided via cooling coils in many (but not all) of the air handling units." (As-Built Drawings, 1974; As-Built Drawings, 1981; As-Built Drawings, 1993; As-Built Drawings, 1996)

In addition, in order to provide humidity and temperature control, the building has heating capabilities provided by natural gas/diesel fuel boilers and electric steam boilers. "The total heating capacity of these systems is 4,800 MBTUH (fuel/natural gas boilers B-1 and B-2) and the total humidification capacity is 320 kW (electric steam boilers B-3, B-4, B-5, B-6, and B-7)." (As-Built Drawings, 1974; As-Built Drawings, 1981; As-Built Drawings, 1993; As-Built Drawings, 1996) Building heating capability is provided via piping from these units to heating coils in some (but not all) of the air handling units.

Heating and cooling coils within many of the air handling units serve to control temperature. Heating is supplied generally through the aforementioned natural gas and/or diesel fuel boilers that serve a hot water supply piping system (water or water-glycol based). Similarly, cooling is served by various chillers located throughout the facility that are connected to one cooling loop. The condenser side of the chillers are water cooled (via the existing 3-bay cooling tower) and the medium for heat transfer in the evaporator side of the chiller is also water or a water-glycol mixture (i.e., no known direct expansion units which utilize CFC based refrigerants as a heat transfer fluid).

Electric steam boilers feed heating coils within the air handling units to provide a mechanism for controlling the humidity in the facility. Similarly, remote re-heat terminal boxes also provide a local mechanism for reacting to the changing but stringent requirements of a clean room environment. Terminal units are supplied via a heating piping directly connected to the boxes themselves. As the temperature within the clean room changes (as, for example, machines go "on" and "off"), a regulating valve within the terminal unit regulates the amount of hot water that is allowed to enter the heating coil within the box. It should be pointed out the heating and cooling are provided locally and are not part of a central utility system that feeds the entire site.

Besides temperature and humidity control, Fab 4 was designed to be a positive pressure, Class 100 (or better) clean room environment. The general clean room arrangement of the fab is a "ballroom" type design, where a combination of outside and return air that is filtered is supplied to the entire area via a series of ductwork and supply air diffusers. Individual HEPA filters on approximately 300 vertical laminar flow (VLF) hoods above processing steps reduce particle count within the clean room environment further (since it only circulates existing air through its fans and HEPA filter which are located in the clean room atmosphere), particularly above steps where the wafer is exposed. Hence, the concentrated areas of filtration are where the processing takes places versus throughout the entire facility). (This "older" design is in contrast to modern methods including a bay and chase design with side-filtering HEPA filters and a bay and chase design with full vertical laminar flow originating from the HEPA filters above the ceiling). While a number of the air handling units are HEPA-filtered (to reduce particles), the VLF hoods provide the general method for achieving low particle counts above process steps.

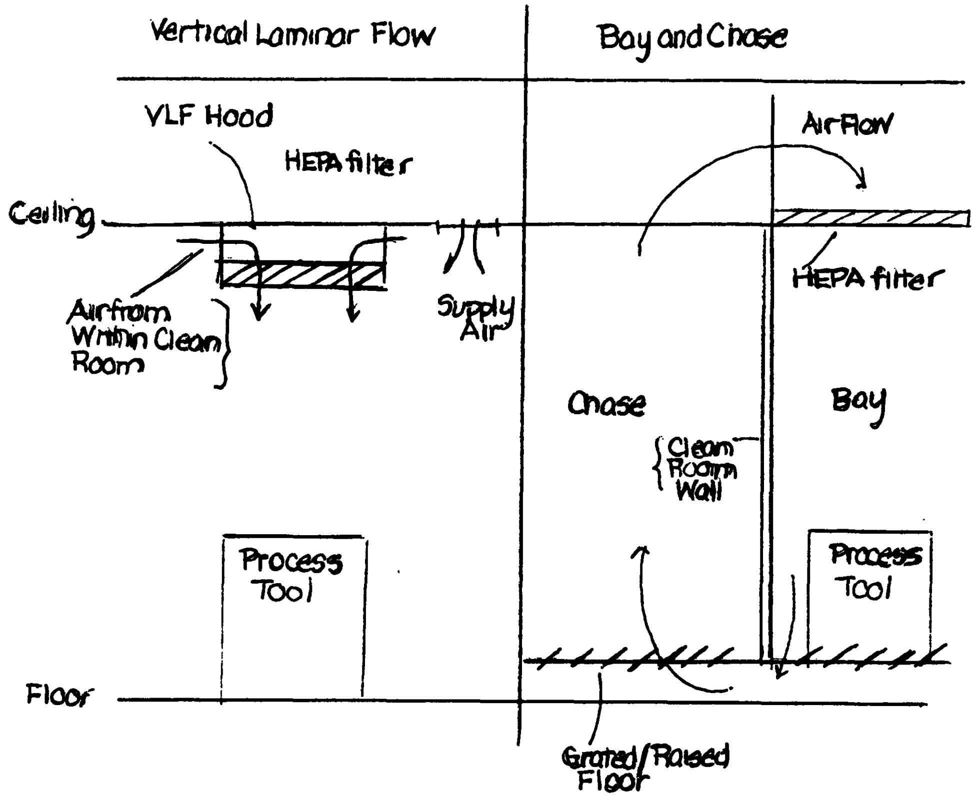


Figure 6-15: Fab 4 Vertical Laminar Flow (VLF)
Source: Intel Corporation

From a process piping perspective, the building has a number of utility systems. "A localized deionized water system provides "ultra-clean" 18 MΩ resistance water (capable of filtering particles greater than 1.2μ and providing 110 gallons per minute of capacity) for wafer cleaning steps." (As-Built Drawings, 1996; Personal Interview with Intel General Site Services Project Manager, 1996) Process gas piping (nitrogen, oxygen, hydrogen, etc.) provide gases necessary for the semiconductor process of building layers. Drain piping (including solvent piping, hydrofluoric acid, and acid piping) provide a mechanism for collecting waste generated by the processing and locally treating it. In particular, the other utilities include compressed air, process chilled water (essentially, water that is used cool the manufacturing tools locally), etc. are also part of the vast mechanical network within the building.

The electrical system of the building consists of one main 15kV service that is "stepped down" by various transformers to provide 480V 3-phase power or 120V/208V 3-phase power to the process tools and the utilities supporting them (i.e., chillers, air handling units, etc.). The entire building electrical network is supplied through approximately 60 power and distribution panels, as well as a number of emergency power panels (supplied via an emergency generator). The power distribution network is not necessarily centered in one utility room; various interior and exterior transformers have been added throughout the years to meet the additional power requirements imposed on the facility.

With respect to specific electrical capabilities, the documented total average monthly demand (as opposed to the total connected capacity) of the facility is approximately 3.9MVA (according to January, 1992 data). "At a voltage of 480V/277V, the facility's primary existing infrastructure has the capability to support approximately 6.25 MVA while at a voltage of 120V/208V (sometimes stepped down from 15kV and sometimes stepped down from 480V), the capability is 3.75 MVA. In addition, the emergency bus network of the facility is sized at 500 kVA, supplied through an emergency generator (approximately 600kW) and a series of Uninterruptable Power Supplies." (As-Built Drawings, 1996)

Environmentally, the building is permitted for two waste streams -- airborne emissions and wastewater output. With respect to airborne emissions, the site is permitted as a whole to release a certain amount (tons or pounds) of emissions per year (VOCs) to the atmosphere. As the oldest facility on site, Fab 4 was generally regarded as the largest contributor to the site's airborne emissions. One of the major environmental systems consists of Fab 4's four "general" exhaust scrubbers which remove and treat potentially environmentally hazardous materials from the clean room environment. These scrubbers remove the air, spray it with water, and remove any particles from the air before exhausting it to the outside (the particle "contaminated" water is treated locally as part of the on-site waste treatment before being released to the city's sewer system). In addition, Fab 4 has the capability to locally treat As (arsenic) exhaust and solvent exhaust at various points throughout the building. The major observed difference is that arsenic (As) and solvent exhaust gases are passed through the roof for treatment outside while other scrubber treatment is localized on the first floor by coring ductwork penetrations through the concrete floor to mesh with a complex collection network.

Similarly, Fab 4 and Fab 5 currently share one of the two permitted wastewater discharge outfalls (Fab 15, the remaining fabrication facility on site, has its own permit). "As such, the permits together allow the site to discharge a certain amount of treated water to the city's sewer system (approximately 875 gallons per minute or 1.26 million gallons per day)." (Personal Interview with Intel Oregon Environmental, Health, and Safety Engineer, 1996) The waste treatment system generally collects all aqueous manufacturing materials and treats it on-site before it is released into the city's treatment system. This waste stream -- consisting of corrosive materials, hydrofluoric acid waste, scrubber exhaust water waste, etc. (but not including storm and sanitary wastes which have their own connections to the city system) -- are neutralized (i.e., pH balanced) in a series of tanks and waste treatment steps before release to the city's sewer network. Solvent waste, for example, as well as a few other systems are collected on-site for potential off-site disposal or reclamation and do not enter the treated wastewater stream.

Two implications of the wastewater discharges to date. "First, because of the recent ramp-up of Fab 15 and the accompanying decline in Fab 4, the city has allowed the Aloha campus permits to remove the volume distinctions between the two different outfalls. Specifically, Fab 15 has exceeded its original permit yet is consequently able to discharge excess wastewater up to the difference between the allowable level of Fab 4 and Fab 5's joint permit and its current discharge rate. Secondly, the wastewater stream does not currently include reverse osmosis or "brine" discharge levels from the centralized DI water system. Currently, this waste is discharged directly into the storm system without any treatment." (Personal Interview with Intel Oregon Environmental, Health, and Safety Engineer, 1996) However, future requirements will dictate that this stream also be accounted for as part of the entire wastewater neutralization process and included under the current permits.

As the first semiconductor manufacturing facility on site, Fab 4 was originally designed to be self-sustaining. As such, Fab 4 has numerous systems which have been replaced and rehabilitated as access to centralized utility connections and other building systems have come about. Yet, as an older facility, Fab 4 has numerous systems which have reached the end of their useful lives and require replacement and/or rehabilitation. As such, it is important before one tries to understand the capabilities of the facility to assess the condition of the existing equipment and its internal systems.

After conducting walkthrough of the facility with other engineers, Table 6-16 details a potential list of identifiable salvageable equipment requiring little or no major maintenance programs and their system capacities.

	System	Equipment	Capacity
Mechanical	Oil Free Air	Compressors located in Fab 5	800 CFM @ 90 psi
	Nitrogen	Served from centralized campus plant	700 CFM @ 90 psi
	Heating, Ventilation,and Air Conditioning (HVAC)	Roof-Top Air Handlers (3)	12,000 CFM; 27,000 CFM; 28,000 CFM
		Water Cooled Chiller	560 tons
		Air Cooled Chillers (2)	200 tons; 200 tons
		Cooling Tower	1,350 tons
		Electric Steam Boilers (2) - Humidification	80 kW; 120 kW
		Natural Gas/Fuel Oil Hot Water Boiler (1) - Heat	2,400 MBTUh
	Process Vacuum	Pump Set	220 CFM @ 27" Hg
		Pump Set	300 CFM @ 27" Hg
	Industrial Water	Booster Pump Set	250 GPM @ 40 psi
	Ultra Pure Water (UPW) Deionized Water System	Carbon Filters (Pre-Treatment)	100 GPM
		Final Filter Housings	300 GPM
Environmental	Acid Waste Neutralization (AWN) System	Treatment system shared with Fab 5	125 gallons per minute (GPM)
	Acid Fume Scrubber	Scrubber and Fan	20,000 CFM
Electrical	Electrical Distribution	HV Switchgear	3,200 A, 480 V, 3 Wire
		Pad-Mounted Transformers	1,500 kVA, 480 V
		Transformers, 480V-208/120V	
		Motor Control Center (MCC)	800 A, 480V
		Distribution Panelboard	800 A, 120/208V

Table 6-16: Fab 4 Salvageable Equipment List
Source: Intel Corporation, General Site Services (GSS) Organization

In addition, it is also important to understand the state or condition of major systems which will be essential in defining any further role for the facility. As such, specific commentary on some of remaining systems within Fab 4 are discussed below:

1. Heating system -- three boilers, all probably requiring some re-tubing and re-work. "One major potential problem with the heating system is if one shut down the boilers for rehabilitation work and drain the pipes, then the copper and steel pipe and the fitting which have expanded over time will shrink. As such, when one turn the boilers "on" again, the pipes will leak for quite awhile until all the pipes expand and fill the seams." (Personal Interview with Intel Oregon General Site Services Mechanical Engineer, 1996) Probable resolution -- rehabilitate the boilers and replace all the heating pipe with new lines.

2. Heating, Ventilation, and Air Conditioning (HVAC) system

(a) First Floor Air Handlers -- probably old but can easily be retrofit. Existing coils (i.e., heating and cooling) within many of these air handlers would just have to be cleaned to allow the coils to fulfill their original capabilities again. Fans would probably only have to have their bearings changed and greased to make them last another 20 years.

(b) Chillers -- except for the air cooled chillers, many of the existing chillers are old and would probably need to be rehabilitated

3. Sprinkler System -- reworked in the past few years. Separated now by zones versus at one time when each floor was an entire zone. System is wet-pipe system (meaning that water is within the pipes at all times). System is extremely modifiable. Existing mains could also be utilized to serve new role as new lines could be retrofitted where existing branches were.

4. Process Gas and Solvent Piping Systems -- bulk chemical distribution (BCD) piping is generally old and deteriorating. At the direction of one of the department heads, the systems were cleaned and removed. If manufacturing was placed back within the facility, these systems would have to be replaced.

5. Electrical Distribution System -- generally in good condition. No transformers appear to be PCB-contaminated. Major parts of the high and medium voltage system have been replaced in recent years. Similarly, most electrical equipment is designed to last for a long time (provided that maintenance is performed). Hence, one of the major problems is having power optimally organized so as to be in the vicinity to a connection when needed. All main distribution panels will probably remain but branch panels would probably be disconnected in lieu of replacing them when known requirements are identified and incorporated.

(c) "Brainstorm" Balance Sheets for Alternatives:

As detailed in Appendix 1, "thought sheets" have been provided for each of the alternatives. While not necessarily useful at first, the issues and constraints brought forth by these sheets are intended to allow one to determine the key measures for each decision factor more easily.

(d) Consolidate Constraining Measures:

As previously mentioned, creating common measures is an essential part of the analysis. In this case, for each decision factor (technical, strategic, and financial), the objective is to create a set of measures that the alternatives can be judged upon.

With this in mind, one can simplify a bit (if necessary) the analysis by grouping similar functions together. For example, in our case -- (a) clean room manufacturing, (b) non-clean room manufacturing or manufacturing support, (c) administrative, (d) warehouse, and (e) other alternatives -- may be five potential categories of use that we can consider together.

<u>Decision Factor #1: Technical Measures:</u>

Consolidating technical requirements and technical issues creates the basis for understanding potential requirements of alternatives versus the ability to meet them. At the same time, the intent is to bring forward potential technical difficulties as well as illuminate those alternatives that are best met by the facility.

(1) Ceiling and Ceiling Height

Architecturally, the ceiling height on the second floor is limited currently by the placement of vertical laminar flow hoods (VLFs) which extend from the ceiling downward. At its lowest point, from the top of the finished floor to the bottom of the VLF, the approximate distance is less than 6'-6" in some areas, depending on the functional area. For example, as detailed in Table 6-17, the ceiling height can vary significantly within Fab 4:

Table 6-17: Approximate Ceiling Heights (Fab 4)

Functional Area	Distance from finished floor to bottom of ceiling (feet)	Distance from finished floor to bottom of VLF hood (feet)
Lithography	10'-2'	6'
Diffusion	10'-2'	6'-6"
Wet Etch		6'-6"
Thin Films	10'-2'	6'-6"
Dry Etch - Chlorine Etch (CLAM) Room	11' - 12'	No VLFs - (above ceiling)
Dry Etch - LAM Area	8'	VLFs at ceiling level
Dry Etch - AME Area	9'	No VLFs - (above ceiling)

Located between approximately 9'6" and 10'2" above finished floor (AFF), the ceiling cannot necessarily support all the equipment height requirements of new manufacturing processes. For instance, 6-inch ion implanters with an approximate height of 8' to 9' would be difficult at best. 8-inch ion implanters, with their larger size (over 20' long) and support requirements for over 10' height would not necessarily fit either. Similarly, 4-inch diffusion furnaces required approximately a height of 7 feet and were horizontally configured while today's 8-inch technology are vertically configured and would require approximately 10 to 12 feet clearance, close or beyond the capabilities of the existing building. In addition, while the equipment itself may actually fit in the facility, the steps necessary to "get it in" (i.e., knocking down exterior walls, etc.) may not justify the action, although it has been done before.

The possibility of raising the ceiling is limited by three factors: (a) HVAC ducting requirements, (b) existing structural and non-structural roof members, and (c) UBC building height restrictions. First, HVAC requirements largely dictate the need for flexibility in ceiling plenum spaces for supporting manufacturing functions. With the need to provide large quantities of air without unnecessarily high velocities, this in turn translates into a need for large ductwork (essentially to reduce air speed while maintaining pressure). Secondly, the existing roof framework limits the amount of vertical shift that accompanies the possibility of moving the ceiling up. In Fab 4's case, two large structural beams limit the amount of vertical displacement. "The top of these beams is generally at the 36' AFF elevation at the exterior walls (+/- since the top of the beams change with the roof slope from the ridge line in the center to the exterior walls where storm drains are located). While the thickness of each of the beams varies (16" at the minimums and 46" and 30" at the maximums), this inhibits the plenum area greatly." (As-Built Drawings, 1974) As such, the minimum distance between the bottom of the structural beam and the top of the ceiling can be as little as 3' at its minimum point and up to 7' (based on a 10' ceiling). As such, one possibility could be to raise the entire roof, although this would also necessitate raising all the elements and systems running throughout the interstitial space.

In addition, cross members and open web joists running at a 90 degree angle to the structural members also creates interference. These joists are approximately 2' high, thereby reducing the open areas in the interstitial space from an estimate of seven feet (7') to approximately five feet (5') at its highest points.

Similarly, movement in the design of modern clean rooms towards utilizing Pace Clean Air Units would also be limited by the ceiling and interstitial heights. As such, commercial "off the shelf" products would probably not be feasible but "custom made" products (sold at a very high premium) could be considered should modern semiconductor manufacturing be considered.

With this in mind, one can create the following table summarizing the existing condition versus the present and future needs:

Table 6-18: Ceiling Height Requirements

Technical Measure	Ceiling Height			
Function	**Existing Condition**	**Present Need**	**Future Need**	**Action or Cost**
Clean Room Manufacturing (Class 1, Class 10) - Full VLF	6-6"	15'-0"	20'-0	Remove VLFs (to 10'-2" height); raise roof to raise ceiling; install raised floor grid system
Less-Clean Room Manufacturing (> Class 100) or Manufacturing Support - Side Supported VLFs	6'-6"	12'-0"	15'-0"	Remove VLFs (to 10'-2" height); raise roof to raise ceiling; potentially install raised floor
Administrative	10'-2"	9'-0"	9'-0"	Remove VLFs
Warehouse	10"-2'	-	-	Remove VLFs

(2) Seismic Concerns

Built in 1975-1976, the facility was originally constructed under 1973 Uniform Building Code guidelines for Seismic Zone 2 requirements. However, with the eruption of Mount St. Helens in 1980 and the resulting seismic zone restructuring in the Northwest, the general metropolitan area now falls under 1994 Uniform Building Code requirements for Seismic Zone 3.

The chief concerns with this change are with the attachment of the VLF hoods and the structural roof beams. Should the facility continue to maintain its H6 occupancy rating using the VLF hoods, the problem will remain but will not necessarily be required to be fixed according to the practice of "grandfathering" allowed by the building code. However, it should be noted that Intel policy, as well as potential demands from building officials upon review of drawings constituting a major renovation, may ultimately cause seismic upgrading to be included in any renovation undertaken.

In addition, should the building remain an H6 occupancy after closure to support other manufacturing, it is "highly likely" that the VLF hoods will be removed to accommodate a bay and chase manufacturing environment similar to Fab 5 (ballroom design with side VLFs filtering air to processing bays) versus the modern bay and chase environment in Fab 15 (full bay and chase with full vertical laminar flow originating from Pace units in the interstitial). However, if specific processing tools and steps could be put in place to take advantage of the height limitations while still providing the necessary room requirements for the process, then there could be a potential fit. Hence, if a manufacturing step that meets these requirements cannot be identified, the problem will thereby lend itself to be resolved with the removal of the hoods and/or the raising of the roof and creation of a larger interstitial space and ceiling height.

Secondly, concern with the steel columns appears to be surrounded by the fact that the reinforced masonry brick columns are not adequately supporting the seismic load required by the large tapered roof beams (50' and 60'). "In short, the seismic load basically doubles when going from zone 2 to zone 3 but what the author is unsure of is whether those loads controlled the design of the roof structure. Specifically, the governing load (or the greatest load) could be wind load, snow load, dead and live loads, or the seismic load. Because of the relatively "loose" structural connection of the tapered beam to the concrete column, it would appear that a more robust connection to the concrete column is probable since it looks like there is a high load being applied. In addition, it doesn't look like the diagonal angles (2x2x1/4) are doing much work for horizontal loads if they are connected only to the masonry wall." (Telephone conversation with Structural Engineer, 1996)

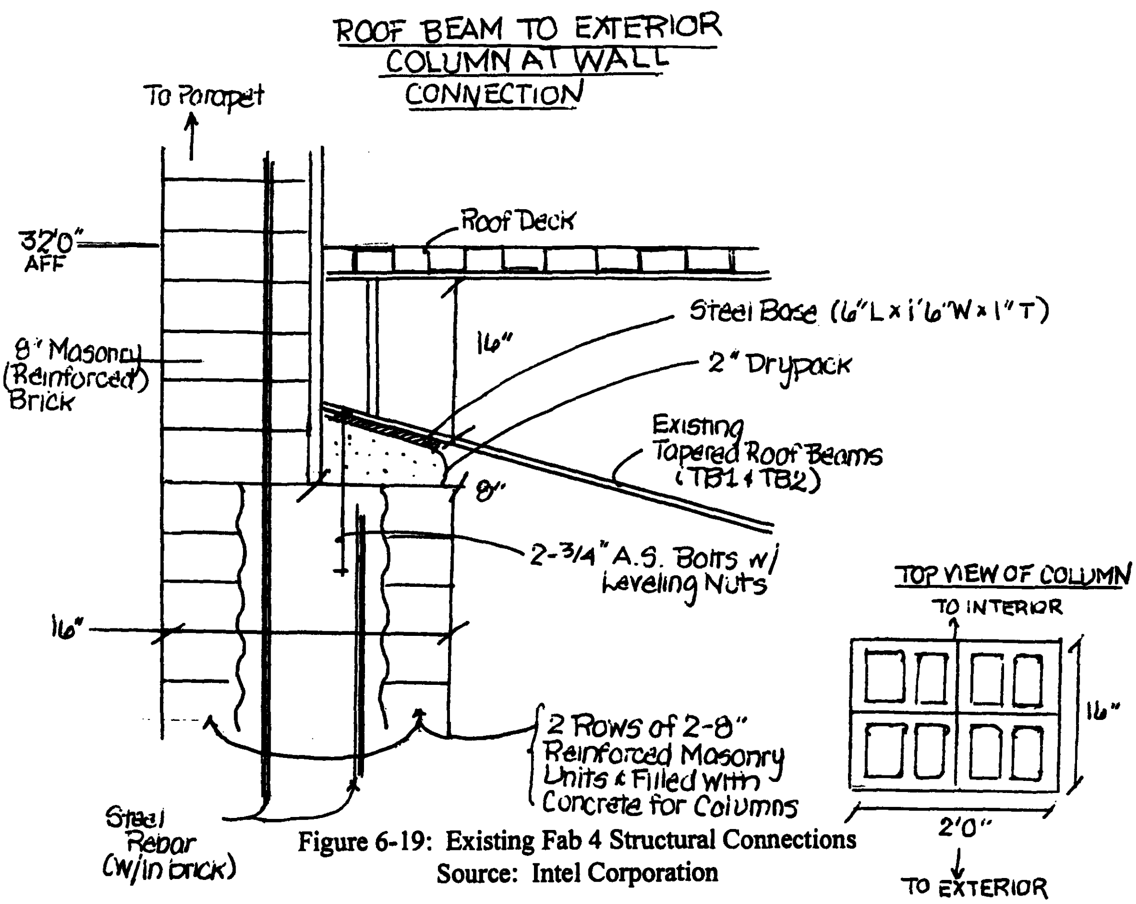


Figure 6-19: Existing Fab 4 Structural Connections
Source: Intel Corporation

One potential possibility would be to reinforce the entire structure utilizing steel (versus brick) as the major structural frame for the roof support. One advantage of this would be that this type of arrangement would also allow one to simultaneously raise the roof to increase the ceiling height requirements.

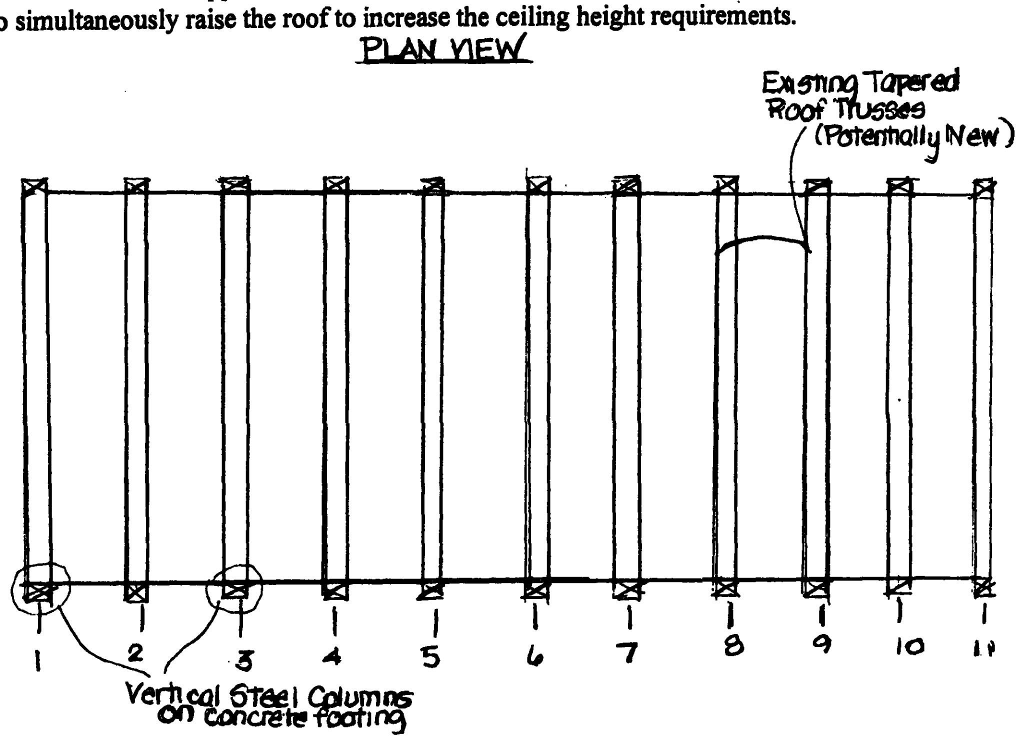


Figure 6-20: Potential Fab 4 Structural Modification
Source: Intel Corporation

As stated in the 1994 Uniform Building Code, if the facility occupancy code is changed, "severe modifications may not be required if the new occupancy is less hazardous or has less occupants" but remains up to the jurisdiction of the Building Official. For example, should the H6 occupancy be reclassified to S1 (warehouse/storage area capable of supporting a "moderate" hazard), major structural upgrades would likely not be required since both the hazard is less in an S1 facility (versus an H6) and the number of SF/occupant in an S1 (300 SF) is greater than for an H6 (200 SF). However, should the space be reclassified to B2 (Office), while the hazard would be less, the number of additional occupants might justify the Building Official requiring that structural upgrades be undertaken.

In any case, if the building occupancy is changed from H6 to another occupancy code and then the company intends to re-file for H6 occupancy (when an appropriate manufacturing mission is identified that can meet the particular requirements of the building), the facility will then become subject to the most recent version of the Uniform Building Code and all the modifications necessary to comply with it. As expected, this would most likely prove to be a highly expensive undertaking.

Consequently, one can summarize the results as follows:

Table 6-21: Seismic Requirements

Technical Measure	**Seismic**			
Function	**Existing Condition**	**Present Need**	**Future Need**	**Action or Cost**
Clean Room Manufacturing (Class 1, Class 10)	Zone 2B	Zone 3	Zone 3	
Less-Clean Room Manufacturing (> Class 100) or Manufacturing Support	Zone 2B	Zone 2B or Zone 3	Zone 3	Depends on whether facility is "grandfathered" or whether VLFs are used
Administrative	Zone 2B	Zone 3	Zone 3	
Warehouse	Zone 2B	Zone 2B or Zone 3	Zone 3	Depends on Building Officials' interpretation

(3) Facility Size

One of Fab 4's major contributing independent constraints is its relatively small size, particularly when viewed against today's standards. Fab 4 is approximately 22,000 SF of Class 100 clean room space while today's modern and Intel standard semiconductor fabrication facilities range from 75,000 SF (medium size) of clean room space to 150,000 SF (large size) of sub-Class 1 clean room space.

The benefits of a large semiconductor manufacturing area are simple -- economies of scale can be maximized as more and more tools and equipment can be installed and subsequently, larger and larger quantities of products are produced. In short, throughput can be maximized, allowing large volumes of product to be passed through the facility at any time. This is consistent with Intel's current strategy -- to produce high volumes of chips at diminishing margins to maintain revenue and yet still cover fixed, variable, and overhead costs. As such, by investing in larger and larger fabs, Intel is able to produce large volumes of chips to satisfy the demand of its customer base at that particular time while also planning for the future. By aligning its facilities construction strategy with its corporate manufacturing strategy, the possibilities for using a small (in this case, 22,000 SF) fabrication facility to contribute to the overall Intel manufacturing strategy are deemed minimal at best, unless a small niche market outside of its stated strategic goals is sought after.

As such, a summary of the space requirements is depicted below:

Table 6-22: Facility Size Requirements

Technical Measure	Facility Size			
Function	**Existing Condition**	**Present Need (Economic Size)**	**Future Need (Economic Size)**	**Action or Cost**
Clean Room Manufacturing (Class 1, Class 10)	22,000 SF	75,000 SF	100,000 SF	Fab 4 cannot support large scale manufacturing
Less-Clean Room Manufacturing (> Class 100) or Manufacturing Support	22,000 SF	depends on function	depends on function	
Administrative (non-fab support)	22,000 SF	25,000 SF*	> 50,000 SF	
Warehouse	22,000 SF	40,000 SF*	> 40,000 SF	

*Based on information provided by R.S. Means, Construction Cost Estimating Guide, 1992

(4) Clean Room Environment

In general, Fab 4 seems most likely to support a clean room environment similar to Fab 5. That is, Fab 5 uses a modified bay and chase design which uses ULPA filters in similar arrangement to VLF hoods although they are attached to the chase-side of the bay walls. In this manner, full vertical laminar flow is not achieved because the filtered air does not originate from the ceiling but from the sidewalls. The pressurized air is then exhausted through open grates located at the bottom of the bay/chase walls.

Table 6-23: Clean Room Capability Requirements

Technical Measure	Clean Room Capability			
Function	**Existing Condition**	**Present Need**	**Future Need**	**Action or Cost**
Clean Room Manufacturing (Class 1, Class 10)	Class 100	Class 1; Class 10	< Class 1	Fab 4 cannot support without major renovation investment
Less-Clean Room Manufacturing (> Class 100) or Manufacturing Support	Class 100	Class 100; Class 1,000; Class 10,000 (function dependent)	function dependent	
Administrative	N/A	N/A	N/A	
Warehouse	N/A	N/A	N/A	

(5) Vibration Concerns

Fab 4's close proximity to the active railroad line (estimated at 350' at its northwest corner and 425' at its northeast corner) results in potential ground disturbances being felt when a train passes by. With limited means for ensuring vibration isolation as well as the increasing demand for smaller and smaller line widths, the ground disturbances felt by process equipment within the fabrication environment has been a major concern of Intel in recent years.

By virtue of its age and the products it produced during its lifetime, vibration concerns were not necessarily a consideration when designing Fab 4. In addition, the higher line widths manufactured within the facility at the time also allowed for more movement during critical steps. Similarly, certain parts of the process (particularly, photolithography) cannot operate under an environment subject to vibration. As such, should any manufacturing be considered for the facility, the effects of vibrations on the equipment, the proposed process, and the product within the fabrication area should be evaluated before a decision is made.

(6) Materials Handling System, Process Flow, and Integration Effects

Material handling is an essential part to semiconductor fabrication capabilities. Generally, all manufacturing functions are arranged in the same facility so that the product does not necessarily have to leave the clean environment. Automated material handling systems or manual handling methods are utilized, depending on the production volumes as well as the distances between work areas.

Removing manufacturing functions out of a fabrication environment (Fab 5 or Fab 15) and putting them in Fab 4 could potentially have "serious" implications (including line yield losses and increase possibility of wafer damage). As such, since it would appear to be optimal to minimize the amount of movement between facilities, limited front-end and back-end processing steps are most justified than actual functional areas of manufacturing.

Similarly, the problem of actually moving the wafers from one environment to another provides a technical challenge as well. That is, if the wafers are removed from a clean environment and transported through a non-clean or less-clean environment, additional steps (including perhaps an additional wet step) must be taken to remove any additional particles. If the wafer moves between facilities, then this might have to be repeated at both ends. This type of arrangement would lend one to believe that yields could suffer (from the introduction additional particles caused by the vibration resulting from movement) and might be difficult to support.

Technically, the challenge of constructing an automated or manual handling system also exists. For example, the distance from Fab 15 to Fab 4 is approximately one thousand feet while the distance from Fab 5 to Fab 4 is approximately 300 feet. Between the facilities are administrative facilities and an open service yard. "Constructing a monorail system to transport wafers back and forth between the facilities is not only expensive ($1,500 per linear foot of track) but also would require that the production wafers themselves leave the production area at a point in time." (Telephone Conversation with P.R.I. International, 1996)

(7) Environmental Concerns

"Currently, the entire Aloha site is permitted for approximately 190 tons of pollutants per year to be exhausted to the atmosphere." (Personal Interview with Intel Oregon Environmental, Health, and Safety Engineer, 1996) Before its manufacturing operations ceased, Fab 4 was seen as the largest contributor to the environmental discharge permit. Hence, any consideration for using the building in another manufacturing capacity (or leasing it to others) must take this monitoring requirement into account. In particular, perhaps the age of the equipment and the technology utilized (something which could limit the amount of "treatment" that it can perform) would have to be upgraded to maintain the higher standards required.

Similarly, the potential environmental liability of the facility should be considered. For example, if an administrative function were to be located in the facility, would past manufacturing practices in the facility present any potential long-term health hazards?

(8) Adequacy of Utilities -- see Alternative/Requirements matrix and preceding technical description of Fab 4's capabilities.

Decision Factor #2: Strategic Measures

By reviewing Intel's past, it becomes readily apparent that executing a well-defined and well-executed corporate strategy has been the driving force that has made Intel what it is today. As a brief history, Intel took a major risk in the early 1990's (particularly when viewed in light of the economic throes which dominated the industry in the mid-1980's) when it decided to invest extremely large sums of money in building the necessary capacity requirements to meet the forecasted demand for its future high-technology product - the Pentium® microprocessor. At the same time that other large microprocessor companies like IBM, Digital, and Motorola were investing in incremental manufacturing capacity, Intel committed its financial resources to creating large-scale capacity for its future product. Obviously, the strategic decision paid off by not only allowing it to reap large sums of revenue from a high margin product but also by creating a high barrier to entry (investment costs) for other firms.

(a) "Fit" with corporate strategy

Currently, Intel's strategy can be summarized as follows – "... continue to stimulate demand for its microprocessors in three distinct market segments (large businesses, small businesses, and individual customers) and become the preeminent building block supplier to the new computing industry worldwide." (Intel Annual Report, 1995) The competitive tools that Intel plans on using to achieve a continued competitive advantage are focused on two areas: (a) manufacturing capability and (b) commitment to research and development.

To become the world's preeminent building block supplier, Intel has pursued a strategy of creating a "brand name" for its products by investing in large scale marketing and advertising campaigns. As evidence of the success of this strategy, its "Intel Inside" logo is now generally regarded as one of the most recently recognized trademarks throughout the world.

Similarly, Intel has pursued its strategy by investing heavily in the introduction of new and more innovative products, with shorter development times between product introductions. With microprocessor lifetimes averaging only 18 months between new product introductions, Intel relies upon a strong research and development base, as well as the necessary manufacturing infrastructure (personnel, facilities, and equipment tools) necessary to implement this strategy. Similarly, as the primary means to achieve this end, Intel continues to readily invest in both research and development resources as well as the fixed production assets (equipment and facilities) necessary to support that vision.

In addition, Intel has decided to stimulate demand for its products by vertically integrating into other areas of the computer components and assembly process (outside of its traditional microprocessor and logic manufacturing channels). In fact, Intel supplies the computing industry with not only the microprocessors but the chips, systems, and software that are the ingredients of computer architecture today. By entering such functions as motherboard assembly and even computer assembly itself, Intel hopes that it will alleviate much of the capacity constraints currently present in the industry. Hence, by satisfying current demand for computer products, the company hopes to stimulate demand for upgrades and products that will require its advanced microprocessors in the future.

Another aspect of strategy that should be pointed out concerns Intel's approach toward the value chain. While Intel has recently become a supplier of the major building blocks to the computer industry, it has not vertically integrated many of its lower-value functions. For example, while it performs the test and packaging of its products, it does not pull its own silicon ingots or generate many of its own material supplies. Rather, Intel outsources many of these functions and performs many of the higher-valued added steps in-house. However, strategic supply chain theory would also imply that the less of the value chain that a company performs itself, the more it will have to give away to other firms. Hence, the objective is to maintain leverage over those functions a company outsources (to restrict the amount of its margin that it will have to give away) by outsourcing only "commodity-like" functions or operations while maintaining and performing the high-valued steps in-house.

(b) "Fit" with long-term and short-term facility strategy

Facilities play a major role in Intel's outlook on meeting demand requirements for its microprocessors. With respect to decommissioned facilities, however, Intel's strategy is less defined. In light of continuing construction of new fabrication facilities, Intel's strategy does not necessarily explicitly include a role for older and decommissioned facilities. Yet, the risk associated with these elements of Intel's strategy -- current facilities, future facilities, larger wafer sizes, and future cost competitiveness -- must be taken into account when evaluating their effect on renovating facilities.

When viewing Intel's facilities strategy by looking at its domestic and worldwide locations, it becomes apparent that Intel has decided that it does not want to concentrate most of its production capabilities within a specific region or state. As such, the corporation has decided that it wants to reduce its risk and reliance by not "putting all its eggs in one basket". With wafer fabrication facilities currently operating in New Mexico, Arizona, and California (as well as in Oregon), Intel's willingness to invest more resources into one region does not appear to be a policy supported by upper management.

With respect to new facilities, Intel currently has announced plans which significantly affect the role of Fab 4 as a potential fabrication facility. Within Oregon, for example, Intel owns approximately 350 acres of land on which the next development facility D1-B has been constructed. With approximately 100,000 SF of clean room space, the potential for expansion on the site itself presents Intel with the opportunity to construct new facilities versus investing in renovating older and smaller facilities. In comparison, the Aloha site is relatively constrained to approximately 50 acres, with limited potential for expansion. This expansion could essentially be fueled by two mechanisms: (1) acquiring adjacent properties from existing landowners or (2) converting parking areas to parking decks and creating additional development space. In fact, the latter has been employed most effectively on Intel's Santa Clara site to create space for additional manufacturing and administrative areas in a constrained area.

Similarly, developments outside of Oregon also make one question the willingness of Intel management to invest in renovating Fab 4 for direct manufacturing purposes. First, within the past year, Intel announced a new fabrication facility (Fab 16) planned for construction in the Fort Worth, Texas metropolitan area. "According to publicly released material, as the newest advanced logic wafer fabrication facility, the first phase of the plant will be approximately 800,000 SF, consisting of 75,000 SF of "class 1" clean room space. As the newest fab, the factory plans on building logic products on 0.25 micron technologies originally, with progression to smaller geometries planned in the future. Upon completion, the facility in Fort Worth is expected to cost $1.3 billion and be operational by 1999." ("Intel Employee Bulletin", 1996) Secondly, Intel also owns the rights to develop approximately 700 acres of greenfield land within the metropolitan Phoenix area that could potentially be used for additional manufacturing facilities.

In that same vein, strategically the ability of newer facilities to meet future demands also should be considered. At the time that Fab 4 and her sister plants were constructed, little was known about the future of the semiconductor marketplace and its demand. However, with sales expected to top $300 billion by the turn of the century, the demand for silicon-based products will continue to exist. As such, even though requirements for those future products or the processes necessary to support them are not necessarily well defined, Intel appears to have positioned its newer facility assets to be more flexible to accept future roles. For example, investing during the construction phase in higher floor-to-ceiling heights (at a higher initial cost), larger footprint (SF) facilities, modular packaged air handling units for HEPA filtering, raised floors, and removable walls and partitions appears to make the newer fabrication facilities more flexible to accept future demands on their infrastructure. The strategic implication of this is that older facilities will not be able to readily meet those demands without large scale renovation costs while newer facilities will be more flexible to be retrofitted to meet future requirements. As such, newer facilities currently appear well provisioned and designed to offer many advantages over their counterparts.

Finally, as wafer sizes have increased (from 4-inch to 6-inch to 8-inch to 12-inch), the potential average cost per die (assuming yield remains constant) would be lowered. Hence, as wafer sizes increase and producing at smaller wafer sizes become cost-prohibitive, retrofitting facilities capable of only supporting small wafer sizes does not appear to be a sustainable policy. However, if a niche market is identified where product cost is not necessarily as much of a concern, then smaller fabrication facilities would appear to offer the space to do so.

(c) Corporate Guidelines

Intel has also made a corporate decision regarding the level of fixed assets that it will apportion for its employees. During the downturn of the semiconductor industry in the mid-1980's, Intel found itself with numerous facility assets for its limited and downsized headcount. "As a means to avoid this problem in the future, upper management decided that it would only build and own facilities to support eighty percent (80%) of its workforce at each site while it would lease facilities for the remaining twenty percent (20%)." (Personal Interview with Intel Oregon Strategic Site Planner, 1996)

Similarly, Intel also has a corporate policy regarding the distance that any employee must walk in order to reach a building. Essentially, the intent of this policy is to restrict parking lots from being constructed far away from where the employee works. "Specifically, the distance from any parking space to the closest entrance must be designed such that 80% of personnel can walk less than or equal to 700 LF and 90% of personnel must be able to walk less than or equal to 1,000 LF to reach the entrance." (Personal Interview with Intel Oregon Strategic Site Planner, 1996) In the past, space constrained sites have utilized parking decks to overcome this requirement while conserving valuable space.

Decision Factor #3: Financial Measures

As with most major decisions, financial analysis is an important part of the decision-making process. With the large magnitude of potential costs associated with many of the alternatives facing Fab 4, it is important to understand the value of financial measures in the decision-making process and the steps necessary to create a valid model.

(a) Weighted Average Cost of Capital (WACC):

At the heart of financial analysis is establishing a hurdle rate, discount rate, or weighted average cost of capital (WACC) for the alternatives. In Intel's case, the corporation sets a standard rate of fifteen percent (15%) as the basis for making its capital investment decisions. As a mechanism to derive whether that figure is indeed accurate, the author shall refer to common financial management techniques.

According to the referenced material (Brealey and Meyers, 1991), the weighted average cost of capital (or project hurdle rate) can be derived as follows:

$$WACC = k_d (1-T_c) (Debt\$/(Debt\$+Equity\$)) + k_e (Equity\$/(Debt\$+Equity\$))$$

where:

k_d = cost of debt to the firm
k_e = cost of equity to the firm
T_c = corporate tax rate to the firm
Debt$ = Market Value of Debt to the firm
Equity$ = Market Value of Equity to the firm (otherwise known as market capitalization)

In addition, the cost of equity can be derived as follows:

$k_e = r_f + \beta_e (r - r_f)$

where:

k_e = cost of equity
r_f = risk free rate of return (generally, based on the 30-year treasury bond rate minus one percent (1%) for liquidity)
β_e = equity volatility
$(r - r_f)$ = risk premium of the stock market (historically, eight percent (8%))

Similarly, the cost of debt can be derived from the annual report by weighing the interest rates of outstanding debt by the amount of debt outstanding.

With these facts in hand, one can estimate the following values based on the 1995 Annual Report:

(a) k_d = (183M$/533M$) x 7.3% + (350M$/533M$) x 6.0% = 6.45%

Interest bearing short term debt:
183M$ (not including drafts payable) at a weighted average interest rate of 7.3%
Interest bearing long term debt:
350M$ at a weighted average interest rate of 6.0%

(b) k_e = (7% - 1%) + (1.57)(8%) = 18.5%

(Equity Beta is based on information provided by "Market Guide Report" from the website "www.dbc.com")

(c) WACC = (6.45%)(1-0.368)(533M$/(533M$+12,140M$)) + (18.5%)(12,140M$/(533M$+12,140M$)
WACC = 0.17% + 17.7%
WACC = 17.9%

Hence, 15% may actually be low for Intel's hurdle rate. However, this estimate of the hurdle rate does not necessarily include the lower risk associated with a facility expansion versus the risk associated with implementing a new manufacturing process.

Similarly, understanding the firm's depreciation schedule and the value of existing assets (both gross book value (GBV) and net book value (NBV)) are essential elements in the analysis. For example, Intel (for financial reporting purposes) uses straight line depreciation on its assets. These assets have varying depreciation schedules but generally conform to the following: (a) equipment - 4 years, (b) original facility construction - 39 years, and (c) facility capital investments - 10 years. In Fab 4's case, the author believes that the original facility was actually depreciated on a twenty (20) year schedule (following standards of the time) while improvements were capitalized over a ten (10) year schedule.

With the exception of capital improvements in the last ten years, both Fab 4's equipment as well as its facility value are essentially zero. "Fab 4's net book value (NBV) was approximately $1.3 million during operation but an additional $400,000 was expensed during the fourth quarter to "write down" the shell of the facility to a value of $900,000." (Personal Interview with Intel Oregon Fab 4 Finance Department, 1996) Hence, any capital investments would have to take into account depreciation expense effects, depreciation tax shield effects, and any other effects on the corporation.

(b) Defining Costs and Revenues:

(1) Annual Costs:

For the five general areas described above, an estimate of the annual operating costs (per square foot) are estimated as follows:

Table 6-24: Estimated Annual Costs
Sources: (1) Intel Facilities Construction Technology (FCT) Finance Group, (2) Intel Oregon Fab 4 Finance Department (Aloha Campus), and (3) Author's Estimates

	Approximate Annual Costs ($/SF)
Clean Room Manufacturing (Class 1, Class 10)	$175 per SF
Less-Clean Room Manufacturing (> Class 100) or Manufacturing Support	Class 100 ($50 - $75 per SF) Class 1,000 ($15 per SF)
Non-Operating Costs (Building Holding Costs)	$20 - $25 per SF
Administrative	$5 per SF
Warehouse	$3 per SF

Similarly, as described in the assumptions for financial calculations, salary and/or hourly labor costs, as well as property tax costs, have been estimated for inclusion.

(2) Initial Investment Costs:

As one might expect, the level of investment dollars required for each alternative can vary significantly. The costs for modification can vary from a few hundreds of thousands of dollars to hundreds of millions of dollars. Hence, because of their importance, it is first best to understand the potential magnitude of costs associated with each type of alternative.

Table 6-25: Estimate of Uncertainty
Sources: (1) Intel Oregon General Site Services Organization,
(2) R.S. Means' Construction Cost Estimating Guide, (1992) and (3) Author's Estimates

	Estimate of Uncertainty	Estimated Investment Costs
Clean Room Manufacturing (Class 1, Class 10)	+/- 25%	(H) > $50 Million
Less-Clean Room Manufacturing (> Class 100) or Manufacturing Support	+/- 25%	(M) $5 Million to $50 Million
Administrative	+/- 15%	(L) $500,000 to $5,000,000
Warehouse	+/- 15%	(L) $500,000 to $5,000,000
Demolition	+/- 50%	(L) $500,000 to $5,000,000 (M) > $5 Million

With this in mind, it becomes apparent that the option of demolition suggests the most uncertainty with its cost. As alluded to earlier, requesting an estimate from specialized demolition contractors can give the company more understanding of the magnitude of costs, as well as to establish a "baseline" for comparison against which all other costs could be compared.

Similarly, more detailed estimates were calculated for a number of these options. A summary chart of the estimated detailed costs as shown in Appendix 2 and Appendix 3 are as follows:

Table 6-26: Estimated Investment Costs
Sources: Calculations based on (1) R.S. Means' Construction Cost Estimating Guide, (1992),
(2) Intel Facility Construction Technology (FCT) Historical Construction Cost Data (1989), and
(3) Author's Estimates

	Estimated Investment Costs (without equipment)
Clean Room Manufacturing (Class 1, Class 10)	$35 Million - $50 Million
Less-Clean Room Manufacturing (> Class 100) or Manufacturing Support	$10,000,000 - $12,500,000
Administrative	$3,000,000 - $4,000,000
Warehouse	$500,000 (Seismic Not Included) - $1,500,000 (Seismic included)
Demolition	$5,000,000 - $6,000,000

(3) Opportunity Costs and Potential Savings

As the third component of the financial analysis, one needs to estimate the potential revenues, opportunity costs, and savings associated with each alternative. While direct manufacturing may appear to be the only function which directly generates revenue per se, it should also be apparent that rearrangement of other functions (whether they be manufacturing support, administrative, etc.) to create additional manufacturing space can also be considered as potentially creating additional revenue. Arguably, this assumes that the level of additional manufacturing space created will generate an amount of revenue that is directly proportional to that generated by the existing space.

While sometimes difficult to define, opportunity costs represent potential avoided costs or savings incurred by taking an action. For example, if Fab 4 was converted to an administrative facility, a potential opportunity cost would be the leasing costs currently paid for additional administrative facilities. Similarly, some other additional opportunity costs are effects could result from economies of scale, economies of scope, or shared functions (for example, administration, marketing, sales, etc.).

(c) Comparison of Similar Alternatives:

With this information in hand, the purpose of the next step is to compare similar alternatives to one another. For example, one scenario might be the comparison of using leased administrative facilities to house personnel (base case) versus converting Fab 4 to an administrative facility and moving those personnel on the Aloha campus or even constructing a new facility elsewhere to avoid paying the leasing fees. A summary of these scenarios are provided in Appendix 2.

(d) Comparison of Non-Similar Alternatives:

Similarly, as depicted in cost estimates in the Appendix 3, estimates of potential construction and demolition costs have been included for various alternatives. The difficulty with estimating many of these costs arises first from the fact that limited corporate or even non-corporate data exists for many of the potential renovation projects under consideration. Secondly, the relatively high level of uncertainty associated with these cost estimates results from the fact that costs generally become more refined as the project is designed (typically by an Architect-Engineering firm).

<u>Step 5: Compare and Contrast to Draw Conclusions:</u>

(a) Perform "coarse" elimination

Based on the technical requirements and constraints presented above, the following conclusions about alternatives within the five general categories of use can be drawn:

<u>Demolition</u>:
1. Any demolition or construction activities which affect on-going processes can be eliminated.

<u>Do Nothing</u>:

<u>Sell/Lease</u>:

<u>Renovate for Direct Manufacturing</u>:
1. Exclude photolithographic, metallization, and dry etching functions that require limited vibrations for dealing with smaller and smaller line widths.
2. Potentially exclude diffusion and ion implantation functions because of limited ceiling height (10' maximum)

Renovate for Non- Manufacturing or Manufacturing Support:

1. In accordance with 1994 Uniform Building Code requirements, exclude A2.1 occupancies or greater and any education (or type "E" occupancy); therefore, one cannot relocate cafeteria from Fab 15 to Fab 4

(b) Perform thorough elimination

As a means to effectively evaluate the alternatives, a summary table of alternatives and the accompanying factors is attached in Figure 6-27, located in Appendix 4. As such, from the combination of technical, strategic, and financial factors described above and those highlighted in the table, one can draw the following conclusions with respect to alternatives within each of the five general categories of use:

Demolition:

1. When compared to the potential of demolishing the facility to fulfill another need, the choice does not appear justified. The "value" of the facility as an existing asset compared to the "value" of the land after the facility is demolished (given that an identified need does not exist) does not appear to suggest that anything required could be constructed in its place. At the same time, the potential environmental liabilities that could be mitigated by demolishing the facility do not appear to be dominant factors. Similarly, any demolition would be more expensive and technically difficult to do than demolishing two facilities at once (in this case, Fab 5). Economies of scale and interference issues suggest that the cost would also be lower. Thus, the demolition of the facility for the purpose of retaining the land for future use does not appear to be justified.

2. Parking decks and additional parking spaces are not warranted by Intel guidelines and current manning estimates. At the same time, although the site is constrained, the likelihood that parking decks could be constructed without interfering with existing parking arrangements or at a reasonable cost do not appear justified. As such, eliminate the possibility of demolishing the facility for the reason of constructing a parking deck.

3. Constructing a new and bigger manufacturing facility would be limited on one side by the existing parking (which could potentially be overcome by constructing parking decks), and the railroad tracks, by 198th Avenue on another side, and by existing facilities and an existing service yard on the remaining two sides. Therefore, expansion would also be limited by building requirements for expanding closer to property lines. At the same time, when compared with the required economical size of modern semiconductor facilities and the amount of available property and infrastructure at the Ronler Acres site, the need for a new manufacturing facility in the Oregon area does not appear justified for the Aloha campus. Similarly, costs to construct a new warehouse or an administrative building is greater than the costs to lease facilities or renovate Fab 4 in its present condition. Hence, eliminate demolishing the facility to construct a new facility.

From this, one can conclude that any demolition of the facility at the present time is not warranted.

Do Nothing:

It appears financially beneficial to use Fab 4 in some capacity since Fab 15 and the Aloha campus will exist for at least an additional ten (10) to fifteen (15) years. As such, considering the annual holding costs for not occupying the facility, it would make sense to use the facility to serve a function or many functions, even though a function may not be readily identifiable. Similarly, the potential benefits of "grandfathering" the facility's H6 occupancy classification for potential future use also appears to be financially and strategically justifiable for the short-term. Based on these facts, the alternative for doing nothing is marginally justifiable for the short-term but not in the long-term.

Lease/Sell:

Leasing or selling the facility violates Intel's current concerns with physical security, technology transfer issues, parking constraints, and span of control issues with such things as environmental permitting, utility cost sharing, etc. For these strategic reasons, leasing or selling Fab 4 does not appear to be justified.

Direct Manufacturing:

1. One of the major reasons for supporting H6 occupancies is that "grandfathering" might allow the facility to be used "as is" versus requiring significant upgrades to meet today's construction standards (in particular, the seismic requirements). However, at the discretion of the building official, any significant rearrangements might require these upgrades anyhow. As such, should seismic upgrading be necessary, the most feasible way to do so might be by removing the existing roof and ceiling structures. Hence, if the facility requires seismic upgrading, then removing the roof and ceiling at the same time (as well as considering changing the structural framing system from a brick-to-steel interface to a steel-to-steel interface) would probably be the most "cost competitive" means of accomplishing renovations. As such, if seismic modifications are required, removing the roof and potentially expanding the height of the facility might offer advantages over accomplishing the tasks separately.

2. The prospects of using the facility for a single high technology, high volume manufacturing function is highly unlikely because of the building's existing infrastructure and the building's technical limitations (size, type of construction, etc.). Similarly, Intel is not currently capacity constrained and is able to meet demand for its high technology products (although this changes dynamically). However, the additional revenue that could potentially be generated by additional manufacturing space does make the possibility "extremely attractive." At the same time, however, total throughput could also be increased by "farming out" portions of the fabricating process to create additional manufacturing space. This leads to two options: first, consider utilizing the facility to support specific manufacturing functions (including current areas considered constraints) versus supporting an entire manufacturing line comparable to today's high technology standards; and secondly, consider using the facility to support an entire product line back-filled from another facility that is changing process and product.

3. With respect to supporting certain manufacturing functions from within other high technology manufacturing functions, Fab 4 is more likely to support Fab 5 operations rather than Fab 15 operations because of the closer proximity to Fab 5 and the lack of both technology and corporate support for an adequate wafer transport mechanism between them. Similarly, Intel will probably not support additional 6-inch wafer line expansion in lieu of 8-inch and soon to be 12-inch manufacturing lines. Hence, the only alternative is to move functions which are not 6-inch dependent and could support 8-inch or 12-inch requirements. This leads to the suggestion to eliminate major pieces of manufacturing equipment - in particular, ion implantation and large vertical diffusion furnaces - that are more wafer size specific than other pieces of equipment.

4. With respect to supporting products from other facilities, there does not currently appear to be a need for that. Current production on 6-inch wafer sizes also does not appear to be capacity constrained (i.e., Fab 5, Fab 6, Fab 7, Fab 8, and Fab 9). In the event that future demand for products requires additional back-filled products to be manufactured, then Fab 4 could be utilized to support these requirements. However, no demand for this type of expansion for certain products was found to exist during the course of this research.

Non-Manufacturing or Manufacturing Support:

1. Non-semiconductor manufacturing operations appear more suited for warehouse facilities. As such, large open spaces with a large shipping dock and potentially high ceilings for stacking materials is more technically feasible. Similarly, the costs of leasing such space appear to be lower than the costs of owning. At the same

time, Intel Oregon already operates two sites which perform these functions. Therefore, this option of non-semiconductor manufacturing can be eliminated.

2. As discussed earlier, seismic modifications appear to be a non-issue in most instances since it is "most likely" that Intel will upgrade no matter what. If the building is modified "significantly" (even if it retains its H6 occupancy rating), the local building code official will most likely make Intel change it. Hence, functions which don't severely change the existing layout but maintain H6 would appear to offer short-term cost advantages; functions which require seismic modifications might be "cost prohibitive" when compared against constructing new.

3. Current front-end processing under consideration is sequentially timed with photolithographic functions. That is, currently those functions which Intel performs in-house (wafer cleaning, wafer coating to accept resist, etc.) do not appear to be easily able to be broken apart from their existing arrangement. Since relocation of photolithographic equipment is not technically feasible, potentially utilizing the facility to support the limited front-end processing steps examined does not appear justified.

4. With respect to back-end processing steps, a number of additional conclusions can be made. First, a sort and test floor is currently zoned B2 in AL-4. The area is not constrained and will free up additional space once Fab 4 testers were removed. In addition, expansion capability exists if need be. Moving this function to Fab 4 would only create additional administrative space which (according to manning requirements discussed with planners) is not required at this time. At the same time, it would be sacrificing the H6 occupancy and require major modifications. The costs of constructing new administrative space (B2) to accommodate a sort and test floor appear to be marginally less than modifying an existing H6 class facility. On a site and corporate level, all sites appear to have adequate sort and test capability. Fab 15 already has additional area zoned H6 to support a potential sort and test floor; Ronler Acres' D1-B already includes a designated area for its sort and test floor. "Outside of Oregon and located in Arizona, Fab 12 (which did appear to be limited) recently authorized the expansion of another facility to accommodate Sort 12." (Personal Interview with Intel Oregon Industrial Engineer) Hence, although the facility would appear suited for a sort and electrical test floor (particularly, because of its clean room requirements, cooling requirements, non-vibration requirements, etc.), the fact remains that Intel does not have an identifiable need for a sort and test floor. As such, eliminate the potential of using Fab 4 as a sort and electrical test platform facility.

5. Similarly, back end steps like goldgrind and backgrind currently take up no fabrication area manufacturing space since they are located on the first floor of the facilities. The process flow merely requires that they be transported from the second floor to the first floor environment via an elevator. Similarly, these areas are not currently constrained such that they cannot meet the existing demands on them. Hence, one does not gain anything by relocating either of these functions. Eliminate from further consideration any relocation of goldgrind and backgrind functions.

6. Test and assembly operations are currently centralized in Arizona, Malaysia, and a recently announced expansion in Costa Rica. Since these processes are generally more labor intensive and many of the overseas facilities are located in relatively inexpensive tax havens, costs of performing them overseas would appear to be justified. With respect to equipment and space requirements, high volume and relatively large size facilities offer economical advantages over relatively small facilities like Fab 4. Thus, eliminate from further consideration any additional test and assembly operation expansions.

7. For Intel, considering vertical integration to pull its own silicon ingots and cut them into silicon wafers does not appear feasible: first, Intel currently has two sources of supply; and secondly, the facilities required to do this, as well as the materials management skills, do not currently exist at Intel. In addition, the policy would appear to contradict Intel's strategy of outsourcing most functions which it does not feel constitute core manufacturing competencies. From a technical standpoint, the requirements for a high ceiling requirement to accommodate the silicon pullers would also be constrained by the existing facility. As such, consideration for pulling silicon ingots does not appear to match with Intel's current policy guidelines.

8. While the company emphasizes the need for research and development, no function requiring the existing space within the Intel Oregon community was identified. Since research and development focuses on future manufacturing possibilities, technical constraints could limit the possibilities. However, although WIT processing appears to be the next manufacturing horizon, the tools and research necessary to investigate the potential of this type of manufacturing has not necessarily been explored. Thus, with no identified need and with Intel's high-end manufacturing research and development currently being performed in the newest fabs prior to their conversion to high-volume manufacturing facilities, this alternative does not appear justifiable in the near term.

9. Warehousing costs are considered minimal from outside sources. From a technical standpoint, using Fab 4 is a very feasible alternative, particularly since it can be climate controlled (if necessary), offers an elevator and loading dock, and would not necessarily require any seismic modifications according to the 1994 Uniform Building Code. However, based on the costs for utilizing existing warehouse space or leasing additional space, as well as the strategic guidelines from Intel to limit on-site warehousing, this alternative does not appear to be a long-term solution.

10. With respect to a training facility, Employee Resource Center (ERC), or Intel University expansion, the building will have to be re-zoned if any classroom space is included in these functions. However, if the training facility only includes equipment (and not classrooms) to maintain its H6 occupancy classification, the function would offer a short-term solution.

11. Relocating functions from Fab 15 would initially appear to offer great benefits over other alternatives. However, with respect to direct manufacturing functions, Fab 4 is more likely to support Fab 5 operations rather than Fab 15 operations because of the closer proximity to Fab 5 and the lack of a well-defined wafer transport mechanism between them. With respect to non-manufacturing or manufacturing support functions, Fab 4 could offer some advantages by opening up additional space on the second floor (or manufacturing area) but the implications should also be considered from the first floor (or subfab) level as well. First, relocating the gymnasium from Fab 15 would not gain any additional manufacturing space because of Fab 15's current layout and construction. In particular, the bathroom and the front entrance area would limit the ability to expand manufacturing in Fab 15 beyond its current configuration. Similarly, relocating administrative functions from Fab 15 would potentially open up second floor space. On one wing of the facility, relocating administrative functions would also require relocating the existing cafeteria/kitchen – previously described as "infeasible" according to the existing requirements. On the other end, relocating administrative functions would require moving many of the analytical laboratories, office space, and other miscellaneous functions located on the first floor. At the same time, the requirement to maintain exit widths and exit passageways would require re-design of the existing layout.

Basically, after reviewing technical, financial, and strategic issues, the following major category from the original alternatives remains – non-manufacturing and manufacturing support. Within this framework a multi-occupancy facility (for reasons detailed previously in this chapter in Section 6.1) is more feasible than a single-occupancy facility largely because of the small amount of space required for many single functions identified.

Among the specific alternatives remaining are:

1. Convert to administrative facilities -- justifiable if one includes holding costs. However, while the costs to convert the second floor of Fab 4 to support administrative space are much lower than converting the facility to support manufacturing operations, current leasing costs and new construction costs make renovating the facility less feasible. At the same time, current administrative facilities on the Aloha campus are not constrained. Similarly, Intel's recent announcement to expand Ronler Acres by constructing a new 400,000 square foot administrative facility would seem to limit the requirement for additional administrative space within the Oregon area. While current Intel guidelines for personnel being housed in leased facilities is greater than corporate mandates, the new construction of administrative and support facilities at Ronler Acres would make that appear a short-term problem. As such, using the facility for administrative space might not offer many advantages.

2. Wet etch processing -- justifiable since infrastructure exists (waste piping, wet stations, etc.) and does not require strict materials handling controls before or during the process (because the solvents clean the wafers afterward) but materials handling after steps is questionable.

3. Planarization -- highly justifiable from a technical (Class 100 or Class 1,000 clean room requirement) and strategic viewpoint (creates more open space in an existing cleanroom). More justifiable for Fab 15 (because of the large amount of space the function currently occupies within the clean room environment) but difficult because of materials transport required after planarization (moving from Fab 15 to Fab 4 and back). This is largely due to the fact that a higher number of transport movements would be required because of the increased number of planar steps. Would appear to be more feasible for Fab 5 (because of proximity and fewer number of steps) but existing space saved would be minimal by relocating function.

4. Combine Fab 4 and Fab 5 roles together -- difficult to justify in short-term (Fab 5 currently can meet demand; recent expansion project in bottleneck area was approved) but able to see with an investment in a material management method or a means of transporting wafers from one fab to another (i.e., tunnel connecting the facilities).

5. Reclaim, Arsenic Parts Clean and Quartz Clean – relocating these functions from Fab 5 to Fab 4 are non-feasible because Fab 5 already uses the facilities in Fab 15 (Arsenic Parts Clean) or has the functions currently located on the facility's first floor and out of the manufacturing floor environment (Quartz Clean). For Fab 15, it offers the opportunity to gain approximately 15,000 SF of additional manufacturing space. However, technically not only would rearrangement have to take place within the manufacturing floor but also significant changes would also have to take place on the sub-fab level. Very attractive offer with upside potential but would require large investment in rearrangement costs (Fab 15) and renovation costs (Fab 4) and require limited H2 expansion capability (1,500 SF). Reclaim, on the other hand, would require a lower investment cost because it is essentially a wet process that could be retrofitted into existing areas (namely, wet bench areas with drains in subfab). Similarly, if a single Oregon reclaim facility was created, it too could open additional manufacturing space in fabs to be built on Ronler Acres. Shipping and transportation costs are minimal.

6. Training rooms -- technically offers the advantage of H6 occupancy with minimal investment. Building exceeds space requirement (5,000 SF) greatly. Would need to consider multi-occupancy facility.

Recommendations:

1. Short-term:

Utilize Fab 4 as a Class 100 or "greater" (Class 1,000) manufacturing support facility. Generally regarded as the "best" option within this group from a strategic and financial perspective, the use of the facility as a combination of a 6,000 SF - 10,000 SF reclaim facility (which according to estimates provided by others can generate "savings" (Personal Interview with Intel Financial Analyst, 1996) and creates strategic leverage over a sole-source supplier) could be combined with other potential H6 occupancies which would not require seismic upgrades (and hence, large cost expenditures). For example, use of the facility as a training area (with a small requirement of 5,000 SF) would complement full use of the facility.

Currently, for example, D1-B has approximately 25,000 SF dedicated to wafer reclaim, planarization, and quartz cleaning. With the exception of quartz clean (where movement of glass could create a safety concern), these options appear very feasible although a proper transport system would have to be well thought out. Hence, as build out of Fab 15 continues, this space could be converted to additional manufacturing space but only for functions which do not require significant infrastructure below to support them. For existing facilities (like Fab 15), the costs of rearranging and modifying the existing layout would have to be closely considered with the anticipated demand and capacity requirements. With respect to wafer reclaim, the alternative would not create much more additional space within Fab 15 and would not require a dedicated transport mechanism. However, for new facilities in the

Oregon vicinity or those facilities that have not yet been built out, this option creates more flexibility in their need for manufacturing space and could eliminate the requirements for additional clean room space.

2. Long-term:

From long term perspective, Fab 4 must be considered along with Fab 5. These two facilities have the capability to support operations together or to be demolished together and have another facility built in its place. Utilizing a suspended steel tunnel to connect both facilities at the manufacturing level would appear to be very feasible even while maintaining Fab 5's production. Setting and anchoring steel columns in concrete footings should not necessarily interfere significantly with the on-going manufacturing processes vibration but will require the use of a crane which may interfere temporarily with employee parking in the area. Similarly, the construction of a 200' walkway across the service yard would present additional engineering challenges for supporting it. With such a long span, it would seem conceivable that at least one support mechanism would have to be located in the service yard between the facilities.

With the exception of photolithographic functions (which cannot be exposed or located near the light), most other functions are not susceptible to the immediate changes introduced by combining the facilities. To mitigate the potential risk associated with introducing natural light into the environment, an opaque tunnel could also be constructed. The material handling system could be designed to move throughout the administrative offices but a walkway would appear more feasible. Depending on the functions performed in each fab, the cleanliness of Fab 4 could potentially only have to be marginally upgraded while utilizing many of the existing utilities. The most practical way to do this would be to raise the roof of the facility and construct a steel structure around it, allowing replacement of the ceiling and the air handling systems and allowing a higher floor-to-ceiling height (and larger interstitial space) to be installed. Photolithographic, ion implantation, and diffusion furnaces could remain in Fab 5 while wet etch functions, planarization, and other non-vibration sensitive functions could be performed in Fab 4. As such, additional equipment could be added to both facilities, allowing the equivalent throughput of the facilities to be competitive with existing processes. With respect to cost and demand analyses, however, it would appear that the operating costs of both facilities together would be "competitive" with current wafer fabrication cost structures (although detailed analysis would be required).

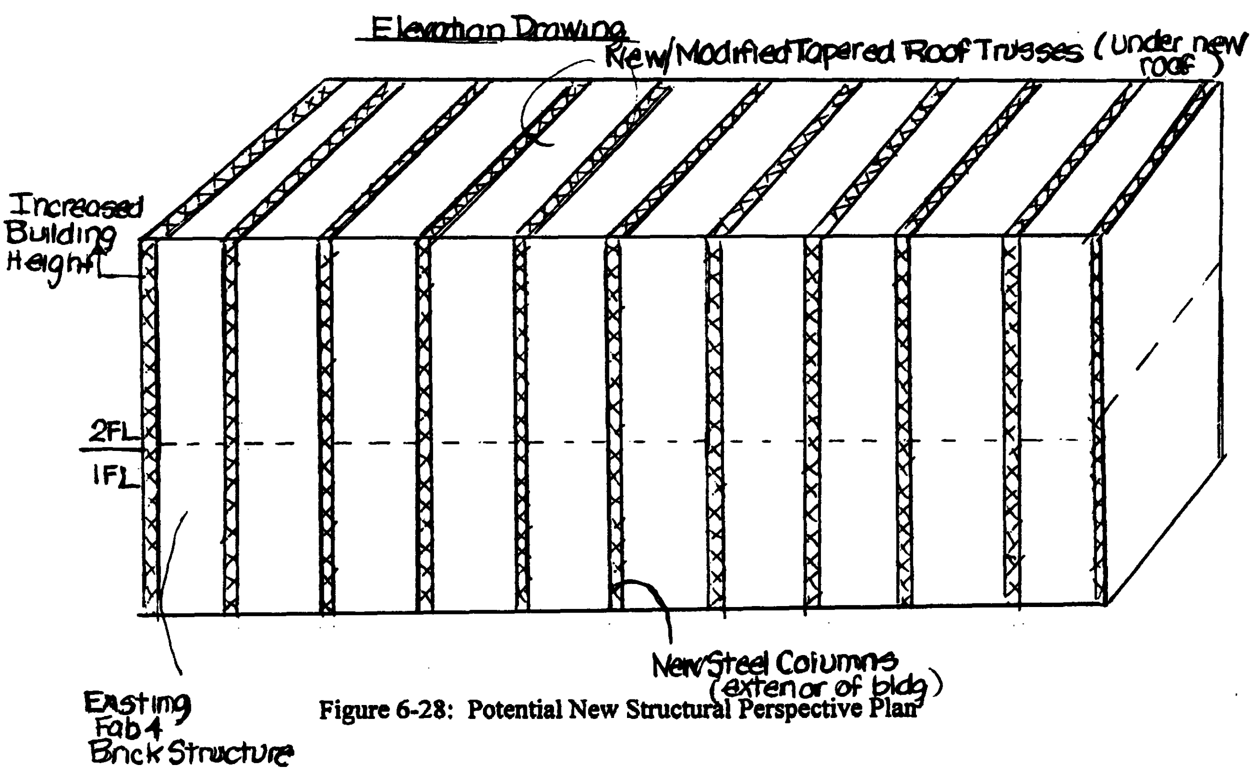


Figure 6-28: Potential New Structural Perspective Plan

6.2 Past Applications to Fab 1A and Fab 3

As a way of verifying the integrity of the methodology presented, one can utilize the same framework (although with significantly less detail) to analyze past decommissioning events. For instance, in Intel's case, there have been four such events which have taken place during its short history – Fabs 1, 1A, 2, and 3. Fab 1 was located in Mountainview, California; Fab 1A was also located in Santa Clara, California; Fab 2 was located in Santa Clara, California as well and was a relatively small fab (8,600 SF); and Fab 3 was located in Livermore, California. This research examines both Fab 1A (Santa Clara) and Fab 3 (Livermore) and highlights their decision-making by applying the methodology.

Example 1: Intel's Fab 1A (Santa Clara, California)

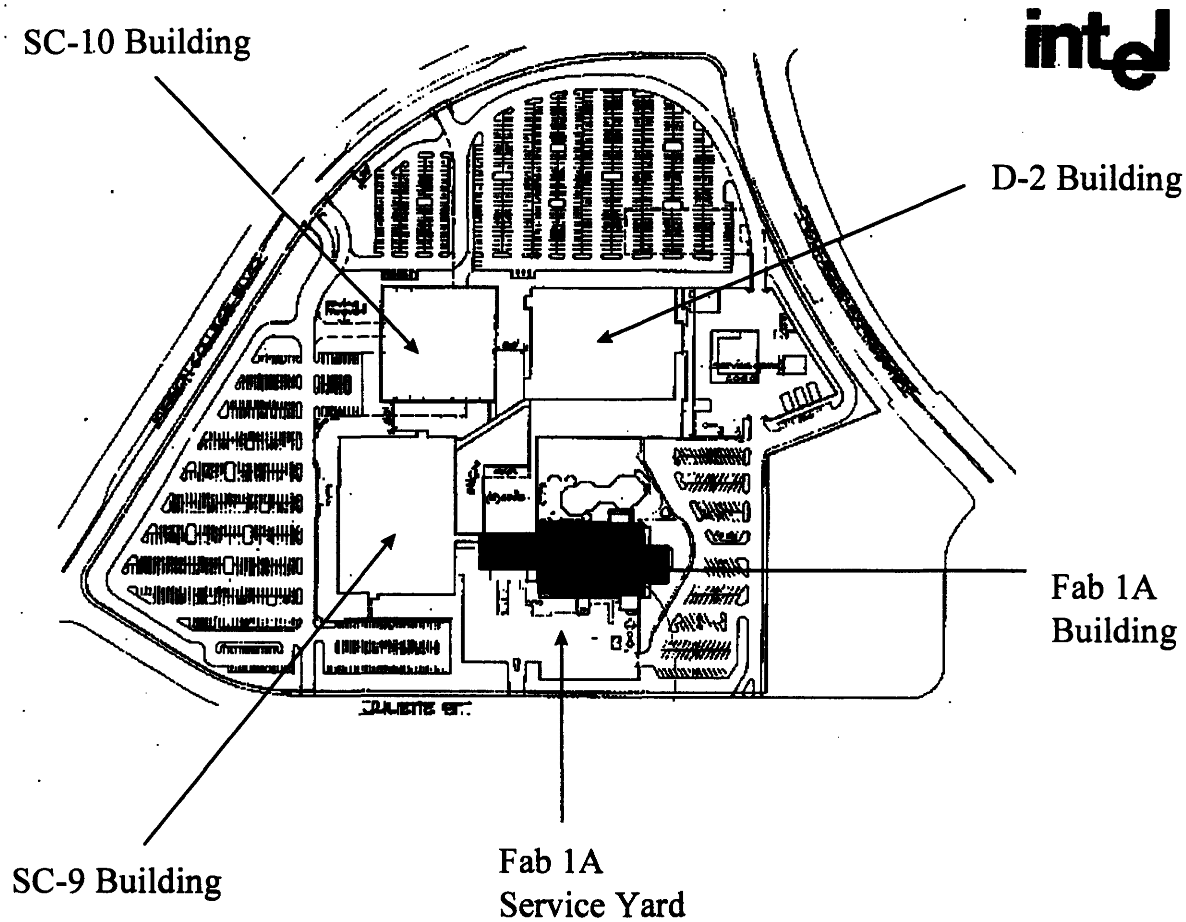


Figure 6-29: Santa Clara, California Site Plan (1987)
Source: Intel Corporation

Step 1: Establish Reference Values

Fab 1A was located in Santa Clara, California and constructed in the mid-1970's time frame. "Its building footprint was approximately equal to Fab 4 (22,000 to 23,000 square feet) and its manufacturing floor space consisted of approximately 17,000 SF of Class 100 or greater clean room space." (Personal Interview with Intel Plant Manager, 1996) The building was generally zoned as an H6 semiconductor manufacturing space. Fab 1A was a 4-inch wafer fabrication facility specializing in the production of EPROMs, embedded controllers, and programmable logic devices. Due to the cost disadvantages of a 4-inch factory, combined with latent production capacity in other 6-inch fabrication facilities, Fab 1A was shut down after all manufacturing capabilities were transferred to those facilities. Originally, it was intended that Fab 1A would be converted to a manufacturing support facility.

With little known about the original building, one can draw potential issues to light. First, located in the heart of California, it is anticipated that both environmental and seismic issues were principal design criteria. Secondly, with respect to a site assessment, the building was positioned on the west corner of the site. Three other facilities (two administrative (SC-9 and SC-10) and one manufacturing/research and development (D-2)) were located on the site. There are three principal site assessment factors that should be highlighted: (a) the site is constrained on all three sides, (b) the large amount of parking required to support the facilities, and (c) the service yard for Fab 1A was located towards the road and not between the adjacent manufacturing facilities.

Step 2: Develop Alternatives

Basically, at the time of closure, the facility was positioned for three potential alternatives: (a) research and development (Intel Components Research function), (b) administrative space, or (c) back-end processing (including a test and sort floor). Of course, demolition may have been considered (particularly since there were limited adjacencies at the time of its closure) but there does not appear to be a record of this.

With respect to potential future requirements, the Santa Clara site appeared to be dependent on the future of D-2.

Step 3: Establish Decision Factors

As in the previous discussion, technical, strategic, and financial factors were generally considered for the analysis.

Step 4: Generate Measures

While not all information may be available, a building code review of the previous alternatives would represent both H6 and B2 occupancies. Since B2 (or administrative space) represented an increase in the number of personnel working in the area, exit distances and exit widths would have to be re-calculated. However, as shown previously, the requirement for H6 minimum distances of 100 LF to any two exits probably made the additional requirements for B2 minimal.

A test and sort floor represented an interesting code analysis. Generally considered a B2 occupancy (because it does not directly include semiconductor manufacturing equipment), a sort floor could also be accepted as an H6 occupancy. In fact, as a result of conversations with two of Fab 1A's managers, it appears in this case that it was (although it may have been eventually rezoned as B2 for potential tax saving purposes).

Hypothetically, it would appear that technical measures could consist of the following. First, as a constrained site, maximizing available space would appear to be the best policy. Secondly, if the building was designed similarly to Fab 4, then the ceiling height constraint may have existed, limiting the sizes and types of equipment that could have been retrofitted. Thirdly, the type of clean room environment (Class 100 with VLF hoods) may have also been a measure, considering that D-2 was "state of the art" at the time (1991), capable of operating in a sub-Class 1 environment. Fourthly, with respect to existing utilities, it was well known that the air handling and electrical systems would have to be replaced under any potential renovation since the fab was "old". Finally, because of its location in California, seismic concerns would likely have to be re-addressed. At the time of this analysis, D-2 was known to have been constructed utilizing a network of piles to minimize the effects of earthquakes. While it is anticipated that Fab 1A was also constructed with stricter seismic requirements in mind, it is conceivable that those seismic measures may have needed to be upgraded to meet current requirements.

With respect to strategic measures, the potential future capabilities of the site would have to be examined. At the heart of the site was the newest development and manufacturing laboratory in Intel's asset base. As such, the future of the site needed to consider how to best use this facility and maximize the available manufacturing area contained within it. Similarly, since administrative space also appeared to be centered in two facilities, any further expansion of the site also needed to take those requirements (and parking requirements as well) into consideration.

Strategically, the Santa Clara site represented Intel's current domestic and world headquarters, as well as the heart of Silicon Valley and the semiconductor knowledge and expertise contained within it. With the construction of D-2, Santa Clara became the "model" of Intel development and research.

Financially, the only supposition that could be made was that at the time (1991), Intel had just undertaken major investments in its infrastructure to support the upcoming Pentium® manufacturing and introduction. As such, additional capital expenditures made available for renovations of existing facilities may have been minimized.

Step 5: Conclusions

D-2 represented a major investment in research and development. As such, unless an organization was willing to move to a "less than ideal" clean room environment (compared to D-2), research and development should be focused in the best fabrication facility. Similarly, while D-2 was growing, using Fab 1A for administrative space did not necessarily coincide with the principle of "close to the customer." In this case, SC-10 and SC-9 apparently were closer to D-2 and appeared large enough to suffice.

Reviews of early drawings for D-2 indicated that there was not a test and sort floor included in the plans. Assuming that the floor was previously located in SC9 or within Fab 1A itself (to support Fab 1A's operations), relocating a sort floor to Fab 1A made sense if one of two conditions were met: (a) relocating the existing sort floor from one of the administrative facilities created additional administrative that was needed or (b) Fab 1A could be maintained as H6 (if intended) with a test and sort floor and hence, not be subject to required upgrades to meet current code requirements.

Summary:

With the growth of manufacturing in Santa Clara and the need for expansion capabilities on a limited site that represented Intel's Corporate Headquarters, two methods for optimizing space availability were employed. First, parking spaces were converted to parking decks to accommodate future facilities. In turn, those facilities were built on the same constrained site. Similarly, D-2 was expanded beyond its original floor plan requirements. In the courtyard between Fab 1A and D-2, the building's footprint was expanded greatly. Eventually, Fab 1A was utilized more fully as a test and sort floor and re-named SC-7.

In summary, one could draw the following conclusions. First, the strategic decision to expand Santa Clara operations and D-2's role to Intel placed a premium on the use of space. As a facility well suited to accept a sort and test floor (although some would argue that administrative space would be better), it appears that it made the best available use of space at the time since demolition and construction of a new sort floor space would have probably cost more than re-using existing space. The key elements of this analysis was generally the strategic decision factor. If D-2 was not constructed, then the decommissioning of Fab 1A would have had different implications for the site. For example, if Intel had decided to abandon all manufacturing operations on site and make the site the protoypical "headquarters", then administrative space probably would make more sense. Similarly, if Fab 1A's service yard was common and shared between D-2 and Fab 1A, then this too would have had different implications: D-2 could not necessarily expand toward Fab 1A and the facility might have remained more of a research and development center, as opposed to a manufacturing capable facility.

Example 2: Intel's Fab 3 (Livermore, California)

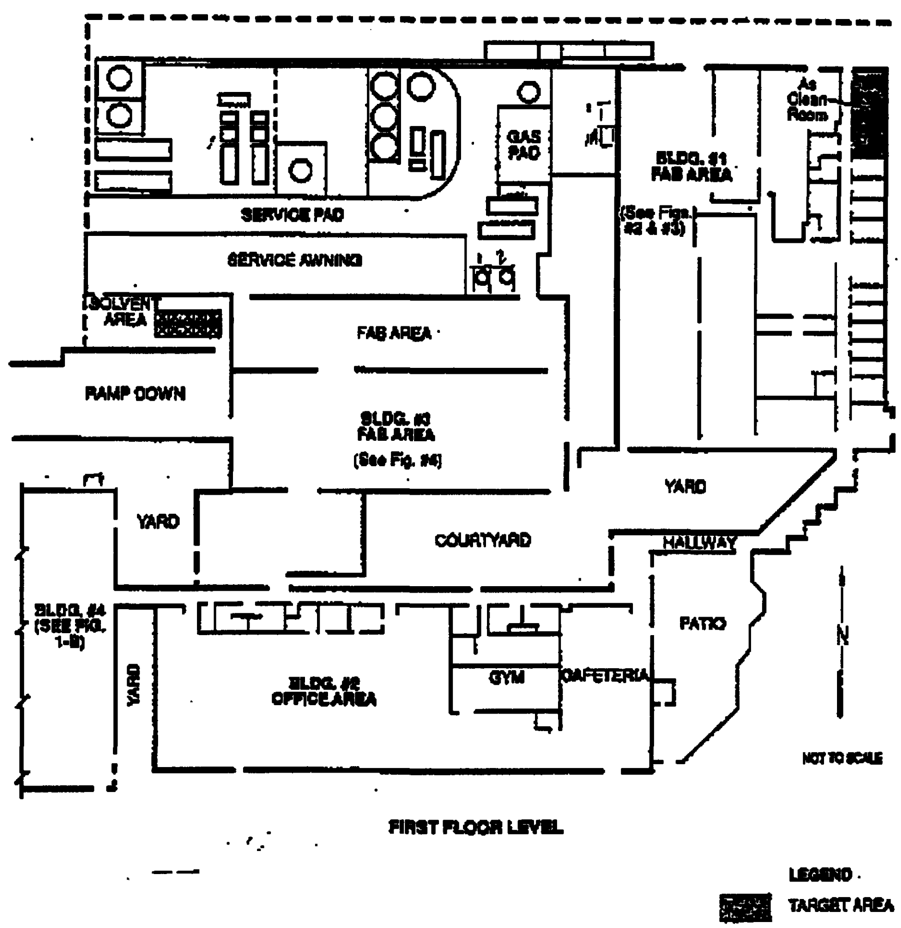


Figure 6-30: Fab 3 (Livermore, California)
Source: Intel Corporation

Step 1: Establish Reference Values

Fab 3, located in Livermore, California, was shut down in October, 1991 and consisted of a nine acre (9 AC) site that included four buildings totaling approximately 150,000 square feet of space. In addition, Intel owned approximately twenty-two acres (22 AC) of additional property in the same vicinity.

While all buildings were connected by corridors, the site generally consisted of two (2) two-story administrative facilities and two (2) two-story semiconductor manufacturing facilities. Building 1 consisted of approximately 10,200 square feet of manufacturing space (on its second floor) while Building 2 consisted of approximately 13,600 square feet of semiconductor manufacturing space on its second floor as well.

Step 2: Develop Alternatives

Generally, three alternatives were proposed: (a) sell the facility, (b) lease the facility, and (c) demolish the facility. As a 4-inch wafer manufacturing facility, the plant was not considered cost competitive with other manufacturing sites. In particular, the alternative to renovate was not considered because of corporate direction.

Step 3: Establish Decision Factors

As described previously, we can use the same general factors of technical, financial, and strategic factors that were developed in Chapter 5.

Step 4: Generate Measures

With respect to technical measures, existing size was considered to be a major constraint. The building (and even the site that was constructed with it) was considered "small" by today's factory standards (approximately 150,000 square feet of total space and 25,000 square feet of manufacturing space). Secondly, it appears that the discontinuity of manufacturing between two small facilities made the process flow difficult. Although the manufacturing across the buildings seem to have been broken up functionally, it would seem that material movement was done by hand between adjacent facilities. Perhaps this did not necessarily cause concern for products and processes with limited steps. However, as newer processes required more and more steps, requiring more and more movement, existing material handling methods would probably have been problematic. Third, the proximity to the railroad tracks does not appear to have been as close as in Fab 4's case. As such, potential vibration concerns with passing railcars may not have been as much of a concern with Fab 3. Fourth, the facility was built using an older manufacturing facility design. Vertical laminar flow hoods and low floor to ceiling height distances were probably concerns as well.

Strategically, the facility was considered a satellite facility. The Livermore site was located approximately 45 miles from any other site. With the small amount of manufacturing taking place, its limited workforce, and the distance to other Intel sites, Fab 3 was more or less "alone." Although significant opportunities existed to expand the site (an additional 22 acres were owned on the other side of the railroad tracks), Intel decided that the facility's location did not make expansion an economically viable alternative. Hence, from a strategic perspective, the site did not mesh well with the corporations' short and long-term strategy of larger and larger manufacturing sites. Finally, with the growth of manufacturing in Santa Clara (with the construction of D-2) and Intel's long-standing policy of not putting "too many eggs in one basket" (California in this case), duplicating facilities at Livermore did not necessarily make strategic sense.

Financially, the site was not able to reap the rewards of economies of scale because of its location. With a small workforce and a small manufacturing operation, the costs of supplies, distribution networks, and labor was prohibitive. In addition, the simple fact that a 4-inch facility could not cost-compete with larger wafer fabrication facilities may have made its financial livelihood "limited" at best. Secondly, with Intel's movement from producing all types of semiconductor devices to those reaching mass markets, the limited manufacturing capabilities of the site did not appear to be aligned with those directions. With this in mind, from a financial perspective, the costs of demolishing and/or upgrading the current facilities versus constructing new facilities generally were the key determinants.

Step 5: Conclusions

Overall, the strategic viability of the site would have been the central issue. Because of its proximity to an existing site, coupled with Intel's movement toward integrated and larger manufacturing sites, manufacturing did not appear to be an option. At best, the facilities could be used for other purposes (warehousing, administrative, etc.) but the economies (scale and scope) associated with performing these functions along with manufacturing and/or in centralized locations made this alternative appear to be unattractive. Similarly, corporate direction to limit satellite sites appeared to have sealed Fab 3's fate. Technically, manufacturing was difficult to justify without a market for low-volume or customized chips. Financially, the manufacturing operations could not compete with other larger and more modern Intel facilities which had additional capacity. Strategically, while the site offered opportunities for expansion, potentially the costs of doing so were lower in other areas of the country (i.e., New Mexico and Oregon) or internationally (Ireland). In addition, the company did not want to extend all of its operations within the Silicon Valley environment.

With the anticipated demand for manufacturing facilities in the area, the value of the building was probably greater than the value of the land if the facilities were demolished. As such, selling or leasing the facilities and removing Intel from this "satellite" network appeared to be the best alternative.

Summary:

Fab 3 was shut down with the intent of selling and/or leasing the facility (although not necessarily the equipment). Although companies that potentially needed capacity were identified prior to this decision being made, the building was only recently sold. Apparently, the market demand for manufacturing capability and/or manufacturing capacity was overestimated (or the market demand diminished suddenly). Consequently, Intel probably paid the additional holding costs for mothballing the facility until the buyer was identified.

6.3 Future Applications to Fab 5 and Fab 6

Step 1: Establish Reference Values

Example #1: Fab 5

"Constructed in the 1978 and opened approximately a year later, the role of Fab 5 has changed significantly over the years. In its first role, Fab 5 complemented Fab 4 as the second 4-inch manufacturing facility on the Aloha site. However, in the late 1980's, the facility was converted from a 4-inch production facility to a 6-inch research and development facility and re-named D1. Finally in 1991, the facility was upgraded to convert it from a research and development facility to a full 6-inch wafer production facility." (Newboe, 1993) During its life span, Fab 5 has grown from a single manufacturing facility to one now consisting of an annex, the old facility itself, and a passageway between.

Currently, the facility encompasses approximately 36,000 square feet of Class 100 and Class 10 manufacturing space. The clean room is a bay and chase design with laminar flow provided by HEPA filters and fans located on the sides of the walls separating the bay from the chase. This design is in contrast to traditional vertical laminar flow where the air is returned through the chase and filtered above the bay's ceiling. Similarly, the facility is approximately 42' high and has an additional two feet (2') to three feet (3') of additional floor to ceiling height (when compared to Fab 4). In addition, the second floor consists of a concrete waffle slab with vinyl composition tile laid on top of it. This feature is similar to Fab 4 but is in contrast to modern designs which feature a two foot (2') grated raised floor below under which the air is returned to the chase for re-filtering. The first floor (subfab) has largely remained the same but has had many utility systems retrofitted in the past due to renovations as well as many systems removed from it. In addition, the main electrical switchgear equipment, boilers, and chillers were relocated to the adjacent annex during the recent renovation.

The gown room and central utility area portion of the facility is offset from the main facility. This portion is zoned B2 and is located adjacent to the existing facility. Electrical and mechanical equipment are located on the first and third floors of the annex while the gown room is located on the second floor.

Step 2: Develop Alternatives

Generally, many of the same issues facing Fab 4 will also face Fab 5. That is, while its size is larger and its ability to accommodate manufacturing equipment and support systems is greater (because of its numerous upgrades), the potential decisive factor regarding Fab 5's future will be the ability to maintain cost competitiveness (versus both internal and external sources).

As such, alternatives could range from: (a) demolish the entire facility, (b) renovate and maintain as a production facility, (c) renovate for research and development, and (d) act in lock-step with Fab 4's future by combining roles.

Step 3: Establish Decision Factors

Technical, financial, and strategic factors will probably also be the same decision factors utilized in the analysis of Fab 4.

Step 4: Generate Measures

With respect to technical measures, existing size (when viewed in terms of today's standards) is a constraint. Fab 5 has approximately half the space of modern wafer fabrication facilities. Secondly, the air handling system and the filtering system for maintaining clean air may be a limiting factor. Fab 5 does not appear entirely capable of Class 1 manufacturing required for smaller and smaller line widths. Third, process and integration factors might restrict the types of processes which could potentially be retrofitted into Fab 5. Currently, the process that Fab 5 is producing does not require as many steps as required by today's manufacturing standards. For example, planarization within Fab 5 only consists of two to three steps; however, for the current generation microprocessor, planarization requires nine to ten steps depending on the process. As such, it may not be possible to fit the amount of equipment within Fab 5 to maintain the same throughput on a different process. Similarly, producing at a lower throughput (by limiting the amount of equipment placed inside) could make the facility even less competitive on cost (since the absorption cost per wafer would be higher).

However, some items make Fab 5 more "viable" to continue as a wafer production facility. First, the facility has a relatively high floor to ceiling height. As such, it would appear able to accommodate the largest pieces of equipment necessary for wafer processing (i.e., ion implanters and diffusion furnaces). Second, the facility's systems are more modern and upgraded to meet manufacturing requirements than Fab 4's were by virtue of the two major renovations. Third, during the recent renovations, seismic concerns may have been fixed already.

Strategically, the facility today produces products that Intel as a customer requires to manufacture its own motherboards. Hence, should Intel continue to be a part of the motherboard and components manufacturing process, then Fab 5 will continue to have a large customer. As viewed from the corporate level, the likelihood of Intel exiting from motherboard and components assembly would seem highly unlikely in the near future.

Financially, the facility's major obstacles to surviving for a long time are its ability to compete on cost and volume. Currently, it would appear that Intel is able to supply its own chipsets (the products from Fab 5) at a lower cost than if purchased from outside vendors. However, if that changes and Intel could purchase similar products at lower cost, then Fab 5 might not be able to compete with outside vendors. Similarly, as additional fabrication facilities cease manufacturing production, Fab 5 might not be able to compete against internal producers who use 8-inch technology to produce the same process.

Step 5: Conclusions

From a strategic perspective, utilizing Fab 5 as a source of chipsets would appear to make sense as long as the facility can maintain lower costs (in relation to internal and external suppliers). From a technical perspective, Fab 5 is well positioned to accept additional manufacturing roles, provided that the size of the facility and its cleanliness do not limit the roles that it can accept. As such, two potential routes appear most feasible. As products leave other large production facilities, the products could be moved to Fab 5. Since these products would appear to have a smaller demand but receive higher margins, this would justify Fab 5's manufacturing role. Secondly, if demand for products which are removed from other facilities exceeds the capabilities of Fab 5, then additional manufacturing space could be freed up by combining the roles of Fab 4 and Fab 5 together.

Example #2: Fab 6 (Chandler, Arizona)

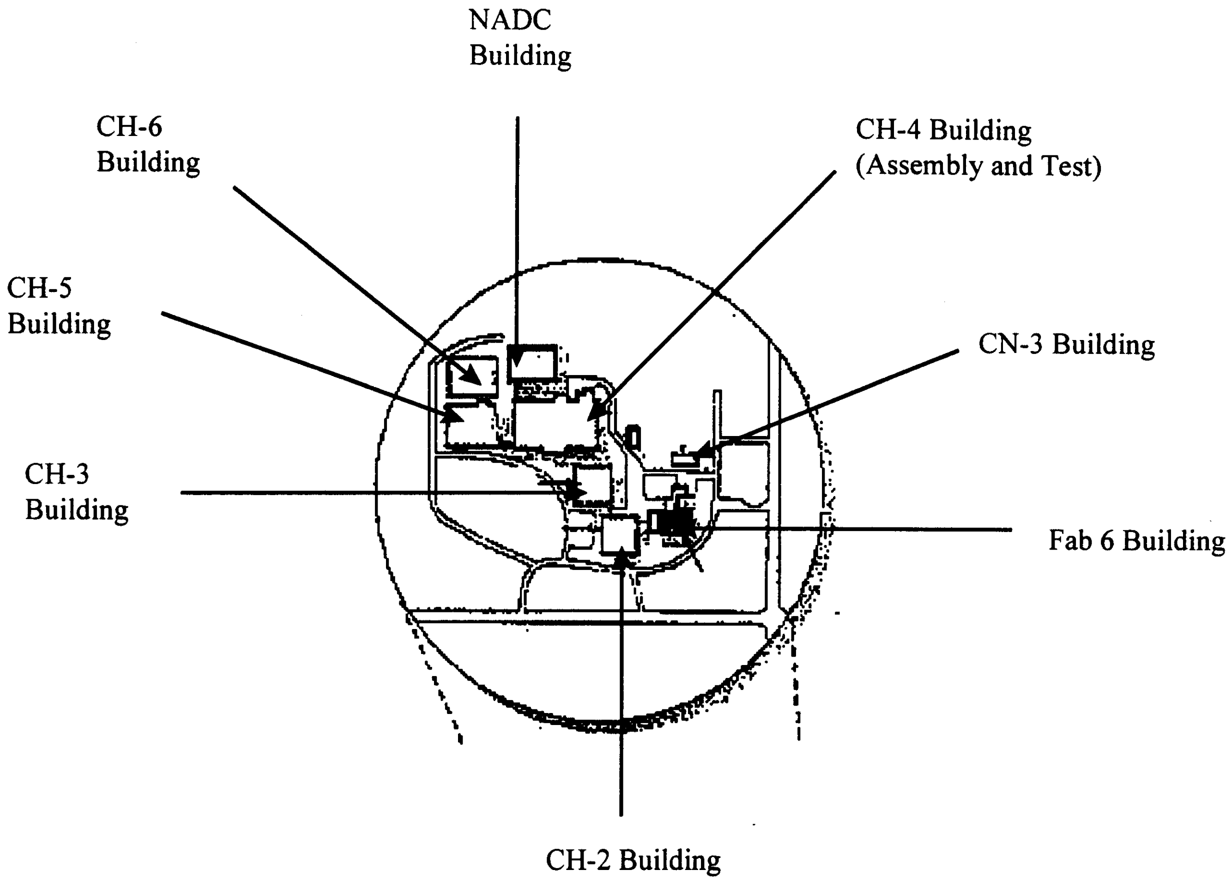


Figure 6-31: Fab 6 Site Location Plan (Chandler, Arizona)
Source: Intel Corporation

Step 1: Establish Reference Values

Built in the late 1970's, Fab 6 was constructed in Chandler, Arizona (a suburb of Phoenix) using the same design template that was used for Fab 4 and Fab 5. Without any specific detailed information about the facility, it would appear that Fab 6 more closely resembles Fab 5 than Fab 4 in its size (30,000 + square feet), cleanliness and arrangement (Class 10 and Class 100 bay and chase) and current process support capability (6-inch wafer production). In contrast to Fab 4 and Fab 5, Fab 6 also has an integral wafer test and sort floor already as part of the manufacturing facility.

When viewed as part of an integrated site, the role of Fab 6 in the Chandler site appears to be secondary rather than primary. With the exception of CH-4 (which is Intel's only domestic assembly and test area), all other functions on the Chandler site could be viewed upon as non-direct manufacturing. In addition to strictly supporting Fab 6 and Chandler Assembly and Test operations, many of the facilities on site provide general administrative functions. Specifically, a number of other groups - Semiconductor Products Group (SPG), New Package Design, New Product Development, North American Distribution Center (NADC) and a dedicated Engineering test floor - are located on the Chandler site and are examples of some of the non-manufacturing functions which the site currently supports.

Intel as a whole has a relatively large presence in the Phoenix area. In addition to the main Chandler site (and two other satellite offices), Intel currently operates another wafer manufacturing facility (Fab 12) in another suburb (Ocotillo, Arizona). This facility is one of Intel's newer wafer fabrication plants and represents a large investment in infrastructure. Similarly, Intel currently owns approximately 700 acres in the Phoenix area for potential development of additional manufacturing facilities.

Some points of interest that might be relevant issues for Fab 6. First, the facility itself has an existing wafer sort and test floor within its walls. Second, the facility's integration into the site would appear to allow it more flexibility than other manufacturing oriented sites. For example, most modern Intel sites include common service yards and common utility building (CUBs). Fab 6, on the other hand, appears to be the only wafer manufacturing facility on site requiring many of these types of services. Hence, any upgrade of the facility would not necessarily have to take into account existing requirements for other facilities. Similarly, as the only wafer manufacturing facility on site, any major renovation, demolition, and/or construction work on the facility would not necessarily immediately impair other critical site activities (in particular, cause the shutdown of other manufacturing facilities). Third, the facility's location also appears to allow more possibilities than if it were integrated into the center of the site (like Fab 12). By virtue of its location on the perimeter of the site, the number of adjacencies that would have to be dealt with for evaluating certain alternatives would appear not to be as great. Finally, as one of two sites in close proximity to one another, the possibilities for Fab 6 would not necessarily be limited to the types of roles that could be supported on the local site. Rather, potential uses that could complement existing manufacturing operations in Fab 12 could also be considered.

Step 2: Develop Alternatives

Based on the brief information provided above, a tentative list of alternatives could include the following: (1) demolish the facility, (2) retain sort and test floor capabilities through renovation, (3) convert to administration facilities, (4) convert to test and assembly packaging research and development area, and (5) renovate for manufacturing and/or manufacturing support activities.

Step 3: Establish Decision Factors

The technical, financial, and strategic decision factors appear to be the dominating factors for consideration for semiconductor manufacturing facilities.

Step 4: Generate Measures

With little specific knowledge about the facility, one can assume that renovations to upgrade its capability to support 6-inch wafer production have made the facility more current than Fab 4 but less capable than Fab 5. That is, since Fab 5 essentially underwent two major renovations in the course of a few years, many of its systems were replaced rather than rehabilitated. Since Fab 6 was not required to support research and development activities between changes in its manufacturing roles (but was retrofitted to support 6-inch wafer production), one can assume that many of its systems would probably need to be replaced. With this in mind, one could theorize that some of the major technical constraints of the facility would include its smaller size; ability to support more complex wafer production processes (requiring additional equipment for the same throughput); ceiling height and vertical expansion capabilities; age and condition of existing utilities; and water resource requirements (if expansion was considered). Unlike Fab 4, some of the issues which probably would not be considered constraints are its horizontal expansion capabilities (when viewed from the site plan); interdependencies with other facilities; and seismic and vibration concerns.

Strategically, Fab 6 would appear to be providing products that Intel currently requires to support the manufacturing of many of its motherboards (EPROMs) as well as a host of other uses. As long as this demand continues and markets exist for its products that customers are willing to pay margins which cover all operating expenses, then the viability of Fab 6 would appear to be long-term. However, should market demand dwindle, cost pressures from other suppliers, cannibalization from other Intel products, or production by other companies on an 8-inch wafer lower margins significantly, then Fab 6 would have to re-evaluate its immediate strategy. Similarly, as one of two

Intel sites in the area, the potential problems associated with closing down manufacturing facilities appears to be minimized because of the proximity of another wafer manufacturing facility, as well as a test and assembly division. In addition, potential future expansion in the Phoenix area (as a result of the ownership of land) makes the availability of a talented workforce highly valuable. As such, any potential closing would probably want to take this into account. Third, as mentioned previously, any potential renovation or expansion of Fab 6 would have to take into account Fab 6's potential value to both sites in the area and not just to the Chandler site. Transportation costs to and from the Ocotillo site would be considered minimal if a role was identified that could use Fab 6's manufacturing capabilities.

Financially, minimal renovations for manufacturing and/or manufacturing support functions requiring existing clean room conditions, ceiling heights, adequate area size, etc. would probably be justifiable when compared against potential revenue streams. Secondly, conversion to an administrative facility would probably cost less but the potential returns are limited (opportunity costs of not leasing additional facilities) and the violation of potential Intel guidelines may preclude its consideration. Demolition might be considered at a lower cost than Fab 4, for example (because of the lower types of restrictions facing such a possibility) but would have to be weighed against both the need for additional space as well as the holding costs of putting other functions within the facility's walls.

Step 5: Conclusions

As a largely administrative and non-manufacturing site, the most feasible alternatives at this time would appear to be conversion to an administrative facility or leveraging the facility's existing wafer test and sort floor capabilities. In light of Fab 12's recent ramp up to higher production levels, utilizing Fab 6 as a dedicated wafer test and sort floor for the Phoenix manufacturing sites might prove worthwhile because of its proximity. However, without any understanding of projected demands and current sort capabilities, the potential use of Fab 6 as an administrative facility appears to be the most feasible alternative at the time.

6.4 Summary

The purpose of this chapter has been to demonstrate the application and use of the methodology developed in Chapter 5. The framework was applied to an existing decommissioned wafer manufacturing facility (Fab 4) as well as to past decommissioning efforts (Fab 1A and Fab 3) and potential future activities (Fab 5 and Fab 6). As such, besides demonstrating the usefulness of this framework, the chapter has attempted to encourage a way for the reader to "think about" how to apply the framework to evaluate alternative uses for other facilities.

Chapter 7: Conclusions

7.1 Summary of Research

The main purpose of this thesis research has been to study end-of-life strategies for decommissioned semiconductor manufacturing facilities. With the dynamic growth of the semiconductor industry in the past five years, this problem is only now coming to the forefront of strategic and financial planning sessions.

The major result of this research has been to develop and propose a general methodology that could be utilized for evaluating alternative uses for such facilities. As detailed in Chapter 5, the methodology consists of five major steps: (1) establish reference state; (2) develop list of alternatives; (3) establish decision factors; (4) generate measures for comparison; and (5) compare and contrast to draw conclusions.

During the research, three general decision factors were identified -- technical, strategic, and financial -- and specific measures for each of these factors were detailed. By utilizing a quantitative and qualitative evaluation framework centered around these measures, the "most feasible set" of alternatives is generated.

The methodology developed here was intended to be process oriented and not outcome oriented. That is, the major contribution of this methodology is the fact that it delineates a general model to think about alternatives and presents a framework for how to go through certain steps. In contrast, an outcome oriented methodology would focus on the results and not necessarily spend enough time describing the process before reaching conclusions.

7.2 Summary of Application to Fab 4

After developing the methodology, the framework was applied to Fab 4 to demonstrate its strengths and weaknesses. For Fab 4, recommendations resulting from the framework suggested short-term and long-term strategies. In the short-term, with no clearly identifiable function, utilizing the building's capabilities and space while minimizing the investment resulted in a multi-occupancy manufacturing support role. In the long-term, Fab 4 needs to be thought of as part of an integrated site versus an individual facility. With Fab 15's lifetime expected to last for a significant number of years, the composition of the Aloha campus is clearly not going to change. However, Fab 4's future appears to be more closely tied with Fab 5. That is, the total combination of space between Fab 4 and Fab 5 is equivalent to the manufacturing space of Fab 15. At the same time, as newer plants are brought on line and older products are moved out of 8-inch capable fabs, older generation products will still need to be produced. Fab 4 and Fab 5 together could sustain that capability if market demand requires other facilities to modernize and produce new products in the future. Three major issues facing Fab 4 - seismic modifications, materials handling, and ceiling height - could potentially be solved by constructing a steel frame around the building and constructing a walkway between Fab 4 and Fab 5 over the existing service yard. At the same time, steel construction could potentially also change the type of construction from Type III non-combustible to Type IV non-combustible (since the structures would be steel) leading to an increase in the amount of H6 space that could be apportioned.

Similarly, a number of other conclusions became apparent. First, while financial criteria were originally thought to be the major driver for decision-making, technical and strategic considerations dominated the application of the methodology. The fab's small size, the condition of its infrastructure, and its integration into the site precluded many alternatives from being considered further. From a strategic standpoint, Fab 4's role needs to be thought of on more than an individual building level. When considered on a site or even local level, the possibilities for Fab 4 become more strategic in nature versus merely trying to match an existing facility with potential roles that can be transplanted.

7.3 Implications of the Framework and Future Research

While the framework presented herein was applied specifically to one facility (Intel's Fab 4) in a specific industry role (semiconductor manufacturing), it is hoped that the general nature of the framework will allow it to be utilized throughout other industries. As a process methodology, it provides a rational sequence of steps that decision-makers should go through before making decisions with long-standing ramifications.

As a tool which can be used in other semiconductor manufacturing situation, the author hopes that the framework will find significant relevance. At the same time, applying this type of framework to other situations in other industries (such as hospitals, pharmaceutical, biotechnical fields and specialized chemical, research and development, etc.) could offer many insights. For example, as today's hospitals became older and older and public funding for expansions becomes more limited, how can these "specialized" facilities be considered after they have served their useful lives? Similarly, as industrial sites (auto manufacturing, steel manufacturing, etc.) continue to be closed because of their age, what types of issues would this framework bring to light that are not already being considered? With this in hand, the potential for additional research into expanding the applicability of this framework across both the semiconductor and other industries appears quite valuable. Potentially, this framework might find its niche in other industries where single-purpose facilities with specific characteristics designed for the industry they serve is the most relevant area for further research.

7.4 Implications of Facility Planning

One of the benefits that this research engagement provided the author with was the opportunity to see the vast changes which have taken place in the facility design process. From the group of facilities designed in the 1970's which support relatively small-scale manufacturing to today's large-scale manufacturing sites, the lessons learned from experience with facilities has led to the incorporation of many insights. Because of the inherent need for flexibility to deal with technological innovation and changes in process technology, modern semiconductor facilities have moved more of their traditionally fixed support systems (i.e., clean room walls, clean room flooring, clean room air filtration units, process equipment utility connections, etc.) to more modular arrangements. Similarly, as today's facilities are constructed with future requirements still uncertain, companies have become more willing to initially invest in areas which could create flexibility (higher floor to ceiling heights, additional space for more air handling units, additional space available for clean room buildout in the future, etc.) with the hope that these investments today could potentially offer great technical and financial rewards in the future.

For the future, designing flexibility into wafer fabrication facilities will remain vital. Unlike the structures of the past, a wafer fab's lifetime is no longer expected to be twenty years supporting similar generations of products and processes. Consequently, the fab of the future must be flexible but still technically and financially feasible to support even today's products. Similarly, as the fabs become larger and larger, potential roles that they could be retrofitted for after their service life would appear to be more limited than the smaller fabrication facilities that are leaving service today. To emphasize this point, the need for 200,000 square feet of renovated administrative or warehouse space from one of today's modern fabs would not appear to be foreseeable in this author's opinion. As such, today's design must look beyond the fab's lifetime and prepare it to accept future manufacturing roles in the future.

7.5 Concluding Remarks

As I look back on this research, I would still propose that the truth of the matter is that the issue of evaluating potential uses for semiconductor facilities remains a difficult and complex issue to discuss. While I hope that this research can provide some mechanisms for thinking about how to approach this problem, I also realize that there are shortcomings with its universality.

As such, I would leave this topic with two points. First, planning for adaptive re-use before the facility is actually shut down would appear to offer numerous advantages over waiting until the facility is decommissioned. As alluded to in the discussion of life-cycle analysis, as well as during the discussion of options pricing, starting the process as early as possible would appear to be the best strategy. Finally, since companies can no longer walk away from existing facilities without suffering negative publicity and potential liability, the issue of decommissioning facilities will become more important in the future as greenfield sites become more limited and environmental legislation and restrictions become more stringent. As such, I would contend that looking at today's facility assets and evaluating how best to mitigate their future risk would be very advantageous over waiting to see what the future holds.

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APPENDIX 1: BALANCE SHEETS FOR ALTERNATIVES

Balance Sheets for Alternatives

1. Alternative #1: Demolition -- Demolish and build new facility

Technical Feasibility and Technical Challenges:
(TC) - Demolition would have to not affect the "normal" production processes of the other fabs (i.e., no wrecking ball)
(TC) - Construction (similar to demolition) could not affect the production process (whether through vibrations or whatever)
(TC) - Additional parking requirement for displaced workers - can the site accommodate?
(TC) - Potential increases in site wastewater disposal permits
(TC) - No specific role for a new building has been identified -- don't want to just build a facility for the sake of building one

Efficiencies Gained and Efficiencies Lost (including financials):
(EL) - Key financial point: the incremental value of additional space that is not needed (i.e., if the site isn't space constrained and Intel would only be using the facility for creating "more" elbow room) is ZERO
EG - The incremental value of additional space that MAY be needed in the future is greater than zero
(EL) - High cost of demolition
EG/(EL) - New facility could be constructed to accommodate specific mission (versus retrofitting) -- downside; small footprint of building would limit the size of a facility that could be put in its place

Corporate Strategy and Support:
(CS) - Would construct only if it could not be accommodated in Ronler Acres' plan and the mission needed to support F5/F15
(CS) - Would consider only if new land acquisition costs and "loss of proximity to other functions" were higher than complete demo

BOTTOM LINE (KS) - Corporate would support only is mission was identified. With full knowledge that the site was planned to be shut down this year, no party has stepped forward as a potential occupant (other than IMO). Even with the arrival of "new" corporate group (author's note: I can't remember his name), the probability of using the facility in the future must be considered (i.e., say 10% chance?). Highly unlikely unless a function in Intel "steps forward". General impression is that management will not "force" a function into the facility.

2. Alternative #2: Demolition -- Demolish and convert to parking spaces
(Parking lot and/or Parking garage)
Technical Feasibility and Technical Challenges:
(TC) - How to demolish building without interfering with existing manufacturing in F5 and F15 (i.e., ground vibrations from equipment/materials plunging to the ground might affect the processes within F5 and F15). Is it even possible to demolish the building using heavy equipment?
(TC) - How to even PROVE (through structural analysis or vibration calculations) to F5 and F15 plant managers that a brick wall hitting the ground from an elevation of 40' won't affect a submicron process in their fab
(TC) - How to create additional parking for those employees displaced by the activities/dumpsters/equipment (are the existing parking lots able to absorb this loss of available space)
(TC) - Parking garage -- even if you don't demolish the facility and put a garage somewhere on campus, how to deal with the displaced workers from the area that you're developing for the garage (i.e., what about the workers who used to park on the asphalt before)
(TC) - How to maintain access to service yard for deliveries to F5
(TC) - How to eliminate uncertainty with respect to underground utilities
(TC) - Can only construct asphalt parking lots during the seasons when the asphalt plants are producing asphalt -- i.e., they open in the late spring and close in the early fall

(TC) - How to demolish building without affecting the existing connection to the annex and employees located there -- i.e., would probably have to find another location for functions located in the annex (so as not to constantly disturb them).
(TC) - Demolition of exterior walls and foundations without disturbing manufacturing process equipment in F5/F15 (i.e., transmission through the ground -- would need to know ground soil boring results)
(TC) - Coordination -- advantages/costs of demolition during winter (i.e., when the ground is frozen) vs. advantages/costs of demolition during summer (i.e., when the ground is thawed) -- key point: under what situation would sound travel further in the ground, thereby increasing the risk of affecting the process
(TC) - Potential interference with on-site activities (i.e., trucks, parking, workers, etc.)
(TC) - Intel "policy" will require that most materials be recycled and not transported to the dump -- implies a requirement for construction oversight

Efficiencies Gained and Efficiencies Lost (including financials):
EG - If the building doesn't have a defined use and any use is going to require a $1M investment for seismic upgrades, why wouldn't you demolish?
EG - Relieve uncertain environmental uncertainty (i.e., don't know what's there) and environmental legislation uncertainty (don't know what future legislation could do to make environmental clean-ups more expensive) that you could face in the future if you decide to demolish it later (i.e., "know what's there before it kicks you later").
EG - Loss of annual operating expenses
(EL)/EG - Loss of an asset on the books but pre-tax charge for write-down
(EL) - Why open up a can of worms if the building's present state isn't bothering anybody
(EL) - If you were only going to use the space for parking, wouldn't it be cheaper to develop other land (i.e., area by the mitigated wetlands) rather than demolish an entire facility at a substantially higher cost
(EL) - Parking garage -- if you decided that a parking garage was the only alternative, why wouldn't you just develop ex
existing asphalt parking areas rather than demolish an entire facility
(EL) - High costs for "little" benefit (since there is already adequate existing parking); high cost because it involves demolition of a building for a relatively small number of spaces (80-100)
EG- Potential property tax relief (because a building no longer exists)
EG - Increase in employee morale (closer parking) and potential increase in employee satisfaction (and improved productivity)
EG/(EL) - Value of the land might be worth "more" or "less" to a potential buyer

Corporate Strategy and Support:
CS - Intel guidelines suggest that no parking will be greater than 1000' away from the building. Currently, some spots are going to violate this.
(CS) - Does Intel really want this site becoming another Santa Clara (because of its land constrained design), particularly in light of Ronler Acres up the road?
(CS) - The number of existing parking spaces (approximately 2,000) are adequate to support existing occupancies on Aloha -- why increase?
(CS) - Will Aloha campus support another fab in the future -- "highly unlikely"

BOTTOM LINE (KS) - Corporate will not support. Would support only if corporate guidelines were being severely violated (i.e., 10% of all spaces are over 1,000 feet away; not 0.25%) and costs to construct (via demolition to an existing facility) were less than could be accomplished via land acquisition or reviewing existing parking plan and constructing a parking garage where existing AC (asphalt concrete) pavement is.

3. Alternative #3: Demolition -- Demolish and do nothing (i.e., plant grass and let the cows roam)

Technical Feasibility and Technical Challenges:
TF - reduce potential environmental liabilities by taking care of the problem now (rather than waiting to discover them in the future)

(TC) - Demolishing building without affecting the production (i.e., wafers) and operations (i.e., blocking service yard access) to other fabs

Efficiencies Gained and Efficiencies Lost (including financials):
(EL) - Key financial point: the incremental value of additional space that is not needed (i.e., if the site isn't space constrained and Intel would only be using the facility for creating "more" elbow room) is ZERO
EG - The incremental value of additional space that MAY be needed in the future is greater than zero
(EL) - potential high investment cost when compared with actual land acquisition value
(EL) - potential high cost to demolish piece-meal when compared with wrecking ball approach
(EL) - operating costs ($500k) could be applied elsewhere in the company

Corporate Strategy and Support:
CS - If building is of "no-use", then why hold onto an asset which is not benefiting the company or the shareholders (i.e., financial sinkhole)
(CS) - What about the potential use of the facility in two years, three years, four years, etc. -- if we demolish it and then find a use for it later, then it will cost us more to construct new
(Author's Note: Should probably work out a financial "break-even" point for demolishing and leaving alone)

BOTTOM LINE (KS) - Corporate would probably support but not in the near term. That is, after sitting for a year without any occupants or anything on the horizon, corporate would probably approve its demolition. However, the key aspect when determining the facility's demolition is whether the anticipated "additional" costs of demolishing F4 without affecting F5 (since we know any affect on F5 and its production capabilities is worth millions of $) are worth it when compared against the "expected" life of F5 and the potential ability to demolish both of them at once.

4. Alternative #4: Status Quo -- Do nothing

Technical Feasibility and Technical Challenges:
TF - With the utility system states defined, this option does not represent any technical challenges, other than the routine maintenance to support operations
(TC) - Nature of the building "load" would change. That is, instead of requiring a "cooling load" most of the year (to offset heat generated by equipment and personnel), the building is now required to support a "heating load" to make up for the loss. Ability to support for sustained periods?

Efficiencies Gained and Efficiencies Lost (including financials):
EG - If valued as an option, leaving in "present state" condition after decommissioning may be financially advantageous
(EL) - Key financial point: the incremental value of additional space that is not needed (i.e., if the site isn't space constrained and Intel would only be using the facility for creating "more" elbow room) is ZERO
(EL) - The cost of operating the facility ($500K) and the budget for maintaining it (i.e., GSS budget) could be spent elsewhere (Author's Note: Is that statement generally true -- that is, utility costs could be spent elsewhere but GSS budgeting costs may not be totally eliminated because headcount will always be there to support other functions)

Corporate Strategy and Support:
(CS) - Would only support is the list of "potentials" on the horizon is positive (i.e., probably would not support if nothing looked favorable on the horizon) or the "potential future value" is much greater than knocking the walls down
(CS) - Would support only if costs of doing nothing now and waiting are "very likely" to be less than the costs of doing something immediately and changing your mind in the near future.
(CS) - Would only support if the potential chance of being able to renovate in the future for manufacturing and the increases in marginal revenue are greater than the potential investment as well as the "lost" costs of operating the facility up until that time.

5. Alternative #5: Sale -- Sell/lease the facility

Technical Feasibility and Technical Challenges:
(TC) - How to control VOC, HPM, and wastewater emissions (without expensive monitoring systems) -- site is basically permitted as a "site" not by specific "building"
(TC) - How to restrict access (and perhaps technology transfer) between the "sold" or "leased" building and the other building
TF - Potential exists to monitor electricity usage, natural gas consumption, etc. via meters
(TC) - Parking -- where would non-Intel occupants park (i.e., intermixed with Intel parking or in their own separate lot)
(TC) - Interconnections and interdependencies between facilities would have to be "disconnected" before turnover or sale

Efficiencies Gained and Efficiencies Lost (including financials):
EG - Sale or leasing will bring in additional $ (taxed at capital gain level) -- i.e., opportunity to "make money" on a building that no longer "makes money" for Intel
(EL) - Loss of depreciation tax shields

Corporate Strategy and Support:
(CS) - Potential problems with this scenario (i.e., transfer of technology; security; emissions monitoring; etc.)

BOTTOM LINE (KS) - Corporate would not and did not support for an integrated site. There are just too many potential problems that could result versus the "true" benefits received. However, if the facility was stand-alone, the decision might be worthwhile, as long as a potential buyer existed (i.e., in the case of F3, no one existed and the company was responsible for paying the O&M and property taxes until a buyer could be found - i.e., years!)

6. Alternative #6: Direct Manufacturing -- Semiconductor manufacturing facility for existing <u>on-site</u> manufacturing purposes

(a) Potential constraint (functional) processing -- i.e., photolithography (typical bottleneck), annelva (sputter), ion implantation, CVD, diffusion, etc.

(b) Non-constraint processing -- i.e., wet etch, (wet processing stations), Planar, Parts Clean (quartz clean/implant parts clean/corrosive parts clean/sputter parts clean/etch parts clean)

Technical Feasibility and Technical Challenges:
(TC) - Vibration concerns and their effect on equipment (particularly equipment which deals with extremely small line widths (eliminates photolithography "right off the bat")
(TC) - Size of equipment (probably excludes ion implanters and diffusion furnaces already)
(TC) - Constraint processing -- ability to upgrade structure from Class 100 to Class 10 or Class 1 bay and chase (small ceiling height and interstitial area)
TF - Non-constraint processing -- ability to function in a Class 100 environment (makes Planar and Parts Clean functions attractive)
(TC) - Hazardous Process Material (HPMs) required for process - limitations imposed by building's H2 areas (makes non-HPM like Planar (H6) and wet processing for parts clean (H6) attractive)
(TC) - Material handling system between two fabrication areas (need to maintain Class 1/10 environment)
(TC) - Feasibility of passing a material handling system through an office environment (technically able to and allowed to according to UBC -- potential fire stopping requirements?)
(TC) - Material handling system between two fabrication areas which might cause additional "shaking" of the wafers, additional particles moving between wafers, and creating "opportunities" for higher defect densities (less of a concern with wet processing steps because wafer is subsequently immersed in liquid?)
(TC) - Difficulty predicting what "would be" or "is" the constraint (i.e., a "floating" constraint). With different products, different processes, and different routes, the number of steps involved at any one functional step might vary.

TF - Ability to create additional Class 1/10 fab space out of existing fab area would offer great advantages over trying to construct/create new fab space (i.e., problems with zoning, additional costs of constructing "new" vs rearrangement within an existing clean room area)
(TC) - If you relocate a processing step, the capacity and availability of existing systems to meet that need (i.e., if you try to increase the capacity too much, you'll end up having to buy equipment in other functional areas to support a "balanced" situation)
(TC) - Even if you eliminate a "bottleneck", what is the "next" bottleneck (i.e., if you get rid of one, something else will soon take its place as the constraint in the system) == extensive analysis across products and processes and even future processes
(TC) - Ability to move equipment without interfering with the 24/7/52 production -- i.e., can the system "absorb" stopping for a few days in one functional area while the other area is brought on-line
(TC) - Potential requirement to shut down the fab while these changes are taking place (i.e., loss of revenue and production)
TF - Availability of loading dock area and Acid Storage Room and Solvent Storage Room areas
(TC) -Wet processing - ability of existing UPW and neutralization system to support requirements
(TC) - Would need to "accurately estimate" the true incremental increase in WSPW
(TC) - Tool costs (i.e., equipment costs) and installation costs -- high investment
TF/(TC)- Ability to create a "passageway" (perhaps even a building link) between F4 and F5. Major question might be whether or not the buildings' structures can accommodate such a link (largely because they're masonry walls and columns and a passageway between the two buildings without any columns in the service yard would require some SERIOUS steel beams to span approximately 200')

Efficiencies Gained and Efficiencies Lost (including financials):
(EL) - If you can function in Class 100 with the VLF hoods, you're going to have to pay for the seismic upgrade for them as well as the building seismic upgrade.
EG - Creating additional fab space within the area would allow throughput to increase, thereby increasing revenue.
(EL) - Ability of workers to move within the entire fab area to move lots, discuss with co-workers, etc.
(EL) - Communication between workers becomes more difficult
EG - Potential cost advantages of "rearrangement" of existing fab space vs. "new construction" for additional fab space
EG/(EL) - Potential need to purchase additional equipment to maintain existing production while moving the function elsewhere (i.e., you would probably buy additional machines to create "some" capacity and then move all the equipment over)
EG/(EL) - If you strive to increase throughput of a line where capacity was constrained, you would have to budget for additional equipment in order to achieve it (= high additional investment)
EG/(EL) - If you move a function that is well integrated into the fabrication layout, then you would have to rearrange the other functions in the fab area to take advantage of the move. That is, if you need to keep all functional areas together, then you would probably have to re-arrange the entire fab to take advantage of all the open space. (== high cost)
EG - On the other hand, if moving one functional area creates enough capacity by running parallel lines (for example, by setting a standard - say, all Boron implants take place in F4, all Arsenic implants take place in Fxx), then you might be able to maintain the arrangement "as is" and achieve a justifiable increase in throughput (sounds like a system optimization problem with all the possibilities)

Corporate Strategy and Support:
CS - Would support if it created a large increase in throughput for a minimal investment
CS - Would support if forecasting predicted a long-term demand > supply
(CS) - Would not support if it cost more than building new (i.e., marginal revenue , marginal "bang for the buck")

BOTTOM LINE (KS) - Would really need to give you SOME ROI and short payback period (i.e., 2 yrs) to make it justifiable

1. Alternative #1a:
== Potential Specific Investigations -- Annelva (Sputter) Farm

?Why only annelva sputter - could potentially move all metallization functions to F4 but the problem is that lithographers are needed to develop the metal layers and vias (then the metal etchers remove the extra metal) -- lithographers would be a "concern" because of the vibrations
== ANNELVA is such a constraint in F5 why wouldn't you think about it? The problem with annelva is two-fold: (a) concerns with transporting out of the clean-room environment and back into a clean room environment (i.e., materials handling) and the effects on its 'yield; and (b) an existing authorization to expand the Annelva function currently in place
- Description of existing way that it's run -- F5 currently has a problem performing all four metal layers on the 653 process (unsure whether capacity is the issue or machine problems). Currently, F5 ships chipsets to F9 for the metal 3 layer to be performed down in NM.
- Annelva is a Hi-Vac function -- requires a lot of vacuum pumps.
- Unsure whether annelva

7. Alternative #7: Direct Manufacturing -- Semiconductor manufacturing facility for off-site manufacturing
   (a) Current Intel supported technology (i.e., microprocessors, chip sets, "flip chip" processing in SC, etc.)
   (b) Non-Intel supported technology (i.e., ASIC or "custom chipmaking")

Technical Feasibility and Technical Challenges:
(TC) - Vibration concerns
(TC) - Size of equipment and problems with ceiling height interference
(TC) - Size of facility (space)
(TC) - Air quality standard of the facility as it exists today to support another Intel manufacturing process
(TC) - Hazardous Process Material (HPMs) required for process - limitations imposed by building's H2 areas
TF - Availability of loading dock area and Acid Storage Room and Solvent Storage Room areas
TF - Ability to work on facility without interfering with any ongoing production
(TC) - Additional "support" requirements -- potential office area, parking area, etc.

Efficiencies Gained and Efficiencies Lost (including financials):
(EL) - Requirement to train or hire additional people in OR or relocate other Intel employees from outside OR to support manufacturing
(EL) - Identifying an internal Intel group (i.e., it's already been well advertised and nobody came calling)
EG - Ability to support a pilot manufacturing operation or other small scale mission (i.e., like Components Research)

Corporate Strategy and Support:
(CS) - Difficult to "force" another business unit into a building when Intel's capital expenditure budget was $3.6B for FY96
CS - Appears as an effective use of an Intel asset that has "some" value attached to it
(CS) - Difficult to "sell" as a production facility when Intel clearly has moved toward "high volume" production
(CS) - Difficult "sale" with Ronler Acres and its greenfield site up the road

BOTTOM LINE (KS): Corporate won't support unless it's a "perfect match" of requirements (haven't identified one yet -- for example, IMO Mask Shop said "no")

8. Alternative #8: Direct Manufacturing -- Non-semiconductor manufacturing (for example, circuit boards assembly, computer assembly, etc.)

Technical Feasibility and Technical Challenges:
(TC) - Circuit board manufacturing is more like an automobile assembly line operation. It "requires" more open space (for storing inventories and goods and work in process) versus fab space
(TC) - Economies of scale perhaps more prevalent in large, open area manufacturing
TF - Space is available and mission has "limited" utility requirements; building would have to be "gutted"

(TC) - Would need to incorporate a shipping deck (to receive inventory, to stock goods, to ship goods) and an elevator that might be larger than existing

Efficiencies Gained and Efficiencies Lost (including financials):
(EL)/EG - Intel currently leases space within OR for production (i.e., Cornell Oaks) and has a dedicated facility already (HF or JF). Would it be "cost efficient" to have another facility?
(EL) - Most of Intel's sites are single-function and not "multi-function". Would it make sense to have both semiconductor manufacturing and PC board assembly taking place on the same site?

Corporate Strategy and Support:
(CS) - Is demand outstripping Intel's supply of these products - author is NOT under that impression
(CS) - "Semi-warehouse" space (to assemble these products) is not exactly expensive. Why would you move this function into a facility (incurring renovation and demolition costs), particularly if a downturn occurs?
(CS) - Is Intel venturing too far away from its "core competencies"?

BOTTOM LINE (KS) - ROI would have to be extremely HIGH to justify. Margins on these products are considered to be "low" (in comparison to microprocessors). Perhaps if demand was expected to be much higher but the author doubts that Intel would approve such a provision.

9. Alternative #9: Combine Fab 4 and Fab 5 roles together
   (a) Construction
   (b) Demolition

(b) Demolition -- Do nothing (for x years) or put a miscellaneous function in there and demolish F4 and F5 together

Technical Feasibility and Technical Challenges:
TF - Parking issues would probably not be as much of a concern because F5 and F5 support personnel would not be on-site (i.e., arrangements wouldn't have to be made for replacing parking that is consumed by demolition equipment)
TF/(TC) - If Fab 15 could absorb the potential vibrations without affecting the process, the "wrecking ball" method of demolition might be able to be applied

Efficiencies Gained and Efficiencies Lost (including financials):
(EL) - Key financial point: the incremental value of additional space that is not needed (i.e., if the site isn't space constrained and Intel would only be using the facility for creating "more" elbow room) is ZERO
EG - The incremental value of additional space that MAY be needed in the future is greater than zero
EG - Costs of demolishing both buildings at the same time
(EL) - Projected lifetime of F5 is 5 years. However, F4 was considered for shutdown as early as 1988 (eight years before shutdown). As such, forecasting is very "subjective" -- are you willing to bet on F5's future when you don't truly know what it will hold?

Corporate Strategy and Support:
CS - Would support if costs for demolition justified costs of "doing nothing" and holding on to a facility
(Author's Note: Actual bids from contractors would REALLY help this decision)

10. Alternative #10: Semiconductor manufacturing support -- front end processing
    (a) Wafer cutting (from ingots)
    (a) Internally put "epi" layers on silicon wafers

(Author's Note: Epitaxial layer is a CVD function (not diffusion in a furnace) and is grown by passing silicon wafer through an RF-reactor with a gas around it)

Technical Feasibility and Technical Challenges:
(TC) - Intel doesn't currently have the technological "know-how" to understand how its done

Efficiencies Gained and Efficiencies Lost (including financials):
EG - Cost for (test) wafers without epi layer (for 8") is close to 50% less than cost with epi layer (for 8") -- what are expectations for 12" (300 mm) wafer
(EL) - Scenario has been looked at before (many times) at Aloha campus -- still not justifiable

Corporate Strategy and Support:
(CS) - Intel's "know how" is in creating microprocessors, not putting "epi" on wafers

BOTTOM LINE (KS) - Does not appear that this option has a lot of local support. Has been looked at many times and still unsure why it would be profitable now (versus in the past). Perhaps because of the larger and larger volumes of wafers being passed through Intel plants, the scenario might prove "rosier" than before.

11. Alternative #11: Semiconductor manufacturing support done in-house -- back end processing and "semi-clean" support functions -- Relocate from Fab 5 and/or Fab 15

(a) Wafer sort and E-test floor
(b) Goldgrind/Backgrind
(c) Test and assembly (packaging) operations
(d) Planarization
(e) Arsenic Parts Clean, Quartz Clean rooms, etc.
(f) Analytical labs

Technical Feasibility and Technical Challenges:
(TC) - Goldgrind and Backgrind take place on the first floor (subfab) -- what advantage would you gain by moving those functions out of there (ability to put in more fab support equipment)? Difficult to justify. (Question whether the product moves from the clean room to backgrind/goldgrind without passing outside of a cleanroom environment)
(TC) - Assembly (packaging) operations are currently shipped overseas and are "highly" labor intensive. Since the cost of labor is less overseas, would the savings from shipping costs versus the increased total labor costs justify the expense (I would suspect that this has already been investigated).
(TC) - Test and assembly operations are large-scale, support multiple products and processes and occur in large facilities. Test operations, in particular, I've been told require large, expensive pieces of equipment. What would be the advantages of placing those functions is a 22,000 SF facility? Difficult to justify.
== Only look at wafer sort facility

Technical Feasibility and Technical Challenges:
TF - No requirement for vibration limits
TF - Might not need to put raised floor in if you can use subfab utilities and core drill through floor
TF - Potential to raise ceiling slightly and add raised floor (with utilities underneath) -- i.e., can use 18" floor vs 24"
TF - Sort equipment does not appear to have height restrictions (biggest pieces of equipment in sort floor are Lieberts)
TF - Existing infrastructure to accommodate a large heat load (i.e., chilled water system) and process utilities (i.e., air, electricity) -- similar heat load vs cooling requirements
TF - Lower air quality standards (Class 10,000) make it feasible for consideration (i.e., less clean room requirements; hence, less HVAC requirements: hence, easier to accommodate in small interstitial space)
(TC) - Moving pieces of equipment in (how do you get them upstairs and through the door) -- small elevators and limited door access
(TC) - Sort appears to "like" large open areas (but with columns) -- would probably have to consider demolishing some walls (not a big problem)
(TC) - Small size of dumbwaiter (elevator) to move wafers around

(TC) - Requirement for WIP storage and shipping storage (proximity to loading dock area) - (a) space availability and (b) temperature/humidity requirements
(TC) - Logistics moving lots back and forth from 1Fl to 2Fl to 1Fl
(TC) - If you decide to relocate function, how do you move the function while maintaining production and not building up an inventory that you can't process (and affecting other functions down the line) -- i.e., the Beer Game where a "hiccup" turns into a nightmare on steps following it
TF - Can bring up another sort floor (in addition to existing sort floor) without interrupting production flow
(TC) - Would you put sort floor on 1Fl or 2Fl
(TC) - Dedicated sort floor for Oregon or other places? (i.e., does Oregon need another sort floor)

Efficiencies Gained and Efficiencies Lost (including financials):
(EL) - Advantages of on-site sort (that is, when F12 was considering, there are serious advantages for yield engineers to be able to go to a sort facility on-site vs driving away or calling)
(EL) - Depending on whether on 1Fl or 2Fl - if on 2Fl, wafers would have to travel from 2Fl manufacturing area to 1Fl backgrind/goldgrind through AL3 to F4 to 2Fl and back to loading dock area on 1Fl
EG - If you "parallel" sort functions, reduce the demand on AL4 sort
EG - Ability to support other sites
(EL) - High equipment investment costs (if equipment is not in warehouse or available)

Corporate Strategy and Support:
(CS) - No real need to support OR requirements at present. AL campus sort floor has "unoccupied" area to expand into right next to the existing facility as well as additional space (6,000 SF) for S9K's and Trilliums where 4" equipment used to be.
(CS) - Ronler Acres (RA) has its own sort floor planned and (perhaps) the ability to expand into new building space as construction continues into the future on its "greenfield" property - no foreseen need to support their requirements
(CS) - F12 is going to build their own sort floor (S12) expansion
(CS) - Costs to create building shell are "small" in comparison with equipment. Costs to convert administrative space to sort floor space are probably the same as to convert fab Class 100 space to sort floor space -- i.e., isn't admin. space "less valuable"
(CS) - Sort is not the production "bottleneck" -- Sort only becomes the constraint when demand for a particular product exceeds its abilities. Since times for each wafer to be tested are "variable" (i.e., one product could take 20 minutes per wafer while the next product could take 2 hours per wafer), demand for certain products dictates production and sort abilities to process.

BOTTOM LINE (KS) - Facility is well suited for sort floor (case and point -- look at SC's F1). Ability to maintain H6 occupancy rating also a "bonus" if you decide on a future manufacturing function in the future. High cost for equipment expected. Problem is "nobody needs sort capacity" -- why do it? Fab 15 appears to have had a dedicated sort floor designed into it and they're not going to use it because the existing sort facility has "more than enough" space and "more than enough capability" to expand its space within its current location. Only way that it would be viable would be if you needed to sort another fab's products.

== Relocate Planar Function to F4:

Technical Challenges and Technical Feasibility:
(TC) - Materials would have to be manually "pass-through" (increased labor requirements), brought back and forth on carts (potential for mishaps and increased "shaking"), wiped down before passed through again; you really don't care what happens when it exits but F15 to F4 but you're PARTICULARLY concerned about what happens after the wafer is planarized!
TF - Requirements for air quality are "less" stringent (still might be greater than Class 100)
TF - "Dirty" and utility support requirements in place (not necessarily sure that they would be adequate, though) -- UPW, drains, scrubber requirements, nitrogen availability, etc.

(TC) - removing equipment from Fxx and re-installing in F4 (size of doors; size of equipment; effects on production)
TF/(TC) - Size of equipment appears to be less than 7'0 (at least for Westechs); minimum ceiling height below hoods can range from almost six feet to seven feet (need to be specific where you would put them)
(TC) - emergency power requirements? (I don't think so but I'm not sure)
(TC) - wafer handling system and long distance required == would need to be 2-track system at least because lots would have to be "coming" for planarization and "going" back to the fab for additional processing (i.e., insulation or metallization)
(TC) - slurry requirements -- even if you move this equipment out of the subfab in F15, how much benefit do you really get? In other words, are there excessive amounts of other equipment (like process or vacuum support equipment) already in that place?
TF - slurry is characterized as non-hazardous and stable (even though one type of slurry contains Iron Cyanide). NO requirements for H7 occupancy but access to loading dock required.
TF - Planar totes and equipment are highly "modularized" -- totes fit inside of equipment and can be left alone until the tote is empty.
TF/(TC) - Capability of existing F4 DI water to support? If not, then F15 has additional UPW capacity and could be routed to provide the need.

Efficiencies Gained and Efficiencies Lost (including financials):
(EL) - If feasible using VLF hoods, you would need to add seismic restraints in the building alteration costs
(EL) - Appears to be a minimal effect on F5 because there are only 2-3 polish steps in P652/P653 processes (vs. 9-10 in P854 process alone); similarly, planar just doesn't take up a whole heck of a lot of space in F5, but it does take up a lot of space in F15
(EL) - Interrupted process flow - outside of manufacturing space and across campus
(EL) - Potential need to have additional WIP storage racks (i.e., slowing down the process) or need additional labor to continuously move wafer lots back and forth
(EL)/EG - If you increase throughput in fab, you might" need to increase upstream or downstream processes (i.e., sort, other wafer processing areas)
(EL)/EG - Additional fixed costs, variable costs, direct (manufacturing personnel) and indirect costs (supervisors, engineers, etc.) because you're now using two facilities versus one. Increased variable costs (utilities; materials; consumables;), increased preventative maintenance requirements and service contracts with vendors?

Corporate Strategy Support:
(CS) - Would support if F15 didn't look like there was any way it was going to meet capacity requirements for the future
= Need to compare marginal revenue benefit to marginal costs to renovate and operate

BOTTOM LINE (KS) - Material handling is a "big" concern, whether or not technically it can be overcome; "political" issue; otherwise, might support if you could show significant increase in revenue and short payback period. Could potentially add some additional processing steps (i.e., add an additional wet step after returned from F4) but this too could be a "political" nightmare. Would need a "strong" on-site driver.

== Relocate Planar Function within F15 across the hall and maintain planar slurry room where it is:

Technical Feasibility and Technical Challenges:
TF - Planar is a "dirty" function that doesn't need to be within a Class 1 environment
(TC) - Would have to be able to pump pressurized supply lines and gravity return lines across the hallway on the 1Fl and through boiler and electrical rooms
(TC) - If you attempt to add additional support tools in existing slurry room, the limited ceiling height in the front of the room might prevent you.
(TC) - If you attempt to put another function in there, the HPM required for the process might not be allowed to be stored in that area (for example, for litho, the developer)

(TC) - Most AWN drains are gravity and (potentially) run in the F15 subfab trench. If you place the function across the hall, the drains would have to run in the mechanical and electrical rooms (potentially allowed by the code) and across the hallways (potentially allowed by the code). Drain system might have to be pressurized to allow it to do so. (Author's Note: there are no solvents in the Planar function).

Efficiencies Gained and Efficiencies Lost (including financials):
EG/(EL) - Gain of available area in fab but essentially no gain in subfab -- unsure whether this is entirely feasible? Are there any functions that need limited subfab requirements and could be accommodated (probably not any wet etch stations or functions using vacuum pump systems -- unless you put them above ground like in F4 LAMs)
EG - Would create an additional 12,000 SF of Class 1 space
(EL) - If moving between Class 1 and Class 100 spaces (if constructed as such), then you would have to have "pass throughs" and "wipe downs" after each return from the Class 100 space
EG - Potential to use non-high vacuum support functions in this area -- i.e., wet stations, Litho (assume that it only uses N2 or CDA and does not directly have large vacuum pumps supporting them) and potentially Diffusion (limitation would probably be size of equipment).

Corporate Strategy and Support:
CS - Would support if it created "cheap" additional clean room space and capacity

BOTTOM LINE (KS) - Costs to relocated planar room would include relocating electrical and mechanical rooms (high costs). Planar still need access to outside loading dock to receive the 300 gallon totes that are important to its process. Hence, maintaining the room "makes sense" -- the only question is whether moving the fab equipment makes any additional space available for use. If so, then would find some support

=== Manufacturing Support - Relocate F15 Parts Clean Areas
Objective: Create a "single" waste handling area on campus

Assumptions:
(1) Can't relocate many areas in the subfab (first floor) because of their importance to F15 operations and/or their H2/H7 zoning. For example;
  (a) Bulk Chemical Storage Areas (Hazardous Storage Areas #1 and #2) -- Provides access from outside for hazardous materials and piping to existing systems throughout the fab for many chemicals
  (b) Solvent Pumping and Storage Rooms #1 and #2
  (c) Corrosives Pumping and Storage Rooms #1 and #2
  (d) Electrical Room South (H6)
(2) Consequently, we can summarize as follows:
  Two floor availability to relocate:
  (a) Litho Parts Clean and Etch Parts Clean (3,600 SF)
One floor availability to relocate:
  (a) Implant Parts Clean, Quartz Parts Clean, and Wafer Reclaim (Regen)

Technical Feasibility and Technical Challenges:
TF - Can do without interfering with day to day manufacturing: can build up F4 without affecting the existing Parts Clean; can move all the Parts Cleans over to F4; demolish F15 Parts Cleans; and then move people over -- i.e., can do independently
(TC) - Subfab capabilities within the area enclosed by H2/H7 occupancies are "limited" -- would have to relocate a function which doesn't require vacuum pump support (i.e., any functions with vacuum pump support would be "hard-pressed" to fit in the area or would have to be located in H6 area east of Electrical Room South)
TF - Couldn't move Bulk Chemical Storage Room (provides HF, Acids, etc. within large totes) largely because it requires access to the outside and is classified as H2/H7
(TC) - If electrical equipment passes "in" and "out" of this room, would it have to be explosion-proof?

Efficiencies Gained and Efficiencies Lost (including financials):

(EL) - Recently consolidated this function within F15 -- why would you want to move them back away (i.e., why did you move them in the first place)
(EL) - "Superhighway" through buildings transporting goods
(EL) - Potential for things to break and/or get lost (i.e., quartzware, parts, etc.)
EG - Would create an additional manufacturing space, provided that a function which doesn't require much support equipment could be found (i.e., don't have room on subfab level)

Corporate Strategy and Support:

Author's Note: Really need to understand the functions of all these parts clean. In other words, what materials are used in their process (i.e., UPW, Corrosives/Solvents, etc.) that would be required in F4)

12. Alternative #12: Vertical integration functions (i.e., perform all semiconductor manufacturing operations)
    (a) Pull own silicon wafers
    (b) Wafer cutting (from ingots)
    (c) Perform ALL wafer sort, electrical test, assembly operations for ALL Intel products (Intel currently subcontracts much of this for its "older" products)
    (d) Reclaim wafers

Technical Feasibility and Technical Challenges:
(TC) - Silicon growing and wafer cutting require different utilities, tools, worker "know-how", etc. than currently exists
(TC) - Pulling own silicon wafers requires a large and tall Crowalski (?) machine to grown ingots and high power consumption
(TC) - Need to develop in-house expertise

Efficiencies Gained and Efficiencies Lost (including financials):
EG - Intel would no longer be subject to the delivery schedules, costs, etc. of its suppliers -- would be doing it "in-house"
(EL) - High initial investment
(EL) - Would Intel invest in 6", 8", and 12" technologies or which ones?
(EL) - Would Intel find it "profitable" to pull outside operations in-house that doesn't require leading-edge technology (i.e., wafer sort equipment, etc.) when compared against the cost of space (i.e., would it still be cheaper to outsource when you take everything into account)
(EL) - Intel would have to secure their own channels of supply and delivery for Si

Corporate Strategy and Support:
(CS) - Intel makes "chips", we don't make silicon -- conflict with current corporate strategy to maintain a relatively "low" headcount so that it can absorb changes in the market
(CS) - Counter "core competencies"
CS - Would guarantee a non-foreign supplier of silicon and perhaps gain strategic advantage if the current suppliers decided to increase their prices

BOTTOM LINE (KS) -- Don't believe corporate would support. While there are a limited number of suppliers for silicon, the author believes that Intel probably already exerts enough 'influence' to receive favorable pricing (i.e., Intel is probably one of the biggest buyers (by volume) of Si wafers). Ability to guarantee Si from more than one source has already been negotiated (Sumitomo and xxx). With respect to test/assembly, Intel would definitely not support. As a "mature" product, Intel probably already receives a premium on price and can afford to pay (if any) higher price to have outsiders perform the functions. Doubt that this is economically or strategically justifiable.

== Internally reclaim wafers

Technical Feasibility and Technical Challenges:
TF - entirely "wet process" -- facility currently has large wet station capability and scrubbed exhaust capabilities
TF - not exactly a "rocket science" process (i.e., current Intel employees could learn the process easily)
(TC) - small space requirements (5,000 SF)
TF - Class 100 requirement met -- wafer is cleaned at the beginning of the process anyhow and "new" boxes are used to transfer products (so you don't have to worry about shaking up particles)
TF - Existing DI water capacity to meet 159 gallons per minute requirement (2-30HP and 2-40HP pumps through 4" pipe == x GPM) @ 0.1μ maximum filtration (Loop 1)
TF - No known equipment height requirements or limitations
(TC) - Would need to perform both seismic upgrades (i.e., VLF hoods and structural) if VLF hoods are re-used

Efficiencies Gained and Efficiencies Lost (including financials):
(EL)/EG - Centralize all operations for all domestic fabs (i.e., NM, CA, AZ, OR)?
(EL)/EG - Reclaim feasible for 300mm and/or 200mm (i.e., do you wait until 300mm comes into production or is it anticipated that the process is feasible for 200mm as well)
EG - Potential to take advantage of existing truck routes (Danzig) that travels between sites LTL or full-payload (i.e., wafers would be low volume products but might require "special" handling)
EG - Potential to use existing tools in warehouse storage (i.e., wet benches)
EG - Should Ronler Acres develop into 4-5 large production fabs, the ability to save reclaim $ with a "close" function would save potential vendor costs or costs to incorporate additional space in new fab design and construction (i.e., probably would build as Class 1 with less HEPA filters to achieve Class 100)
EG - Minimal capital investment ($6M estimate for equipment)
EG - Potential for cutting down time between "shipping reclaimed materials" and "receiving reclaimed materials" (might reduce silicon purchasing requirements)
EG - Potential value of "space" that could be saved from other fabs if function is required to be performed "in house" (i.e., new designs and existing fabs) could range from $3,750/SF (savings from taking up potential Class 1 cleanroom space) to $165/SF (savings from taking up potential administrative space)

Corporate Strategy and Support:
CS/(CS) - Intel is in the business of producing microprocessors -- why get involved with cleaning wafers? Isn't this outside of Intel's core competencies?
(CS) - Intel "told" SilMax to construct a facility in NM when F11 opened -- ability to "walk away" from this arrangement without damaging the long-standing relationship (back to SC days)
CS - Potential for OR reclaim site to justify itself just based on 8" production levels of F15 and D1-B or 12" production levels of D1-B "possible".
CS - Potential in future for D-2 12" production levels -- anticipate production starting in mid-98 and reclaim soon thereafter
(CS) - Ergonomic problems with F4 arrangement

BOTTOM LINE (KS) - Potential for facility re-use highly dependent on corporate support. Numbers appear to justify for all domestic sites but unsure about justification for just OR. Limited requirements for clean room space (i.e., Class 100) makes VLF hoods "possible" as well as lower renovation costs than might otherwise be incurred.

13. Alternative #13: Research and Development Facility

Technical Feasibility and Technical Challenges:
(TC) - Ceiling height and the movement toward larger machines/equipment
(TC) - Limited space
(TC) - "Old" utility supply systems
(TC) - Existing Class 100 air quality (i.e., high technology would probably want a higher clean room environment)

Efficiencies Gained and Efficiencies Lost (including financials):

(EL) - Corporate research is not currently located in OR (except for PTD, per se) -- costs to relocate personnel
EG - "Free building" -- wouldn't have to construct a new one every time Corporate Research wants one

Corporate Strategy and Support:
(CS) - Currently strategy of construct development lab - renovate to production facility seems to be working well --
(CS) - Corporate research and technology development are the "brains" which generate revenue $ later -- why "force" them to do something when they haven't expressed an interest in doing so?
(CS) - Why not construct a new facility at Ronler

BOTTOM LINE (KS) - Corporate wouldn't support unless it found a specialized group that the facility would meet its needs. Nobody has expressed interest so why would it be best to "push" the facility upon a group.

14. Alternative #14: Administrative facilities

Technical Feasibility and Technical Challenges:
TF - lowest ceiling height is 9' -- "normal" administrative space ceiling height is 9'6"
TF - lower air movement requirements (i.e., not as many air handling units are required to move air) and lower # of air changes per hour required
(TC) - "one-way" decision (i.e., if you make into an admin. facility, can you convert it back at minimal cost)
(TC) - need to give up H6 occupancy code
TF/(TC) - air handlers on roof or maintain air handlers in basement (i.e., ductwork cuts into open area and could create additional exit corridors around them)
TF/(TC) - need vs. UBC requirement for bathroom fixtures (i.e., no requirement if adjacent to existing facility with adequate facilities)
TF - high heating load (people) -- large cooling capability existing
TF - little or no humidity constraints above and beyond normal cooling -- existing humidity control "limited"
TF - for an "open area", existing exits appear to meet size and number requirements
TF - existing stairwells (while below 1993 UBC new construction requirements) does meet "rise and run" requirements of renovations of facilities
TF - small existing entrance to facility appears to be able to be re-worked (i.e., the existing column structures are located far enough from the existing entrance to permit re-working the wall)
TF/(TC) - seismic upgrade requirements MAY or MAY NOT be required by Building Official (i.e., lower health hazard but higher occupant loading) -- Intel policy will more than likely require
TF - ability to use as "temporary" admin. facility while AL3 and AL4 are being seismically upgraded
TF - no need for raised floor -- can put carpet tile on slab (i.e., save height requirements)
(TC) - additional parking requirements (i.e., admin. has a higher occupancy load than manufacturing)
TF - exist SS drains and CW systems to support bathrooms in place (from prior admin. functions)
(TC) - additional heating requirements (i.e., people generate less heat than equipment)

Efficiencies Gained and Efficiencies Lost (including financials):
(EL) - Relatively high investment to upgrade facility for admin. (most costs are demolition and workstations) when compared against new construction costs -- potential to gain the same advantages by just using off-site facilities
EG/(EL) - 2Fl versus 1Fl admin. facility? == economies of construction might suggest 2Fl but 1Fl demolition would be extremely high
(EL) - proximity of building to support manufacturing functions -- would generally have to be a non-direct manufacturing support function
EG - property tax relief (minimal)
EG - potential to work utilities to provide emergency power to other facilities
(EL) - potential additional Traffic Impact Fees
(EL) - potential for additional parking to support additional personnel in facility (i.e., higher occupancy than just manufacturing where 90 people per shift)
EG - corporate depreciation tax shield for a number of years (based on 20-39 year lifetime for "new" facilities and 10 years for "upgrade")

EG - lower utility costs and lower maintenance requirements than manufacturing

Corporate Strategy and Support:
CS - Intel policy currently states that <20% should be in off-site facilities (Intel currently has 24% off-site) -- i.e., given data, 11,220 in all of OR == 4% = 450 people; facility (based on 150SF/person) can accommodate 150 single-offices per floor
(CS) - Building probably still won't be able to house more than 400 people after renovation, leaving >20% off-site
(CS) - New 4 floor, 400,000SF office facility at Ronler Acres -- do we really need additional 25,000 SF of office space?
(CS) - Cheaper to build new and larger than renovate old and smaller facility
(CS) - Ability to "buy out" of existing leases at little or no cost?

BOTTOM LINE (KS) - With the announcement of RA2 and the long-term strategic plan for Aloha, the only scenario that would make sense to convert to Admin. would be if F15 were expanded. After reviewing existing plans and "walking around AL3 and AL4", it just doesn't seem like the admin. areas are too "cramped." The same could be said about the need for conference rooms. -- reviewing scheduling and existing rooms "open". Summarize -- corporate would only support if you could create additional manufacturing space on Aloha.

15. Alternative #15: Warehouse (controlled environment and uncontrolled environment)
    (a) Potential stores consolidation point

Technical Feasibility and Technical Challenges:
TF - Low utility requirements (heating/cooling/electricity) if "uncontrolled environment" -- minimal utility requirements if "controlled environment"
(TC) - small elevator, loading dock, annex hallway, and doors to move equipment in and out
TF - Building official wouldn't necessarily require seismic upgrading because of lower occupancy rating and lower hazard (Intel corporate policy would probably still require it)

Efficiencies Gained and Efficiencies Lost (including financials):
EG - Equipment and/or other materials could be stored centrally and easily without the need for "requesting from warehouse" or waiting for delivery from warehouse
(EL) - Warehouse space is generally "cheap"; why sacrifice a complex facility with many capabilities for such a "limited" role?
EG - "Limited" human resource requirements
EG - Would create additional space "near" F15 (for example, F15 stores is located across the hall in the NWS corner) -- F4/F5 stores is located on 1Fl in hallway of AL3 which leads to annex (no "real" need dictating that something move in that area)
EG - Stores "consolidation" might eliminate the need for "duplicate" warehouse parts (i.e., if F5 and F15 share the same part, then both places wouldn't have to keep it in storage)
(EL) - Additional distance to travel for employees

Corporate Strategy and Support:
(CS) - Intel already owns a "normal" warehouse (TW1?) -- why have another?

BOTTOM LINE (KS) - Intel corporate would probably not support because the building would only "buy" you 25,000 SF of space (1FL demolition would be "expensive"), limited access, and a questionable long-term benefit. The only potential the author sees is if moving a warehouse function could create additional fabrication space.

16. Alternative #16: Training Facility
    (a) Internal training

Technical Feasibility and Technical Challenges:

TF - Low ceiling height (no known equipment height limitations)
TF - Little utility requirements (no known requirements other than regular domestic water and perhaps acid drains)
(TC) - Limited use of space (5,000 SF)
TF - Use "in-house" resources and existing tools (in warehouse) to teach -- would only need to pay for shipping of tools (when compared against the "cost" to store for a year)
(TC) - Would this still qualify as H6 classification or would it be required to be "re-zoned"?
(TC) - How to maximize utilities such as to minimize costs (i.e., how much would the facility actually be occupied and what type of utilities would you keep in place to accommodate this -- i.e., more of a "classroom" environment or non-classroom "cleanroom" environment)
TF - Very "limited" construction requirements (minimal if located in diffusion or ion implant areas with high ceilings and existing ductwork that could be modified) but additional construction requirements if in photolithography, wet etch, etc.
(TC) - How to transport equipment to 2Fl (i.e., doors wide enough; small elevator)
(TC) - What to do with 1st Floor -- do you leave all utilities in place or do you demolish them? Can you drain the existing DI water system and leave equipment in place or would they deteriorate when not used (DI requirement is big $)

Efficiencies Gained and Efficiencies Lost (including financials):
EG - Save external training $
(EL)/EG - How to "maximize" for all types of clean room arrangements in OR (i.e., Fab5, Fab15, D1-B)
EG - Very "limited" investment costs and "limited" changes to the facility if you ever decided to go backward to fulfill a manufacturing demand (i.e., once the thing is on-site, you could probably justify putting it anywhere)
(EL) - Why would you put the equipment in a fab if you don't require anything other than cold water, electricity, and drains (i.e., similar to F11's arrangement) -- why wouldn't you just put in next to a function like the ERC?

Corporate Strategy and Support:
CS - Potential for Intel-OR training facility
(CS) - Potential "waste" of Class 100 clean room space -- "can't we find a user?"
CS- Potential "stepping stone" use of space until a user can be found -- are we looking "short term" or "long-term"
(CS) - Can "in-house" training already be performed using existing resources and no dedicated space or can it be done "cheaper" by using other "available" space

BOTTOM LINE (KS) - If no other use is identified for the facility, it seems "justifiable." Only concerns are limited space (i.e., building would have to be multi-functional), manufacturing (H6) zoning, and whether the function can exceed the $500K that it costs to operate the building each year. Otherwise, option appears to have a ROI 20-years down the road. Key decision from management would be (a) are we just trying to find space to put this function or (b) are we willing to invest to make this appear more like a "real fab" to simulate the environment?

17. Alternative #17: Relocate functions -- Non-manufacturing, non-administrative space (i.e., gymnasium, cafeteria/kitchen, child care center)

Technical Feasibility:
(a) Gymnasium space - "feasible" as long as occupant load doesn't exceed 300 occupants
-- ?Author is unsure if Intel medical programs (like HMO) reimburse or subsidize for joining a local health club -- if so, then why would Intel consider building a "larger" gym?
(b) Cafeteria/Kitchen - could only be kitchen (A.3); cafeteria space is A.2.1 and has an occupant load greater than 300
-- infeasible
(c) Child Care Center - "feasible" but probably not corporate supported (i.e., "highly unlikely")
-- need to compare with what's existing in New Mexico to see what's in place
-- ?Is this "potentially" covered under Dependent Care Assistance Program (DCAP) Intel benefits (i.e., $5,000 on a before-tax basis to pay for eligible dependent care expenses)

Summary of Technical Feasibility/Technical Challenges; Efficiencies Gained, Efficiencies Lost; and Corporate Support:
(a) Gym -- basically, none; the reason for expanding into F4 would be to create additional space which is being demanded by current users (it is, however, questionable whether such demand exists other than during lunch time). Heating/air conditioning/bathrooms/lockers/showers would have to be incorporated into the system. Most gyms have televisions or windows so thought would have to be given to this as well.

Advantages -- away from "normal" manufacturing elsewhere in campus; potential to stir up additional interest in exercising among workers if they don't have to wait for machinery; close by; minimal investment

Disadvantages -- definite change in occupancy (kiss H6 good-bye and hello A3); limited ability to turn it back into anything (potentially, B2 office); creates a high traffic area between AL3/AL4 and F4;

BOTTOM LINE (KS) - I'm not sure the demand really exists. If AL were the only site with a gym in OR (and not HF, JF, or RA), I could see it potentially becoming a centralized location (without taking into account projected parking limitations during lunch time). Most sites appear to have facilities in place already. Similarly, the ability to use the existing gym space for something else is "questionable" at best. Its proximity to the cafeteria (which probably isn't able to move except within F15 -- that is, unless F5 is a different construction -- i.e., Type I or Type II and the existing auditorium (which isn't likely to move either) makes it appear "infeasible" as a long-term solution.

(b) Cafeteria/Kitchen - basically UBC limits where the cafeteria can go; Fab 4 is Type III construction and can't support high occupancies (like A2.1)

(c) Child Care Center - basically, a lot of limitations. First, corporate support; secondly, ability to control entrance and exits access (i.e., you don't want 5-yr old walking around F15 cleanroom space and how do you control who comes and goes without a front entrance on F4); thirdly, liability concerns (probably none in Oregon because certification isn't even required); fourthly, willingness to put children in a potentially dangerous environment (i.e., a semiconductor manufacturing site isn't a "safe" place); fifth, an on-site or OR driver for this proposition ((I haven't heard from anyone); sixth, corporate support for starting such a program ("if we do it in OR, do we have to do it everywhere?); seventh, requirement to change occupancy;

BOTTOM LINE (KS) - I really don't think that this proposition would work. The "potential" downsides far outweigh the positives. Risks, requirements to 100% "double check" that everything is non-ingestible, non-flammable, non-harmful, etc. makes a potential nightmare on a site with semiconductor manufacturing.

18. Alternative #18: Employee Resource Center

APPENDIX 2: Direct Comparison of Financial Analyses

NPV (WHL&F4)

	0.365									
Options: Lease vs F4										
Lease Facilities: (including holding	End of Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
"Holding costs" for doing nothing with F4	$475,000	$475,000	$475,000	$475,000	$475,000	$475,000	$475,000	$475,000	$475,000	$475,000
After-Tax Leasing Costs - Net of Tax Effects	$251,460	$251,460	$251,460	$251,460	$251,460	$251,460	$251,460	$251,460	$251,460	$251,460
O&M (Expense) - Net of Tax Effects	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910
Total Costs	$768,370	$768,370	$768,370	$768,370	$768,370	$768,370	$768,370	$768,370	$768,370	$768,370
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$668,148	$580,998	$505,216	$439,318	$382,016	$332,188	$288,859	$251,182	$218,419	$189,929
Cumulative NPV (Cost)	$3,856,271									
Lease Facilities (not including Fab 4 holding	End of Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total Costs	$293,370	$293,370	$293,370	$293,370	$293,370	$293,370	$293,370	$293,370	$293,370	$293,370
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$255,104	$221,830	$192,896	$167,735	$145,857	$126,832	$110,289	$95,903	$83,394	$72,517
Cumulative NPV (Cost)	$1,472,356									
F4 as Warehouse:	End of Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
NBV Asset (1/97)	$900,000	$720,000	$540,000	$360,000	$180,000	$0	$0	$0	$0	$0
Depreciation Charge	$180,000	$180,000	$180,000	$180,000	$180,000	$0	$0	$0	$0	$0
NBV (1/98)	$720,000	$540,000	$360,000	$180,000	$0					

NPV (WHL&F4)

Capital Tax Effects - Depreciation Tax Shield	($65,700)	($65,700)	($65,700)	($65,700)	($65,700)					
Demolition (Expense) - Net of Tax Effects	$174,625									
Capital Improvements to	$82,500									
Capital Tax Effects - Depreciation Tax Shield	($3,011)	($3,011)	($3,011)	($3,011)	($3,011)	($3,011)	($3,011)	($3,011)	($3,011)	($3,011)
Seismic Modifications	$0									
Capital Tax Effects - Depreciation Tax Shield	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O&M (Expense) - Net of Tax Effects	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910
Property Tax (Expense) - Net of Tax Effects	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260
Factory Headcount	$180,000	$183,600	$187,272	$191,017	$194,838	$198,735	$202,709	$206,763	$210,899	$215,117
Total Costs	$458,584	$205,059	$208,731	$212,476	$216,297	$285,893	$289,868	$293,922	$298,057	$302,275
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$398,768	$155,054	$137,244	$121,484	$107,538	$123,600	$108,972	$96,084	$84,727	$74,718
Cumulative NPV (Cost)	$1,408,188									

NPV (D&DN)

Options: Demo vs Do										
Demolition (at End of Year 1):	End of Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
NBV Asset (1/97)	$900,000									
Depreciation Charge (1/97 - 12/97)	$180,000									
NBV (1/98)	$720,000									
Building Asset Write-Off - Net of Tax Effects == NBV of $900K expensed to $0 off books	$457,200									
Capital Tax Effects - Depreciation Tax Shield	($65,700)									
Capital Improvements to Area	$440,000									
Capital Tax Effects - Depreciation Tax Shield	($16,060)	($16,060)	($16,060)	($16,060)	($16,060)	($16,060)	($16,060)	($16,060)	($16,060)	($16,060)
Demolition (Expense) - Net of Tax Effects	$4,445,000									
O&M (Expense) - Net of Tax Effects	$301,625	$6,350	$6,350	$6,350	$6,350	$6,350	$6,350	$6,350	$6,350	$6,350
Property Tax (Expense) - Net of Tax Effects	$48,260	$15,875	$15,875	$15,875	$15,875	$15,875	$15,875	$15,875	$15,875	$15,875
Factory Headcount Support	$270,000									
Total Costs	$5,880,325	$6,165	$6,165	$6,165	$6,165	$6,165	$6,165	$6,165	$6,165	$6,165
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$5,113,326	$4,662	$4,054	$3,525	$3,065	$2,665	$2,318	$2,015	$1,752	$1,524
Cumulative NPV (Cost)	$5,138,906									

NPV (D&DN)

Do Nothing (for an undetermined amount of time):	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
	$1,997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Remaining Capital Improvement Depreciation Charges -- Need to verify this with Finance	$180,000	$180,000	$180,000	$180,000	$180,000					
Capital Tax Effects - Depreciation Tax Shield	($65,700)	($65,700)	($65,700)	($65,700)	($65,700)	$0	$0	$0	$0	$0
O&M (Expense) - Net of Tax Effects	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625
Property Tax (Expense) - Net of Tax Effects	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260
Factory Headcount	$270,000	$283,500	$297,675	$312,559	$328,187	$344,596	$361,826	$379,917	$398,913	$418,859
Total Costs	$554,185	$567,685	$581,860	$596,744	$612,372	$694,481	$711,711	$729,802	$748,798	$768,744
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$481,900	$429,251	$382,582	$341,190	$304,457	$300,243	$267,558	$238,574	$212,855	$190,022
Cumulative NPV (Cost)	$3,148,633									
Do Nothing and not including depreciation:										
Capital Improvement Depreciation Charge	$180,000	$180,000	$180,000	$180,000	$180,000					
Capital Tax Effects - Depreciation Tax Shield	($65,700)	($65,700)	($65,700)	($65,700)	($65,700)	$0	$0	$0	$0	$0
O&M (Expense) - Net of Tax Effects	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625
Property Tax (Expense) - Net of Tax Effects	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260
Factory Headcount Support	$270,000	$283,500	$297,675	$312,559	$328,187	$344,596	$361,826	$379,917	$398,913	$418,859
Total Costs	$619,885	$633,385	$647,560	$662,444	$678,072	$694,481	$711,711	$729,802	$748,798	$768,744

NPV (D&DN)

WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$539,030	$478,930	$425,781	$378,754	$337,121	$300,243	$267,558	$238,574	$212,855	$190,022
Cumulative NPV (Cost)	$3,368,870									
Applicable Data for Incorporation:	End of Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
NBV (Pre-Tax Effects)	$720,000	$540,000	$360,000	$180,000	$0	$0	$0	$0	$0	$0
Potential Depreciation	$180,000	$180,000	$180,000	$180,000	$180,000					
(Expense) Potential Building Write-Off -- Net of Tax Effects	$457,200	$342,900	$228,600	$114,300	$0	$0	$0	$0	$0	$0
(Capital) - Existing Potential Depreciation Tax Shield	($65,700)	($65,700)	($65,700)	($65,700)	($65,700)					
Potential Demolition Costs - Net of Taxes	$4,445,000	$4,533,900	$4,624,578	$4,717,070	$4,811,411	$4,907,639	$5,005,792	$5,105,908	$5,208,026	$5,312,186
Potential Capital Improvement Costs	$440,000	$448,800	$457,776	$466,932	$476,270	$485,796	$495,511	$505,422	$515,530	$525,841
Capital Improvement Depreciation	($16,060)	($16,381)	($16,709)	($17,043)	($17,384)	($17,732)	($18,086)	($18,448)	($18,817)	($19,193)
Factory H/C Support	$270,000	$275,400	$280,908	$286,526	$292,257	$298,102	$304,064	$310,145	$316,348	$322,675
Do Nothing and Demolish at end of Year Two --	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Building Asset Write-Off - Net of Tax Effects		$342,900								
Capital Improvements to Area		$448,800								
Capital Tax Effects - Depreciation Tax Shield		($16,381)	($16,381)	($16,381)	($16,381)	($16,381)	($16,381)	($16,381)	($16,381)	($16,381)

NPV (D&DN)

Demolition (Expense) - Net of Tax Effects		$4,533,900								
Depreciation Tax Shield	($65,700)	($65,700)								
O&M (Expense) - Net of Tax Effects	$301,625	$301,625	$6,350	$6,350	$6,350	$6,350	$6,350	$6,350	$6,350	$6,350
Property Tax (Expense) - Net of Tax Effects	$48,260	$48,260	$15,875	$15,875	$15,875	$15,875	$15,875	$15,875	$15,875	$15,875
Factory H/C Support	$270,000	$275,400								
Total Costs from Above	$554,185	$5,868,804	$5,844	$5,844	$5,844	$5,844	$5,844	$5,844	$5,844	$5,844
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$481,900	$4,437,659	$3,842	$3,341	$2,905	$2,526	$2,197	$1,910	$1,661	$1,444
Cumulative NPV (Cost)	$4,939,387									
Do Nothing and Demolish at end of Year Five --	End of Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Building Asset Write-Off - Net of Tax Effects					$0					
Capital Improvements to Area					$476,270					
Capital Tax Effects - Depreciation Tax Shield					($17,384)	($17,384)	($17,384)	($17,384)	($17,384)	($17,384)
Demolition (Expense) - Net of Tax Effects					$4,811,411					
Capital Tax Effects - Depreciation Tax Shield	($65,700)	($65,700)	($65,700)	($65,700)	($65,700)					
O&M (Expense) - Net of Tax Effects	$301,625	$301,625	$301,625	$301,625	$301,625	$6,350	$6,350	$6,350	$6,350	$6,350
Property Tax (Expense) - Net of Tax Effects	$48,260	$48,260	$48,260	$48,260	$48,260	$15,875	$15,875	$15,875	$15,875	$15,875
Factory H/C Support	$270,000	$275,400	$280,908	$286,526	$292,257					

NPV (D&DN)

Total Costs from Above	$554,185	$559,585	$565,093	$570,711	$5,846,739	$4,841	$4,841	$4,841	$4,841	$4,841
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$481,900	$423,127	$371,558	$326,306	$2,906,863	$2,093	$1,820	$1,583	$1,376	$1,197
Cumulative NPV (Cost)	$4,517,821									
Do Nothing and Demolish at end of Year Eight --	End of Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Building Asset Write-Off - Net of Tax Effects								$0		
Capital Improvements to Area								$505,422		
Capital Tax Effects - Depreciation Tax Shield								($18,448)	($18,448)	($18,448)
Demolition (Expense) - Net of Tax Effects								$5,105,908		
Capital Tax Effects - Depreciation Tax Shield	($65,700)	($65,700)	($65,700)	($65,700)	($65,700)					
O&M (Expense) - Net of Tax Effects	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625	$301,625	$6,350	$6,350
Property Tax (Expense) - Net of Tax Effects	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$48,260	$15,875	$15,875
Factory H/C Support	$270,000	$275,400	$280,908	$286,526	$292,257	$298,102	$304,064	$310,145		
Total Costs from Above	$554,185	$559,585	$565,093	$570,711	$576,442	$647,987	$653,949	$6,252,912	$3,777	$3,777
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$481,900	$423,127	$371,558	$326,306	$286,593	$280,143	$245,844	$2,044,088	$1,074	$934
Cumulative NPV (Cost)	$4,461,565									

NPV (AL&R)

Options: Lease vs. Rehab vs. New										
Assumption: F4's existing depreciation is only taken into account in "rehab"										
Construct New:	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Capital	$3,351,000									
Capital Tax Effects - Depreciation Tax Shield	($31,362)	($31,362)	($31,362)	($31,362)	($31,362)	($31,362)	($31,362)	($31,362)	($31,362)	($31,362)
Construction Indirects (Expense) - Net of Tax Effects	$350,428									
O&M (Expense) - Net of Tax Effects	$71,003	$71,003	$71,003	$71,003	$71,003	$71,003	$71,003	$71,003	$71,003	$71,003
Property Maintenance (Expense) - Net of Tax Effects	$2,540	$2,540	$2,540	$2,540	$2,540	$2,540	$2,540	$2,540	$2,540	$2,540
Property Tax (Expense) - Net of Tax Effects	$63,500	$63,500	$63,500	$63,500	$63,500	$63,500	$63,500	$63,500	$63,500	$63,500
Factory Headcount Support	$360,000	$367,200	$374,544	$382,035	$389,676	$397,469	$405,418	$413,527	$421,797	$430,233
Admin Relocation Expenses - Net of Tax Effects	$13,970									
Total Costs	$4,181,079	$472,881	$480,225	$487,715	$495,356	$503,150	$511,099	$519,207	$527,478	$535,914
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$3,635,720	$357,566	$315,755	$278,853	$246,280	$217,525	$192,141	$169,730	$149,942	$132,470
Cumulative NPV (Cost)	$5,695,982									
Lease Facilities:										
After-Tax Leasing Costs - Net of Tax Effects	$127,406	$127,406	$127,406	$127,406	$127,406	$127,406	$127,406	$127,406	$127,406	$127,406
O&M (Expense) - Net of Tax Effects	$74,740	$74,740	$74,740	$74,740	$74,740	$74,740	$74,740	$74,740	$74,740	$74,740
O&M (Common Maintenance) - Net of Tax Effects	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910	$41,910
Factory Headcount Support	$90,000	$91,800	$93,636	$95,509	$97,419	$99,367	$101,355	$103,382	$105,449	$107,558
Total Costs	$334,056	$335,856	$337,692	$339,565	$341,475	$343,423	$345,411	$347,438	$349,505	$351,614
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$290,483	$253,955	$222,038	$194,147	$169,773	$148,471	$129,853	$113,578	$99,351	$86,914
Cumulative NPV (Cost)	$1,708,564									

NPV (AL&R)

Rehab F4 (including existing building depreciation):										
Capital Improvement Depreciation	$180,000	$180,000	$180,000	$180,000	$180,000					
Capital Tax Effects - Depreciation Tax Shield	($65,700)	($65,700)	($65,700)	($65,700)	($65,700)	$0	$0	$0	$0	$0
Interior Demolition Costs - Net of Tax Effects	$873,125									
New Renovation - Capital Improvement	$1,031,250									
New Capital Tax Effects - Capital Depreciation Tax Shield	($37,641)	($37,641)	($37,641)	($37,641)	($37,641)	($37,641)	($37,641)	($37,641)	($37,641)	($37,641)
New Seismic Modifications - Capital Improvement	$1,100,000									
New Capital Tax Effects - Capital Depreciation Tax Shield	($40,150)	($40,150)	($40,150)	($40,150)	($40,150)	($40,150)	($40,150)	($40,150)	($40,150)	($40,150)
(Expense) - Indirect Expense Costs - Net of Taxes	$394,176									
H/C Relocation Costs - Net of Tax	$13,970									
O&M Costs - Net of Tax Effects	$170,085	$170,085	$170,085	$170,085	$170,085	$170,085	$170,085	$170,085	$170,085	$170,085
Property Taxes - Net of Tax Effects	$63,500	$63,500	$63,500	$63,500	$63,500	$63,500	$63,500	$63,500	$63,500	$63,500
Factory H/C Support Costs	$180,000	$183,600	$187,272	$191,017	$194,838	$198,735	$202,709	$206,763	$210,899	$215,117
Total Costs	$3,682,615	$273,694	$277,366	$281,112	$284,932	$354,529	$358,503	$362,558	$366,693	$370,911
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$3,202,274	$206,952	$182,373	$160,726	$141,662	$153,273	$134,775	$118,521	$104,237	$91,683
Cumulative NPV (Cost)	$4,496,475									
Rehab F4 (not including existing building depreciation):										
Total Costs	$3,748,315	$339,394	$343,066	$346,812	$350,632	$354,529	$358,503	$362,558	$366,693	$370,911
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$3,259,405	$256,631	$225,572	$198,291	$174,326	$153,273	$134,775	$118,521	$104,237	$91,683
Cumulative NPV (Cost)	$4,716,712									

NPV (FR&N)

Options: Lease vs. Rehab vs. New										
Assumption: F4's existing depreciation is only taken into account in "rehab" option										
Construct New:	End of Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital	$71,718,750									
Capital Tax Effects - Depreciation Tax Shield	($671,214)	($671,214)	($671,214)	($671,214)	($671,214)	($671,214)	($671,214)	($671,214)	($671,214)	($671,214)
Construction Indirects (Expense) - Net of Tax Effects	$8,036,719									
O&M (Expense) - Net of Tax Effects	$1,397,000	$1,397,000	$1,397,000	$1,397,000	$1,397,000	$1,397,000	$1,397,000	$1,397,000	$1,397,000	$1,397,000
Property Maintenance (Expense) - Net of Tax Effects	$4,445	$4,445	$4,445	$4,445	$4,445	$4,445	$4,445	$4,445	$4,445	$4,445
Property Tax (Expense) - Net of Tax Effects	$508,000	$508,000	$508,000	$508,000	$508,000	$508,000	$508,000	$508,000	$508,000	$508,000
Wastewater Permitting (Expense) - Net of Tax Effects	$317,500									
Direct Factory Headcount Support-Net of Tax Effects	$13,430,250	$14,101,763	$14,806,851	$15,547,193	$16,324,553	$17,140,780	$17,997,819	$18,897,710	$19,842,596	$20,834,726
Indirect Factory Headcount Support - Net of Tax Effects	$8,032,750	$8,434,388	$8,856,107	$9,298,912	$9,763,858	$10,252,051	$10,764,653	$11,302,886	$11,868,030	$12,461,432
Total Costs	$102,774,200	$23,774,381	$24,901,189	$26,084,336	$27,326,642	$28,631,062	$30,000,704	$31,438,827	$32,948,857	$34,534,389
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$89,368,869	$17,976,848	$16,372,936	$14,913,804	$13,586,171	$12,377,998	$11,278,376	$10,277,408	$9,366,122	$8,536,373

NPV (FR&N)

Cumulative NPV (Cost)	$204,054,904									
Rehab F4 (including existing building depreciation):										
Existing Capital Improvement Depreciation Charges	$180,000	$180,000	$180,000	$180,000	$180,000					
Capital Tax Effects - Depreciation Tax Shield	($65,700)	($65,700)	($65,700)	($65,700)	($65,700)					
Interior Demolition Costs - Net of Tax Effects	$5,238,750									
New Renovation - Capital Improvement	$34,650,000									
New Capital Tax Effects - Capital Depreciation Tax Shield	($1,264,725)	($1,264,725)	($1,264,725)	($1,264,725)	($1,264,725)	($1,264,725)	($1,264,725)	($1,264,725)	($1,264,725)	($1,264,725)
New Seismic Modifications - Capital Improvement	$1,100,000									
New Capital Tax Effects - Capital Depreciation Tax Shield	($40,150)	($40,150)	($40,150)	($40,150)	($40,150)	($40,150)	($40,150)	($40,150)	($40,150)	($40,150)
(Expense) - Indirect Expense Costs - Net of Taxes	$4,610,100									

NPV (FR&N)

O&M Costs - Net of Tax Effects	$1,606,550	$1,606,550	$1,606,550	$1,606,550	$1,606,550	$1,606,550	$1,606,550	$1,606,550	$1,606,550	$1,606,550
Property Taxes - Net of Tax Effects	$317,500	$317,500	$317,500	$317,500	$317,500	$317,500	$317,500	$317,500	$317,500	$317,500
Wastewater Permitting (Expense) - Net of Tax Effects	$317,500									
Direct Factory Headcount Support-Net of Tax Effects	$13,430,250	$14,101,763	$14,806,851	$15,547,193	$16,324,553	$17,140,780	$17,997,819	$18,897,710	$19,842,596	$20,834,726
Indirect Factory Headcount Support - Net of Tax Effects	$8,032,750	$8,434,388	$8,856,107	$9,298,912	$9,763,858	$10,252,051	$10,764,653	$11,302,886	$11,868,030	$12,461,432
Total Costs	$67,932,825	$23,089,625	$24,216,433	$25,399,580	$26,641,886	$28,012,006	$29,381,648	$30,819,771	$32,329,801	$33,915,332
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$59,072,022	$17,459,074	$15,922,697	$14,522,293	$13,245,726	$12,110,363	$11,045,650	$10,075,038	$9,190,147	$8,383,351
Cumulative NPV (Cost)	$171,026,361									
Rehab F4 (not including existing building depreciation):										
Total Costs	$67,998,525	$23,155,325	$24,282,133	$25,465,280	$26,707,586	$28,012,006	$29,381,648	$30,819,771	$32,329,801	$33,915,332
WACC (adjusted for year)	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05
NPV (Cost)	$59,129,152	$17,508,752	$15,965,896	$14,559,857	$13,278,390	$12,110,363	$11,045,650	$10,075,038	$9,190,147	$8,383,351

APPENDIX 3: Background Information for Financial Analyses

	0.365				
Lease Costs and associated tax shields					
Option #1: Continue to Lease Warehouse Facilities (totaling 22,000 SF of Administrative Space)					
(Existing Expense) Leasing Costs -- Cost/SF (use 22,000 SF as basis for comparison) ; $1.50/SF/month x 12 months/yr = $18/SF/year;	SF	$18.00	22,000	$396,000	
(Existing Expense Tax Shield) - Annual Tax Shield for Leasing Costs				($144,540)	
After-Tax Leasing Costs	$251,460				
Note: Full leasing costs will be a deductible expense					
Note: After Tax Cost = Lease Payment - Tax Savings					
Note: After Tax Cost = Lease Payment x (1 - Tax Rate)	$251,460				
Note: Lease payments are based on 3 year leases without inflation adjusted costs					
Note: This does not take into account inflation					
(Existing Expense) Annual Utility Costs:					
Note: Based on estimated facilities costs == $3.00/SF/year	SF	$3.00	22,000	$66,000	
(Existing Expense) Tax Shield from Utility Costs				($24,090)	
Note: Tax Shield might already be taken into account since this condition already exists					
Option #2: Convert 2FL of F4 to Warehouse (Minimal Renovation)					
(Based on estimated spreadsheet costs (subcontractors) + prime cost (Baugh-25%)					
(Expense) 2FL Demolition Costs	LS			$250,000	
Note: Based on estimates					
(Expense) 2FL Contingency		10%		$25,000	
Subtotal				$275,000	
(Expense Shield) - Tax Shield for Demolition Costs				($100,375)	
(Capital) 2FL Renovation Costs				$75,000	
(Capital) 2FL Contingency		10%		$7,500	

Warehouse, L&F4

Subtotal				$82,500	
(Capital Shield) - Annual Depreciation Charge for Renovation Expenses				$8,250	10 years
Note: Based on zero salvage value;					
(Capital Tax Shield) - Annual Depreciation Tax Shield for Renovation				($3,011)	
(Capital) - Seismic Modifications:				$0	
(Capital) - Seismic Contingency		10%		$0	
Subtotal				$0	
(Capital Shield) - Annual Depreciation Charge for Seismic Modifications				$0	
(Capital Tax Shield) - Annual Depreciation Tax Shield for Seismic Modifications				$0	
Note: Unsure whether this would be a "sunk" cost -- that is, if you do ANYTHING in Fab 4, seismic modifications will be required by Intel policy and/or building code					
(Existing Expense) Annual Utility Costs:					
Note: Based on estimated facilities costs == $3.00/SF/year	SF	$3.00	22,000	$66,000	
(Existing Expense) Tax Shield from Utility Costs				($24,090)	
(Expense) Annual Property and Building Taxes					
Note: Potential existing property tax for re-classified warehouse shell without any equipment = $19K/quarter = $76/yr					
Note: Estimate potential existing property tax for re-classified administrative facility as $25K/quarter = $100K/yr	LS			$76,000	
(Expense) Tax Shield from Property Taxes				($27,740)	
Existing H/C Intel Support Costs					
Note: Based two GSS persons (Security already exists on site)					
(Existing Expense) Existing Intel H/C Support (GSS)	LS	$90,000	2	$180,000	
Note: No Tax Shield from non-Intel H/C support because they already exist on the books				$0	

"Quick" Cost Analyses:						
Financial Assumptions:	**Data Value**					
Based on After-Tax (AT) Cash Flows						
Based on Real $ (that is, costs of inflation are not directly taken into account, except that any increase in cost according to inflation will result in a corresponding increase in the expense tax shield)						
Positive values are "costs" and negative values are "savings" or "negative costs"						
WACC (Discount Rate) = 15% for "Go vs. No Go" decisions (Standard Intel Rate)	0.15					
Corporate Tax Rate = 36.5%	0.365					
New Bldg Construction Depreciation Period - 20 years (Admin) and 39 years (Fab)	39					
Renovations to Existing Building Depreciation Period - 10 years	10					
Equipment Depreciation Period - 4 years						
No Land Acquisition Costs -- new facility would be constructed on RA						
Salvage Value(s) = $ 0	0					
Construction Costs are expected to rise 2% per year						
Comparison #1a: Demolish F4	**UNIT**	**COST**		**COST**	**TOTAL**	**Source**
(Expense) Demolition Costs	LS			$7,000,000		KS Estimate
(Expense Tax Shield) - Demolition Expense				($2,555,000)		
(Capital) Site Re-Development Costs	SF	$20	22,000	$440,000		JB Estimate
(Capital) - Annual Depreciation				$44,000		
(Capital Tax Shield) - Annual Depreciation Tax Shield				($16,060)		
(Expense) Incremental Change in Annual Operating and Maintenance Costs (ie, Grounds, Sprinklers, etc) - based on $5K/month for entire campus today	LS			$10,000		KS Estimate
(Expense Tax Shield) - Incremental Tax Shield Increase in Annual Operating and Maintenance Costs				($3,650)		
Note: Estimate annual potential property tax for site with no building on it = $25K/yr ($1/SF/year for commercial property)						
(Expense) - Annual Property Tax (Property Alone)				$25,000		
(Expense Tax Shield) - Annual Tax Shield for Property Tax Expenses				($9,125)		
Comparison #1b: Do Nothing for x Years	**UNIT**	**COST**		**COST**	**TOTAL**	**Source**
(Existing Expense) - Annual Operating Expenses (based on existing unoccupied state)	LS			$475,000		J. Ptacek

Demo&Do Nothing, Cap&Expense

(Existing Expense Tax Shield) - Annual Operating Expenses	LS			($173,375)		
(Existing Shield) - Dept 5401 Depreciation -- based on 1/1/97 NBV of $900,000 for all capital improvements remaining on the building				$900,000		
(Existing Shield) - Estimated Building Renovations Depreciation				$180,000		
Note: Estimate over 5 years remaining; $0K salvage value;						
(Existing Depreciation Tax Shield) - Dept 5401 Depreciation Tax Shield				($65,700)		
Note: Existing property tax for H6 fab is $69K/quarter = $276K/yr						8/15 notes
Note: Potential existing property tax for re-classified warehouse shell without any equipment = $19K/quarter = $76/yr						8/15 notes
(Existing Expense) - Annual Property Tax (Bldg in H6 unoccupied state)				$76,000		
(Existing Tax Shield) - Annual Property Tax Shield				($27,740)		
Existing H/C - GSS Support == Factory Headcount Support based on 3 assigned individuals	Ea	$90,000	3	$270,000		
Note: No effect on expense tax shields because individuals already are employed by Intel						

"Quick" Cost Analyses:					
Financial Assumptions:	**Data Value**				
Based on After-Tax (AT) Cash Flows					
Based on Real $ (that is, costs of inflation are not directly taken into account, except that any increase in cost according to inflation will result in a corresponding increase in the expense tax shield)					
WACC (Discount Rate) = 15% for "Go vs. No Go" decisions (Standard Intel Rate)	0.15				
Corporate Tax Rate = 36.5%	0.365				
Construction Costs increase at 5% per year	0.5				
New Bldg Construction Depreciation Period - 20 years	20				
Renovations to Existing Building Depreciation Period - 10 years	10				
Equipment Depreciation Period - 4 years	4				
Salvage Value(s) = $ 0	$0				
Operating Functions are Non-Revenue Generating - hence, look at ALL tax effects					
Intel H/C includes 2% annual pay raise					
Option #1: Construct New, 1FL, 28,000 SF (22,000 SF Usable Admin Space) Administration Facility at RA	**UNIT**	**COST**		**COST**	**TOTAL**
(Capital) Construct New 1FL facility at RA	SF	$100.00	28,000	$2,800,000	
(Capital) Construct New Contingency	LS	5%		$140,000	
Size/Cost Multiplier		5%		$147,000	
Note: Normal size for administration facility is based on larger footprint (ie, no construction economies of scale -- need to adjust)					
Parking lot and lighting construction	Stalls	$1,200.00	220	$264,000	
Note: Based on (22,000 SF)/(100 SF/person) = 220 persons					
(Capital) Land Acquisition Costs				$0	
Subtotal				$3,351,000	
(Capital Shield) Annual Depreciation				$85,923	
(Capital Tax Shield) - Annual Depreciation Tax Shield				($31,362)	
Note: Based on 39 year depreciation period for bldg; straight-line; no salvage value					
(Expense - Indirects) Architect-Engineering Design Costs (New Construction)	LS	6.50%		$217,815	
(Expense - Indirects) Construction Management Costs (New Construction)	LS	4%		$134,040	
(Expense - Indirects) Permitting and fees	LS			$200,000	
Subtotal				$551,855	
(Expense Tax Shield) - Tax Shield from Indirects				($201,427)	

(Expense) Annual Utility Costs					
Note: Based on existing AL3 & AL4 costs ($5.35/SF/year) and reduced 5% for newer construction and lower fees	SF	$5.08	22,000	$111,815	
(Expense Shield) Tax Shield from Utility Costs				($40,812)	
(Expense) Annual Property Maintenance and Support					
Note: Based on 43,560 SF per acre == estimate 0.5 acre for building and 1.0 acres for support (including parking and roads)					
Note: Based on existing AL site ($60K/yr) for approximately 16 acres of building and 32 acres of parking and grass (not including new east parking lot and "soon to be developed" west parking lot) == ratio of 2:1 parking to building space & $2,000/ac/year	AC	$2,000.00	2	$4,000	
(Expense Shield) Tax Shield from Maintenance and Support Costs				($1,460)	
(Expense) Annual Property and Building Taxes					
Note: Potential existing property tax for re-classified warehouse shell without any equipment = $19K/quarter = $76/yr					
Note: Estimate potential existing property tax for re-classified administrative facility as $25K/quarter = $100K/yr	LS			$100,000	
(Expense) Tax Shield from Property Taxes				($36,500)	
(Expense) Wastewater Discharge Permitting Costs	LS			$0	
Note: Assume current RA discharge permit can assume the additional "minimal" wastewater discharge of an administration facility without requiring an increase in the permit					
Existing H/C Non-Intel and Intel Support Costs					
Note: Based on a dedicated security personnel assigned to an "unattached" facility and three GSS persons					
(Existing Expense) Existing non-Intel H/C Support (GSS) - Security	Ea	$90,000	4	$360,000	
Note: No Tax Shield from non-Intel H/C support because they already exist on the books				$0	
Existing H/C Intel Relocation Costs					
(Expense) Relocating offices (Tri-County Moving) - 220 persons	Office	$100.00	220	$22,000	
(Expense Shield) Tax Shield for relocating offices				($8,030)	

Option #2: Continue to Lease Administration Facilities (totaling 22,000 SF of Administrative Space)					
(Existing Expense) Leasing Costs -- Cost/SF (use 22,000 SF as basis for comparison) ; $0.49/SF/month - $0.76/SF/month == estimate $0.76/SF/month x 12 months/yr = $9.12/SF/year;	SF	$9.12	22,000	$200,640	
Note: WSJ average nationwide cost = $19.00/SF/year					
(Existing Expense Tax Shield) - Annual Tax Shield for Leasing Costs				($73,234)	
After-Tax Leasing Costs	$127,406				
Note: Full leasing costs will be a deductible expense					
Note: After Tax Cost = Lease Payment - Tax Savings					
Note: After Tax Cost = Lease Payment x (1 - Tax Rate)	$127,406				
Note: Lease payments are based on 3 year leases without inflation adjusted costs					
Note: This does not take into account inflation					
(Existing Expense) Annual Utility Costs:					
Note: Based on similar "admin" facilities costs -- AL3 & AL4 SF (136,000 SF + 181,000 SF = 317,000 SF) and FY95 Utility Costs ($1.7M) == $5.35/SF/year	SF	$5.35	22,000	$117,700	
(Existing Expense) Tax Shield from Utility Costs				($42,961)	
Note: Tax Shield might already be taken into account since this condition already exists					
(Existing Expense) Common Maintenance Costs -- based on $0.25/SF/month (average) == $0.25 x 12 months = $3.00/SF/month	SF	$3.00	22,000	$66,000	
(Existing Expense) Tax Shield from CAM Costs				($24,090)	
(Expense) Existing non-Intel H/C Support (GSS) - Security	Ea	$90,000	1	$90,000	
(Existing Expense) Tax Shield from non-Intel H/C support				$0	
Option #3: Convert 2FL of F4 to Administration Facility (Renovate)					
(Based on estimated spreadsheet costs (subcontractors) + prime cost (Baugh-25%)					
(Expense) 2FL, Interstitial, and Roof Demolition Costs	LS			$1,250,000	
Note: Based on estimates					
(Expense) 2FL Contingency		10%		$125,000	

Subtotal				$1,375,000	
(Expense Shield) - Tax Shield for Demolition Costs				($501,875)	
(Capital) 2FL Renovation Costs					
Note: Based on estimates and relocating existing office furniture == office furniture is a MAJOR expense	LS		22,000	$937,500	
(Capital) 2FL Contingency		10%		$93,750	
Subtotal				$1,031,250	
(Capital Shield) - Annual Depreciation Charge for Renovation Expenses				$103,125	10 years
Note: Based on zero salvage value;					
(Capital Tax Shield) - Annual Depreciation Tax Shield for Renovation				($37,641)	
(Capital) - Seismic Modifications:				$1,000,000	
(Capital) - Seismic Contingency		10%		$100,000	
Subtotal				$1,100,000	
(Capital Shield) - Annual Depreciation Charge for Seismic Modifications				$110,000	
(Capital Tax Shield) - Annual Depreciation Tax Shield for Seismic Modifications				($40,150)	
Note: Unsure whether this would be a "sunk" cost -- that is, if you do ANYTHING in Fab 4, seismic modifications will be required by Intel policy and/or building code					
(Expense - Indirects) Architect-Engineering Design Costs (Renovation)	LS	8.00%		$280,500	
(Expense - Indirects) Construction Management Costs (New Construction)	LS	4%		$140,250	
(Expense - Indirects) Permitting and fees	LS			$200,000	
Subtotal				$620,750	
(Expense Tax Shield) - Tax Shield from Indirects				($226,574)	
Existing H/C Intel Relocation Costs:					
(Expense) - Relocating offices (Tri-County Moving) - 220 persons	Office	$100.00	220	$22,000	
(Expense Shield) - Tax Shield for relocating offices				($8,030)	
(Expense) Annual Utility Costs -- Note: Should be more than single story admin facility but UNSURE whether to also take into account existing $475K estimate for "do nothing" -- assume that it will be half-way between (ie, once machines are turned off)					
Note: Based on similar "admin" facilities costs -- AL3 & AL4 SF (136,000 SF + 181,000 SF = 317,000 SF) and FY95 Utility Costs ($1.7M) == $5.35/SF/year (vs. $425K/22KSF = $19/SF/year)	SF	$12.18	22,000	$267,850	
(Existing Expense) Tax Shield from Utility Costs				($97,765)	

(Expense) Annual Property and Building Taxes					
Note: Potential existing property tax for re-classified warehouse shell without any equipment = $19K/quarter = $76/yr					
Note: Estimate potential existing property tax for re-classified administrative facility as $25K/quarter = $100K/yr	LS			$100,000	
(Expense) Tax Shield from Property Taxes				($36,500)	
(Expense) Wastewater Discharge Permitting Costs	LS			$0	
Note: Assume current AL discharge permit can assume the additional "minimal" wastewater discharge of an administration facility without requiring an increase in the permit == hence, already included in O&M costs					
Existing H/C Non-Intel and Intel Support Costs					
Note: Based three GSS persons (Security already exists on site)					
(Existing Expense) Existing Intel H/C Support (GSS)	LS			$180,000	
Note: No Tax Shield from non-Intel H/C support because they already exist on the books				$0	

"Quick" Cost Analyses:					
Based on After-Tax (AT) Cash Flows					
Positive values are "costs" and negative values are "savings" or "negative costs"					
WACC (Discount Rate) = 15% for "Go vs. No Go" decisions (Standard Intel Rate)	0.15				
Corporate Tax Rate = 36.5%	0.365				
Construction Costs increase at 2% per year	0.5				
New Bldg Construction Depreciation Period - 20 years (admin) & 39 years (fab)	39				
Renovations to Existing Building Depreciation Period - 10 years	10				
Equipment Depreciation Period - 4 years	4				
No Headcount (H/C) Changes (ie, no "hirings" and no "firings")					
No Land Acquisition Costs -- new facility would be constructed on RA					
Salvage Value(s) = $ 0	$0				
Miscellaneous Cost Information:					
Clean Room Shell	SF	$300	22,000		$6,600,000
Clean Room Buildout	SF	$2,075	22,000		$45,650,000
Primary Shell	SF	$230	22,000		$5,060,000
Primary Buildout	SF	$1,040	22,000		$22,880,000
Building Systems Shell	SF	$135	22,000		$2,970,000
Building Systems Buildout	SF	$815	22,000		$17,930,000
Fixed Space Shell	SF	$230	22,000		$5,060,000
Fixed Space Buildout	SF	$815	22,000		$17,930,000
Office Space	SF	$165	5,000		
Option #1: Construct New Class 1 Facility (22,000 SF of Fabrication Space) at Ronler Acres (100,000 SF of Total Space)	**UNIT**	**COST**		**TOTAL**	**Source**
Total New Facility Construction Costs (Direct and Indirect Costs)	SF	$3,750	22,000	$82,500,000	FCT
Total New Administration Facility Construction Costs	SF	$125	15,000	$1,875,000	
Land Acquisition Costs				$0	
Subtotal (Direct and Indirect Costs)				$84,375,000	
(Expense - Indirects) Architect-Engineering Design Costs (New Construction)	LS	$0		$5,484,375	
(Expense - Indirects) Construction Management Costs (New Construction)	LS	$0		$3,375,000	

Class 1 (F4&New) Cap&Expense

(Expense - Indirects) Permitting and fees	LS	$0		$3,796,875	
Subtotal (Indirects)				$12,656,250	
(Expense Tax Shield) - Tax Shield from Indirects				($4,619,531)	
(Capital) - Subtotal (Direct Costs)				$71,718,750	
(Capital Shield) Annual Depreciation				$1,838,942	
(Capital Tax Shield) - Annual Depreciation Tax Shield				($671,214)	
Note: Based on 39 year depreciation period for bldg; straight-line; no salvage value					
(Expense) Annual Utility Costs					
Note: Based on estimate of $100/SF/year for fab space	SF	$100	22,000	$2,200,000	
(Expense Shield) Tax Shield from Utility Costs				($803,000)	
(Expense) Annual Property Maintenance and Support					
Note: Based on 43,560 SF per acre == estimate 1.5 acre for building and 2.0 acres for support (including parking and roads)					
Note: Based on existing AL site ($60K/yr) for approximately 16 acres of building and 32 acres of parking and grass (not including new east parking lot and "soon to be developed" west parking lot) == ratio of 2:1 parking to building space & $2,000/ac/year	AC	$2,000	3.50	$7,000	
(Expense Shield) Tax Shield from Maintenance and Support Costs				($2,555)	
(Expense) Annual Property and Building Taxes					
Note: Existing Property Taxes are based on building itself as well as equipment value inside. Since we assume we'd be installing the same equipment, only the building shell property tax should matter (ie, ignore the value of any equipment inside)					
Note: Estimate potential existing property tax for new fabrication facility shell as $200K/quarter = $800K/yr (NLT 1% of GBV - $80M)	LS			$800,000	
(Expense) Tax Shield from Property Taxes				($292,000)	
(Expense) Wastewater Discharge Permitting Costs	LS				
Note: Assume current RA discharge permit cannot assume the additional wastewater discharge of a manufacturing facility without requiring an increase in the permit -- estimate based on 200 gpm requirement	LS			$500,000	
(Expense Shield) Tax Shield from Wastewater Permitting Costs				($182,500)	

Class 1 (F4&New) Cap&Expense

(Expense) - New Factory H/C Support Costs - Direct Headcount	Ea	$90,000	235	$21,150,000	
Note: Based on Direct Headcount per shift equivalent to F15 (800 SSTs/75,000 SF) x 22,000 SF = 235 SSTs (60/shift) == all new hires to Intel					
(Expense Shield) Tax Shield from Direct Factory H/C				($7,719,750)	
(Expense) - New Factory H/C Support Costs - Indirect Headcount (including GSS)	Ea	$110,000	115	$12,650,000	
Note: Based on 2 Indirect H/C per 1 Direct H/C == 115					
(Expense Shield) Tax Shield from Indirect Factory H/C				($4,617,250)	
Option #2: Rehab F4 for Class 1 Manufacturing Operations					
(Expense) - 1FL, 2FL, Interstitial, and Roof Demolition Costs	LS			$7,500,000	
Note: Based on estimates					
(Expense) - Contingency		10%		$750,000	
Subtotal				$8,250,000	
(Expense Shield) - Tax Shield for Demolition Costs				($3,011,250)	
(Capital) - Fab Class 1 Renovation Costs	SF	$1,500	22,000	$33,000,000	
Note: Based on estimates from background information					
(Capital) - Contingency		5%		$1,650,000	
Subtotal				$34,650,000	
(Capital Shield) - Annual Depreciation Charge for Renovation Expenses					
Note: Based on zero salvage value; 10 year improvement period				$3,465,000	
(Capital Tax Shield) - Annual Depreciation Tax Shield for Renovation				($1,264,725)	
(Capital) - Seismic Modifications:				$1,000,000	
(Capital) - Seismic Contingency		10%		$100,000	
Subtotal				$1,100,000	
(Capital Shield) - Annual Depreciation Charge for Seismic Modifications				$110,000	
(Capital Tax Shield) - Annual Depreciation Tax Shield for Seismic Modifications				($40,150)	
Note: Unsure whether this would be a "sunk" cost -- that is, if you do ANYTHING in Fab 4, seismic modifications will be required by Intel policy and/or building code					
(Expense - Indirects) Architect-Engineering Design Costs (Renovation)			8.00%	$3,520,000	
(Expense - Indirects) Construction Management Costs (New Construction)			4.00%	$1,760,000	
(Expense - Indirects) Permitting and fees			4.50%	$1,980,000	

Subtotal				$7,260,000	
(Expense Tax Shield) - Tax Shield from Indirects				($2,649,900)	
(Expense) Annual Utility Costs -- Note: Based on historical utility costs ($1.7M for 22,000 SF of clean room space) x 1.25 for Class 1 = $100/SF/yr x 1.15 (for "unideal" arrangement and potential re-use of existing equipment)	SF	$115	22,000	$2,530,000	
(Existing Expense) Tax Shield from Utility Costs				($923,450)	
(Expense) Annual Property and Building Taxes					
Note: Existing Property Taxes are based on building itself as well as equipment value inside. Since we assume we'd be installing the same equipment, only the building shell property tax should matter (ie, ignore the value of any equipment inside)					
Note: Estimate potential existing property tax for new fabrication facility shell as $125K/quarter = $500K/yr (NLT 1% of GBV - $40M$)	LS			$500,000	
(Expense) Tax Shield from Property Taxes				($182,500)	
(Expense) Wastewater Discharge Permitting Costs	LS				
Note: Current AL campus discharge permit cannot assume the additional wastewater discharge of a manufacturing facility without requiring an increase in the permit -- estimate based on 200 gpm requirement	LS			$1,100,000	
(Expense Shield) Tax Shield from Wastewater Permitting Costs				($401,500)	
(Expense) - New Factory H/C Support Costs - Direct Headcount	Ea	$90,000	235	$21,150,000	
Note: Based on Direct Headcount per shift equivalent to F15 (800 SSTs/75,000 SF) x 22,000 SF = 235 SSTs (60/shift) == all new hires to Intel					
(Expense Shield) Tax Shield from Direct Factory H/C				($7,719,750)	
(Expense) - New Factory H/C Support Costs - Indirect Headcount (including GSS)	Ea	$110,000	115	$12,650,000	
Note: Based on 2 Indirect H/C per 1 Direct H/C == 115					
(Expense Shield) Tax Shield from Indirect Factory H/C				($4,617,250)	

Class 1 Clean Room Data (based on 1989 data)			
(Adjustment for 1990 - 1997 CPI)	1.35		
(Adjustment for 1990-1997 Construction Cost Increase) - based at 5% per year	1.41		
Final Cost (Total Direct Costs and Total Indirect Costs) - 1990	$77,300,000		
Final Cost (Total Direct Costs and Total Indirect Costs) - 1990	$108,768,863	$4,476.08	
Total of Indirect Costs	$10,700,000		
Total of Direct Cost	$66,600,000		
Total Construction Time	20 months		
Actual to Budget Cost	1.20		
Total Size	229,700 SF		
Class 1 Clean Room Size	24,300		
Estimate of Cost/SF for Class 1	$3,181		
(NOTE: This is based solely on all costs spread out for the clean room area)			
	Original (SF)	Build Out (SF)	
Process Clean Room (Class 1) - includes both bays and chases	24,300	36,700	
Semi-Clean Fab Support (Class 10 to 1,000)	15,100		
Class 10 (Gown Room, Vestibule)	2,780		
Class 100			
Class 1,000	12,320		
Non-Clean Fab Support (Sub-Fab and Chem Rooms)	33,500		
Mechanical and Electrical Space	25,800		
(NOTE: This includes penthouse and above)			
Miscellaneous			
New Construction: Costs as a Percentage of Total Direct Cost		*Percentage*	
Cost Code #1: Clean Room Areas	$8,000,000	11.94%	
Cost Code #2: Site Work	$790,000	1.18%	
Cost Code #3: Shell	$14,900,000	22.24%	
Cost Code #4: Finishes	$6,500,000	9.70%	
Cost Code #5: Mechanical	$30,000,000	44.78%	
(NOTE: Includes $4M of process pipe indirects)			38.81%
Cost Code #6: Electrical	$3,500,000	5.22%	
Cost Code #7: Furniture	$300,000	0.45%	
Cost Code #8: Fit-Up and Communications	$1,700,000	2.54%	
Cost Code #9: Landscape and Parking	$1,300,000	1.94%	
	$66,990,000	100.00%	
New Construction: Costs as a Percentage of Floor			

	$66,990,000	100.00%	
New Construction: Costs as a Percentage of Floor			
Subfab Area			
Fabrication Area			
Exhaust Penthouse			
"Potential" Applicable Costs to Fab 4 Renovation:			
Cost Code #1:			
*NOTE: Some costs have been changed according to Subcontractor/Contractor Evaluation Sheets			
Clean Room Components:	Class 1/10	Class 1000	
*Mipolam Flooring (assuming this is flooring underneath raised floor)	$2,100,000	$70,000	
Access Flooring - Raised Floor (assuming this includes "open grating" and "perforated" panels)	$970,000		
Clean Room Walls	$1,500,000	$40,000	
*HEPA Ceiling	$2,000,000	$410,000	
Clean Paks/Fan Coils - Clean Room	$1,920,000	$310,000	
Mechanical	$490,000	$40,000	
*Electrical	$425,000	$65,000	
Subtotal	$9,405,000	$930,000	
Estimate of Cost/SF of Clean Room Components	$347	$75	
Estimate of General Cost/SF of Clean Room Components	$425		
Cost Code #3:	Class 1	Other	
Roof Deck	$55,000	$130,000	
Roofing (Single-ply membrane with ballast rock)	$200,000	$420,000	
Estimate of Cost/SF of Re-Roofing (based on 36KSF roof)	$6.95		
Cost Code #4 and Cost Code #7:	Class 1	Other	
Exterior/Interior Doors and Windows (assuming these are clean room windows)	$160,000	$590,000	
Air Showers/Sliding Doors	$300,000	Level 3 - $200K	
Gown and Shoe Change Furnishings	$200,000		
Painting	$175,000		
Rest Rooms	1,528	$20,000	
Estimate of cost/SF for bathrooms		$13.09	
Miscellaneous Furnishings		$90,000	

Subtotal	$1,535,000		
Estimate of Cost/SF	$63.17		
Cost Code #5 (HVAC, Plumbing, Fire Protection):			
Heating and Cooling Systems (Chillers, Boilers, Pumps, Towers, and Installation)	$1,400,000		
Make Up Air Handling (MUAH) Equipment and Installation	$910,000		
All Piping	$2,340,000		
All Ducting	$1,120,000		
Controls Hardware	$3,200,000		
Test and Balance	$300,000		
Scrubber Ducting	$1,300,000		
Solvent Exhaust Ducting	$200,000		
Miscellaneous (Dumbwaiter)	$35,000	Level 3	
Subtotal	$10,805,000		
Estimate of Cost/SF	$445		
Cost Code #5 (Process Piping):			
Stainless Piping	$5,800,000		
Non-Stainless (Excluding DI, BCD, and Waste)	$2,900,000		
Bulk Chemical Distribution	$700,000		
Waste Systems (AWN, Solvent, HF, and nR resist)	$2,600,000		
Subtotal	$12,000,000		
Estimate of Cost/SF	$494		
Cost Code #6 (Electrical) and Cost Code #8 (Security, Fire, Autocall):			
Fire Alarm Systems	$620,000		
Lighting Fixtures/Distribution	$930,000		
Subtotal	$1,550,000		
Estimate of Cost/SF	$64		
TOTAL ESTIMATE OF COST/SF applicable to renovation of F4 assuming no re-use of existing piping, air handlers, exhaust, etc.	**$1,498**		
Total Estimate of Cost/SF using "some"	$1,250		
Cost Code #10 (Indirects):			
A/E Fees	$5,004,000	0.064734799	6.50%
Construction Management Fees	$2,650,000	0.034282018	4%
General Conditions (Mobilization, Rentals, Insurance (Bonds), etc)	$1,500,000	0.019404916	2%

Testing and QC	$500,000	0.006468305	1%
Fees and Permits	$1,000,000	0.012936611	1.50%
Contingency (New Construction) - as a percentage of Direct Costs			8.64%
"Potential" Non-Applicable Costs to Fab 4 Renovation:			
Cost Code #2 and Cost Code #9: Site Utilities, Paving, and Landscape	$2,100,000		
Cost Code #3: Building Shell (Concrete, Steel, Fireproofing)	Class 1	Other	
	$5,645,000	$8,450,000	
Cost Code #4 (Interior Finishings) and Cost Code #7 (Furnishings)	$863,472	$4,399,987	
Cost Code #5 (Mechanical)			
Domestic Plumbing	$590,000		
Scrubber Equipment and Installation	$230,000		
Solvent Exhaust Fans and Installation	$150,000		
Fire Protection	$900,000		
RO/DI	$5,200,000		
Cost Code #6 (Electrical) and Cost Code # 8 (Security, Fire, and Autocall):	$3,650,000		

APPENDIX 4: Fab 4 Summary Table

		Alternative #1	Alternative #2	Alternative #3	Alternative #4	Alternative #5	Alternative #6:			
		Demolish and build new fac	Demolish and convert to par spaces (parking deck)	Demolish and retain land foi (or to-be-defined) use	Status Quo- mothball facility retain for future undefined u	Lease (sell) facility (property outside client	Semiconductor manufacturir facility for on-site operation: constraint processing (lithog	Direct Manufacturing Constı processing (Fab 5 annelva)	Direct Manufacturing Constı processing (ion implantation	Direct Manufacturing Constı processing (diffusion)
Tech	Size - Known Square Footage Requirements						10,000 SF	5,000 SF	7,500 SF	7,500 SF
	Type of Environment Required					Class 100	Class 1, Class 10	Class 1, Class 10	Class 1, Class 10	Class 1, Class 10
	Occupany Code Requirements						H6	H6	H6	H6
	Potential Equipment Height Interference					?	N	N	Y	Y
	Seismic Upgrade Requirement					?	N	N	N	N
	Vibration Requirement					N	Y	N	N	N
	Strict temperature and/or humidity requirements					Y	Y	N	N	N
	Potential Environmental Concerns	Y	Y	Y	Y	Y	N	N	N	N
	Utility capacities and requirements currently met					Y	N	N	N	N
	Process flow interruption and/or material handling system requirements					N	Y	Y	Y	Y
Fin	Level of Investment	M	M	M	L	L	H	H	H	H
	Risk	L	L	L	L	H	H	H	H	H
	Return	L	L	L	L	H	M	M	M	M
Strat	Fit with Corporate Strategy	L	L	L	L	L	H	H	H	H

Figure 6-27: Fab 4 Summary Sheets

		Direct Manufacturing Non-constraint processing (wet etch)	Direct Manufacturing Non-constraint processing (dry etch)	Alternative #7: Semiconductor manufacturing facility for off-site function	Alternative #8: Non-semiconductor manufacturing	Alternative #9: Combine Fab 4 and Fab 5 roles together	Alternative #10: Semiconductor manufacturing support - front-end processing	Alternative #11: Semiconductor manufacturing support - back end processes and semi-clean operations	Wafer sort and electrical test floor
Tech	Size - Known Square Footage Requirements	5,000 SF	5,000 SF						
	Type of Environment Required	Class 1, Class 10	Class 1, Class 10	Class 1, Class 10		Class 1, Class 10	Class 1, Class 10		Class 10,000
	Occupany Code Requirements	H6	H6	H6	B2	H2; H6/H7	H2; H6/H7		H6 or B2
	Potential Equipment Height Interference	N	N	Y	Y	Y	N		N
	Seismic Upgrade Requirement	N	N	N	Y	N	N		?
	Vibration Requirement	N	Y	Y	N	N	N		N
	Strict temperature and/or humidity requirements	N	N	Y	N	N	N		Y
	Potential Environmental Concerns	N	N	N	N	N	N		N
	Utility capacities and requirements currently met	Y	N	N	Y	N	N		Y
	Process flow interruption and/or material handling system requirements	Y	Y	N	N	Y	Y		N
Fin	Level of Investment	H	H	H	M	H	M		M
	Risk	H	H	H	M	M	L		L
	Return	M	M	M	L	M	L		L
Strat	Fit with Corporate Strategy	H	H	H	L	M	M		M
	Fit with Corporate Guidelines	M	M	M	L	M	L		M

Figure 6-27: Fab 4 Summary Sheets

		Goldgrind and/or backgrind	Test and assembly operations	Planarization	Arsenic Parts Clean, Quartz Clean rooms, etc.	Analytical laboratories	Vertical integration - pull own silicon ingots	Current wafer sort, electrical test, and assembly operations outsourced	Internally reclaim wafers	Research and development facility
							Alternative #12:			**Alternative #13:**
Tech	Size - Known Square Footage Requirements	5,000 SF								
	Type of Environment Required	Class 100, Class 1,000		Class 100	Class 100, Class 1,000					
	Occupany Code Requirements	H6	B2	H6	H2; H6/H7	H2; H6/H7	H6	B2	H6	H2; H6/H7
	Potential Equipment Height Interference	N	N	?	N	N	Y	N	?	Y
	Seismic Upgrade Requirement	N	Y	N	N	N	N	Y	N	N
	Vibration Requirement	N	Y	N	N	Y	N	Y	N	?
	Strict temperature and/or humidity requirements	N	N	N	N	N	N	N	N	N
	Potential Environmental Concerns	N	N	N	Y	N	N	N	N	N
	Utility capacities and requirements currently met	Y	N	N	Y	N	N	N	Y	N
	Process flow interruption and/or material handling system requirements	N	N	Y	Y	N	N	N	N	N
Fin	Level of Investment	L	M	M	L	L	M	M	L	H
	Risk	L	M	M	M	L	L	L	L	M
	Return	L	L	H	M	L	L	L	M	M
Strat	Fit with Corporate Strategy	M	L	M	L	L	L	L	L	M
	Fit with Corporate Guidelines	L	L	M	L	L	L	L	M	M

Figure 6-27: Fab 4 Summary Sheets

		Alternative #14 Administrative space	Alternative #15 Warehouse space	Alternative #16: Fab training facility	Alternative #17 Relocation non-manufacturing space from Fab 15 to create additional manufacturing space	Gymnasium	Cafeteria/Kitchen	Administrative Offices	Training rooms	Alternative #18 Employee Resource Center and/or Intel University
Tech	Size - Known Square Footage Requirements			2,500 SF 5,000 SF		5,000 SF	20,000 SF			5,000 SF - 10,000 SF
	Type of Environment Required									
	Occupany Code Requirements	B2	S2	H6 or B2		A3	A2.1	B2	B2	B2
	Potential Equipment Height Interference	Y	?	?		N	N	N	N	N
	Seismic Upgrade Requirement	Y	N	?		Y	Y	Y	Y	Y
	Vibration Requirement	N	N	N		N	N	N	N	N
	Strict temperature and/or humidity requirements	N	?	N		N	N	N	N	N
	Potential Environmental Concerns	N	N	N		N	N	N	N	N
	Utility capacities and requirements currently met	Y	Y	Y		Y	Y	Y	Y	Y
	Process flow interruption and/or material handling system requirements	N	N	N		N	N	N	N	N
Fin	Level of Investment	L	L	L		L	H	H	H	L
	Risk	L	L	L		L	L	L	L	L
	Return	L	L	L		L	H	H	H	L
Strat	Fit with Corporate Strategy	L	L	M		L	M	H	M	L
	Fit with Corporate Guidelines	M	L	M		L	M	H	M	L