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LOW COST SPACE OPERATIONS: EMPTY PROMISE
OR FUTURE REALITY?

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ABSTRACT

The Space Shuttle has been heralded as the cost-effective replacement for unmanned boosters. Many hardware-oriented studies have been performed, showing potential cost savings as compared to past operations. More recently, studies of management approaches and implementation procedures have indicated a potential for significant additional improvements in effectiveness. To what extent are these potential reductions in costs and complexities likely to be realized? To reorient the internal NASA thinking on hardware and procedures is but a small part of the problem. Is it possible for a government service to be efficient and self-supporting? These questions must be considered in the broader context of government operations as affected by national politics and economics and by potential commercial and foreign competition.

INTRODUCTION

The outstanding technical successes of both the Apollo program and the NASA unmanned space exploration program were not without adverse critics, even among NASA's satisfied customers: the price paid for the success, from the standpoint of the payload world, was long lead times, complex administrative and hardware procedures, and extensive overhead (paperwork), all of which detracted from the timeliness of the scientific investigations and from the investigators' sustained attention to their primary interests. As long as funding was reasonably readily available, however, their criticisms tended to remain at the "healthy griping" level, despite their increasing realization that this support ultimately came at their own expense as taxpayers, and hence was in competition with other needs.

The end of the Apollo program, however, coincided approximately with the beginning of a world-wide realization that national economies were in trouble. The space shuttle, initially conceived as transportation to a space station, became simply the replacement for unmanned boosters, and its justification shifted to its potential cost effectiveness as a launcher and space platform, while the space station concept was indefinitely postponed. A large number of NASA-sponsored studies were performed, analyzing the potential cost impact of changed hardware constraints made possible by the shuttle (weight, volume, g-loads,

etc.); generally, savings ranging from a few percent up to a factor of two were shown possible. These hardware estimates were readily acceptable, as it is easy to compensate for such modest reductions by postulating a corresponding increase in volume of business. No one need lose his job.

This semi-comfortable posture proved untenable almost from the beginning, as it unrealistically assumed a constant total expenditure (unit cost times volume of business), and the projected reduction in unit complexity was too modest to satisfy the aforementioned critics anyway. Furthermore, there was always an uneasy feeling that there might be more to cost reductions than mechanical hardware considerations; claims were even being made by some people to the effect that the hardware as such accounted but for a small fraction of the costs, and that savings by factors of 10 to as much as 1000 could be obtained by revising management philosophy and implementation procedures, without adversely affecting safety and experimental success ratio. Studies were never funded to substantiate or disprove these claims adequately. The proponents of procedural changes were generally left to pointing to other complex space programs which in fact have been highly efficient and cost effective from the customer's standpoint, such as the USAF Space Test Program and NASA's Airborne Science Program; and thence to argue endlessly about the degree of applicability of this management experience to other programs, in particular to the space shuttle. To attempt to resolve this uncertainty quantitatively is to risk losing face (pride in past procedures) and losing jobs (volume of business is not likely to increase that much in the near future).

Meanwhile, and on an increasing scale as the underlying uneasiness becomes more explicit, a different series of management studies is continuing to be funded under the heading of planning for the shuttle operational era. The underlying assumptions are that the NASA mission model (some five shuttle launches per month) is valid and that the management of such an operation is necessarily immensely complex (otherwise, why would we need such multiple and elaborate studies to develop management schemes?). The results of these studies are thus quite predictable: they will preserve high costs (complexity and employment) and ignore the possible economic

inconsistency between that and high volume of business. I say "possible" economic inconsistency because there is always the "solution" of massive subsidies.

It is not the purpose of this paper to quantify, defend, or even review the various proposed hardware and management schemes. It is clear that some measure of cost reduction for space operations is achievable, and the question I wish to explore is what are the main impediments to implementing lower cost, more efficacious practices, of whatever nature. In so doing, I may sometimes appear critical of NASA. Such is not my intent. In fact, I question the extent to which the problems can be resolved by NASA and the aerospace industry independently of resolving some broader societal and national issues.

It is also not my purpose to propose solutions, and especially not a single, logical, documented, reasonably comfortable and acceptable solution. My biases may be evident, but the format and length of this paper preclude such complete analyses.

The purpose of this paper is to bring into the open certain fundamental issues which underlie the general malaise regarding the cost effectiveness of the shuttle, and thereby to stimulate thinking and discussion. This is but the first step toward finding solutions.

The views expressed herein are my own, not necessarily those of NASA and/or the Ames Research Center management.

IMPEDIMENTS TO COST EFFECTIVENESS

Our approach will be to start with problems internal to NASA, as this agency has been the world leader and prime focus, and is still the largest single driving force in civilian space activities. We will quickly be led to the larger factors which impede cost effective solutions, as, in fact, few of a government agency's problems are independent of broader societal problems. We will be addressing the difficulties in implementing any significant reductions in complexity, not the smaller savings which would hardly affect employment.

The most significant internal NASA problem derives from the momentum generated by past successes and by the intense personnel training which was a part of it. There is a justified pride in the past achievements, and a sincere belief that the procedures employed were essential. Since generally the same leadership and work force are now approaching space shuttle operations and payloads, it is not surprising that the transferability of the experience should go unquestioned. The point is not whether this experience is, in fact, uniquely transferable, or whether equally valid, though vastly different experience exists in other programs, both domestic and foreign. The point is that the former is psychologically

acceptable, the latter is not; the former tends to be accepted prima facie, the latter to be summarily rejected; and the largest manpower and fiscal resources are concentrated in the former camp (obviously, the proponents and users of simpler methods never had a requirement for so much larger resources). The initial problem, then, is to open people's minds to the fact that significant reductions in complexity are conceivable and should be seriously investigated, even if the outcome might lead to a significant reduction in work force.

This education process was, in fact, initiated in 1970, and a small but persistent and increasingly influential internal lobby has developed. Since most of the planning resources, however, are devoted to devising the future system within the more complex frame of reference, detailed operational plans with attending facilities and organizational structures are already coming into being; we are thus coming close to having to reverse or abandon a lot of costly recent creation, if in fact there is a simpler approach, and the longer we wait the more difficult it will be. Hence the following developments appear possible: (a) means are found to accelerate the impact of the low cost lobby and to implement its recommendations; (b) competition from other U.S. and from foreign sources of launch services will force NASA out of the launch services business (an advanced R&D role may be retained); (c) the space shuttle will not be cost effective, and will survive only if heavily subsidized.

The first possibility would require understanding and deliberate action by top management. Assuming understanding can break through the ties to the past (a nontrivial problem), management must then not only prevent the generation of needless structures, but start new organizational structures to handle a simplified space transportation and payload accommodation system. There is enough flexibility and turnover to infuse these structures with sufficient fresh leadership and work force to retrain other existing and needed personnel. The next problem, then, is the disposition of the remaining personnel. Normal attrition is too slow and too unselective of talent and talent mix. And at this point we part company with problems that are internal to NASA and within its control.

To transfer excess human and physical resources to another agency simply shifts the problem to another part of the government; the recipient agency, for the sake of its own efficiency, should (like NASA) start new structures, not reshape old ones, and hence hire selectively on the open market. To lay off large numbers of personnel is, contrary to popular opinion, quite straightforward in Civil Service: the unneeded positions are simply abolished by executive decision. The problem is the effect on local employment and business, and the closing of a government activity of any size becomes a national political struggle. Contractors who used to complain about excessive government red

tape join the fight to protect their contracts, appealing politically on the basis of employment and claiming that the executive decision was unsound to begin with: the agency simply doesn't understand what it takes to run its own business. Labor organizations and the public join the pressure groups with equally inconsistent arguments: everyone wants both government cost efficiency and government support of his inefficient project. Investigating committees are set up to study the conflicting claims, pending resolution of which all action directed at efficiency is stopped, very likely by Court order. The process thus becomes as slow as normal attrition, and even more wasteful of resources.

The second possibility, competition from other sources of launch services, will not force NASA into a more cost effective mode, as open and fair competition between commercial enterprises and government agencies is impossible. Either the government agency becomes an independent enterprise, free to survive or collapse in accordance with its degree of commercial competitiveness; or it is protected by regulations which hamper and distort competition, and is probably subsidized as well. A self-supporting government organization is a contradiction in terms: if the organization is able to adjust its operating mode and fees so as to be fully supported by its customers, there remains no government role; especially for a service still considered nonessential, the support of the organization by its customers is the only regulation needed for viability, and the best proof thereof. Hence, competition would force the government out of the launch services business, leaving it to concentrate on commercially risky advanced R&D, such as space stations development.

The third possibility, a subsidized and expensive shuttle, can result simply from inertia, as an extension of the status quo, or from a conscious decision that, for national prestige or public good considerations, the shuttle must be government operated. Domestic competition could be regulated or legislated away, while foreign competition is more likely to be fought by home subsidies; in either case, the point is that the shuttle would not be subject to competitive pressures. This nonsolution to the cost effectiveness problem ignores the possibility that U.S. industry might do an equally creditable job, if motivated by profit and not limited by government regulations; and that greater good and prestige might accrue to the U.S. through this demonstration of democracy and freedom at work than through the continuance of an operation in a mode which no longer has the backing of even its own customers, precisely because of its complexity and cost to the taxpayers.

Can industrial concerns in fact compete successfully if foreign launch services are government operated or subsidized? The affirmative has been seriously suggested as feasible, partly because foreign nation economies are generally in as much or more trouble as ours, and partly because a

powerful mechanism, the multinational corporation, would probably be brought into play. Our purpose here, however, is not to review the validity of proposed solutions, but to surface basic problems not otherwise sufficiently discussed. The problems which are the point of this discussion are as follows.

Just as NASA has difficulty studying alternatives proposed by its low cost lobby, the country seems to have difficulty considering seriously alternatives to increasing government roles, despite past and current negative experiences with the effects of massive nationalization of businesses. Assuming one could get support at high enough levels, the problem of retrenchment would still have to be faced: multinational corporations are a potential threat to nationalistic governments in that they are difficult (almost impossible) to tax and control fully (which helps make them commercially effective and powerful); and in that they may also be a more powerful means to international ties and cooperation than political treaties (the spread of multinational enterprises could make war unthinkable and nationalistic governments obsolete). Most of the world's population is not ready for such retrenchment from nationalism, so that, if in fact there is a viable commercial potential in a multinational launch services corporation, it will have to be attempted in spite of various governments' opposition.

ASSUMPTIONS, ANALOGIES, AND NONSOLUTIONS

Even when stating problems rather than substantiating solutions one makes certain assumptions which should be explicitly examined. In particular, the existence of our problems assumes that: (1) space travel, exploration and utilization are desired by the people; (2) we still have and believe in a democracy in which people's desires count; and (3) we believe that quality of life is strongly dependent on individual freedom (and hence responsibility), so that each and every limitation imposed by government must be justified in a hard way.

The current apparent low popularity of space programs is only an expression of immediate priorities in a physical and economic environment which has deteriorated drastically in recent years; such priorities should be respected, but they do not mean total abandonment of space programs. Fundamentally, space travel (physical and metaphysical) has been a preoccupation and dream of mankind throughout history, and this dream is perhaps more alive and widespread today than ever before (witness the persistent popularity of Jules Verne, Buck Rogers, Star Trek, science fiction in general, and especially the way in which the early Apollo program fired up nearly the entire world's enthusiasms). Furthermore, the commercial interest in space applications (particularly communications, but also navigation, meteorology, materials processing, and earth resources management) shows that the products

are saleable to the public. These then, are the fundamental justifications of space programs: they are a step to the fulfillment of one of man's dreams, and they even have some immediate and recognizable practical benefits. Other spin-offs, technological, intellectual and political, are equally valid but do not have public understanding and backing.

Whether we still have (and believe in) democracy and individualism is not as easily answerable in the affirmative. Historical evidence indicates that these values tend to disappear and governments tend to collapse or become dictatorial whenever government spending (or taxes, to this accuracy) exceeds about 25 percent of national income; the current U.S. figure is around 40 percent. The apparent mechanism for this phenomenon also explains the impreciseness of the figures. It seems that at a level of 15 to 25 percent of income, government becomes powerful enough, coercively and economically, so that it becomes worthwhile for organizations (both labor and management) and individuals to devote significant resources to lobbying (legislation and rulings) and to devising and implementing legal tax avoidance transactions. These activities detract talent, creativeness and other resources from the production of consumer goods and services, but are nevertheless reflected in, and thus distort calculations of gross national product (goods and services) and national income (wages, salaries and profits). This overhead and its regulation are also reflected in higher consumer prices and increased government spending (and taxes), which further stimulates the overhead transactions.

Equally importantly, free bargaining and competition are given up, in this process, in exchange for government protective regulation, legislation, and subsidies. To ask for a competitive (cost effective) launch services organization (private or government), within a high overhead, highly regulated and economically distorted environment is probably inconsistent and unrealistic.

Recent (January 1976) news stories (Wall Street Journal and local papers) concerning the U.S. Postal Service bring out an additional consideration, particularly important because, unlike launch services, postal services are of direct concern to nearly the entire population. Briefly, this organization, with established and guaranteed locations and routes, free from competitive worries and subsidized by nearly \$1 billion per year, neither provides the desired service nor is able to remain solvent. Furthermore, proposals to allow private concerns to compete are reportedly being rejected because they might drive the Postal Service out of business.

A government-controlled organization cannot charge what the required services really cost (and still generate enough volume to be profitable) because both the public and the special interests have been trained to expect unrealistically low prices for government services. The point is perhaps made clearer by looking at another example, U.S.

retail gasoline prices, which are two to three times lower than those in most other industrialized nations. People can be trained to accept very broad ranges of price levels, even perhaps including the true costs of goods and services, depending on the degree of government involvement.

The problem, then, is distorted public expectations, made possible by ignoring the fundamental law that one can't create something out of nothing. The artificially low prices and the large unproductive overhead and subsidies must be supported by the productive sector (which is dwindling because of the overhead).

THE KEY PROBLEM AND A RAY OF HOPE

Briefly stated, the key factor in the proposed methods for truly significant cost reductions is delegation of responsibility. It is assumed that a competent manager is willing to take the responsibility for the safety and operational success of his mission; that the customer (payload owner) is genuinely interested in the proper functioning of his payload; and that both can talk freely to each other and to such other parties as are operationally essential, thus reaching direct agreements and decisions on these safety and other operational matters. This individual responsibility is the basic mechanism for minimizing committees, paperwork, delays (diversions of efforts to nonproductive areas).

Briefly stated, the underlying common thread in the problems outlined in this paper is the unwillingness to assume responsibility and face hard decisions. Individuals, the public collectively, labor and management, all expect the Government to solve their problems for them. We have developed a paternalistic society in which all look to Daddy for a handout; he owes us a living just because we are alive, regardless of what we produce in return, and we are not even mature enough to ask how large the bill is and who is supposed to pay it.

Briefly stated, the key problem is that these two positions are incompatible: collectivism destroys the incentives for individual responsibility. Whether the trend is toward more collectivism or toward responsibility, the evidence suggests that the human race will not reach maturity in time for the first shuttle launch.

The ray of hope, then, is that there are nevertheless enough responsible individuals to speak out and lead the way, at whatever personal risks. The complexity of the total problem need not prevent an aggressive though stepwise start. There is, in fact, continuing progress in this direction.

CONCLUDING REMARKS

Some fundamental problems in the path to cost effective space operations have been identified

in the hope of generating open discussion of the issues involved. It is hoped that the necessarily broad-brush approach of this length-limited paper will not detract from its purpose. We can only find solutions if we are willing to think about the issues.