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OUT-SOURCED PROFITS – THE CORNERSTONE OF SUCCESSFUL SUBCONTRACTING

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ABSTRACT

The purpose of this paper is to describe and explain some highlights associated with the contemporary business practice of out-sourcing more and more of a companies' activities in the belief that doing so will increase profitability. A strong case is made that it will *not* always be possible to make more and more profit out of less and less product and that, worse, there is a strong risk of going out of business directly as a result of this policy. The point is made that not only is the work out-sourced; all of the profits associated with the work are out-sourced, too. The history of the former Douglas Aircraft Company is cited as a clear indication of what these policies have done – and as a warning of what more may be done. The subcontractors on the DC-10 made all of the profits; the prime manufacturer absorbed all of the over-runs. The circumstances under which out-sourcing *can* be beneficial are also explained. They involve better access to improved facilities with which to make more precise detail parts to reduce the cost of final assembly. A strong warning is included about the perils of sub-optimum solutions in which individual costs are minimized in isolation. Indeed, the importance of *thorough* planning, accounting for *all* interdepartmental interactions, cannot be over-emphasized. A case is made that it is better to fill up "excess capacity" with additional work, even if unrelated to the core business, rather than to close it down and sell it off. Such practices can even be necessary for retaining the skills and facilities required to produce the *prime* products, but which would otherwise be under-utilized and become targets for elimination. The inherent traditional imbalance between budgets and head-counts can be resolved in this manner. The paper includes some observations about European experiences, good and bad, with out-sourcing. It closes with a list of recommendations by the author about how to operate and maintain profitable businesses.

INTRODUCTION

Out-sourcing is commonly looked upon by management as a tool for reducing costs. But the unresolved question is "*which costs?*". In addition, there is the matter of "what is the effect on *overall* costs?". The most important issue of all is whether or not a company can *continue* to operate if it relies primarily on out-sourcing the majority of the work that it once did in-house. The experiences of the former Douglas Aircraft Company would suggest that, in the context of the aerospace industry at least, it cannot! In the more general context, it should be obvious that a company cannot control its own destiny if it creates less than 10 percent of the products it sells.

One purpose of this paper is to explain why *selective* out-sourcing can be beneficial to *all* concerned, and why out-sourcing as a supplement to sales activities may be justified but needs to be recognized, on average, as an *added* cost, *not* a cost *reduction*.

A second objective is to discourage wholesale out-sourcing by highlighting the misleading cost-accounting procedures that have concealed its true cost for so many years. The hope is that, in future, make-buy decisions will be based on *complete* assessments of *all* of the costs – and that, in future, make-buy decisions will not be made until *after* the product has been defined and the relative costs established.

The third objective is to ensure that, if out-sourcing *is* to be employed, it is under-stood to be absolutely necessary that detail parts and subassemblies be *designed* with that process in mind. This requires considerable *additional* up-front effort in planning to avoid the situation whereby major subassemblies do not fit together at final assembly, increasing the cost by orders of magnitude more than was saved by designing in isolation from the work-allocation activities.

The inescapable problem with outsourcing work that *could* be done in-house is that it *necessarily* increases the tasks and man-hours to carry out the work way above those needed to perform *all* assembly, including most subassemblies, at *one* site. Experience in the electronics industry has shown that out-sourcing work to regions of low labor rate is only a transitory phenomenon. The reason why the rates were low was that there had previously been no work there. Once the work became available, hourly rates increased, so that the primary electronic companies kept moving the work to yet another as-yet-under-developed area, and the cycle was repeated. This may be cost-effective for small items, with production lives of only a few years at most, but it is inappropriate for large aircraft that may need spare parts throughout a service live in excess of 50 years (80 or more for some military aircraft) and for which the manufacturing program itself may last 40 or 50 years. There are so many aircraft components that *must* be out-sourced, such as engines, avionics, and systems, because today's prime aircraft manufacturers are no longer equipped to undertake such work themselves, that the retention of a determinable minimum fraction of the structures work is a pre-requisite to developing sufficient cash to develop new products. Without new products, as distinct from derivatives, all companies will go out of business, no matter what their line of business.

The correctness of the author's position[1] on these matters is easily confirmed by two facts. It was the suppliers who made all the profits on the extensively out-sourced DC-10s, not the so-called systems-integrating prime manufacturer. (The same thing has happened on aircraft assembled by Boeing, in Seattle, too.) Also, when plans were being formulated for the proposed MD-12 very large transport aircraft, almost all potential suppliers indicated a preference for being subcontractors rather than risk-sharing "partners". Could they have known more about maximizing profits, minimizing risk, etc., than the prime manufacturer who *sought* their help even though it could borrow money at lower rates of interest than potential suppliers could? The DC-8 was manufactured and assembled almost entirely within the Long Beach plant, with only the nose coming from Santa Monica. That policy was changed after the acquisition of the former Douglas Aircraft Company by the former McDonnell Aircraft Company, but the change did not improve the company's profitability. It is time for Boeing to reverse this policy.

[1] The views expressed here are those of the author and not necessarily those of the Boeing management. Conversely, the visible policies of the management are not necessarily those that the author would have recommended, had he been asked.

WHO BENEFITS MOST FROM OUT-SOURCING?

Given that modern management seems to believe that more and more out-sourcing is a necessary step to becoming a systems integrator, and that this is presumably more profitable than being involved in the manufacturing work, one is entitled to ask who receives the greatest largesse from extensive outsourcing. History suggests very strongly that it is the supplier, not the prime manufacturer, who has benefited the most, with no indication that the trend would ever change.

The first issue to be examined, is precisely what is out-sourced and what is inevitably retained. The superficial perspective might be that every internal activity that used to be related to a task that has been out-sourced is no longer necessary. Even that is not true but, worse, it fails to acknowledge all of the *new* internal tasks that had not previously existed. To add insult to injury, contemporary accounting practices do not allow these unavoidable additional costs to be billed against that particular item of work – because it is no longer identified as an in-house task – so these charges are allocated instead as overhead to any *remaining* in-house work. This misrepresentation of true costs furthers the illusion that outside production is cheaper than anything done inside, building the pressure to ship even *more* work offsite, until there isn't any left. The irony of this situation is that it is so easy to understand in the extreme. Suppose that a manufacturer had succeeded in out-sourcing *all* of the work that it wished to isolate from the preferred task of systems integrator. The unallocatable costs from the huge amount of out-sourced work will now appear as overhead on the few remaining tasks, like sales and product support, confirming that these were now even *less* profitable than manufacturing had been when the spiral began!

"What are all of these additional tasks?", one might well ask. The first is the need to write a specification for the product, which must be *more* complete and precise than would be needed for in-house production, for which omissions, refinements, and improvements could have been accommodated without the need for costly legal discussions. One must ask the question as to where the skills for writing such specifications will come from if there is no continued in-house production from which to learn. The next is the obvious need for additional transportation costs associated with off-site production and the increased *total* span time this inevitably causes. These could be avoided by having the supplier co-locate his factory alongside the final assembly site, but only at the cost of a new factory and the perceived higher wages that were to be reduced by removing the work in the first place. No, the additional transportation costs are the least expensive of the options, once the decision to "off-load" the work has been taken. A major source of unplanned costs associated with out-sourcing has been subassemblies that cannot be fitted together because *all* of the drawing tolerances had been consumed earlier in the fabrication process. As a minimum, this has entailed considerable out-of-position work, a lot of rework, delays for replacement parts, and recriminations as the source of any error is uncovered. Whenever it is a drawing error or omission, added costs are incurred in changing the contract. And whenever it was a tool supplied to the subcontractor or built by him and bought-off by the prime manufacturer's inspectors with an undetected error, the costs of fixing the mistake were even greater. These, and other, problems would be diminished tremendously if only internal organizations need to be involved. In order to minimize these potential problems, it is necessary for the prime contractor to provide on-site quality, supplier-management, and sometimes technical support. If this is not done, the performance of the prime manufacturer can never exceed the capabilities of the *least* proficient of the suppliers. These costs do not vanish merely because the work itself is out-of-sight. Yet none of them is acknowledged as a cost of having

out-sourced the work; it is an "accepted" overhead task apparently associated with internal work, which is then perceived as "costing too much".

These financial burdens pale into insignificance in comparison with the consequences of an even greater penalty – the loss of cost-savings from improved designs that cannot be implemented without the implementation costing more than the savings. Suppliers are under just as great pressure as prime manufacturers to maximize their profits, maximize their return on minimized investment, and the like; indeed their interest rates on borrowings are usually higher than for prime manufacturers. So they have no incentive to design assembly tools that permit minimized rework for derivative products, for example, particularly when they have no guarantee that derivatives may ever be made or that that they would be awarded the work. Indeed, they may not even have the expertise to foresee such opportunities. But the prime manufacturer should have the capability to minimize costs by considering such possibilities, if the task had been done in-house. In a recent cost-reduction study in which the author participated, it was found that about 90 percent of the suggestions *could* have achieved a cost saving had it not been for the non-recurring costs, few of which would have been significant if the work had *not* already been out-sourced. A recurring theme throughout this study was a number of problems associated with the *sequence* of assembly. Only detail parts and complete moveable surfaces like flaps and ailerons are free from potential assembly sequence problems (see Ref. 1). It was quite common to find that certain stiffeners could not be installed on fuselage panels *when* the panels were made because they also had to co-ordinate with, or blocked access to, other details on the wing, for instance, at some *later* stage in the assembly process. Somewhere, someone had saved money, and time, on the original design task by not completely planning the *entire* assembly operation. This is one of the most classic of sub-optimum solutions and is discussed, in the context of aircraft production, in Ref. 2.

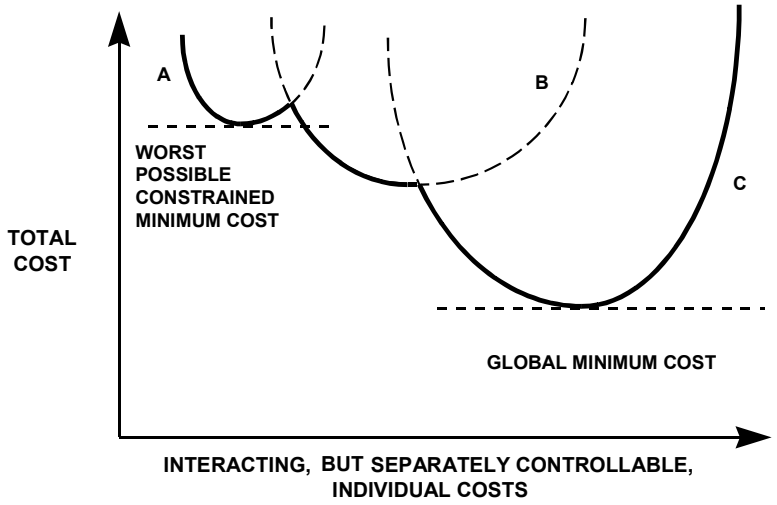

Fig. 1 Difference Between Local and Global Optima, and Between Constrained Optima and Those Defined by Minimizing Single Variables

Figure 1 illustrates how minimizing each step in a process in isolation is *guaranteed* to prevent the attainment of any *overall* minimum cost. Yet, for years, the aircraft industry has been operated on a philosophy of minimizing costs as they occur and of holding each separate department responsible for minimizing its *own* costs, rather than contributing to *overall* minimum costs. For instance, the performance of Engineering is better evaluated in terms of

minimizing problems that occur in Manufacturing, rather than for minimizing the cost of the drawings themselves. Likewise, the Tooling department is traditionally judged on the basis of how little money it *spent*, rather than on the very much greater amount of money it could have *saved* in production, if only its focus had been different. Involving outside organizations in creating some of those costs just makes the task of minimizing the total even more difficult.

THE DISASTROUS RAMIFICATIONS OF "RONA"

A currently in-vogue performance metric, Return on Net Assets (RONA), barely qualifies as a sub-optimum solution. Superficially, it seems to be very appropriate. Who wouldn't want to make the most from all of the assets an organization possessed? It would make an excellent *goal*, by any standards. Only when it is converted into a *performance metric* do its devastating effects become apparent. As a ratio, it can be enhanced by either increasing the numerator or decreasing the denominator. Each activity can be related or totally unrelated. Far too many additional issues are involved. But unless one studies *all* of the cause-and-effect relationships created by changing either numerator or denominator, one cannot possibly tell if a course-of action is good or bad for a company, no matter whether RONA is being increased or decreased. Conversely, if one were to apply RONA unthinkingly, once could easily convince oneself that decreasing assets was *always* a good thing, because doing so would *always* increase RONA – assuming that changes in assets being employed *never* had an effect on the costs of production!

It is the author's belief that this process, and others like it, is what has led the aircraft industry into a state of *excessive* out-sourcing. It is obvious that doing *all* of the work in-house would require a greater supply of capital equipment than subcontracting it all outside. That is not the issue. The first issue is whether or not an *incremental* change in capital facilities or other assets results in a beneficial or undesirable change in revenues and associated profit. There is absolutely no guarantee that a reduction in assets will ever result in an increase in RONA, let alone an increase in profits. That is the great fallacy about this metric. It is applied by far to many with the authority to do so as if reductions in assets are always to be preferred over increases in capital spending. The second issue is whether or not that *same* incremental change in net assets results in any collateral or downstream consequences that had *not* been included in the initial cost/benefit assessment. This brings us to the next great fallacy about the concept of RONA. No allowance is made for the fact that company revenues and/or profits can vary greatly for *other* reasons, while the level of assets might remain unchanged. Using the ratio of two sometimes totally unrelated variables as a basis for strategic business decisions simply doesn't make sense!

RONA might be a worthy *overall* goal, but as a performance metric, it is usually *meaningless* – and a serious threat to the survival of any organization on which it has been inflicted.

The problem with RONA is its superficiality and its plausibility if one does not think too seriously about it. A typical stock-market analyst lacks the deep understanding of what makes *different* companies tick and why their profitability cannot always be assessed by the *same* metrics. The misapplication of *ANY* of the financial assessment tools can do, and has done, great harm to the livelihoods of far too many people. Let us compare two totally different hypothetical companies using RONA as a metric.

The first is probably the case study used to justify the introduction of RONA. Consider an old established company that used to be profitable but which has not responded to changes in the

markets for its sales by developing new products that can be made with its existing facilities and for which there is a real demand. With limited sales, an assessment according to RONA is likely to highlight the obvious – that its revenues and profits are disproportionately small in relation to its assets. But this correct finding does *NOT* imply that the appropriate response is to sell off its assets to improve RONA. Doing so would forever doom the organization to a smaller size with reduced capacity to respond to future marketing opportunities. A far better response to a low value of RONA, for these reasons, would be to develop and sell *new* products that could be produced profitably with the *same* equipment and personnel. In other words, increase the *numerator* instead of decreasing the *denominator*. It is axiomatic that if all of the facilities were *obsolete*, the denominator of the RONA ratio would be low (so that the original hypothesis of a low value of RONA would be invalid), and that the consequently *high* value of RONA would create the illusion of a very successful company, despite its possibly declining sales and profits. Under such circumstances, the stock market might drive the value of its shares to astronomical heights before the bubble collapsed if the company did not change its ways. (The issue of creating new products and needing new facilities to do so refers to a very different context.) For this hypothetical business, RONA could point the way to both good and bad responses. Superior metrics would unambiguously identify *only* the *better* courses of action.

Consider, next, a very different situation. Suppose that some other hypothetical company makes products for which there is a sustained demand, even if it is cyclical. Suppose, further, that its products take a long time to develop and a long time to produce. Some products are seasonal, like many foods. Some of the following observations will even apply to toy-makers, whose development times are notoriously long in comparison with each annual sales period. (The production and sale of fire-works for the Fourth of July would be an extreme case.) In other words, we are examining companies for which rational profit-and-loss assessments cannot be performed by examining the books on any single day, or even for a single quarter, making it far harder for the financial pundits to offer valid advice. Suppose that, unlike the previous hypothetical company, this next one has strong sales, and will continue to do so unless it, too, fails to develop new products. We shall assess such a company, using RONA, *before* such an undesirable state of affairs develops, assuming that it has strong current revenues. Unlike food, which remains edible even if the next crop is indistinguishable from the previous one, most of these companies will need to develop *new* products to stay in business, or they too will be transformed into another of the earlier hypothetical companies with a low value of RONA. Let us suppose that our hypothetical company has a currently high value of RONA, but that there are pressures to make it even *higher*. Now let us complicate the issue with some real constraints, like the presence of competition and a limit to the size of the total market on any one day, even though it might grow steadily with time. This situation is very evident with such electronic devices as personal and office computers. The old ones do not wear out rapidly and new features take time to develop. In spite of this, the cost of the hardware has decreased over the years, even if the same cannot be said for the software. Even so, computer software is unusual because the cost of replicating each product sold is infinitesimal in relation to the cost of its development. As long as new previously unobtainable features in the software are marketed in such a way as to require new more powerful computers to operate them, new software will drive the sales of new computers. However, when the opportunities to use computers exceed the number of hours in the day available for doing so, a new demand will arise, for doing the same *old* things more efficiently. The aircraft industry has already reached this point on several occasions, with major improvements always depending on, and waiting for, advances in propulsion.

For our second hypothetical company to remain in business, it must always be developing new products. It is not clear whether the equipment needed to manufacture its products is its greatest asset or if the intellectual property embedded in it is still more valuable – or if the oft repeated phrase that its employees are always a company's greatest assets is really governing in such a case. In any event, *this* hypothetical company would have a hard time staying in business by focussing only on a step-by-step reduction in assets to enhance its RONA. The issue of whether manufacturing assets are "owned" by this company or by its possible "suppliers" is irrelevant. *Everything* that is needed to develop and manufacture products is part of the "assets" in the denominator of *this* RONA. Also, the numerator must refer to the returns received by *all* those involved. Only at *this* level is RONA a *potential* reliable indicator of business performance. Even so, it may be rendered impractical to apply if the company and its suppliers also have additional products developed by some of the same personnel and made on some of the same machines. It is clearly incomprehensible by the time one adds in possible further products made by the same suppliers with the same machines for one or more *different* prime contractors. With this hypothetical company, too, the application of RONA to a *piece* of the whole story can be dangerously misleading.[2] Ironically, RONA can be a meaningful performance metric for an individual company *ONLY* if that company does *ALL* of its work in-house, with absolutely *NO* out-sourcing. Let us *assume* that the best possible business plan and work-share arrangements have been established, setting aside the complex issue of how this could ever be verified. Now suppose that the leaders of *one* of the organizations involved wished to *change* from this global optimum solution to enhance *their* RONA. By definition, since the change is with respect to a true global optimum, some *other* organization must incur a decrease in its RONA and, if the causes and effects were properly understood, it would logically resist such a change. Even without that tendency, it is not clear that *any* organization involved can increase its *own* RONA by making such a change since, by definition, the *overall* value of RONA would be degraded by *any* change. Transferring work away from where it is best done for the overall good would clearly *add* to the total costs, and *reduce* the profits. Locating the capital equipment at some site other than where it would best be utilized would also be counterproductive. In other words, with respect to the *best* overall business plan for the development and distribution of products, *any* attempt to boost RONA by divesting assets at any one site will be counterproductive – particularly if the *best* business plan *required* that all the work be done by a *single* organization.

For our hypothetical second company that looks forward to an expanding market, the *proper* application of RONA to the *entire* product development, manufacturing, and post-sales support activity would identify not only what work should be out-sourced, and to whom, it would also identify what work must *not* be out-sourced. Any profits will naturally be shared in proportion to the amount of work each participant performs and according to the capital investment each needs to contribute. Any attempt to apply RONA at some lower level, such as for any one company – or, worse yet, for any one department or any one product line, – will *always* be detrimental. It would then have the characteristics of the classic sub-optimum solution described in Figure 1. The application of RONA to *one* part of a co-operative activity in isolation can tell *nothing* about whether too much work has been retained, too much has been out-sourced, or even if the most *appropriate* portion of the work has been retained. If a company has multiple products, it is quite

[2] RONA is not the only inappropriate modern-business performance metric. It is discussed here because of its role in forcing the out-sourcing of work that can no longer be retained, when the best business plan says it should have been, because the capital assets needed to perform such work had been eliminated to enhance RONA.

possible that the optimum level, and kind, of participation might even vary from product to product. There is *no* simplistic universal answer. In other words, while the metric RONA might be the darling of Wall Street, it is dangerously misleading when applied to individual companies, the production of whose products are shared between many contributors.

THE CASE AGAINST *EXCESSIVE* OUT-SOURCING

If the prime manufacturer, or systems integrator, cannot make his fortune by giving all his work away, who does benefit? The subcontractors, of course. They have a guaranteed profit margin, if they wrote the contract properly. They have access to free technical advice if they encounter problems, because the systems integrator cannot allow them to fail. They have virtually no risk; if they are a sole-source supplier, they are likely to be bought out by the systems integrator if they encounter insuperable problems. What more could they ask for, other than that the sources of their work stay in business to *keep* them supplied with work. Not every supplier succeeds, of course, but on average, those organizations with assets used to make products have been far more profitable than those who paid them to do the work. A systems integrator has little option but to assist any of its suppliers in difficulty and is often put in the position of accepting additional costs rather than have their entire production line closed and have to pay penalties to every *other* supplier. The systems integrator, who finally sells the product can raise the price no more than the market will bear. So it is the prime manufacturer, or systems integrator, who absorbs all cost over-runs and whose profits are limited, not most of the suppliers.

While it must be conceded that final assembly has proved to be one of the least profitable activities in manufacturing large aircraft, the point is often raised that certain other tasks that prime contractors perform *are* profitable. Initial sales are competitive and there is little margin for profit. However, the sale of spares is far more lucrative, because there is no competition and there is strong financial pressure to keep all aircraft flying and earning revenue. But who makes the spares? And why is it that so many suppliers who make those spares request that they be the sole source for them, often supplying them directly to the operators? Will those who have that authority today willingly surrender it to make the plans of others who wish to reduce their activities to no more than systems integrators come true? There is more *percentage* profit on the distribution of intellectual data, provided that one does not have to pay to have it updated, but the *volume* of such work is clearly insufficient to support organizations as large as today's prime manufacturers. In any event, how will it be generated if all the work it describes has been out-sourced so that no locals can ever learn such skills in the future? Out-sourcing the generation and distribution of a company's proprietary intellectual data would seem to be fraught with opportunities for potential customers to acquire the knowledge they need elsewhere.

The basic problem with being only a systems integrator is that it does not cover a *sufficient* fraction of the total work for a large company to remain in business. The engines and avionics alone typically represent some 50 percent of the cost of producing large aircraft. There is simply not enough structure involved for too much of it to be out-sourced. Surely even a 5 percent profit on 25 percent of the total work is more valuable that a 15 percent profit on only 2 percent? The latter goal is a guarantee that there will not be sufficient cash generated to ever launch new products, not even derivatives that are perceived as costing less than new aircraft but which are often found to cost just as much, for a product for which passenger comfort or performance might have been constrained by legacy from the earlier design to be less than state-of-the-art.

Is it really all that difficult to comprehend that, along with the work involved, the revenue and profit associated with it have *also* been out-sourced?

UNDER WHAT CIRCUMSTANCES *IS* OUT-SOURCING PROFITABLE?

Having observed that the *total* number of man-hours involved in a task will increase if it is out-sourced, one needs to identify the circumstances under which other factors over-ride the negative influences. The most powerful one is automation. But why should the work not be automated in-house instead? It should, *if* there is sufficient work to keep the machines fully employed. But often this is not the case and only by having multiple customers sharing such facilities owned by an independent subcontractors can the benefits of automation be achieved. Contrary to common perception, the true justification for automation is *NOT* the elimination of jobs on which it is employed. It is the precision it provides that is the primary benefit. It prevents the unnecessary duplication of down-stream work that goes hand-in-hand with out-of-tolerance work upstream. Liaison engineers and shop worker pride themselves on their ability to avoid scrapping discrepant parts that are structurally sound but which do not fit. In the short term, and on isolated occasions, this may be a very desirable trait. But, in the long term, it is *not* the low-cost solution. If the goal is to minimize costs, there is no substitute for doing things right the first time!

It is accepted that prime manufacturers cannot afford to have expensive facilities that are under utilized, even if it would save on downstream rework. It really *is* better to out-source such work, *IF AND ONLY IF* the selected supplier has excess capacity on such equipment. If his machines are already fully committed to other customers, it makes no sense to allocate the work to him without any improved dimensional control. The ultimate in cost saving is self-assembling structure, in which numerically controlled locating holes are drilled in precision details made with thermal compensation. This not only eliminates the need for intermediate assembly jigs that cannot be used on subsequent aircraft, as universal NC machines can, it also frees up the tolerances that have traditionally been absorbed by, and in, such jigs, as explained in Ref. 1. Precision parts, from whatever source, save a fortune on final assembly. It is commonly, but erroneously, believed that parts-count reduction is the key to reducing final assembly costs. It is not! Ref. 3 gives examples of how to design low-cost structures and of what features should be avoided. Ask any aircraft mechanic and you will be told that the bane of his life, and the source of high costs, is parts that don't fit and parts that need shimming. Drilling and filling holes is straightforward, in comparison. In short, it is better to obtain precision parts from outside sources than it is to make imprecise details in-house. (But the converse is equally true.)

One simple fact of critical importance to the issue of any *best* level of out-sourcing is that maximizing the manufacturing work out-sourced does *NOT* equate to minimizing the remaining assembly work to be done internally. The dollar value of out-sourced work is a *very poor surrogate* for internal cost savings. There have been cases in which maximized out-sourcing was directly responsible for the complete remanufacture of the parts before they could be installed on the aircraft. There were predictable reasons for this situation, the avoidance of which in future requires that the *downstream consequences* of out-sourcing be established *before* the work is re-allocated. Far from saving money, the original out-sourcing decision led to a total redesign of the parts, so that they could continue to be out-sourced, but at a lower cost, and inflicted considerable unplanned manufacturing expenses on the program that could never be recovered.

Out-sourcing as offsets for sales can be desirable if looked at from a sufficiently comprehensive viewpoint. But this is *independent* of the idea of out-sourcing for the sake of off-loading work in the belief that doing so will reduce costs. It *will* reduce the profit margin on sales; it may or may not reduce costs. Prime manufacturers should be *very* selective about *what* is out-sourced.

ON THE DOWN SIDES OF DOWN-SIZING

Most employees in the aerospace industry today equate out-sourcing of work they used to do to subsequent down-sizings in their own organizations. This is natural. But some down-sizings are implemented *without* any associated out-sourcing. The consequences of these policies are now well known; diminished motivation and company loyalty amongst both blue-collar and white-collar workers, along with far higher than acceptable attrition rates and a loss of technical skills that it has not been possible to replace.

However, there is another aspect to the policy of downsizing. There appears to be no doubt that salary reductions save money in the short term and decreased pension obligations save money in the long term. Yet the only circumstances under which down-sizing can *continue* to decrease costs is the very rare situation in which *every* department being downsized has excess personnel and equipment. If even *ONE* department is understaffed or under-equipped, the traditional lawn-mowering (across-the-board) reductions in head count *will* cause the total production costs to *increase* in the manner shown in Figure 2. Worse than that, the down-sizing will have converted the even more understaffed or under-equipped organization into the very bottleneck that the Theory of Constraints explains is what must most be avoided if a business is to operate profitably. The other departments will then appear to be overstaffed because they will be behind schedule, waiting for work from under-staffed or under-facilitated departments. Working on the original less critical bottleneck would have been far more effective in increasing profitability than indiscriminate downsizing ever could be.

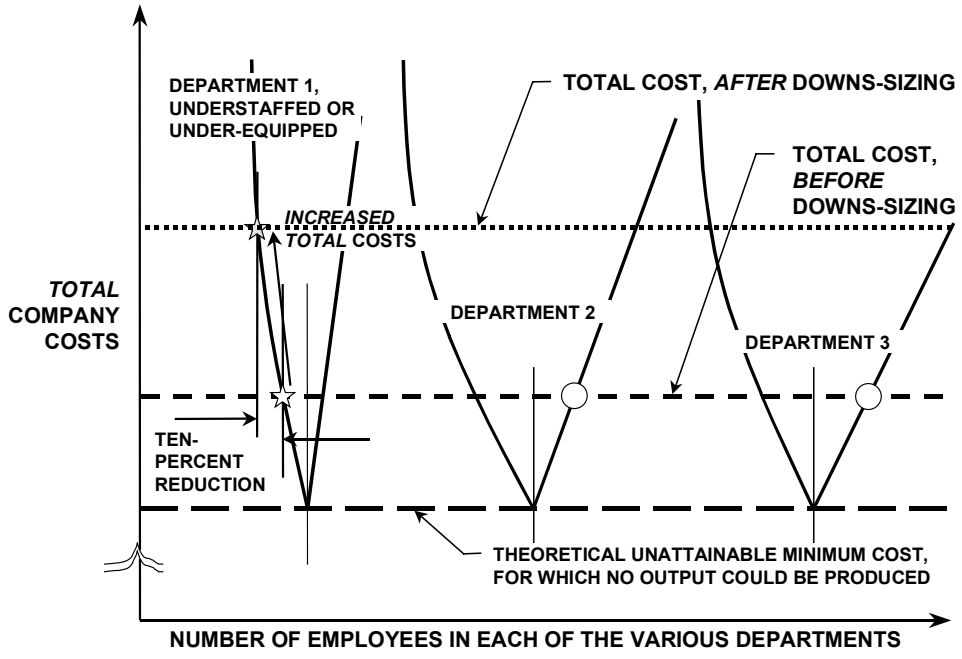

Fig. 2 Typical Effect of Down-Sizing on *Total* Company Costs

A corollary to the Second Law of Thermodynamics states that "perfect efficiency can be achieved *only* when *no work* is being done". It seems strange that, in the most hi-tech of industries, it is not appreciated that this same inescapable law of nature applies equally to business activities as well. Yet the traditional implementation of head-count limits, either on the assumption that all skills are interchangeable, or the belief that none are involved, flies in the face of such realities. The goal of perfect efficiency is quite unattainable, as has been explained in Ref. 4 in novel-like terms that any layman can understand. Head-count reductions are tantamount to the elimination of a number of technical skills and all of the work in which each had been involved.

A far more productive approach to the problem of a mismatch between revenues and salaries is to add additional work to retain skilled workers, even if it means diversifying into non-traditional activities to do so. The former Douglas Aircraft Company pursued temporary outside work that matched its under-utilized facilities during an economic down-turn during the 1970s. It was found that there were many outside customers for the kind of work that only aerospace workers in the so-called "Special Products Division" at the Santa Monica plant were able to provide. To make the work cost-competitive, only the *incremental* administrative costs of the one man finding the work, and his secretary, were added to the direct costs. All other overhead costs would have been incurred, anyway. Today, one German aerospace factory has a novel approach to the head-count problem. In order that it retains a full complement of the skills needed to manufacture space structures, for which there is a limited market, it *consciously* seeks additional work in other industries to fully utilize its workers and facilities. This is acknowledged as being *necessary* to accomplish the *primary* goal, which they could *not* accomplish *without* such diversification. At other factories, with a greater focus on "core activities", head-count limits are enforced even when they cause an immediately identified loss of revenue in some of the departments involved. But wasn't the reason for the head-count reduction supposed to be an *increase* in profitability? Down-sizing can have many effects, but it is inescapable that, if all "excess" capacity has been eliminated, only the less-enlightened, and less efficient, competition will have the facilities to respond to unanticipated sales opportunities.

INTERNAL OUT-SOURCING – THE ISSUE OF WORK SHARE

In companies with multiple manufacturing facilities at different sites, there is an issue of how *much* work should be allocated to each site. An even more important issue is *what* work should be allocated to each site, paying proper attention to the sequence of assembly. These issues are directly analogous with obtaining the best results from out-sourcing. The best *overall* result is *not* achieved by minimizing the work done at the final assembly sites or maximizing the work done where subassemblies are produced. Also, the *design* of the structure *must* be compatible with the work-share allocations. One must also pay attention to the *increase* in inventory costs created by items installed *prior* to final assembly in order to reduce span time at the final assembly site. Inventory costs accrue throughout the span time between installation (no matter by whom) and sale of the product, *NOT* throughout the span time for final assembly alone! Reducing the span time at the final assembly site by improving the efficiency of that task is a good thing. "Creating" that same reduction by merely transferring work to suppliers is *NOT!*

The traditional problem area is the wing-fuselage junction, which is complicated by both structures and systems, for which access is needed. The traditional Douglas Aircraft design practice was to complete the entire wing first, without shimming, and to lower the fuselage on to it afterwards. The Heritage Boeing concept has been to embed a completed center section in the

fuselage and attach the outer wing boxes later. This has required conscious provision for adjustment of some dimensions by deferring the installation of selected fasteners until *all* of the parts are in place. The center wing box has spars where the Douglas designs had ribs, to permit the cross section to be distorted slightly without pre-stressing so that it matches the shape of the completed wing rib at the root of the outboard box. Even with a large fraction of machined precision details, Airbus Industrie also relies on adjustments at final assembly that are accomplished by incompletely defining both sides of the interface at the side of the fuselage. Every one of these different detailed designs is compatible with its own particular assembly sequence. The point to be made is that, if the assembly process is altered by changing the work share between factory sites, one should *expect* that there is a need to *redesign* the wing-fuselage junction. Far too often, it is assumed that this step can be omitted. It cannot!

Another traditional problem created by work-share and out-sourcing decisions concerns the joining together of fuselage barrels, the perimeter of which can be adjusted only slightly by consciously leaving skin splices undone and stiffeners unfastened within a certain distance from all barrel-to-barrel interfaces. This need is contrary to a policy of maximizing out-sourcing. It requires that certain tasks *not* be out-sourced if the work at final assembly is to be reduced rather than increased. Some aspects of this issue have been addressed in Ref. 3, but a new development with the 737 line of Boeing aircraft sheds further light on this issue. The fuselages on the 737 Classic models had been made as three separate barrel sections in Wichita. They were transported to Seattle by rail for final assembly. Invariably there were misalignments at the interfaces, just as on the DC-10 and MD-80 aircraft. A change in work-share allocations resulted in Wichita completing entire fuselages before shipment for the later 737 Next Generation models. Now that Wichita is responsible for tasks they never had to do in the past, the barrel-joins have all been eliminated. The gaps between completed nose, over-wing, and tail sections are now filled by upper and lower clamshells, very similar to the concept used on the DC-9 aircraft, so that the perimeter can be adjusted. This design *was* changed (appropriately) to reflect the change in assembly work-allocation. It sets a precedent that needs to be followed more often.

THE ULTIMATE IN OUT-SOURCING – BADGING ONE'S PRODUCT

Some companies, particularly in the electronics industries, have *no* manufacturing facilities of their own. They only design and distribute their products. It is not possible to employ less assets of one's own; in effect they are "renting" capital equipment from those who actually make their products. This is perceived as beneficial whenever the rate of development of the product is so rapid as to leave a wake of obsolescence in its path. The cost of these assets, while not directly disclosed, is obviously included in the cost they pay for their products. The inherent difficulty with such an approach to business is the need to retain *and develop* the technical skills needed to develop future products. This is very difficult to do if there is no access to observe the latest production techniques. And, if design and development is out-sourced, too, to "save" even more up-front money, the original prime manufacturer is left with no special resource *requiring* that it be involved at *any* level in any future products. One must be able to contribute in some way to products one sells to avoid becoming merely a retailer of other people's products.

MAKING OUT-SOURCING WORK – A EUROPEAN PERSPECTIVE

Because it is a consortium, Airbus Industries has necessarily been involved in the off-site manufacturing of much of it products. The author can see both financial successes and high costs

in their experiences[3], which have been constrained far more by political considerations than in the USA (other than for the award of military products, for which it is necessary to involve as many States as possible in production to ensure Congressional support for each program).

The clear advantage of having a small number of jet engine manufacturers, separated from the airframe manufacturers, is that there are economies of scale, a level of competition, and the means of retaining a critical mass of technical expertise. These are the ideal conditions under which out-sourcing makes sense. The same is true in the avionics industry. It is for these reasons that Airbus makes extensive use of specialty shops in the production of detail parts for their aircraft. A small number of shops produce the small machined parts for *all* aircraft made on the Continent. Other factories concentrate on the production of long skinny machined details, like wing skin planks for the Mystére aircraft. Restricting the manufacture of stiffened panels to only a few sites made it possible to automate this process and introduce self-assembling (jigless) structures long before they were used on the 757. The reason for this level of automation, at the *start* of the process is primarily one of precision, to reduce the costs of *subsequent* assembly steps. *All* of the horizontal tails are built at one site, in Spain, and all of the wings in the United Kingdom, with large wings at Chester and the small wings at Bristol. The underlying principle behind this kind of work-share arrangement is that it is the *only* way, for low-volume production, to economically justify the use of cost-saving equipment that could not be justified if it had to be replicated and under-utilized at a far greater number of sites. In addition, the great majority of Airbus production, other than as offset for sales, is confined within a small area, which has reduced transportation costs with respect to those incurred by the more dispersed production used by the former McDonnell Douglas Corporation.

On the other hand, it seems to the author that Airbus has too many factories involved in the assembly of fuselage barrels[2]. It would seem that this is necessary for the pride of the Nations involved, but it does lead to more splices in the structure than would be involved if only detail parts or panels that had been optimized to limit the number of joints in the structure had been shipped to final assembly. A similar situation arose on the fuselage of the MD-11, which differed from that for the DC-10 primarily by the addition of two short plugs, with many structural breaks that could easily have been avoided by extending one or more of the existing DC-10 barrels instead. But that would have meant renegotiating the contract with the former Convair company for the DC-10. No such problem arose for the stretched DC-8 fuselages, which were the last designed for in-house production. There is a potential problem for Airbus with the wing for the A-3XX. If the outer wing portions are made separately, in Germany, on the basis of work-share allocations for the partners, it is likely that the total wing will then cost far more than having it produced entirely in England. The reason is simple; there would be some very difficult joints to assemble, possibly made even more complex by thermal dissimilarities between aluminum alloys and carbon-epoxy. There is a precursor to this situation within the experiences of BAe. At one stage, the Bristol plant decided to increase its work share by pre-assembling the outboard box out of the detail parts it had been shipping to Chester. Unfortunately, the wing was a tapered box and the outer portion could not be slid inside the inner portion. The wing had been designed for the pieces of the panels to be joined together before the box was assembled. It is hoped that these lessons are heeded in the future, by *all* companies.

[3] Again the views expressed are those of the author and not necessarily those of Airbus management. The observations are offered in the hope that *both* companies can benefit from them.

The Airbus experiences in regard to outside manufacture contain two important messages for Boeing. The first is that it *can* be done economically, but only with thorough planning to ensure that the expensive capital equipment that is not available in-house is fed sufficient work to make it profitable, even if that means identifying many detail parts on a great number of different drawings to avoid having similar parts made inefficiently at a great number of sites. The second message is that the entire assembly process must be *integrated* with the internal and off-site production plans if it is not to cause great delays and increases in costs.

HART-SMITH'S RECOMMENDATIONS

Having indicated the follies of so many of the modern methods of cost control, the author should at least offer his own suggestions for others to criticize in turn, or pay attention to. These recommendations are actually quite simple.

1. Look continuously at the *entire* activity. Do *not* minimize costs in isolation. Understand that *one* global cost minimization is worth far more than even 20 sub-optimum cost reductions.
2. Acknowledge that perfect efficiency cannot possibly be achieved and that it is counter-productive to try to do so.
3. Identify the *minimum* amount of production work that *must* be retained in-house to generate sufficient cash to develop future products. Do not let the tasks performed in-house fall below this level even if some tasks have a higher profit margin than others.
4. Retain sufficient in-house production manufacturing that it is possible for future engineers to acquire the skills needed to develop new products, without which all businesses will fail. Even the work that is out-sourced requires internal expertise to write the specifications.
5. Out-source only on the basis of better facilities; never on the basis of a temporarily lower labor rate. Out-sourcing as offsets for sales must be acknowledged as an *increase* in cost, on average, not a desirable cost saving.
6. Understand that out-sourcing work increases *total* span time and transportation costs. It out-sources all of the profits that are associated with that work. It also entails *additional* in-house activities that would not have been needed if the work had been retained in-house.
7. Recognize the importance of precision in *early* tasks in reducing the larger subsequent tasks. Pay particular attention to self-assembling (jigless) structures as a proven method for eliminating expensive intermediate tooling that has no value once a program is over.
8. Acknowledge that cost-saving techniques that work in other high-volume industries are often quite inappropriate for low-volume industries like aerospace.
9. Find work to fill excess capacity; do not close it down or sell it off to boost RONA. Take on non-core activities, from time to time, if that is what is needed to reach a balance between head-count and budgets. Otherwise, irreplaceable critical skills will be lost and it will not be possible to deliver even core products.
10. Listen *more* to your own employees about how to save cost than to any outside business consultants who have never run a factory producing your kind of product. In any event, if the advice they offer changes every year, it cannot possibly be correct.

CONCLUDING REMARKS

A strong case has been made that out-sourcing all of the value-added work is tantamount to out-sourcing all of the profits. It also *increases* span time and the cost of inventory, as work is done earlier. There are many additional internal costs associated with out-sourced work that are not identified as such. As long as the additional internal work associated with out-sourced activities is reported as extra overhead on the unrelated remaining internal work, instead of being identified as a cost of out-sourcing, the illusion will be created that the more work is out-sourced, the greater is the case for out-sourcing the remaining work. Eventually, when the entire corporate overhead is applied to the sales department – because there is no other department left – sales will be out-sourced, too, because that task will also have become too expensive. Only a *thorough* assessment of *all* costs can distinguish between work best out-sourced and best performed in-house. In any event, there is a *minimum* level of work that *must* be accomplished in-house if a company is to remain in business. In addition, very different designs may be needed for different assembly sequences at multiple sites, whether they be within a large corporation or at someone else's factory. Excessive downsizing can lead to an increase in costs, it can also reduce a company below the critical mass of technology needed to develop future product to stay in business. Work may need to be undertaken *outside* defined core competencies merely to ensure that the staff and facilities are available to perform work that *is* defined to be within core competencies. It can also be far more *profitable* to add work to fully utilize existing facilities than to sell off the facilities and out-source the work. The fate of the former Douglas Aircraft Company, which was reduced to a systems integrator in the early 1970s by excessive out-sourcing of DC-10 production, is a clear indicator of what will happen to other companies which fail to sustain the conditions under which it is possible to launch *new* products. It is hoped that this sacrifice can save the new and expanded Boeing from a similar fate.

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