Challenge in Aerospace Leadership

Needed: A Strategy that Makes Sense for all Boeing Stakeholders

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THESIS

Boeing's globalization strategy is designed to optimize short-term financial performance. This favors the interests of financial stakeholders, but it makes less sense to Boeing's technical community. We identify several areas of practical concern, and explain how each factor threatens our ability to compete effectively in the long-term. Finally, we offer a roadmap for constructing a plan that makes sense to all stakeholders.

I. Overview

Shift in Business Strategy

For decades, Boeing maintained competitive advantage through technical performance of advanced aerospace products. Over the last 5 years, business strategy has shifted steadily in favor of financial performance through cost-cutting, shedding of assets, and increasing reliance on global suppliers. Our new goals are lower unit costs for labor and capacity, leading to higher short-term margins.

Boeing's technical community recognizes a serious risk that cost-cutting and pursuit of short-term financial performance will compromise our ability to compete effectively in the long-term.

As a consequence, we experience a fragmenting technical and manufacturing community; weakened flow of information; loss of accumulated knowledge, skills and experience; and diffusion of control and authority needed to manage current and future programs.

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As Boeing shifts direction, we are losing the essential functions of the integrated technical community without recreating them in the global network. Boeing's technical community challenges all stakeholders: **Build a plan that makes sense to all of us.**

We seek a coherent strategy that balances the long-term interests of employees, customers, suppliers, long-term investors and the public, with the short-term interests of financial stakeholders.

Aerospace Industry Characteristics

Any successful out-sourcing strategy must match the particular characteristics of the industry involved. In Boeing's case, at least 7 features must be factored into any successful out-sourcing strategy:

- **Heavily engineered complex products**, requiring coordination and communication in design, manufacture and operation.
- Vulnerability to **sub-optimization**.

- Very **long production and operational cycles**, at relatively low production rates.
- **Unfavorable population dynamics** – aging and shrinking technical community.
- Dramatic **learning curves**.
- **Critical mass of experience** and first-hand connection to products.
- **Trust and confidence** of our customers, public and regulators.

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Certainly, these factors interact and overlap. Our challenge is to account for these characteristics in a coherent strategy.

II. Risk Factors

Concerns heard in the workplace can be expressed in four categories:

- Steady out-sourcing of design, manufacturing, and service functions has **weakened the infrastructure and flow of information** we relied on for decades of market success.
- **Population dynamics have reached an alarming condition**, where knowledge skills and experience are depleted by layoffs, voluntary quits and retirements.
- **Accounting limitations create bias** in our decision-making.
- **Confidence, trust and the sense of common interest are at historic lows**.

II.A Weakened Infrastructure – Commodity or Community?

Out-sourcing strategies focus on products that are commodities, for the most part. Our daily experience convinces us that our design and manufacturing environment operates largely as a community.

ILLUSTRATIONS OF WORKPLACE EXPERIENCES

A few illustrations would be useful in illustrating our range of concern. The highlighted portions at the bottom of following pages contain composite situations derived from numerous workplace experiences. They are representative, but not do not necessarily correspond to real events.

CASE 1. AIRPLANE SYSTEM CONFLICT, Illustrating:

- Sub-optimization
- Complex products
- Confidence of customers and public

During initial flight test for a new model of airplane, we realize that the navigation system and flight management system interfere with each other. As system integrator, we go to the Nav designer who says, "We agree that I 'met spec' and while I sympathize, I can only wish you the best of luck." We go to the flight management design team, and say, "We believe your unit generates a 'runt pulse' under rare conditions which interferes with the nav system." The flight management team leader says, "We met spec, too, with or without a runt pulse. You might want your lawyers talk to our lawyers." We ask, "Can you tell us where the runt pulse comes from, and what our options are for dealing with it?" The vendor replies, "This unit contains proprietary components. It is part of our competitive advantage - we would like to sell this to Gulfstream and several other customers. Good luck, though."

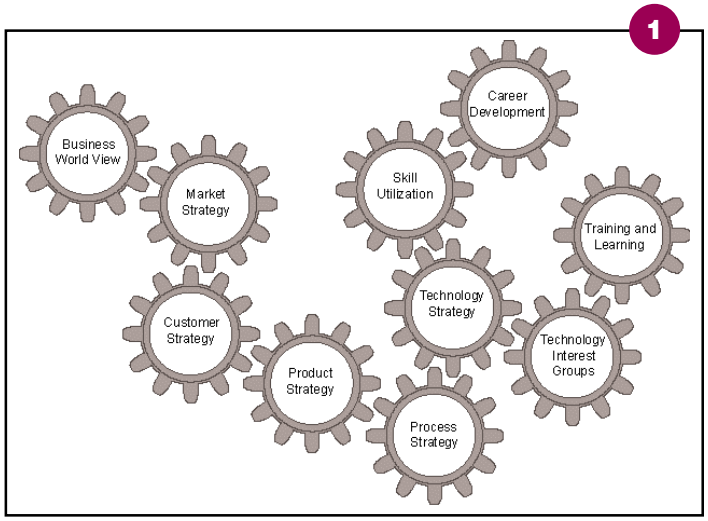
Imagine the same situation, except the interference is discovered during a crash investigation, with a minimum $150 million liability to be divided among the responsible parties. The sub-optimization will probably become more contentious.

Imagine the same situation, but now the FAA is considering grounding the fleet while the problem is analyzed and a solution is verified.

For reference, the DC-10 fleet was grounded for several weeks after the crash in Chicago. The Concorde fleet was grounded for months after the recent crash. Airline and government customers can ground their fleets for various service and performance reasons.

Engineer's View of Out-sourcing

Figure 1 suggests how out-sourcing might fit strategically into a larger picture, **as seen from the perspective of the engineering community**. The primary driving gear is the worldview. It will be the source of the market strategy, which will then determine the customers. From the engineer's point of view, the key gears involve products and processes.



One message we hear is that Boeing's future centers on system integration, project management and supply chain management. We are told we will develop new markets, and maintain the technical and business systems that define "how we build airplanes." In this vision, our suppliers and global partners will be responsible for most of the design and manufacturing, while we will write specifications and handle sales, marketing, final assembly, and certification.

In that case, the supplier network will take up much of the technical activity in the upper-right set of wheels. Process improvement, and much of the research and development would probably also move to the suppliers. Boeing might direct or initiate and possibly finance new ideas in production, but the suppliers would control technical content.

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This prospect creates widespread concern in the engineering community. Our new direction lacks a practical organizational structure for managing the critical flow of knowledge and experience between R&D, design, manufacturing and customer service. In our previous organizational structure, we used a well-knit and strong network of relationships for the flow of information. E-mail and computer network links to suppliers will not substitute for the existing organizational and social connections.

System Integration and Project Management

Boeing claims system integration as a core competency. A system integrator needs a broad range of experience and expertise. Design engineers tend to focus on narrow areas of study, with limited exposure to broader issues. If we intend to retain system integration competency but out-source design, then we should decide how to cultivate and retain the new set of managerial, technical and business skills we will need for that purpose.

CASE 2. WIRE INSULATION, Illustrating:

- Complex products
- Sub-optimization
- Population dynamics
- Process improvement

Suppose we want to switch from Kapton insulation to Teflon (or from Teflon to Kapton). The design and manufacture of wire bundles has been outsourced to three domestic suppliers and one foreign supplier. They may or may not be aware that Lufthansa (for example) uses a series of electronic units which will be incompatible with the new wiring.

Similarly, project management is a simple matter as long as everything goes according to plan. The value or "magic" of project management comes from the ability to recognize when events deviate from the plan, and then reallocate resources to recover from the surprise.

Without question, the challenges of system integration and project management increase in an out-sourced environment.

Our accumulated competence and expertise in project management were acquired primarily in the context of a well-developed internal engineering community. If we intend to translate that core competency to an out-sourced business environment, then we should understand how to cultivate and manage the **new set of skills, knowledge and experience** needed in the new environment.

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Other industries have managed to transfer their vertically integrated functions from internal structures to an external market. For instance, the motion picture industry can draw on human, technical, financial and creative resources available in their community, without maintaining vertically integrated studios. The construction industry benefits from reliable efficient markets for electricians, plumbers, architects, engineers, designers and financial resources needed for a particular project. Silicon Valley is a remarkable reservoir of people, ideas, products, and capital available to companies with out-sourced business models.

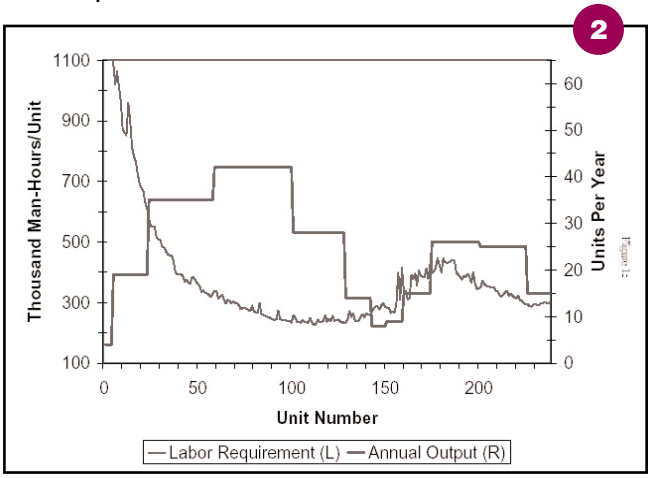
In an out-sourcing environment, the supplier enjoys all potential learning curve benefits and the integrator pursues the supplier for cost concessions.

The aerospace industry has a much smaller, geographically dispersed external community to work with. If we intend to rely on our market for human resources, then we should at least agree on career paths and skills needed for our activities.

Learning Curve

A practical measure of value from an integrated community is found in learning curves. Learning curves measure productivity improvements resulting from accumulated knowledge and networks of relationships. The aerospace industry is famous for breath-taking learning curves.

Figure 2 was taken from a study on organizational learning and forgetting.[1] The



CASE 3. CUSTOMER SERVICE, Illustrating:

- Sub-optimization
- Population dynamics
- Long operational service life

A middle-eastern customer wants to modify a bulkhead on the 737-900X, and calls for advice. We tell them that the engineering design for that model was done by the Moscow Design Center, the parts were manufactured in Turkey, and certified in Europe. The engineering package is now held by a company in Ireland (or Israel, or Italy, or Indonesia or India) and we expect some delay while the changes are coordinated.

jagged line is a learning curve for the L-1011 program. The steadier line shows production rate. The figure is intended to illustrate organizational learning (and "forgetting") as workers come and go. It also illustrates that productivity improvements come from hundreds or thousands of small ideas, mostly coming from the workplace. The production run of the L-1011 was just over 260 units, with a model change about three quarters of the way through.

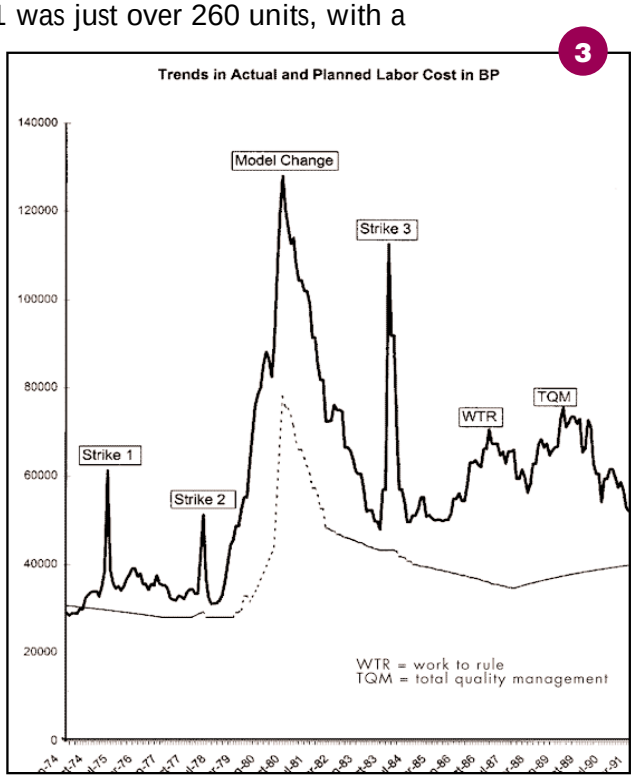


Figure 3 is a more complex case, taken from a similar study.[2] It refers to the "Big Plane" company (BP) for confidentiality reasons, but we are told BP is a large aerospace manufacturer in southern California. WTR is "work-to-rule" and TQM is Total Quality Management. As a point of reference, MD-80 deliveries started in 1980, and DC-9 deliveries ended in 1982.

This case is like the L-1011 example; productivity improvements are dramatic, and take place in countless small steps. Obviously, a well-managed company can benefit enormously from process improvements. In an out-sourcing environment, the supplier enjoys all potential learning curve benefits and the integrator pursues the supplier for cost concessions.

Competing Effectively in the Long-Term

Out-sourcing is basically a trade-off; the pursuit of lower unit costs will steadily dismantle the integrated engineering community. From our perspective in the workplace, "community" adds intangible value that is critical for our long-term success. If out-sourcing decisions discount or minimize that value, the predictable consequence will be the weakening of our ability to compete in the long-term.

II.B Employment Dynamics

Demographic Data

The aerospace industry is notoriously cyclic, with engineering employment levels roughly tracking production rate **(Figure 4)**. Boeing experienced huge layoffs in the

CASE 4. CUSTOMER SERVICE, Illustrating:

- Long service life
- Population dynamics
- Complex products
- Sub-optimization
- Confidence of customers

A tour operator cannot eliminate a serious vibration in their MD-11 center engine. The airplane has been out of service for two months. GE says their mathematical models prove the engine can not be vibrating. The customer acknowledges the airplane had "one or two" hard landings, and their third-party maintenance vendor has been using DC-10 service procedures on the center engine gimbal mount. Unfortunately, the MD-11 design team has retired, and we really should understand why the DC-10 and MD-11 have different mounts for the center engine.

Boeing receives many thousands of customer service requests each year.

'early '70s, and significant layoffs in the '80's, then a series of 4 layoff cycles since 1990 **(Figure 5)**. The demographic damage from the '70s layoffs was profound, and it echoed for decades. Recovery and rebuilding can take root and develop, given a decade between layoffs. However, with 4 layoff cycles in 9 years, compounded by unprecedented quit rates in 2000, our options are relatively limited.

Figure 6 shows the dramatic shift in population for Puget Sound engineers since 1990. Any industry leader must attract and retain good people. Our engineering population is older than at any time since the catastrophic layoffs of the '70's. Layoffs through 2002 will further reduce the number of young engineers.

Figure 7 illustrates the demographic shift year by year. Our failure to retain young people is evident. Even if we begin today to replace that segment of the population, we will still have a gap in skills, knowledge and experience that is over a decade wide.

Interpretations of the Demographic Data

What occurs during the first 5 or 10 years of a young engineer's career? He or she is not learning metallurgy, finite element analysis, or differential equations. New employees are learning why a certain part was made from magnesium, or who they should talk to in the 737 landing gear group.

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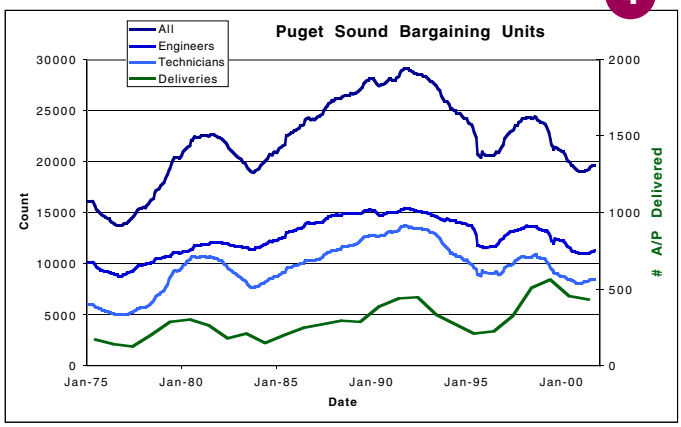

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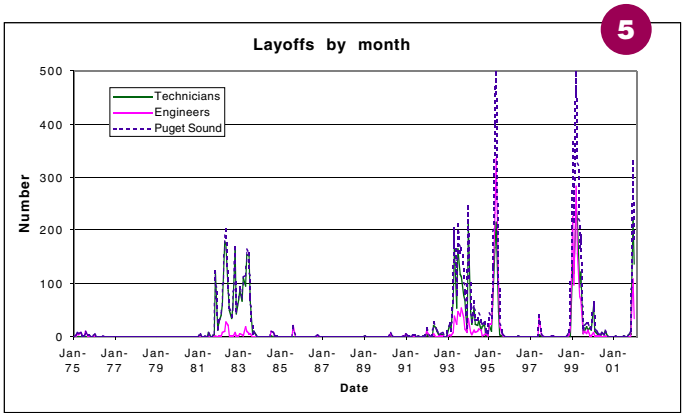

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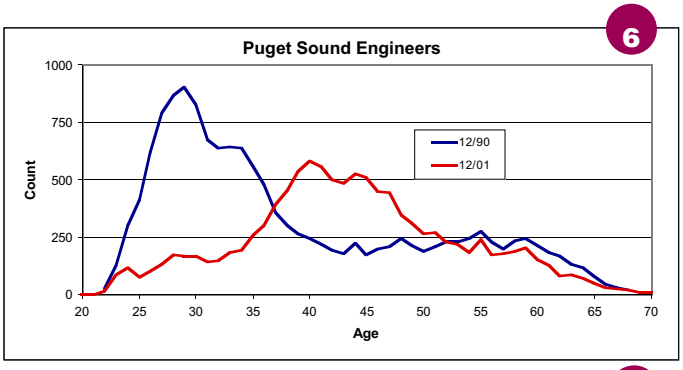

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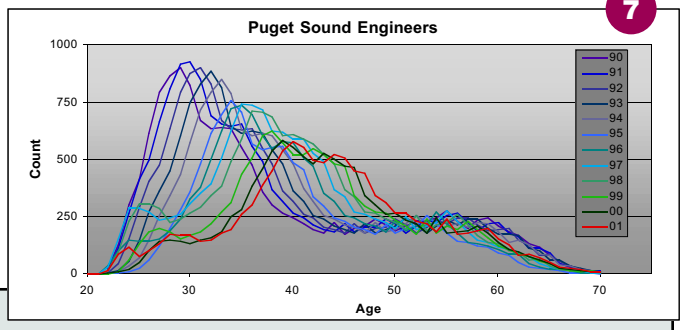


CASE 5. PAINT, Illustrating:

- Complex products
- Long service life
- Sub-optimization
- Learning curve/process improvement

One of our suppliers for the 767 leading edge slat (let's say) switches the sealer-primer-paint system used on their graphite-epoxy skins. We have been getting warranty claims on other composite parts with the same paint system. If the paint is too thick, it will crack over time, starting a chain of events by which water is retained in the interior of the part. This becomes a nagging maintenance issue for customers. Unfortunately, no one communicates this back to the slat supplier, who is pleased with the paint, and intends to use it on all their parts.

If they intend to move a stator in the 757 fan duct, they learn who they should talk to in aerodynamics, propulsion, weights and noise. They learn internal processes and values. They absorb accumulated knowledge that is stored in a network of relationships in the engineering community.

> Even if we begin today to replace that segment of the population, we will still have a gap in skills, knowledge and experience that is over a decade wide.

Two trends are evident in the data. Experienced people are leaving, taking accumulated knowledge with them. Secondly, we failed to attract and retain new people with fresh technical skills. Employees find this demographic situation very alarming. No one understands how it can help us compete, particularly ten years from now, as the bulk of the surviving population reaches retirement age.

Demographic stability

Most people regard this situation as unstable. Instantaneously, it looks fabulous – an entire population of experienced capable people, all thoroughly familiar with "how we build airplanes." If we enjoy any competitive advantage in our design and manufacturing infrastructure, that value is controlled through the experience and knowledge of employees in the technical and manufacturing community.

We normally treat population dynamics as a pipeline, maintaining its dynamic stability by introducing young people at a steady rate, while experienced employees leave for various reasons. Alternatively, we could draw from the labor market seeking experienced employees who could step in with little acclimatization. Some other industries work this way. Part of the miracle of Silicon Valley is its efficient local market for people, products and ideas for the computer industry. This demographic condition might also apply to high-powered consulting firms or law offices that employ the best people in the peak of their careers. Of course you would expect to pay a premium for that hiring model.

Furthermore, even an experienced engineer recruited from the aerospace industry needs months or years to integrate into the community of relationships and learn the idiosyncratic processes that control the flow of our work.

A system integrator or project manager must have high levels of awareness, understanding and authority to operate effectively. Generally those characteristics depend on decades of experience and a network of personal relationships.

CASE 6. DOOR CASTINGS, Illustrating:

- Short production runs
- Population dynamics
- Learning curve/process improvements
- Sub-optimization

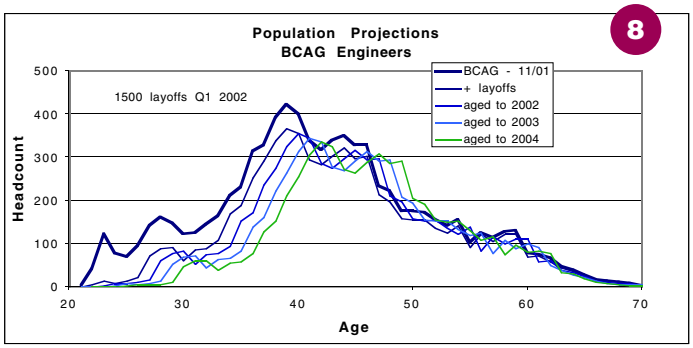
Casting houses are now able to make exquisite castings of very complex parts. For the purposes of discussion, let's say the 737 overwing exit doors are a candidate structure. The door design team is at Northrop, and they recently implemented a new machining process, which reduced their doors' complexity and cost by 30%. They have a contract for 200 ship-sets, and express no interest in our idea for castings. Our team would really like to copy Airbus and make doors common across all models. Some of our wide-body emergency exit doors are made in Poland using an older design. Northrop is not inclined to share their process improvement with the Polish vendor, which lacks the expertise or capital to switch on its own. In the end, we make no changes to any of the doors.

Near-term Projections

Boeing historically manages engineering layoffs through a "retention" rating system, in which supervisors partition the population into 3 or 4 retention groups. Layoffs are sequenced through the retention groups in order, with some exceptions. Retention rankings are reviewed annually. Typically, young engineers are assigned the lowest rating.

> Predictably, we will suffer problems with system integration, project management and customer service when our partners are called upon to supply expertise they never acquired and knowledge that was lost years before.

Figure 8 represents a simple projection of Puget Sound engineering demographics. Four conditions are modeled: we assume 1500 layoffs early in 2002, historic rates of quits at each age level, retirements modeled from our pension actuarial assumptions, and aging year-for-year.



The example of 1500 layoffs represents about 18% of the population. **Figures 9 and 10** present similar projections, with 3000 and 4500 layoffs. Obviously, our short-term decisions will compound or amplify the problems of the last decade. Knowledge will flow outward through layoffs and retirements. In addition, we will defer introduction of fresh technical skills until the next hiring cycle. By the time we deliver the first Sonic Cruiser, a large fraction of our current technical community will be beyond retirement age.

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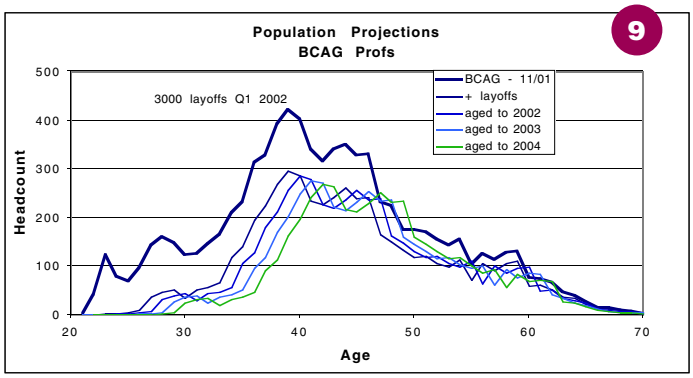
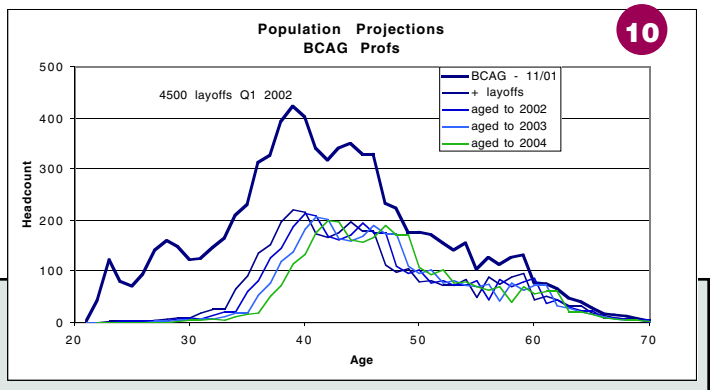




CASE 7. DERIVATIVE DESIGN, Illustrating:

- Process improvements
- Product development
- Population dynamics
- Complex products
- Long production and service times
- Confidence of customers and public
- Sub-optimization

Israel Aerospace Industries performs much of the design work for a special freighter modification (let's say). In doing so, they adapt our finite element engineering model for the new design. After ten years in operation, customers report skin cracking, particularly along a seam near the top of the fuselage, just aft of the wing-body join. During the production run, our Brazilian manufacturing partner switched to a new type of rivet, approved by their regulatory agency, which seems to be associated with the cracking problem. The IAI design team is now working on a military transport of similar design, and cannot be released to deal with our service problem. Our own finite element model has not been updated with the Israeli design changes.

Consider the same general situation, but we want to make a new derivative with extended range based on the Israeli derivative.

Competing Effectively in the Long-Term

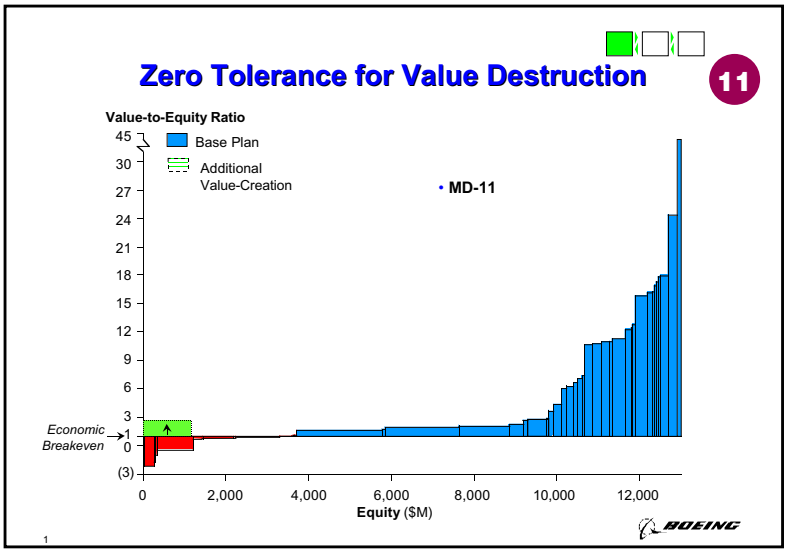
The aerospace industry has contracted by about half in the last ten years. Our competitive advantage has been built on technical competence, and the performance of our products. Our experienced community is dissolving rapidly. Predictably, we will suffer problems with system integration, project management and customer service when our partners are called upon to supply expertise they never acquired and knowledge that was lost years before.

II.C Accounting Limitations

Accounting Criteria

Out-sourcing of commodities focuses on the functional characteristics of the product or work package in question. Another approach focuses on accounting measures, and is not concerned directly with products' intrinsic characteristics.

Figure 11 illustrates a decision-making process based on accounting measures of "value." The $13 billion MD-11 program is broken down into various functions, sorted according to their "value to equity" ratio. The message of the chart is that equity should be productive. Unproductive activities should be improved or eliminated.



In the simplest use of this approach, a threshold could be drawn horizontally at a value-to-equity ratio of 1.1, for instance, representing 10% margin. Any box below that line would be out-sourced, and boxes standing above the line would be kept.

Three shortcomings of this approach deserve mention. First, "value" is an evocative term, with an artificial definition. Second, this analysis ignores interdependence of different activities. Third, strategic factors are invisible to the accounting practices, and are easily excluded when making decisions.

Artificial Accounting Definition

Boeing's cost accounting system is well-adapted for producing financial statements. It is ill-suited for use in management decisions. While details vary by program, Boeing still pools overhead expenses at the program level and above. Overhead is charged broadly in the form of burdened direct labor, computing resources, plant and equipment. Marginal costs are not available at the level of shops or work packages.

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In practice, out-sourcing has little effect on the operational infrastructure retained for design specifications, configuration control, certification, and customer service. Infrastructure must also be maintained for information technology, sales and marketing, and business systems. Overhead

costs actually increase with outsourcing for vendor oversight, materiel activities, rework, repair and scrap on delivered goods.

Suppliers will bear limited responsibility for coordination, system integration, flow of information, future warranty or service issues, and suppliers assume little risk for future customer problems or configuration changes.

We subsidize all those expenses for the suppliers in the form of higher overhead charged to our (remaining) internal organizations. Thus, each out-sourcing action adds to the unit-cost problem. As low-margin activities disappear, the remaining activities bear a progressively greater overhead burden, causing burdened costs to deteriorate steadily. The result is a downward spiral of lower margins, lower capability, and lower margins.

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We consistently over-estimate short-term cost-savings when we make out-sourcing decisions, then provide a positive feedback loop to amplify the errors.

Interdependence

Many of our design, manufacturing, customer service and marketing organizations interact strongly, particularly when a customer configuration is modified, or when service issues come back from customers. We recognize the value of "breaking down barriers" to reduce cost and avoid costly problems. Yet this factor is invisible in the accounting data used to make out-sourcing decisions.

Strategic factors

The elements of **Figure 11** apply equally well if the product is running shoes, cell phones or chocolate ice cream. No strategic content is included automatically. Furthermore, in this decision-making process, a vendor can be compelled to accept a work package, not because they want to have it, but because we want to be rid of it.

Looking at recent decisions, we are dismayed at out-sourcing of leading edge slats, landing gear, customer training, electron beam welding, not to mention research and design of large portions of the Sonic Cruiser. If these products are commodities, then what strategic factors still count in out-sourcing decisions?

Competing Effectively in the Long-Term

Boeing's pursuit of lower unit costs is subject to bias, because the business case consistently over-estimates savings. Accounting studies are never intended to measure interdependencies and strategic factors. Given the pressure to reduce unit costs, only the most daring manager can advocate for intangible factors. Meanwhile, intangible costs are being locked in by the downward spiral, while our ability to retrench or recover in the future is simultaneously compromised.

II.D Confidence, Trust and Common Purpose

Consider three significant indicators of declining confidence in Boeing's new direction. In February 2000, engineers and technicians struck for 6 weeks. The sound-bite issue was "respect." A second indicator is the unprecedented level of

voluntary quits among young and experienced engineers since the strike. A third indicator is the dismal mood in the workplace. One measure of the mood is found in the annual employee survey which has very negative engineering responses to the question *"Is Boeing making changes necessary to compete effectively."* In 2000, positive engineering responses were 9%. In 2001, positive responses were roughly 25% - well below company-wide responses, and far below industry averages for that question.

Motivation

In 2000, a departing Boeing executive gave a wonderful speech, challenging company leaders to communicate a vision we could all understand, and give everyone a way to contribute to our success. Then, we could "drive like mad" to reach our common goals.

It is hard to imagine a more discouraging message than "others can do our job better than we can."

The Sonic Cruiser stimulated great excitement. This was a vision we could understand. However, one theme emerging from the Sonic Cruiser program is that global partners will divide the program up in terms of financing, design, manufacturing, and R&D. This vision obscures what our remaining role might be, and questions whether we will ever benefit from any success.

It is hard to imagine a more discouraging message than "others can do our job better than we can." To be measured by unreasonable comparisons and then be found wanting is terribly demotivating.

The Ultimate Test – Success in the Market

We understand the short-term attraction of cost cutting, but we also know that competition in the long-term depends on investment for the future. McDonnell Douglas' experience is inescapable to us. Customers sent McDonnell Douglas a consistent message: Compete or be displaced. Over time, this business culture consistently failed to compete successfully in major aerospace market competitions – F-22, JSF, Teledesic, MD-11, 717, to name a few - in spite of highly motivated employees with ample expertise and great pride in their work.

Our loss in the multi-billion dollar JSF competition demonstrated the value of building a product your customer wants to buy.

Competing Effectively in the Long-Term

A successful company invests in the future, seeks new opportunities and encourages employees to participate in change. A cost-cutting company simply takes what the market offers, and shrinks away from challenges.

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III. Roadmap to Address Concerns

Our challenge is to create a coherent comprehensive plan that makes sense to everyone. With a credible plan, which explains how our roles are important, we can restore confidence and focus our energy on making products our customers want to buy. To investors, the plan must make sense in financial terms. To employees, the plan must make sense in terms of products and processes. Suppliers will

understand how their requirements and responsibilities figure into the overall picture. In fact, the plan must make sense to all stakeholders.

A credible coherent plan for the future would resolve these questions:

In fact, the plan must make sense to all stakeholders.

1) What will be the source of competitive advantage for Boeing in 5 and 10 years?
2) What markets, products and customers do we want to pursue in 1 year, 5 years and 10 years?
3) What people skills and experience will we need the next decade?
4) What technical and manufacturing critical mass and fabric of relationships must we retain or create to compete effectively?
5) What social, technical and business mechanisms are needed for the flow of information among customers, suppliers, and internal organizations?
6) What financial, technical and strategic criteria will we use to make outsourcing decisions?
7) How can current employees contribute to the success of the entire enterprise?

Suppose our vision is to rely heavily on global supplier networks for design and manufacturing, while seeking competitive advantage through system integration, project management, and supply chain management. A coherent strategy will explain how to create and sustain the culture, infrastructure, technical competence, and authority to manage complex programs and products. When we understand our roles, employees can make productive and efficient decisions about training and career development. We could focus our energy in areas with bright prospects for the future.

In many ways, we have lost the luxury of waiting to cross important bridges. We are nearly across a demographic bridge, and we are mid-span on a bridge to dismantle our internal engineering community. If our out-sourcing strategies prove disappointing, as some other industries have found, then our ability to retreat and recover will be limited.

Every company operates a multi-variable world, responsive to stakeholders in public and private sectors, commercial financial and regulatory environments, local communities and groups in the workplace. We can all carry this challenge to decision-makers: we want to see a plan that makes sense, and we want to contribute in making the plan succeed.

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