INDUSTRIAL STRENGTH DEFENSE

A DISQUISITION ON MANUFACTURING, SURGE AND WAR

MARTIN C. LIBICKI

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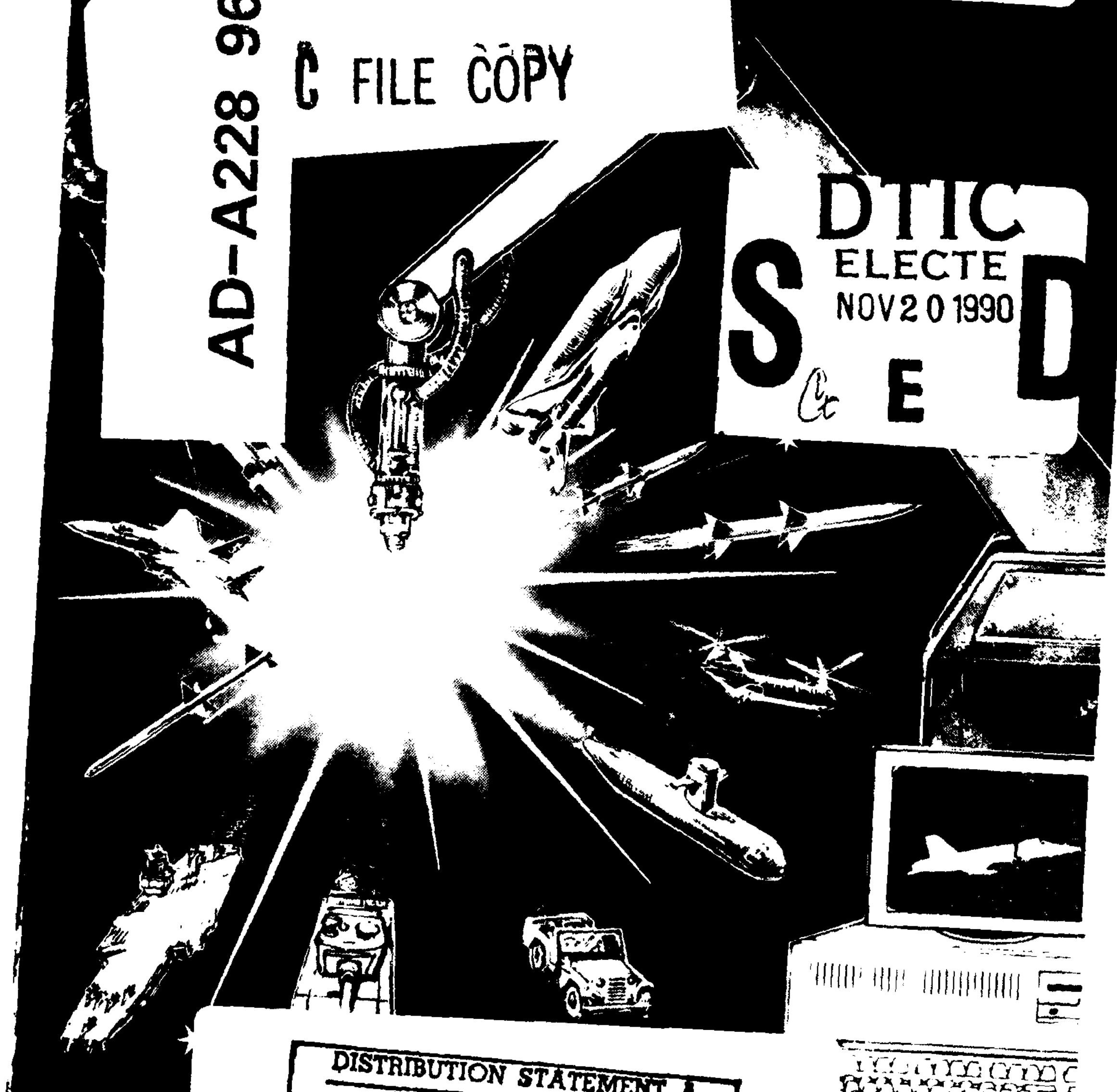

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Finally, in obeisance to the principle that the first shall be last, is my debt to William Taylor, who as director of MCDC, provided considerable encouragement and support for a project whose purpose and direction was anything but obvious at the time.

DEDICATION

To Denise L. Mazorow.

1

INDUSTRY AND WAR

> Defense strategy should be focusing on what should be done in peacetime so that wars, should they occur, may be concluded on respectable terms. Thinking backwards from the material requirements for ending wars suggests that DOD should be very concerned about how industry would respond when asked to multiply production quickly.

Deterrence is making others fear to start wars. War is about ending fighting on respectable terms. Since World War II, the United States has sought deterrence, both nuclear and conventional. So far, deterrence has held. But a deterrence pursued at the expense of the requirements of warfighting is hollow to the extent that it cannot cope with the consequences of its *potential* failure. In effect, DOD is always facing choices between what deters (by minimizing the likelihood of an easy victory by an adversary) and what contributes to the likelihood of successful conflict resolution. For example, a rapidly deployable force structure represents the former; their sustainability, the latter. If a military force is structured only to deny the enemy easy victory, how useful is it if the enemy decides to wage war anyway? Will it matter then that the enemy had to take more pains to start and win a war than its gains are worth in Western eyes?

Conventional Deterrence

Conventional deterrence is meant to avoid (deter) war by maintaining strong peacetime forces. As strategy it has been portrayed by warfighting doctrines which have emphasized the entry into war, rather than the exit. All of our operation plans and resources are bent to the task of engaging American forces in the most expeditious manner. The scenarios then drift into fog. Most see little beyond the first sixty days of war; few, if any, see beyond six months. Compare this to endeavors of comparable time scale. Houses, for instance, are not constructed by digging a hole, and then wondering what to do next. They are constructed from blueprints, by mapping the goal, and then figuring out how to get there from here

Similarly, a warfighting, and thus a war-resourcing strategy may logically start from those actions which have to occur in order to compel the enemy to stop fighting. At issue is the level composition, and disposition of force required. Against the Soviets, there are two basic ways to conclude war. One way is to threaten nuclear annihilation, which, until recently, was preferred. With time this option grows less credible as a means of compelling war's end. The United States knows that it does not have more bombs and cannot take more pain than the Soviets do. So do the Soviets. Although their doctrine used to hold that a major conventional war would rapidly escalate to a strategic nuclear exchange, their war planning now includes significant contingencies which remain non-nuclear over an extended period.

The other way is to develop and employ overwhelming conventional superiority. But with today's budgets, this can happen only by deploying the vast resources of the American (and, if possible, allied) economy in making war goods after war (or its warning) begins. But will a war of such size last long enough for this strategy to work?

By definition, a short war (against Soviet aggression) can end in one of three ways--quick victory, quick defeat, or quick stalemate. The first two may be dismissed as unlikely. It is inconceivable that the United States would accept the loss of its major allies and quit as long as its own home base remains intact. The latter is assured by the size of the oceans and the capabilities of the Navy. Similarly, virtually no one believes that our conventional forces can defeat the Soviets quickly and so compel them to sue for peace. The widespread post-Reykjavik concerns over the adequacy of NATO's conventional forces suggests that avoiding an early defeat would be an accomplishment. And stopping them on the border in Europe is really a draw, particularly if their armed forces remain intact.

A quick, permanent stalemate, effectively ending conflict, while plausible, is, by historic standards, not very likely. Nations consistently underestimate the duration of wars they enter. Examples include our Civil War, Germany's last two invasions of France, and our involvement in Vietnam. More recently, Iraq invaded Iran with only a few weeks of war reserves.

The Korean War--a year of heavy combat, two years of skirmishes--remains the best historical model for a quick conventional stalemate. It is questionable, though, how relevant this model is to a conflict between the United States and the Soviet Union. The war ended as it did largely because the United States (which sought a free South Korea) and China (which sought a friendly North Korea) both felt they had achieved their initial objectives. The aggressor, North Korea, did not, but by war's end it was not the driver. A war between us and the Soviets, of course, would leave no greater power to call a halt to the fighting, and no lesser objectives which could be mutually satisfied.

This leaves the strategy of developing, over the course of the war, the conventional superiority necessary to force war to end. Such strategy requires weapons, lots of them. Thus it requires industry and lots of it. DOD has given a lot of thought to how the two link in supplying the current forces. But DOD has given much less thought to how the two link to arm the forces necessary to finish wars. (Appendix A speaks to why).

Since DOD cannot afford to buy conventional superiority now, it can do so only by deploying the vast resources of the American, and, if available, allied, economies to making war goods after necessity arises. But to deploy the economy is to discover the problem of getting from <u>here</u>, small quantities under business as usual, to <u>there</u>, huge buys with no holds barred.

The United States did this to win WWII. Now, though, the challenge would be tougher. A war with the Soviets would find the United States engaged almost immediately against an adversary which would seek to use its industry as aggressively as we would. The Soviets are not going to stand by and let us build weapons while they do nothing. It is no secret that they <u>have</u> invested in their industry to support surge. The result is likely to be intense competition, one in which the United States could not afford to forfeit a year or two making up for the lack of prior attention.

Moreover, while the US economy could eventually outperform the Soviet one, the interim results also matter. These days an ever larger percentage of the world industrial base lies outside both North America and the Soviet Bloc. This base will supply either one side or the other, but is unlikely to access both. What happens on the battlefields and oceans in the meantime will determine which way their production flows.

None of this is to argue that the ability to boost industrial production cannot play a useful role in peacetime or for the smaller wars which seem to characterize the last forty years. The ability to achieve rapid production on short notice plays a demonstration role in bolstering deterrence. If a large war threatens there is no need to wait for aggression to begin before starting to increase weapons stocks. Lesser degrees of industrial surge also help the United States or its allies to conduct smaller wars without draining supplies needed to deter larger ones. But it is a mistake to think that such surge is peacetime-but-somewhat-more, when it should be thought of as wartime-but-somewhat-less. If the wartime mission and capabilities of wartime surge can be grasped, then those which characterize lesser crises can be more easily understood. Wartime practices can be softened to adapt to less-than-wartime conditions. Hardening peacetime practices, as chapter six argues, is more difficult because it places the burden of proof in the wrong place. It is better to claim the need for the production habits of war, and loosen conditions when one can afford it, than to start with the production habits of peace and justify each deviation on the grounds of emergency.

The Value of Emergency Production

Were industry asked to boost production as fast as possible starting today, it could respond to some extent. However, its reaction time would be slow and the increase in production would be limited. Although the defense industry has a lot of unused capacity in aggregate, it is plagued by bottlenecks. A critical machine here or test equipment there is running around the clock and further production would have to await the year or more required to build, buy, or borrow a new one. Within the innards of many of our weapon systems are many parts available only from abroad. For the most part, their producers are sited in friendly locations. But we may not always be able to access these sources, particularly in war when destruction or interdiction plays havoc with the world's industrial system.

Finally, there is the institutional problem of how to make the acquisition system run efficiently in terms of both planning and performance. Wartime presents an entirely different set of production goals and circumstances than peacetime does. An acquisition system geared to optimize peacetime values may not be very efficient at responding to wartime ones.

If one wishes to produce a lot of weapons in a hurry, there are certain prerequisites. Industry's ability to increase production must be assessed, and where lagging, improved. Provisions to substitute for previously available imports must be made. And, finally, when it comes time to surge, a system, or at least a theory, should be in place to do so with minimal fuss.

Government can do much to resolve these problems beforehand so that industry is ready to respond well at any time. Many such solutions, however, require first information, and then the commitment of resources. Defense policy planners want to know what kind of commitments they have to make to wartime production capability before it does any good. They want to know if there are affordable means of improving industrial responsiveness, and whether these improvements are robust against unforseen contingencies. Finally they want to know how to use these capabilities if need arises.

The essays that are this volume's chapters represent the author's firmly held belief that the problems which stand in the way of surge can be grasped and overcome. The conceptual aspects, while not trivial, are tractable and the resource requirements are not excessive. This is a solvable problem, if the will to solve it exists.

The larger problem of surge is analyzed by concentrating on one category of weapons, precision-guided munitions (PGMs), which merit focus for several reasons. They are important in their own right, and as a harbinger of future force trends, their producers form a coherent field of study, and, not least, there is a considerable data on their manufacture.

Since 1982, for instance, the JCS has been surveying the various theater Commanders-in-Chief (CINCs) to determine what weapons they would need surged first in an emergency. Every compilation has shown that PGMs, as a class, are most often cited as important. Individual PGMs account for between five and eight of the top ten items nominated every time. Correspondingly, they have been most frequently nominated for surge funding.

Technical characteristics of PGMs also make them ideal as a proxy for surge studies. Their production base is private (unlike conventional ammunition) and relatively high-tech. Problems in raising production levels will foreshadow similar problems in fire-control systems, avionics, or aircraft, for instance. Yet, PGMs are required early in conflict, and their relative simplicity makes rapid acceleration feasible within the first year of crisis.

PGMs are also a harbinger of future force structure. Now, PGMs are considered as ordnance, a means by which forces conduct war. Clearly they are a step up from conventional ordnance; in terms of value or killing power, they comprise an ever larger share of the nation's ordnance inventory. But their adequacy is measured to the extent that they can sustain forces. In time, however, PGMs may be looked on as force elements themselves. As they incorporate more and more intelligence, they become even more capable of operating autonomously and taking over the tasks previously performed by platforms. Then, the key supply question would be whether we have enough PGM-based force to prevail.

The PGM industry is both compact and overlapping. Many key suppliers (e.g, Eagle-Picher, Morton-Thiokol, or MA/COM) supply parts for ten or more different models. Shifts in the production of one PGM will affect others. Thus it makes sense to study the sector as a whole.

Finally, thanks in no small part to the JCS study on PGMs, the data base on this industry is far ahead of the data base on any alternative industry. We now know who all the major contractors, and more importantly, subcontractors are. Similarly detailed information is available on the major constraints to higher production.

Table 1-1
Precision Guided Munitions Production Parameters

Name	Users*	FY 86 Buy	Cost**	Prime***
HARM	N, MC, AF	2,150	259	Texas Insts
Harpoon	N, AF	519	583	McDAC
Mk-46 torpedo	N	1,172	156	Honeywell
Mk-48 torpedo	N	123	1,573	Hughes
Phoenix	N	265	737	Hughes
Sidearm	N, MC	200	87	Motorola
Sidewinder	N, MC, AF	4,690	37	Raytheon/Ford
Sparrow	N, MC, AF	3,195	142	Raytheon/GD
Standard	N	1,271	464	GD
Tomahawk	N	249	1,923	McDAC/GD
GBU-15	AF	715	160	Rockwell
IR Maverick	AF, N, MC	1,781	171	Hughes
Laser Maverick	AF, N, MC	1,500	95	Hughes
Paveway II	AF, N, MC	2,982	14	Texas Insts
Copperhead	A, MC	7,420	34	Martin
Hawk	A, MC	550	206	Raytheon
Hellfire	A, MC	7,304	30	Martin/GD
Patriot	A	770	87	Raytheon/ Martin
Stinger	A, N, MC, AF	4,643	53	GD
Tow II	A, MC	16,990	8	Hughes

* Procuring service listed first.

** Unit hardware costs in $1,000. Does not include nonrecurring and support costs. Mk-46 totals include 500 all-up rounds and 672 major modifications. Paveway II also includes 889 Skipper (rocket-boosted), price is blended.

*** Where Service facilities are prime contractor, producer listed builds the guidance and control sections.

Table 1-2
Precision Guided Munitions Technical Parameters

Name	Launcher	Target	Seeker	Range	Propulsion
HARM	Air	SAM	RF	Medium	Rocket
Harpoon	Air,Ship, Sub	Ship	Planar	Long	Cruise**
Mk-46 torpedo	Air,Ship	Sub	Sonar	Short	Motor
Mk-48 torpedo	Sub	Sub	Sonar	Medium	Motor
Phoenix	Air	Air	Radar	Long	Rocket
Sidearm	Air	SAM	RF	Short	Rocket
Sidewinder	Air	Air	IR	Short	Rocket
Sparrow	Air,Ship	Air	Radar	Medium	Rocket
Standard	Ship	Air	Radar	Mid Long	Rocket
Tomahawk	Ship,Sub	Ship*	Planar*	Very Long	Cruise
GBU-15	Air	Ground	TV/IR	Short	None**
IR Maverick	Air	Ground	IR	Medium	Rocket
Laser Maverick	Air	Ground	Laser	Medium	Rocket
Paveway II	Air	Ground	Laser	Medium	None**
Copperhead	Artillery	Armor	Laser	Short	Cannon
Hawk	Ground	Air	Radar	Medium	Rocket
Hellfire	Helo	Armor	Laser	Medium	Rocket
Patriot	Ground	Air	Radar	Mid Long	Rocket
Stinger	Ground	Air	IR	Short	Rocket
Tow II	Ground	Armor	Optical	Short	Rocket

* Some versions use map-based seekers for ground targets.
** Some versions are rocket powered.

Tables 1-1 and 1-2 list PGMs in the FY 86 buy. The first lists procuring and using service (including foreign military sales), the FY 86 quantities, hardware price, and prime contractor(s). The second lists the launching platform, the target, the seeker technology, the range, and the propulsion.

Report Organization

This volume is organized as a series of essays. The central ones, chapters four and five, examine the investment needed to prepare for surge and neutralize foreign source dependence, respectively. The other chapters are organized around this core, with chapter two summarizing some of the predecessor work, and chapters three, six, and seven delving into some of the conceptual bases for surge and beyond.

Chapter four, "Preparing for Surge", was originally written as the Navy's Ordnance Production Base Analysis (PBA). This PBA, responded to a 17 December 1985 memorandum by the Chief of Naval Operations (CNO) asking the Deputy CNO, Logistics to:

> Review high usage rate weapons to determine if any weapons warrant increased surge production investment. The marginal return of surge production investment must be balanced against the risk inherent in reduced weapons stockpiles. . . incorporating weapons surge production as an element of the [Maritime] strategy.

Chapter five, "Foreign Source Dependence", was originally written as the third chapter of MCDC's US Industrial Base Dependence/Vulnerability: Phase II--Analysis. That report responded to the specific request of the Undersecretary of Defense, Policy, as well as more general requests for a Defense Guidance study, and for support to the logistics branch of the office of the Joint Chiefs of Staff.

Chapters six, "A Doctrine for Surge", and seven, "Beyond Surge" originally circulated as an MCDC paper, On Surge. Parts of the original paper can now be found in these two chapters, as well as in chapters two and three.

All three papers have been rewritten to eliminate their mutual redundancies and to incorporate new material.

2

CONCEPTS OF SURGE

> The Department of Defense has sponsored a considerable volume of analytic work over the last six years. The analytic work has suffered from basic confusion over what surge means, how to do it, and how to prepare for it. In the process DOD collected a lot of data on the industrial base; the task now is to put it together and make sense of it.

The following essays may be best understood within the context of the concerns, analysis, and debate which preceded them. They were not created ex nihilo but to fill very specific gaps in the data base which would otherwise support myths encumbering the current state of the art on surge.

Prior analytical work forms a body of knowledge with an unusually high unity. Because the topic is focused and inaccessible outside the defense community, all the relevant work has come from or been paid for by a small group of policy analysts, all of whom either know or know of each other. Most of the literature flows, in one way or another, from previous work.

It is rapidly becoming clear that surge analysis, per se, is at a critical juncture. Further work in this area is difficult to justify as an aid to policy making unless DOD's leadership responds to what currently exists and does something with it. We now know enough to justify or not justify investments in the PGM industry. No further research is needed except to flesh out details pursuant to action.

Early Formulations

In the 1970's, before 1980 when the current defense buildup, DOD had little interest in surge and mobilization. Doctrine held that the next war with the Soviets would begin on short notice and would not last long enough to let industry play any interesting role. The belief in a short war was self reinforcing. Sustainability costs money, and DOD's share of the budget had, at that time, reached its postwar low. Without stocks of munitions and spare parts, the military's ability to fight a long war was problematic. Preparations to do so by substituting industrial production for military goods lacked credibility when the military worried about surviving weeks while industry needed months to do anything.

At its nadir, most of what little industrial preparedness planning taking place was being done for conventional ammunition (whose plants were all Army owned). This, in part, reflected bureaucratic considerations. Since only a small fraction of the conventional ammunition base is being used at any point (in peacetime), it was up to wartime requirements to justify retaining what capacity remained. Assets were held explicitly for their mobilization use.

The vehicle for both documenting and thus conducting industrial preparedness planning was a government form, DD 1519. Once the users had estimated some ammunition requirements, planners would determine whether first current and then potential producers could meet such rates. In essence, the DD 1519 form became the basis of constructing a roster of planned producers. These producers made nonbinding promises to produce their share of ammunition; in turn, they were granted certain privileges when it came time to bidding for production contracts. Ostensibly, the DD 1519 form was filled with information on the ammunition production base. In practice, though, this information never had much detail in the first place, and was rarely audited or subject to any but the most elementary sanity checks. Be that as it may, it represented more activity than what characterized Air Force efforts (which were explicitly ended) or Navy efforts (which were skeletal at best).

Unready for Crisis

Concern for the nation's defense industrial base revived with a start when defense budgets were increased following the 1979 Soviet invasion of Afghanistan. Observers saw money being poured into new procurement in one end and delays and long lead times emerging from the other. A decade of declining defense expenditures coupled with the generic ills of US heavy industry led to a shrinking production base, with fewer producers and less capacity. The base could not respond to a sudden upsurge in orders, particularly one which coincided with a boom in commercial aviation. All this was abundantly documented by the House Armed Services Committee's report, The Nation's Industrial Base: Unready for Crisis.

On a parallel track, advances in Soviet nuclear weaponry had created parity in nuclear strength. Parity reduced America's ability to deter non-nuclear aggression by the Soviet Union by escalating to nuclear brinksmanship. This raised the possibility that a major conventional war could extend indefinitely which, in turn, compelled renewed attention to the nation's ability to support conflict.

Finally, added impetus was generated by the results from Exercise Nifty Nugget in 1978. This exercise, the first of a biennial series, demonstrated serious deficiencies in mobilization; follow-up exercises provided a continuing forum for mobilization advocates to agonize over DOD's problems in that area.

Reagan's election accelerated these concerns. With Dr Fred Ikle's appointment as Undersecretary of Defense, Policy, DOD had a high-ranking official committed, by his writings, to improving industrial mobilization. With him came Sol Love, former CEO of Vought Aircraft, for the express purpose of revitalizing DOD's industrial base programs.

By 1982, the main tenets were in place--two actions:

o The August decision to set $100 million dollars a year aside (FY 1984 through FY 1988) to fund surge projects

o Commitments from the Navy and Air Force to bolster their planning staffs and five documents:

o The 6 March 1982 policy statement by the Deputy Secretary of Defense, much of which was incorporated into the Defense Guidance

o Draft recommendations of the Task Force on Industrial Readiness (TFIRE)

o An official JCS paper defining production surge and discussing methods for ranking surge projects

o A survey of key weapons producers undertaken for the 1982 mobilization exercise, Proud Saber

o A never-released Planning Force attainability study for the newly established Mobilization and Deployment Steering Group (MODSG).

Surge vs. Mobilization

All this activity reflected an implicit decision to emphasize "surge" over "mobilization" in the expenditure of scarce resources and scarcer analytic talent. "Surge" and "mobilization" may be distinguished in two ways, each of which was invariably confused with the other--a circumstance which thwarted clear thinking. The first distinction is that surge is the first acceleration of production from peacetime rates to something 50 to 200 percent higher. Mobilization represents the conversion of the commercial economy to wartime production, presumably later and at higher output levels. The second distinction is that surge is required for small wars or ambiguous situations while mobilization is required for big ones. Surge might also be required to replace US weapons drawn to support allies, as happened twice in 1982; once for the British (in the Falklands) and later for the Israelis (in Lebanon).

The second distinction between surge and mobilization also bespeaks a significant difference in production environments. At its softest expression, surge entails having industry increase production in response to higher orders, and make efforts to reduce lead times but without having to disrupt its commercial work. Habits, rules, prices, priorities, regulations etc. were not to change. Not so surprisingly, neither did the long lead times which such practices engendered. When so queried, industry responded that their surge production rates would be constrained by the same long parts lead times which characterized their peacetime production process. This, in essence, was the message that came back from the surveys of weapons producers conducted for Proud Saber. Production rates after six months into the crisis were only marginally ahead of what they would have been without crisis. After twelve months, the increases were still modest. For the Army, this reinforced what they had learned from trying to finance a surge preparedness program for the TOW antitank missile.

DOD analysts quickly came to two conclusions. First, alleviating the problem would require the purchase of surplus inventories so that industry would not have to wait for new parts shipments before starting its own work. Second, if surge was difficult, mobilization, or meeting the requirements of a large war would be virtually impossible. Therefore, DOD would do best to attack the surge problem and hope the mobilization problem would never arise.

From this arose one major insight and one major fallacy The insight stemmed from the fact that the United States, as a frontline power, would not be able to conduct a mobilization as it had in World War II. Back then, it could afford to wait until production rates could support a cross-Channel invasion before it went ahead, two and a half years into its war. Now, its material resources would be stressed from the outset. A competent mobilization plan would have to concentrate first on <u>faster</u> production and second on <u>greater</u> production. A doubling or tripling of deliveries within the first year of conflict will matter as much as the far greater increments planned for later. There are critical battle lines to be held, and enemy threats neutralized early mean fewer losses in the interim.

The major fallacy, however, was assuming that surge had to precede mobilization. In one sense, it does, if surge is defined as the initial ramp-up, and mobilization as wartime production. But if surge is defined as a modest response to a lesser contingency, industry's response is correspondingly less robust. Confusing the two definitions, as many did, led to the conclusion that a period of tepid production increases has to be borne until the economy as a whole is converted. This confusion was formalized in the 1982 JCS report on surge, which defined surge as a rapid production increase in a peacetime environment.

Surge Analysis

The most important impetus for continuing analytic work on surge and mobilization was the requirement of the 6 March 1982 memorandum by the Deputy Secretary of Defense that the Services conduct annual production base analyses (PBAs)

Among the early PBAs was a 1983 industry-Government effort, the Industrial Responsiveness Scenario (IRS). The Government role was led by the aforementioned Sol Love supported by MCDC's Rod Vawter. The industry role was undertaken by the American Defense Preparedness Association (ADPA), whose study, at least nominally, it was. It was the ADPA which gathered the support of constituent corporations and persuaded them to make serious (though uncompensated) efforts at answering the surge questions.

The IRS study looked at an 18-month surge under three conditions. One was a production increase under current rules and regulations. Another was a production increase with industry allowed to alter its operating environment. The third was an increase with prior preparation (more inventory, or special tools and test equipment).

The results indicated, not unexpectedly, that production would increase modestly if current rules were maintained. The relaxation of rules helped somewhat, although not as much as was later shown possible. In general, the most significant changes were those which allowed the faster disbursement of money and, in some cases, expansion of capacity. Finally, prior preparation helped, with an average of one dollar's worth of investment prior to crisis permitting eight dollar's worth of additional production. Most of the increase was realized in the last six months of the 18 month period.

The study made valuable contributions in at least two respects. It was the first amalgamated study of surge potential, and it illustrated some fixable constraints to industry performance. The study ground rules, however, were vague and subject to widely differing interpretations. Its analytic results were incapable of serious extension. One follow-up action was for DOD to review its current rules and regulations with a view towards potential improvement in mobilization. This effort has yet to produce much. The second (unintended) consequence was to highlight the feasibility of surging sonobuoys with modest funding. The resulting sonobuoy surge proposals have been only one of two such proposals to garner consistent Congressional funding (so far).

The Services themselves responded in their unique but characteristic ways to OSD's requirement for a PBA. The Army took its enormous DD 1519 data base and printed it out--two cubic feet of it. The Navy backed off, pleading inability to do so until its additional manpower were hired in FY 1984. The Air Force threw money at the problem in an FY 1984 project entitled Blueprint for Tomorrow.

Joint Studies

Blueprint divided the Air Force production base into six sectors, missiles, engines, tactical fighters, large aircraft, other (helicopters and general aircraft), and subcontractors. Within each group, ten to twenty corporate representatives analyzed the various impediments to more efficient peacetime, surge and mobilization production and reported recommendations for Air Force action. Consistent with Air Force priorities, most of their attention was devoted to improvements in production that might be forthcoming from additional research and development in manufacturing technology. Nevertheless, the document was well received and briefed all the way up to the SECDEF level.

Alone among the six panels, the tactical missile participants concentrated on barriers to accelerated production. Together with a raft of miscellaneous problems, the members reported that a lack of long-lead inventory and special tooling and test equipment were primary constraints. Relieve them, a task requiring several hundred million dollars, and production could double within six months.

At about the same time, surge studies contracted for by the Naval Air Systems Command were starting to come in. Three, covering the Harpoon, the Phoenix, and the Sparrow (by General Dynamics) were unexceptional. A fourth, also on the Sparrow but performed by Raytheon, observed that there was historical precedent for surge in the Berlin Wall crisis, when Sparrow missile production tripled within a five month period (albeit thanks to deliberately large component stocks). Were surge needed now, some of the testing bottlenecks could be relieved by shortening some tests. The most far reaching result of the Raytheon study was how hard it was to determine how fast Sparrow parts could be supplied without knowing all the military demands which might be placed on Sparrow parts producers. Collectively, they supported over a hundred other military programs, many of whom enjoyed a higher priority. A weapon-by-weapon examination of surge would lack realism if each subcontractor were to assume that the weapon being examined were the only one he had to accelerate production for. A comprehensive study would be required, one which looked at all competing weapons, or at least PGMs, at once.

The Navy tried to start a consolidated study of its ten PGMs, and this effort was taken to the wrap-up meeting of the Blueprint study in June, 1984. Industry applauded, but urged that the scope be expanded beyond Navy PGMs to encompass those bought by the other two procuring Services as well. With that, the JCS representative, AF Lt. Col. James Ross, joined with the head of the tactical missile group to begin the JCS Precision Guided Munitions study.

The JCS PGM study was designed to estimate the cost, in terms of additional inventory and equipment, of preparing industry to be able to surge twenty PGMs simultaneously. It had two phases. The first queried nine prime contractors to ascertain their surge constraints and more importantly, identify their major subcontractors (those which supplied parts which collectively accounted for 80 percent of the total subcomponent cost). The second would query the subcontractors. An intermediate phase would cover PGM components that were supplied directly by the Services themselves (e.g. rocket motors for Navy-supplied munitions).

The hidden agenda in the study was to find out from the subcontractors themselves what their real lead times were--that is, how long it took them to do something rather than what they were quoting to customers. As it transpired, the major study findings were briefed before the subcontractors themselves were queried.

Eight of the nine prime contractors put a lot of work into their submissions and provided an unprecedented list of their major subcontractors, numbering over five hundred. Among those who supplied the Services with PGM parts directly, the response rate was less than half.

The study was to cover both surge and mobilization. Surge would represent the first six months of a ramp-up, mobilization the remaining 18 months. The five-fold and ten-fold ramp-up rates of mobilization were treated disparagingly. Industry, however, took the surge targets seriously even though they were almost always mistaken for consumption forecasts for some lesser conflict scenario. It actually was a ramp-up rate that was thought both plausible and challenging.

Several months into the study, it became clear that two implicit analytical assumptions would dominate the results. One was that PGMs were to be produced under peacetime operation and lead time regimes. In practice, this had been the hidden assumption throughout all previous surge studies, but its implications were not appreciated at the time. The next assumption followed closely. If operating habits were not changed, lead times would be fixed, and the flow of production from work already started would not change. Additional production would come only from new orders, which in turn would not be completed until the entire chain of component and final production were complete, some 12 to 30 months later. The only way to get new orders out faster was to begin its production process beforehand and leave the work unfinished until surge began. In practice, this meant prestocking subcomponents and completing early production processes.

These assumptions yielded a mechanistic formula for calculating surge investment requirements. Companies were told to calculate the number of PGMs to be shipped in excess of planned rates, starting six months after surge and continuing until the point when additional surge production would normally be finished (that is, 12 to 30 months later). This increment would then be multiplied by the cost of those components which had to be ordered more than six months in advance (i.e. almost all) plus whatever in-house work had to be done more than six months in advance, plus the special tooling and test equipment required to meet the higher production rates of surge.

(Another method, which would have cut costs in half, also could have been used. This would have been to prestock successively less inventory to cover every subsequent month after the initial surge production increase. A PGM produced a year after surge, for instance, only needs that inventory which takes more than a year to acquire and install, a smaller amount than the inventory which takes more than six months to acquire and install. Only one of the nine PGM prime contractors used this latter method.)

The JCS study showed that prestocking all the inventory was very costly. The total bill for all 20 missiles was $1.4 billion dollars, 90 percent for prestocked inventory. For Navy PGMs, in aggregate it cost $1.00 in investment prior to surge before an additional $1.60 worth of missiles could be produced six to 24 months after surge began. For the Sparrow, the output was less that the investment.

CNA's Contribution

While the JCS study was going on, a comparable study, undertaken by the Center for Naval Analysis (CNA), showed how wartime changes in operating conditions could lower lead times, and reduce surge investment requirements dramatically. CNA's study was initiated by the interest of the Deputy CNO (for Policy, Plans and Operations) in using manufacturing technology to produce weapons in large numbers. During the initial investigation, industry let on that the DD 1519 data which they were reporting, while accurate as far as it went, really responded to the wrong questions. Industry was being asked to accelerate production for war but under business-as-usual conditions; if asked what they could really do if they had to, their answers would be different.

Armed with that insight, Richard Cheslow of CNA and his crew descended on Honeywell's operations to determine what it would take to boost Mk-46 production from the current 80 per month to 800 per month At first, Honeywell engineers kept referring to their DD 1519 projections, blaming quoted component lead times for the length of time required to accelerate production. CNA researchers concluded that they had to bound the problem by separating process lead time (what the prime contractor needed for its own work) from component lead time (what suppliers needed). If you assume, they argued, that you have all the components you need, how long would it take you to ramp up? The first answer coming back wanted six months for internal lead time and $22 million for additional tooling and test equipment.

At this, CNA started questioning production practices that would not survive if "cost were no object" and if the United States had to "produce torpedoes or learn to speak Russian". This led to the discovery of certain facts of life in PGM production.

Even if a requires a thousand hours of labor input, most of that is done in parallel. The longest series of sequential operations might need less than under a hundred hours. But six months are needed to do these hundred hours because operations are done in batches. While one product is being worked on, the other 79 in a monthly batch are sitting around, in the in box or out box. A six minute operation done in batches of 80 may take a full eight hour shift to complete. If the plant runs just a day shift, it will take the part a full day to get six minutes of work on it. In a five day week at this rate, a part only gets a half hour of work done on it. Granted, some operations such as testing are done one at a time; otherwise, the hundred hours would take four years to complete. Furthermore, it is impossible to transform a batch operation into an assembly- line operation overnight. However, this example suggests that improvements in lead times are possible if one tinkers with product flow in order to switch objectives from cost minimization to flow maximization.

Other changes were possible. At times, torpedo parts might wait in front of empty work stations whose operators were busy tending other sites. In war, work stations could be overmanned to save time if costs were secondary. Even one-at-a-time operations such as final testing can be speeded up if a PGM were moved between test stations on a just-in-time basis. A Sparrow missile, for instance, which is scheduled to run through its final tests in three weeks, is only worked on for 48 hours of that period, half of which is in one long test.

CNA also challenged Honeywell's original $22 million dollar estimate for equipment, mostly test equipment. Much of it could be eliminated with only modest effects on missile performance. Vibration and temperature tests are performed to test for long shelf life; but if a torpedo is urgently needed in war, it will not have time to age. Other tests are deliberately redundant; they are meant to convey information to the producer before it is communicated to the customer through Navy-owned test stands. In electronics, burn-in tests can, in the opinion of industry, be considerably shortened while weeding out almost all of the failures and extending the life of the remaining circuits. Using the suggested changes, the original $22 million was cut to $7 million.

CNA found similar opportunities to reduce lead times and save investment costs among suppliers. Some fraction of the lead times represented just-in-case estimates. Others included plenty of time to comply with Government contracting regulations. Many of them represented queuing times wherein a small Government order would have to wait until it could squeeze around large commercial orders. In one instance, a subcontractor who faced year-long lead times for its forgings indicated to the forging house that he had three years' wortn of orders and ready cash to commit for the entire run. He got them in three weeks.

Extending CNA's analysis to the Sidewinder missile verified the original findings. Lead times, now 12 to 15 months, could be cut to three months--if they had to be.

Clearly, the JCS PGM study and the CNA study were describing separate worlds. The JCS studied a peacetime world that happened to receive additional orders. The CNA studied a wartime world where everything was flexible in the pursuit of acceleration.

Exploring the Subcontractor Base

Phase II of the JCS PGM study was based on a questionnaire mailed to each of the 500-plus key subcontractors. Based on CNA's findings, deliberate redundancies were introduced into the questionnaire in order to measure the play in the lead time estimates or investment requirements. Answers would be matched against each other in an attempt to find places where, if cost were not an issue, subcontractors could improve their quantity and lead time performance. If the response indicated a hook for questions, the respondent was to be called for clarifications.

The questions went out in April 1985 and the answers came back between June and August, but the study managers left no time to query respondents (if they even realized that the questionnaire was so designed). Unaudited responses indicated, however, that subcontractors were quoting lower lead times than the prime contractors were and that, in most cases, process times for component production could be sharply reduced in emergency situations. None of this was noted in the final briefing and the original cost estimates of the PGM Phase I report were never adjusted in light of the new information.

The PGM Phase II data gave the Navy a basis for estimating the surge investment costs of its own PGMs. The FY 1986 Navy Ordnance PBA (discussed in chapter 4) changed the JCS methodology is several ways. Corresponding to the expectations generated by the CNA study, the targets were raised from a 50 - 100 percent increase to a threefold increase over the same six months. Wartime conditions were assumed and, where necessary, communicated explicitly to the respondents. As a result most of the subcontractor base was queried again.

The second query separated sub-tier respondents to the JCS questionnaire (172) from nonrespondents (272), retaining only those firms which supplied Navy-used PGMs (Sidewinder, Sparrow, Phoenix, HARM, Harpoon, Standard 2, Mk-46 Torpedo, Maverick, Skipper or Tomahawk). Most of the respondents were contacted to resolve contradictions, gather further information, or reestimate investment requirements to new production targets. The rest were sent a new questionnaire (see Appendix B), a shortened version of the Phase II one.

Phone calls were used to raise response rates (from near 40 percent in the JCS study to near 70 percent), clarify potential inconsistencies between answers, and determine if the investments required to support surge were limited to irreducible needs. The Navy, it was offered, might be prepared to fund what was needed for surge, not what was desired for its own sake or used to save production costs after surge began.

The Navy PBA concluded that, on average, a dollar invested in industry prior to emergency allowed an additional ten dollars worth of PGMs to be produced within the first 15 months of surge. Without such investment, capacity bottlenecks would postpone significant production hikes beyond 15 months.

In 1987, the Institute for Defense Analysis (IDA) was asked to extend the results of the Navy PBA to those Army PGMs that were examined in the JCS study but not the Navy PBA. Other follow-on studies include a later CNA study of the Sparrow missile which was less optimistic (it was done by a former Sparrow program manager) and a report by IDA on the M-1 tank and the Bradley fighting vehicle using the same methodology (and project leader) employed in the CNA study. The concept of a tri-Service production base analysis was continued in the jet turbine engine production study sponsored by the Air Force.

Foreign Source Dependence

If the production of a PGM requires parts from overseas, a sudden cutoff of that source would obviously disrupt production. In extreme cases, production would cease until a domestic source were available to replace the overseas one.

DOD's concern over the impact of foreign-source dependence on surge and mobilization is of relatively recent origin. Why? Concern about emergency production per se is itself recent. So too is the growth of the yawning trade deficit, and DOD's sensitivity to the impact of imports on domestic producers.

The first such study of foreign source dependence was conducted for the Joint Logistics Commanders. Several weapons were examined, ranging from the Sparrow missile to sonobuoys, the M-1 tank, ammunition items, and electronics gear. Based on this limited sample, the authors concluded that there was considerable foreign source dependence in all systems other than some ammunition items. A Sparrow missile, for instance, contained several foreign-source subcomponents, deprivation of which would shut down production for up to a year. Recommendations would have had project managers pay special attention to all instances of foreign-source dependence, with appropriate documentation thereof at each stage of the weapons approval process.

Foreign-source dependence was also an issue in the second ADPA-MCDC study, the Industrial Responsiveness Analysis. Like its predecessor, the IRS, it looked at industry's potential to surge over an 18-month period under various assumptions, but with a different selection of items ranging from aircraft black boxes, to turbine engines, ammunition, and troop support gear. Again, it showed that the judicious waiver of rules and regulations coupled with proper investments could improve industry's performance (and again its responses were never audited for inconsistencies and implicit assumptions). With most items being electronics, the dependence of the US base on overseas semiconductors and other components was highlighted.

In response to that finding, Dr. Ikle asked MCDC to undertake a comprehensive examination of the foreign-source dependence problem. This was done in two phases. The first was a literature review, US Industrial Base Dependence/Vulnerability Phase I--Survey of Literature, which revealed the paucity of DOD-specific reports and the abundance of industry-specific ones. The second, US Industrial Base Dependence/Vulnerability: Phase II--Analysis, used case studies and new data to discuss the costs and benefits of competing options to alleviate foreign source dependence risks. The three case studies covered PGMs (see chapter five), semiconductors, and industrial materials.

The PGM foreign-source dependence case study builds on the data collected from the JCS PGM study and the Navy PBA. Both had asked subcontractors to report on whether or not they were dependent on overseas components or processes (e.g. offshore assembly). Roughly one-third of the respondents cited at least one case of overseas procurement.

Each respondent was then queried on his citation. First was to ascertain if the dependence was real, current and relevant to PGM production (several citations were misidentified). Second was to estimate how long it would take a domestic producer to replace the foreign source with a domestic one under emergency conditions. Since almost all parts came from allies, the theory was that they would only be inaccessible under wartime circumstances. Third was to calculate how much inventory would have to be held in the United States in order to continue production during the gap between an unanticipated cutoff and the resumption of domestic production. This required multiplying current shipment volume by the length of the recovery period. Separate calculations were also made to estimate additional inventories required to support surge production rates of a 50 percent increase after nine months (a rate which the Navy Ordnance PBA estimates is the maximum given domestic bottlenecks).

The study found that insuring against an unanticipated foreign source cutoff is inexpensive for weapons made to military specifications. Fifteen million dollars would suffice for the entire PGM sector. There are some indications that the cost is much greater for weapons made to civilian specifications (e.g. sonobuoys) or dual-use electronics (e.g. test equipment) where foreign sources account for up to half of the material input, and roughly 10 to 20 percent of the total value added. To date, no similar study of any other weapon system has been completed.

Surge Doctrine

There is no DOD doctrine on surge, and little attempt to write one. Since the concept of surge--more, faster--seems obvious, the need for theory has not been so evident. Yet, there remains a wide chasm between what practitioners see as an obvious need for surge preparedness, and what the DOD hierarchy sees as a nice-to-have but not need-to-have item. So wide is this chasm that it is difficult not to suspect that the concept of surge is not being communicated very well and that the integration of surge and warfighting has not progressed very far.

Official Guidance

Elements in the theory of surge have circulated within the industrial preparedness community and have occasionally worked their way into DOD directives and instructions. The TFIRE group, for instance, proposed revisions to DOD's current procurement regulations in order to have program managers consider surge as an important element in their production planning. DOD instructions have been so rewritten, as have Service instructions. Outside the Army, though, surge is treated as something to talk around whenever the subject comes up, but not something actually worth time or money to address. The Army has gone farther in this area, appending surge option clauses to ammunition contracts, and is investigating its application to other weaponry. There is no known example of a weapon program having been delayed or a contract rejected because it did not consider surge requirements.

By 1985, DOD did rewrite basic industrial preparedness planning guidance, last updated in 1972. The revisions generally codified changes in practice which had already taken place. The 1982 requirements for an annual Service PBA were incorporated. Services were allowed to use planning methods other than the DD 1519 as well. Surge planning was elevated to a level comparable to mobilization planning. Time lines were established to mesh the results of industrial preparedness planning into the Service budget cycle so that surge preparedness programs could be better supported.

Another change in theory was the Navy's switch from consumption to mobilization production targets as basis of its preparedness planning (where monthly consumption requirements were meaningless or evidently unattainable). Prior planning practice was to use the contractor's physical capacity as its production goal. New numbers were first used in the JCS PGM study.

Joint Industrial Mobilization Planning

As noted above, the MODSG made several attempts to get the Services seriously thinking about the production requirements of war. Its first inquiry had the Services study the costs and times needed to complete the JCS Planning Force; its next study looked at this problem for a unit increment of the force (e.g. an Army division, Navy carrier group, or Air Force wing). Its third try was to have the Services estimate an emergency procurement budget, a document which was to be submitted to Congress at the outset of a crisis in order to finance surge and mobilization production levels.

The Services balked at the last, partially because they lacked a theory to estimate this cost but mostly because they feared that OSD would use the hypothetical crisis budget requirements to mark their real-world budget submittal. In frustration, the MODSG had the Institute for Defense Analysis (IDA) estimate an emergency procurement budget for the Services. IDA did a workmanlike job but their product suffered from their inability to impose a uniform regime for treating mobilization requirements. In any case, the

Services never signed up to the IDA numbers, which was the point in the first place.

In an effort to appear responsive, the Air Force picked up AF Lt. Col. Chuck Miller's proposal of a Joint Industrial Mobilization Planning Process (JIMPP). JIMPP, it was explained, would be a comprehensive framework for all mobilization concerns, of which a crisis budget would be but a subset.

But many briefings later, it is still not clear what JIMPP is supposed to do. There are three dominant but not necessarily concordant interpretations.

One holds that JIMPP should coordinate the materiel requirements of the CINC's war plans with the sustainability assets actually available to the CINCs. Efforts to this end have been initiated through JCS (J-4) and OSD (Director of Emergency Planning). Results are still to come. While useful in and of itself, its relationship to surge is tenuous given the short time lines of OPLANs (well below six months) and the longer time lines of industry (which needs six months for anything interesting).

Another is the heightened attention being devoted to a TASC-invented concept of INDCONs, a graduated series of industrial conditions which are invoked as world conditions deteriorate. INDCONs appear to have received official status and have been tested, at least superficially, in the 1987 Command Post Exercise. See chapter six for further description and analysis.

The third definition for JIMPP is the idea that the various industrial data bases of the Services are amalgamated into a common DOD system. A common data base was first proposed in 1981 and was subsequently fleshed out by TASC in its proposal for an Integrated Industrial Data Base Management System. TASC recommended the PGM sector as a test bed for such data. So the PGM study came and went, the data base has been assembled (and even scrubbed), and still there is no DOD system to hold it. Subsequently, the proposed data base was renamed DINET, entertained the possibility of filling it with Census data, and inputs from FEMA's Federal Resource Assessment System, passed over to IDA for further analysis, and, a year later, was handed off to a private contractor. Its current status appears to be as a central repository for mostly unrelated industrial data.

As even ASD(P&A) would admit:

> Much more remains to be done in upgrading DINET's overall value. The DINET project staff is attempting to resolve several technical problems needed to improve the visibility of industrial base issues. Utilizing detailed data that have become available from recent logistics initiatives including the Computer Aided Logistics (CALS), and Defense Integrated Data System (DIDS) modernization projects, work is under way to identify the key relationships between components and end items; and those manufacturers supplying them to DOD organization. If successful, this effort will be able to highlight many of the constraints to rapidly increasing production in a crisis caused by limited production capacity, increased demands on a diminished subtier, and extensive reliance on foreign sources.

The DINET process has had useful spinoffs. One has been to get the Commerce Department to survey key industries for their contribution to mobilization. Another has been to raise the visibility of the Naval Ship Support Office in Philadelphia, which may be DOD's most competent body of industrial preparedness planners. They are now working on Navy's Shipbuilding PBA.

The most recent attempt to build some rigor into the theory of surge comes from the efforts of an OSD-directed task force led by Len Sullivan, former head of DOD's Program Analysis and Evaluation office. Their efforts were bent on reaching some consensus on the relationship between warfighting, sustainability, and industrial production. Chief among their conclusions was the idea that the Defense Guidance, by emphasizing one scenario, a cold-start NATO-centered war, was undercutting the role that surge could play in the nation's defense. An alternative scenario that focused on surge during conditions of ambiguous warning would bring better balance into war planning.

Chapter six goes into all these issues in some greater detail. Historically it started as a spin-off from the Sullivan study but it stands on its own as a search for doctrine.

3

THE VALUE OF ACCELERATING PRODUCTION

DOD's ability to get more weapons in a hurry has considerable value when conflict is to exceed six months or when DOD can take advantage of warning time.

The value of surge preparedness is governed by the value of surge itself. The value of weapons on hand is tangible and specific. The promise of weapons to come is harder to assess. Two theories of value may be noted. One is that surge investment may be a more cost-effective way of providing resources that have only a small year-to-year likelihood of being used. The other is that surge allows one to support minor contingencies without an extended risk of Central Front deficiencies.

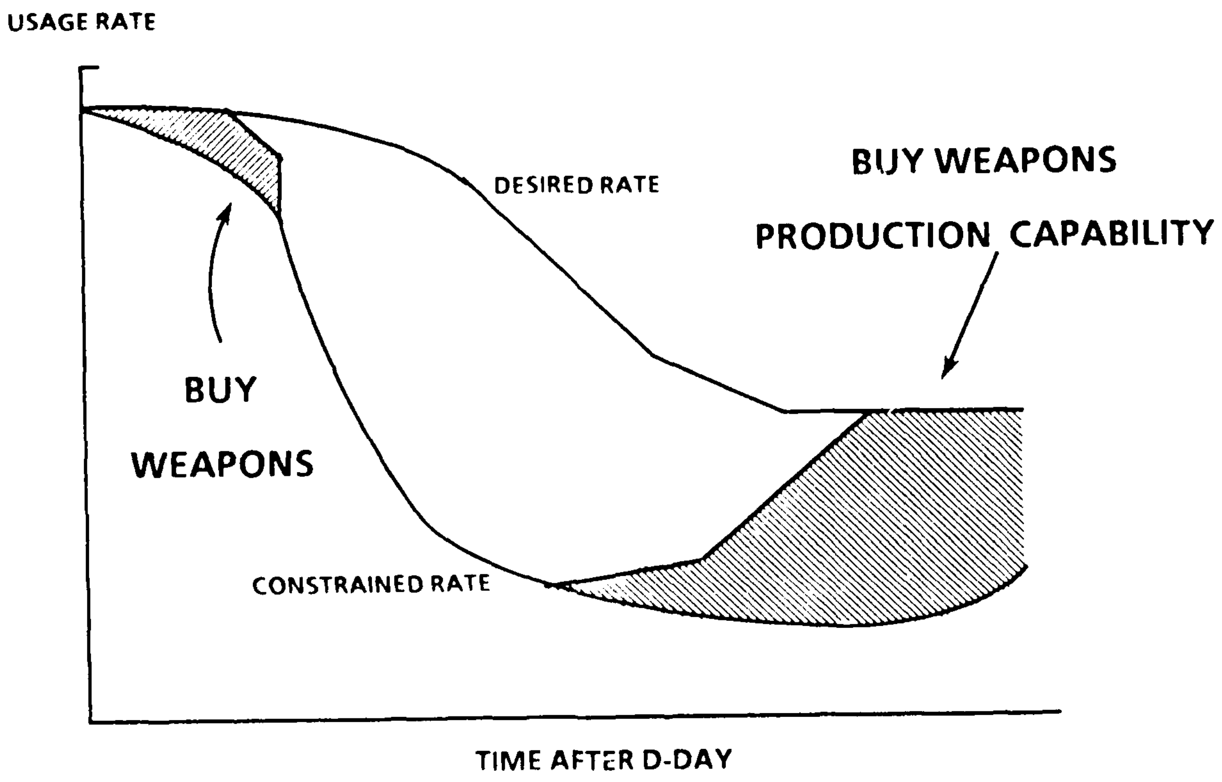
Munitions Tradeoffs

When munitions are short, usage must be constrained below optimal levels. Figure 3-1, on the following page, illustrates this with two curves. One portrays the desired rate of usage; it is a function of shooters and targets. The other is a projected usage rate, taking supply constraints into account. When supplies are tight, usage is limited, and warfighting opportunities have to be forgone. Fire may have to be held back until the putative target is more firmly identified or within closer range. If the shortfall is sufficiently grave, one may be forced to withdraw. The results are threats that cannot be neutralized, platforms put at greater risk, and the possible loss of strategic objectives.

The same chart shows two basic fixes. One buys more weapons so they are on hand for the first day of combat. The other invests industry with the capability to accelerate weapons

FIGURE 3-1

OPTIONS FOR ALLEVIATING ORDNANCE SHORTFALLS



production. The first fix yields immediate capability; the second, however, may ensure greater numbers of weapons for a given outlay of peacetime funds.

Two factors govern the trade-off. One is the relative cost of acquisition versus investment; the other the relative value. The comparison indicates the more cost-effective policy.

Critical to the comparison is the idea that industrial investments yields the promise of weapons rather than the weapons itself; it means more weapons later in the crisis. If the costs of reserving later weapons deliveries is smaller than buying them outright, so is the benefit. The problem is how much. Unfortunately this difficult exercise has never been contemplated, much less carried out. It has not helped that the current paradigm denies the existence of a trade-off (particularly for weapons used to destroy a countable number of targets). Current guidance to cover all possible targets within the first 60 to 180 days of conflicts suggests that anything less creates, in theory, the risk that one will not be able to fight beyond those early months. Having but 30 days worth of weapons means one would not be able to fight on day 31, and would be unable to use weapons delivered on day 32. If US sustainability is that bad, then despite the fact that 80 percent of DOD is spent on conventional forces, we lack conventional deterrence.

Instead, any subjective valuation of the weapons-now versus weapons-later tradeoff has to focus on the entire spectrum of threat/conflict possibilities in order to yield a probabilistic range of time-dependent valuations. While, intuitively, a weapon available sooner is, by that fact, more valuable, the argument that one available several months later has no value is difficult to defend.

The most basic determinant of later weapon deliveries is the likelihood that war will persist several months later and thus require the weapons available. If the average war of sufficient size to deplete weapons inventories has less than a fifty-fifty chance of lasting six months, then a weapon which takes six months to reach the front is, by that fact, half as valuable.

That is the basic formulation, but then there are nuances. If the war has ended after six months but tensions persist then later deliveries--given the nearly depleted stocks on both sides-- contribute significantly to deterring the next round. Conversely, war may be going but it was the early conflict that determined the final outcome At the nine month period a tacit understanding may have developed (as it seemed to in Korea in 1951) that heavy fighting was in abeyance pending negotiations. This could lower the value of later deliveries even though war was not yet over.

Escalation to strategic nuclea. conflict must be considered tantamount to ending the war if relevant production plants are targeted. Thus, a high likelihood of nuclear exchange lessens the value of surge preparation. Similarly, the likelihood of sabotage against domestic plants (versus destruction of weapons dumps) will affect the trade-off. Also the percentage of munitions which would survive transshipment to the front in wartime should be compared to the percentage that would survive intact at the front.

Another factor is when specific weapons are needed. Some weapons, by their nature, are used heavily at the outset when threat platforms are moving in theater, and conditions are volatile. Others are more important when threat platform levels have declined and conditions have stabilized.

Deterrence calculations play a role. If one believes the enemy is deterred by making an early victory difficult then weapons should be available early. If, however, it is the prospect of ultimate victory which matters, then a weapon available later still retains a lot of its value.

Inventory levels also count. Where initial stocks are relatively full, additional weapons are a safety stock and could easily lie unused for at least as long as newly produced material takes to arrive. The more inventory one has, the later it is that any new war reserve additions would be used, and the less important it is to have more weapons at the outset. Similarly, if platforms are lost too fast, later deliveries may not have any place to go.

Finally, there is the ever-present chance that current stocks may prove of markedly diminished value due to changes in technology or doctrine from the other side. Investments in surge production may be altered to meet the specifications of redesigned weapons faster than the existing stock of weapons can be withdrawn and reworked. More broadly, newly produced materiel may be qualitatively better than stocks if producers are able to incorporate the results of wartime performance data into their production.

Surge for Contingencies

The other way to evaluate surge is to examine the likelihood that prior contingencies may reduce stocks available for deterrence, and for that reason, must be replaced quickly.

Examples are not hard to find. In 1973, Israel called on the United States for large numbers of tanks. In so doing, they depleted US Army assets in Europe, exposing the Central Front. The Army tried to surge tank production, but capacity limitations of its tank turret hull producer led to disappointing results. The Central Front remained vulnerable for longer than it should have.

The value of a contingency surge is directly proportional to the odds that such surge would be required, and the extent to which surge can close the gap. If the odds of a Central Front conflict increased in the critical months following a weapons-depleting contingency, having the ability to close the gap more quickly would be that much more valuable. Surge would put weapons on the frontline prior to conflict.

This formulation, however, does not apply to all weapons. Some, such as the Phoenix missile, are not sold overseas, and could not be depleted by the contingencies of allies. Others, such as the antisubmarine Mk-46 torpedo, are unlikely to be used in quantity other than in a very large conflict.

In a broader sense, however, this valuation could be used for all contingencies which allow sufficient warning for surge. Given a year's head start, the ability to deliver weapons faster makes a direct difference on the front line; a weapon so delivered is equal in value to one already there. But, only some wars are preceded by actionable warning, as chapter six argues. For those that are, surge preparations can come in handy.

Beyond surge, the values sharpen. The longer war lasts, the more it is that later battlefield results are the determining ones, and the more important are new weapons compared to those on hand when war began. By war's end, almost everything of value may reflect war production rather than pre-war stocks. The ratio between our war production and theirs would help fix who ended up where.

Industrial production would also matter during the immediate postwar period, particularly if the war is short and leaves both sides wary of renewed fighting. Rebuilding forces quickly may be the only way to keep the Soviets from trying their luck again. Finally, the industrial base capable of surge can contribute to deterrence even before surge is called for. A defense strategy that tells the Soviets that our industry will be used to eventually reverse possible early setbacks in the Central Front may deter even if they believe that they stand a good chance of doing well at the outset. Such prospects would also help bolster our beleaguered forces in the meantime.

Cost Effectiveness and Caveats

The next chapter shows that a properly constructed surge preparedness program can reserve surge production capacity at pennies to the dollar. Thus while values of deliveries may fall after surge begins, the costs of such deliveries may fall even faster. Getting a weapon to the front on day zero means buying it. Accelerating its delivery may mean investing in the information, tools, and components of production, costing far less.

But bear in mind that surge preparations reduce not the cost of weapons but the cost of ensuring their availability when needed. If one knew that a weapon would definitely be used, the cheapest way to assure availability would be to produce it in the most economical way. But since 1945 most weapons, PGMs in particular, have not been used in war; they are purchased against the possibility that they may have to be used, as deterrence. In a strategic sense DOD is purchasing availability. Hitherto availability was purchased only through direct acquisition. Surge preparedness however purchases a modified form of availability at greatly reduced costs.

Finally surge and acquisition is not an either-or proposition. Halting production lines to pay for surge investment will itself make such investment less effective. Restarting cold weapons lines takes longer than ramping up warm ones. Private companies which maintain excess capacity in order to meet current demands economically may be inclined to rededicate or eliminate such capacity in the absence of active orders. One cannot substitute for the other; they are complementary.

4

PREPARING FOR SURGE

> A joint Navy-MCDC study estimated that investing \$550 million dollars would allow industry to triple the production of ten PGMs within six months of go-ahead under wartime crisis conditions. Surge would make \$5.5 billion dollars' worth more of PGMs available within the 15 months, a substantial increase in assets. The study also found that limited capacity was the major problem--90 percent of the investment needed. Long lead times were the minor problem--10 percent of the investment needed.

In December, 1985 the Chief of Naval Operations requested information on the costs and benefits of investing in the industrial base to improve its ability to increase munitions production on short notice. The Navy's 1986 Ordnance Production Base Analysis (PBA) was thereupon undertaken to generate a set of production targets and then estimate, first, what industry could do in support of those targets, and second, what investments would be required to reach them.

For the Navy, munitions largely mean precision-guided munitions (PGMs). Conventional ordnance can destroy ships and aircraft, but not without the user platforms getting so close to their targets that they risk being destroyed by adversary PGMs first. Though conventional ordnance is still useful against ground targets, the increasing proliferation of antiaircraft and antiship missiles makes stand-off missiles mandatory against heavy defenses.

Navy supplies of PGMs, however, are still not up to levels considered adequate by munitions planners. Despite the several billion dollars a year being spent to buy weapons, inventories were, on average, only a fraction of planning requirements by the end of FY 1987. Even before the most recent budget cuts, most bins would not have been filled until well int the next decade. Even then, increases in the sophistication and size of the threat create the possibility that future inventories may still be undersized, or filled with less-than-preferred PGMs. Tighter budgets over the next five years make the chances of reaching even these goals increasingly problematic.

Within the last few years, though, several key DOD officials have suggested that the risks of low munitions stocks could be mitigated. If industry could accelerate weapons production early in conflict, the Services would not have to rely exclusively on weapons on hand at D-day in order to sustain their warfighting. These officials also recognized, though, that industry is not currently configured to accelerate production quickly. PGMs now take 12 to 30 months to make, a period which would have to be substantially shortened if the impact of accelerated deliveries were to be felt in time. Several key sectors of the PGM industry are recognized bottlenecks and cannot expand production much without added capacity. Thus, if a wartime production surge is to make a difference, investment in industrial capacity would be required. The key question is what that would cost and how much sustainability such investment would buy.

Methodology

As chapter two indicates, the study had two important predecessors. One was the JCS study of PGMs, the primary data source available on the industry. The second was CNA's study of the Mk-46 torpedo and AIM-9M missile, the primary methodological source. Therein lay a dilemma. The CNA study illustrated how intense face-to-face interviews with the various producers elicited innovative suggestions for expanding production quickly with minimal investments. However, there was neither the time nor the resources to make a comprehensive survey of the hundreds of prime and subcontractors which comprised the industry.

This introduced another question: what ground rules are to be assumed for the surge period? The CNA study proved that assumptions made a large difference. Willingness to trade money for speed and an widespread sense of urgency led to changes in operating procedures capable of reducing lead times on their own.

The decision was made to use wartime conditions in its surge scenario, for two reasons. One stems from the position of the US Navy. Each Service in a sense is configured for its own war. The Air Force concentrates on strategic warfare, the Marine Corps on rapid intervention, the Army on medium-scale conventional war, and the Navy on large-scale conventional war. There are many Navy PGMs, such as those involving submarines, which are unlikely to be expended in a war that does not involve the Soviets. There are other Navy PGMs, such as the Phoenix missile or the Standard missile, which will not see much expenditure short of conflict on the high seas. Indeed, it is difficult to conceive of a smaller war putting much dent in Navy's supplies of PGMs. The smaller wars were not the problem; the bigger ones were.

The other reason was that the JCS study had shown that surge investments without urgency were a dead end in terms of cost-effectiveness. Table 4-1 shows the ratio between recommended investments and additional production over the surge period.

In aggregate, for the cost of one PGM, one could provide industry the means to produce 1.6 PGMs during the surge period, six to 30 months later (omitting McDonnell-Douglas, which used a different methodology, drops the number to 1.35:1). Such investment is only justified if one believes that PGM availability can be postponed that long and still retain 60 percent of its warfighting value. No one in the Navy was going to be convinced to give up a PGM out of stocks to buy a promise worth 1.6 PGMs some six to 24 months after war's onset. The cost was too high and the time frame was too long. Scrubbing the JCS data could reduce costs somewhat but not enough to matter while operating under its assumptions.

The study rules thus follow CNA's wartime assumptions. Cost was no object, and factories worked at maximum rates, with alternative product specifications allowed where appropriate. In addition, the study assumed that if workers with hard-to-find skills were available at all, they would be channeled into defense work under the general pressure of wartime exigencies. Defense-specific skills shortages (e.g. MILSPEC microwave technicians) were treated as real constraints which had to be addressed.

Table 4-1
Cost Effectiveness of Surge Investments: JCS PGM Study (dollar costs in millions)

PGM	Investment Cost	Added Production	Ratio
Sparrow	178	175	.98
Phoenix	78	90	1.15
HARM	40	53	1.33
Standard 2	132	183	1.39
Sidewinder	31	44	1.42
Mk-46	105	167	1.59
Standard 1	63	116	1.84
Tomahawk	101	268	2.65
Harpoon	46	137	2.97
TOTAL	774	1,223	1.60

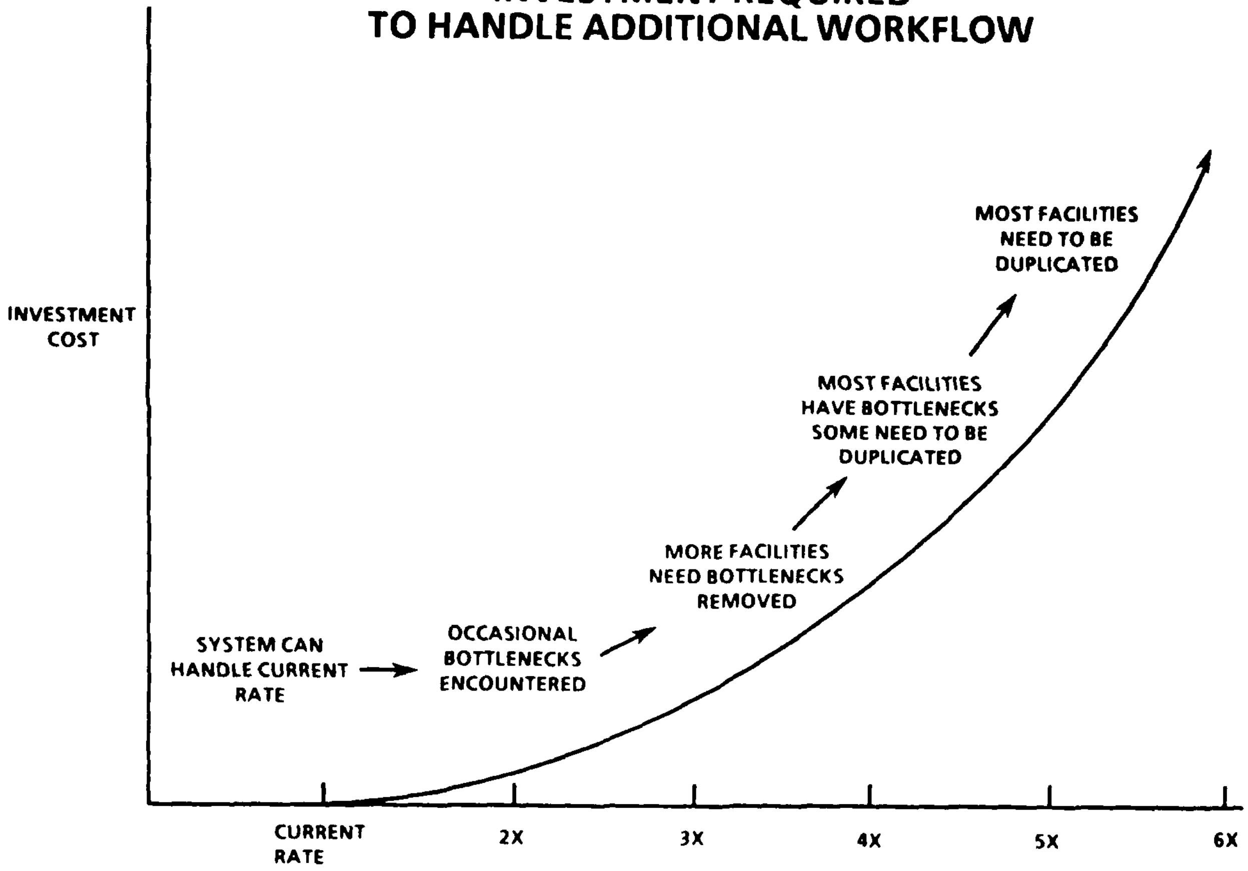
Production Targets

The other major consideration was how great a ramp-up the study would use as its goal. Asking production to triple rather than double or increase five fold was a compromise among competing objectives. Requirements calculations suggested that 5X might better support combat objectives. Data from the JCS study, though, indicated that building the capacity needed to reach 5X would be prohibitive. Most industries now run one main shift plus some overtime work. Getting to 3X within a week of 168 hours (7 days of 24 hours each) would require only the addition of certain select equipment. Reaching 5X rates might require duplicating the whole plant and investing in "brick and mortar." In that case, the relationship between investment and capacity would be nonlinear, with 5X being, in general, not affordable. Figure 4-1 illustrates this relationship.

Under the scenario, all work at industrial facilities was divided into three parts. Ordnance work, of all kinds for all claimants,

FIGURE 4-1

INVESTMENT REQUIRED
TO HANDLE ADDITIONAL WORKFLOW



was to be tripled. Other military work was to be held constant. Commercial work was to be displaced if necessary. Ordnance was treated separately from other defense work in part because repeated surveys of the CINCs have indicated that PGMs remain their highest wartime surge priority. In addition, it would have overstated costs to reserve capacity at facilities with PGM work to support a surge in other defense programs when excess capacity was unavailable for surging such programs at facilities with no PGM work. Since having to accelerate other DOD programs was less important and less likely than doing so for PGMs, it was assumed that facilities with other defense programs did not have to provide commensurate surge capacity for them.

There was little question that tripling production within six months was quite feasible. Operating in a peacetime surge, Raytheon increased production from a contract rate of 150 per month (which had not yet been reached) to 420 per month in the five months following the 1961 Berlin Wall crisis. Specifically, monthly production rates were 120 in August 1961, 50 in September, 150 in October, 250 in November, 330 in December and 420 in January 1962. A DOD "production compression" program to provide additional parts inventory supported this increase. As to the long-term viability of a sustained 168-hour/week pace, there are many industries where such operations are standard. They include steel, nonferrous metals, petroleum, chemicals, paper, cement, and semiconductors.

The scenario used was a wartime surge starting with no warning. PGM production was to triple within six months. Industry was to estimate what investment they needed to accelerate all munitions together. However, only that part associated with the ten PGMs was counted as a cost of surge.

Table 4-2 shows the total production requirements for ten PGMs. Consistent with the recent Navy Mobilization Production Targets, they were baselined from industry's expected production in spring 1988 (for all claimants) and then tripled. Navy was assumed to be the only claimant for six weapons; Air Force shared claimancy on a 60:40 basis on four others (Sidewinder, Sparrow, HARM, Maverick). Weapons upgrade programs were assumed to roll into new production on the theory that assets available on D-day would be expended before they could be upgraded. The third column is what each month's current hardware production costs (Air Force's 60 percent share in parentheses). Hardware costs (rather than the larger total program costs) were used as best representing the cost of buying additional PGMs rather than the capacity to make more.

Table 4-2
Production Requirements for Selected PGMs (dollar costs in millions, production per month)

PGM	1988 Base	Cost	(AF Share)	Target
Sparrow	300	45	(27)	900/month
Phoenix	25	20		75/month
HARM	200	48	(29)	600/month
Standard 2	120	58		350/month
Sidewinder	400	19	(11)	1200/month
Mk-46 torpedo	120	19		350/month
Skipper	300	8		900/month
Tomahawk*	20	40		60/month
Harpoon	40	24		120/month
Maverick	400	44	(27)	1200/month
TOTAL		325	(94)	

*conventional warhead only

Prime vs. Subtier Producers

PGM production is a multi-step process involving several tiers of producers. The prime contractor, defined as the builder of the guidance and control section, often assembles the finished PGM as well (a few are assembled at Naval Weapons Stations). Most PGM components are mostly purchased from second tier producers who in turn have to buy subcomponents from third tier producers and so on. Some components are furnished directly by DoD; such Government-furnished equipment, GFE, include warheads, fuses, target detectors, safe-and-arm devices, and rocket motors.

About 30 percent of the value added is supplied from the primes, 10 percent from the GFE producers (otherwise identical to second tier subcontractors) and 60 percent from the subtiers. Second tier contractors, in turn, account for 45 percent of the value-added and pass 15 percent (the remainder from 60 percent) across to other second tier producers down to the third tier and lower. The group surveyed by the Navy accounts for a total of 60 percent of the value added: 10 percent as GFE, 45 percent as second tier, and 5 percent as third tier and below.

This study, in contrast to its predecessors, looked at subtiers first and primes last, in part because the key components and their producers had already been identified. First the six month (26 weeks) target for surge was split into 17 weeks for the subcontractors to reach 3X, and 9 weeks for the primes to assemble PGMs from parts. GFE producers, because they work in parallel to the primes were allowed a full 26 weeks. Next was calculated the investment in both capacity and lead time enhancements for subcontractors to reach 3X in 17 weeks. Finally, once that number was established, the prime contractors would be told that their components would arrive at triple rates within four months and then asked to estimate how much capacity and production lead time would be required for them to triple their production.

By contrast, the prime contractors were not examined in much depth. Their complex and lengthy production processes would have required a detailed examination of their manufacturing through repeated site visits to assess their lead times and capacity requirements. Time prevented this approach. Consequently the study <u>assumed</u> that primes could, in fact, reduce internal lead times to 9 weeks but no new evidence was developed to prove this. Data from both the CNA and related studies indicate that a range of 4 to 8 weeks is not unreasonable under wartime conditions, but without specific engineering studies, such estimates remain soft.

The study thus concentrated on what subcontractors (whose share of value added is roughly twice that of the primes) would need to meet 3X in 17 weeks. This required that two basic questions be answered from each facility. The first, <u>how much</u>, was whether affected facilities had the capacity to accommodate 3X under wartime surge; if not, they needed investment in capacity. The second, <u>how fast</u>, was whether lead times could be reduced into the

17-week period. If not, they needed investment in prestocking. Where internal lead times could be reduced to below 17 weeks, only key subcomponents had to be stockpiled; otherwise, some work in process would have to be prestocked to make the 17-week goal.

Two other considerations called for prestocking complete components. In some cases it was cheaper to prestock components and wait for postsurge capacity to come on stream than to buy additional capacity to get to 3X rates. In others, production would be paced by the time needed to train specialized workers for the subcontractor's specific jobs; prestocking subcomponents, in such a case, was of no help.

This basic how-much-how-fast criterion was then applied to the 444 facilities identified in Phase I of the JCS study which supplied parts to a Navy-used PGM. As mentioned previously, of the 444, roughly 60 percent (272) had not responded to the JCS Phase II questionnaire. They were mailed a new five page questionnaire (see Appendix B). Responses for the 172 which did answer were reviewed to see if how much and how fast determinations could be derived from their data. A quarter of them had indicated that they could meet the 17-week time frame with no or nominal capital requirements. The remaining responses did not allow a good fix on 3X requirements (i.e. they could meet 2X but not 5X) or contained major contradictions, omissions, or investment requirements that did not yield to interpolation. They were called for clarification.

Key to understanding the study's methodology is that both the JCS Phase II questionnaire (designed with CNA's methodology in mind), and the study questionnaire were explicitly designed to spot contradictions as a quality control check. Facility data on current lead times, current business base, and distribution of workers per shift were compared against both capital and lead time requirements to determine whether the latter reflected authentic needs under potential wartime conditions. In many cases, particularly when needs, so defined, had enormous resource implications, there were contradictions. Some facilities claimed a need for more capacity despite using few shifts or doing mostly commercial work. Others indicated that their process times were no shorter in wartime than in peacetime, or that process times would exceed total lead times. Follow-up conversations also examined other ways of economizing capacity and lead time requirements, such as working around the clock, operating under wartime conditions, using work-arounds, differentiating the nice to have from the need to have investments, or running smaller batch sizes. For these clarifications, follow-up phone discussions were indispensable.

The total verified response rate was 64 percent as of 22 May 1986 when the data was cut off. A number of questionnaires trickled in afterwards, but too late to verify. For reasons discussed below, it is likely that 90 percent of the total costs were covered.

Table 4-3
Data Sources for Prime Contractor Investment Requirements

PGM	Source	Comments
Mk-46	CNA Study	Wartime specifications.
Skipper	Program Office	Capacity = 1000/month.
Tomahawk	Program Office	Capacity = 63/month.
Sidewinder	PBA Data	Filled-in questionnaires.
Sparrow	CNA Study	650/month rate costed for Raytheon.
	IRA Study	250/month rate costed for GD.
Harpoon	JCS Study	Confirmed by company.
HARM	JCS Study	Interpolated between 300 and 800/mo.
Maverick*	JCS Study	Mobilization rates.
Standard 2*	JCS Study	Interpolated between 110 and 400/mo.
Phoenix*	JCS Study	Interpolated between 60 and 200/mo.

*Some of these costs may be avoided by factoring in special test equipment currently being developed for scheduled second sources for these PGMs.

Added to subcontractor capacity requirements were those from the prime, sources for which are noted in table 4-3. Where JCS data was used, adjustments were made to account for equipment which would have been installed between the surge day of the JCS study and that of the Navy study. This reduced costs in at least two cases. Except for the Mk-46, and to a minor extent, the Sidewinder, there was no basis for closely questioning the requirements for prime contractor test equipment, which makes up the overwhelming bulk of the requirement. It is likely that scrutiny would have eliminated some of this requirement, as it did in the subtiers. However, it is difficult to say how much.

Summary of Benefits and Costs

Benefits

Figure 4-2 illustrates the additional production quantities which result from reaching the production targets of a three fold increase in six months.

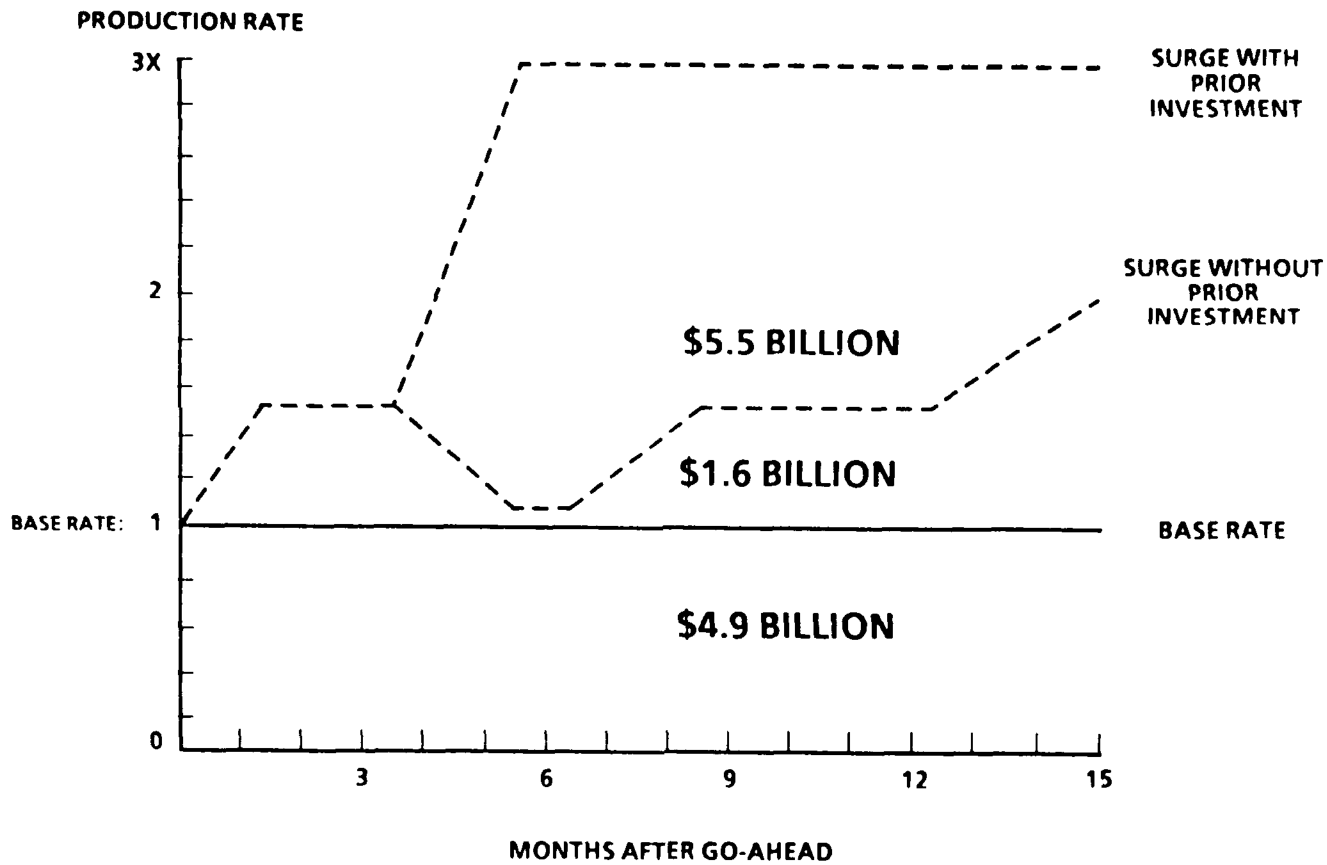
The lowest line is a straight line extrapolation of anticipated early FY 88 production rates. Fifteen months' worth of PGMs at $325 million a month means $4.9 billion of PGMs.

The middle line represents production in a wartime surge without prior investment. At first, primes accelerate deliveries by shortening their own lead times, reaching internal capacity limits quickly. After several months, internal lead times have hit their low, and output drops to prewar component delivery levels. A sustained rise up to capacity levels does not begin until the longest lead components are produced, shipped, and incorporated into final PGM production. For a typical PGM this process takes up to nine months even in very accelerated modes. Roughly one year after surge begins new capacity starts to come on stream at both prime and subtier levels, leading to production increases a few months later. At that point production can rise to virtually unlimited levels. All in all, however, wartime surge, by itself, adds $1.6 billion worth of PGMs over and above peacetime rates.

The top line represents wartime surge production with prior investment. Within the first six months, investments in additional capacity and prestocked subcomponents combine to raise production

FIGURE 4-2

MONTHLY PRODUCTION RATES UNDER WARTIME SURGE



to target levels. Investment allows industry to produce another $5.5 billion worth of PGMs.

Table 4-4 estimates key parameters for each individual PGM. The base rate is the anticipated monthly production rate as of early 1988 (as forecast two years earlier). The maximum rate is what production would have been limited to in a surge without investment. As the rate limiter shows, production is sometimes constrained at the prime contractor level; other times because of limitations at a key subcontractor. Lead time is a combination of the time required to acquire components plus the internal process lead times of the prime contractor (in parentheses).

Table 4-4
Parameters of PGM Production in Surge Without Investment
(production in units/month, lead time in months)

PGM	Base Rate	Max	Lead time	Rate Limiter
Mk-46	120	220	7 (1)	Gyro/afterbody
Skipper	300	500	7 (1)	Gyro/generic
Maverick	400	650	8 (2)	Actuator/motor
Sidewinder	400	700	7 (1)	Prime/generic
Sparrow	300	360	8 (2)	Prime
Tomahawk	20	32	12 (4)	Seeker/generic
Standard 2	120	150	9 (2)	Prime
Harpoon	40	60	10 (3)	Seeker/engine
Phoenix	25	35	12 (4)	Gyro/ARA
HARM	200	220	10 (2)	Prime

The best way to assess the benefits of surge preparedness in it terms of its ability to produce more weapons in the field when they are needed. Using notional aggregate data, Navy inventories would be a third of Navy's planning requirements. Were a wartime surge to have started, existing production contracts would have been accelerated but with limited effectiveness because of system bottlenecks. Fifteen months later, assets would have reached half of requirements, an increase which in peacetime would have taken almost two years to accomplish. With surge investments, assets, however, reach two-thirds of requirements. Simply put, for every two PGMs available when surge begins, surge itself adds one more; and investing in surge adds another.

If the surge investment is paid for by reducing inventories, initial availability would be reduced somewhat. This difference persists over the first few months of surge, but by month six, surge production has made up the difference. By month 15 the difference widens, into, as figures below show, a ten to one difference.

Costs

It required $550 million dollars worth of pre-crisis investment to realize a production increase of $5.5 billion dollars. Table 4-5 segregates these costs by PGM. Displayed in successive columns are estimates for prime contractor costs and subcontractor costs. Parenthetically displaced are the approximate percentage of subcontractor costs which had to be estimated from unknown or unallocated data (see below for further analysis). In the next column is an estimate of the benefits, that is the additional production available because of the investment in surge capacity. The last column is the ratio of the value of additional production to the cost of investments required to facilitate them.

The investment costs which permit surge do not include anything for expenses borne once surge begins (that is, production costs). It is quite possible, therefore, that the surged PGM costs significantly more than normal production. But all that is really besides the point. If the weapons are needed then the costs of conducting surge are more than worth it. If the weapons are not needed, then the money never has to be spent. By contrast, if the PGMs are purchased outright then the money is spent whether or not a crisis situation arises in which they might be used. Surge, in that sense, is a cost savings device. Laying out a percentage of the cost up front preserves the option to produce PGMs. Of course, if the probability that the nation would have to surge approaches 100 percent, it is much more efficient to buy the PGM and have it available when needed, rather than buy an option for the PGM and then pay equally much or more to produce it and have it available six to 15 months after it is needed.

Table 4-5
Costs and Benefits of Surge Investment (dollar costs in millions)

	Investment Costs					
PGM	Prime	Subtier	(Percent)	TOTAL	Benefit	Ratio
Mk-46	0	6	(30)	6	250	40:1
Skipper	0	5	(20)	5	100	20:1
Maverick	10	22	(20)	32	650	20:1
Sidewinder	4	10	(10)	14	250	18:1
Sparrow	38	24	(15)	62	900	15:1
Tomahawk	0	41	(45)	41	600	15:1
Standard 2	50	41	(10)	91	1100	12:1
Harpoon	5	63	(10)	68	400	6:1
Phoenix	38	28	(30)	66	350	5:1
HARM	125	40	(10)	165	900	5:1
TOTAL	270	280		550	5500	10:1

The ratio between costs and benefits is the same whether dollars or quantities are under consideration. Take the Mk-46. Six million dollars buys 40 more torpedoes; invested in production facilities it buys the option on 1,600 more torpedoes. The ratio between the two, 1600:40 is the same as the ratio between the two costs. The torpedoes bought outright may have more value to the fleet, because they are available at once rather than six to 15 months later. Unless they are more than 40 times more valuable, though, surge investment would be worth more than buying more.

The PGMs may be split into two groups. Cost-value ratios for seven of the ten are quite high, from 12:1 on the Standard 2 missile to 40:1 on the Mk-46 torpedo; their aggregate ratio is 15:1. By contrast, the aggregate ratio for the remaining three PGMs is 5:1. For the Phoenix and the HARM missile, enormous requirements for test equipment yield the notably high costs and low ratios. The low ratio on the Harpoon is temporary, resulting from an unusually high base rate in 1988; reaching 3X on next year's base would have been less costly.

Table 4-6 shows that most of the required investment is for tooling and test equipment; prime contractors, though they account for only 30 percent of the value added, account for 60 percent of the investment requirement. Only a fraction is for the early purchase of inventory, most of which to be purchased by second tier suppliers for subcomponents further down in the procurement chain. By contrast, 70 percent of the JCS recommended investment is for inventory and 30 percent for tooling. The JCS study required more subcontractor than prime contractor equipment because it assumed a twofold increase in subcontractor capacity but, on average, only a 50-percent increase in prime contractor capacity.

Table 4-6
Investment Requirements by Type (dollar costs in millions)

	Navy PBA	JCS PGM
Prime Contractor Tooling	270	200
Subcontractor Tooling	180	350
Inventory of Components	35	1,200
Inventory of Subcomponents	65	0
TOTAL	550	1,750

One salient distinction between the two studies was the JCS recommendation to buy components (items bought by the prime contractor) versus this study's findings that subcomponents (items bought by subcontractors) would be more economical to purchase. The JCS study accepted prime contractor lead times in excess of six months; getting a PGM made that quickly would therefore require the prime contractor to add stocks. This study baselined a prime contractor lead time of two months. Thus any component which could be delivered within four months did not have to be stocked. Where lead times exceeded four weeks, the subcontractor would buy subcomponents if that was what was needed. In some cases, however, subcontractors themselves either had extended in-house process times (in which case they would have to prebuild their own components to a certain level) or would not be able to hire and expand fast enough to meet threefold rates (so that his components had to be purchased by a prime contractor). The latter only took place 17 times out of 285 companies surveyed.

Specifics of Surge Investments

Almost all of the work in this study was devoted to an investigation of two inputs. One was the true lead times for components going into PGMs and the other was the investment requirements of reaching target rates.

Of the 285 subcontractor firms surveyed, over half, 153, could meet both capacity and lead time requirements with no investment. Of the rest, 62 could do so quickly enough but needed more capacity, 42 had the capacity but would need help doing so in time, and 28 lacked both capacity and timeliness.

Lead times for both in-house processing and for total production (i.e. with subcomponent lead times added) were much shorter in a crisis mode (see table 4-7) then under normal conditions. In-house (and total) lead times for integrated circuits, for instance, consistently fall in the 8-to-12 week range regardless of source. Other common in-house lead times are 6-to-12 weeks for hybrid circuits, 4-to-10 weeks for connectors, 2-to-6 weeks for batteries, and 2-to-4 weeks for printed wiring boards. Many such items quote long lead times now, stemming from the discretionary scheduling actions of producers operating in a peacetime mode and working fewer shifts than capacity allows. Even in wartime however, certain complex mechanical assemblies would need 10 to 24 weeks to build. Prestocking materials or work in process would greatly facilitate meeting their production targets.

In some cases, however, respondents with longer lead times did not need additional inventory in order to ramp up production within 17 weeks. Many said so explicitly, citing their ability to use inventory already on the shelf or their ability to accelerate in-line production to effect the needed increase.

Table 4-7
In-House and Total Lead Times in a Wartime Surge

LEAD TIMES (number of facilities)

Months	In-house	Total
Up to 1 month	75	30
1 - 2 months	110	43
2 - 3 months	76	72
3 - 4 months	18	68
4 - 5 months	2	24
5 - 6 months	4	21
6 - 7 months		11
7 - 8 months		10
8 - 9 months		6
Total	285	285
Mean	1 3/4 months	3 1/4 months

NOTE: A few facilities making items with very dissimilar lead times were listed separately for each type of item.

The myth persists that the primary requirement of industrial preparedness planning is to prestock components in order to overcome long lead times. As this chart shows, it has little basis in fact. The only valid reason to prestock components at the prime contractor level is that relying on so many subcontractors to all meet production targets creates a risk that at least one will fail and thus bottleneck the whole schedule. Prestocking at the prime reduces to one the number of sites where schedule-threatening errors can occur. To date, however, no one has succeeded in quantifying that risk.

While 45 percent of all respondents needed some amount of investment, most of the requirements were accounted for by a handful of companies. Twenty facilities (see table 4-8) accounted for 81 percent of the capacity requirement, 76 percent of the component prestocking requirement, and 71 percent of the subcomponent prestocking requirement, for a total of 78 percent of the entire recorded investment at the subtier level--70 percent of the extrapolated requirement.

Table 4-8
Top Twenty Facilities Ranked by Investment Requirements

Name	State	Product
Texas Instruments	Texas	Seekers (Harpoon, Tomahawk)
Northrop	Mass.	Gyroscopes, Accelerometers, ARAs
Thiokol	Utah	Rocket Motors
Avantek	Calif.	Microwave Devices
Thiokol	Alabama	Rocket Motors
Hercules	Texas	Rocket Motors
Teledyne-CAE	Ohio	Cruise Missile Engines
Motorola	Arizona	Target Detection Devices
Lear Siegler	Michigan	Gyroscopes, Accelerometers, ARAs
MA/COM	Mass.	Microwave Devices
Raytheon MSD	Tenn.	Metal Parts (Sparrow)
Atlantic Research	Virginia	Rocket Motors
Aerojet	Calif.	Rocket Motors
Santa Barbara Research	Calif.	Target Detection Devices
Sunstrand	Wash.	Accelerometers
Bendix Cheshire	Conn.	Gyroscopes
Hercules	Maryland	Rocket Motors
Corning	New York	Radomes
United Space Boosters	Alabama	Rocket Motors
TRW	Ohio	Mk-46 Afterbody

As the list of the top twenty makes clear, certain types of devices recur as posing problems for surge--rocket motors, microwave devices, gyroscope/accelerometer/ARA systems, and target detector devices.

Rocket Motors

Producing rocket motors can be done within four to eight weeks if necessary, but advancing much beyond current rates means adding capacity. Because producers sell almost all their output to the Government (mostly DOD but also NASA), very little production increase is available from displacing commercial work. Many key manufacturing functions, particularly those which involve chemical processes, run around the clock under normal conditions. As a result, the industry has limited expansion capacity and would need almost $50 million for new capital, roughly a third of the total subtier requirement. The industry also faces potentially heavy prestocking requirements resulting from long subcomponent lead times, particularly for rocket motor cases, but also for nozzles, initiators, and selected chemicals.

Microwave Devices

The microwave problem is that production steps suffer from unpredictable reject rates, indicating a technology which is still as much art as science. The art requires a highly skilled work force that often has to be trained several months on specific parts before they become proficient. Although the need for capital and materials inventories is modest, meeting PGM production goals would require prestocking finished devices because there is a long and difficult learning curve associated with an unanticipated increase in product demand even under wartime surge conditions.

Gyroscopes, Accelerometers, and ARAs (attitude reference assemblies)

Gyros and related components are a problem area due to their complexity and the length of their production process. Internal lead times of up to 24 weeks are required even under wartime conditions; materials acquisition can add several months to the front end. These assemblies are also the rate limiter on programs which are otherwise well endowed with capacity, such as the Mk-46 torpedo, the Skipper, and to a limited extent, the Phoenix program. Meeting targets would require $33 million in investment, two-thirds to add capacity and the other one-third to prestock materials.

Target Detection Devices

Producers of target detection devices require $13 million to meet surge goals. Although the devices themselves can be built within roughly two months, the lead times for parts can extend up to seven months even in a crisis. Test equipment drives expenditure requirements, with major complexities in both design and production. It has been suggested by one producer that if Government regulations were waived in favor of black box standards, these devices could be produced in half the time (and cost) with greater reliability. Nevertheless, at least one major program has been seriously delayed by problems in getting target detectors to work.

Seekers

Texas Instruments is the only seeker manufacturer, making a miniature equivalent of a planar array for the Harpoon and the Tomahawk missiles. A similar device is also used on the Mk-48, a PGM not surveyed in this study. The facility's capital requirements, in a class by itself, mostly went for test equipment to stock some twenty plus stations, many in anechoic isolation, currently averaging over one hundred hours a week use.

Test Equipment

The defense industry's requirements for additional test equipment (and burn-in chambers for components) is a thread that runs through all sectors that use electronic devices. Such equipment accounts for almost all of the capital requirements of the prime contractors and roughly half of all other capital needs. This is so because the military needs maximum in-field reliability (PGMs have to work right the first time) which means much more testing than civilian products get. Many producers who serve both military and commercial markets find that their production lines, otherwise the same, are differentiated solely by the additional defense-dedicated test equipment. Further, since such test equipment is costly, and can be run with little or no personnel present, economics strongly favors around the clock operations in peacetime. All these factors eliminate the capacity which would otherwise be available for surge by adding shifts and/or displacing civilian production. Unless test regimes change in emergencies, additional production would require more test equipment.

Crisis requirements for test equipment could easily lead to long production delays. Even though Hewlett-Packard, the only full line producer of test set modules, indicated that it could expand production several fold, the early weeks of surge will create orders that usually take months and years to accumulate. Also, up to half of the components in today's test equipment modules come from overseas. Prestocking test equipment components, 10-20 percent of the module costs, would allow test set module production to accelerate within weeks, but would not cover the time required by customers to turn modules into completed test sets.

How Good Are These Cost Estimates?

This study, based on survey information, may misestimate the costs of preparing for surge for three types of reasons. One is the lack of 100 percent coverage, another is specific factors which can lead to overstated costs, and the third is specific factors which may lead to understated costs.

Coverage

The total response and verification rate was 64 percent as of data cutoff, 22 May, although many more questionnaires have come in since. It was distributed in ways which suggest that 90 percent of the costs were covered. Table 4-9 illustrates why. First the total sample was divided into three parts, respondents to the JCS PGM Phase II questionnaire, nonrespondents who were judged key (sole sources, multiple programs, expensive parts), and the rest. Costs were then extrapolated for each category. Only ten Phase II respondents were unverified. Their earlier responses suggested that they would account for no more than $5 million in requirements.

Considerable attention was focused on the key subcontractors. As a result, the group's response rate was 65 percent--enough to make a meaningful projection of the total class. Only 35 percent of the other 185 responded but their surge requirements were so small that reasonable errors in extrapolation were unlikely to make large differences in the total. As such, the additional $30 million investment requirement for the nonrespondents is correct plus or minus no more than 50 percent. More importantly, the error, over the whole sample is plus or minus five percent.

Table 4-9
Response Rate by Category of Respondent (dollar costs in millions)

Type	Number Asked	Verified	Costs Known	Projected
Phase II respondents	172	162	221	226
Key Nonrespondents	87	57	21	31
Nonkey Nonrespondents	85	66	8	23
TOTAL	444	285	250	280

Where costs may be overstated

Several factors may lead to overstated costs. The most important was the in-practice assumption that, with a few minor exceptions, PGMs would be produced under current product standards (with a few minor exceptions) rather than wartime exigencies. CNA's study strongly suggested that many tests could be scaled back with only modest harm to performance. When the equipment is in place, one might as well use it. But it may be more cost-effective for surge contingencies to buy only that equipment absolutely needed for critical tests and calibration; cut down on other tests until postsurge test equipment orders are in. Among the expendable tests are those that only assure long shelf life (pointless if the PGM will be used quickly), those that attack bugs which appeared in production start-up but did not recur, those that largely duplicate other tests, or those whose cycle time could be shortened. Burn-in might be eliminated entirely if the testimony of semiconductor firms is relevant. Without engineering, however, these tests cannot be identified; the calculations assumed, with a few exceptions, that they were all needed. Were marginal tests culled, however, prime contractor requirements may be as much as halved, and subcontractor requirements reduced substantially as well.

Capital requirements were occasionally overestimated by assuming that all current producers would have to expand to an equal extent. Some producers can accommodate larger increases for less investment than their competitors. This fact was only exploited for five subcontractors (rocket motors, actuators, radomes, strapdown systems, and microwave devices). A few primes are currently building test sets for second sources. Such equipment could have been used to offset certain prime contractor capacity requirements. Capacity now used for PGM repair also could have been allocated to production on the theory that PGMs, once used, do not cycle back for repair. Finally, some categories of capacity can be bought after a wartime surge begins and do not need to be included among prior investment requirements. Some machinery can be bought within weeks; some test modules can be assembled from parts within days.

This study also generally determined subcomponent prestock requirements by reference to existing subcomponent lead times (discounted slightly) when better data was unavailable. Yet, as the JCS study data showed, component lead times as reported by customers generally exceeded what producers, themselves, said lead time requirements were; the latter could be reduced even further in wartime surge if they had to be. A similar scale-down of subcomponent lead times would have reduced prestocking requirements considerably.

Where costs may be understated

The most salient understatement in this sample would be the capital requirements of third tier producers to meet threefold increases. Spot interviews of key third tier producers, however, suggest the total is modest (with the exception of rocket motor case producers) because they are rarely tied to specific PGM programs and can often displace commercial production for surge.

Wartime surge would, in some cases, require that additional production machinery spare parts be stockpiled. Unanticipated increases in machine work hours normally create an unexpected demand for spare parts; if such parts have lead times, then failure to prestock them could mean extended downtime for critical machinery and reduced effective capacity. Only one producer mentioned such a requirement, and so the total additional costs are probably small.

A third assumption that may have led to understated costs was that industries were told not to worry about attracting skilled workers if there were sufficient numbers of such skilled workers making commercial items. Manpower, where available, was assumed to be channeled to defense work. DOD has no such program, though. Moreover, some skills, such as hi-rel microwave technicians or test engineers, are so defense-specific, that they are rarely available outside the defense sector. This latter shortage was reflected to a certain extent in additional prestocking requirements. Nevertheless, some additional costs should be associated with any program to maintain and enlarge the skill base for critical functions.

This study assumed that domestic producers would still be able to access their current overseas subcomponent sources. Without this assumption, additional investments would have to be made, primarily to prestock such parts for as long as it takes for domestic firms to get up to speed. The next chapter argues that the cost of maintaining production schedules is likely to be no more than $15 million for all PGMs (probably $13 million for those covered in the survey). To this one would add the $3 million dollar increment necessary to hit 1.5X in nine months, and perhaps $9 million to cover 3X in six months. The total, however, would be limited by the fact that a lot of the inventory to be acquired to mitigate foreign-source dependence has already been counted as inventory required to meet surge requirements. Thus, $25 million is probably a safe upper bound.

Finally, the study assumed that the domestic industrial base is intact during the surge period. Damage, of course, would delay production as well as reduce capacity and thereby lower the effectiveness of investments in undamaged sectors.

In summary, costs may be reduced by easing test standards (minus $100 to $150 million), distributing second tier capital equipment more evenly (minus $10 million), and factoring in lower third tier lead times (minus $10 to $15 million). Correspondingly costs may have to be increased to include third tier capital requirements (plus $30 million), create standby labor training/shifting programs (plus $15 million), and mitigate potential foreign-source dependencies (plus $25 million). Summed together, adjusted costs would probably be lower than $550 million.

Other Considerations

Further benefits from surge investment were not factored in. One is that prior investment also allows greater production for some time beyond the initial 15-month period. Another uncounted benefit is that buying additional capacity often allows producers to cancel overtime shifts and saves labor costs in peacetime. New capacity, being state-of-the-art, is also likely to lead to lower labor costs and higher reliability. Such investment could also reduce throughput times (which reduces prestocking requirements) and would reduce skill level requirements (which assures being able to hire workers on time).

The cost-effectiveness of surge investment is also sensitive to the expected lifetime of the PGMs program. Additional investment for production lines about to close would yield only a temporary payoff. Additional investment in war reserves, on the other hand, would be useful as long as the weapon is in the inventory--a period which is often but not always longer. As an example of the opposite effect, funds invested in the rocket motor industry would remain valuable even if specific programs end because their follow-on programs will almost certainly have demands for similar equipment.

The Cost Effectiveness of Initial Investments

Although it would take $550 million for industry to be able to triple the production of all ten PGMs, the whole sum does not have to be bought at once. Restricting investment to seven of the PGMs, for instance, saves half the cost and loses only a quarter of the benefits. Due to the methodology used to allocate costs, however, even that estimate is somewhat high. Capacity investments start with a very high cost-effectiveness as the most salient bottlenecks are expanded first. Only later, as more and more facilities have to be duplicated, do overall costs approach the full amount.

The following example may demonstrate this. A facility makes 10,000 gyros, 1000 for each of five PGMs, and 5,000 for other DOD customers. Total capacity is 15,000. Capacity costs $2,000 per gyro to increase. To triple PGM production for all five programs requires a capacity to supply 15,000 PGM gyros while supplying 5,000 to its remaining customers. Capacity must rise by 5,000 at a cost of $10 million, or $2 million per PGM program. Now assume that only three PGM programs are invested with surge capability. The three PGMs need 9,000 gyros, the other two PGMs need 3,000 gyros (assuming a 50-percent increase can normally be accommodated), and other DOD customers need 5,000 gyros. Total requirements are for 17,000 gyros, calling for a $4 million expansion, which is only $1.3 million for each of three PGM programs--significantly less. Similar cost relationships would apply if the five programs were each to ramp up to 2.4X rather than 3X.

All this suggests that the relationship between investment and production increment is nonlinear and that one may achieve very high initial cost-effectiveness by starting with a few PGMs, or with less ambitious surge targets.

Conclusions

Under wartime conditions, the lead times which characterize the peacetime production of PGMs can shrink substantially. Unfortunately, without additional capacity investment to remove bottlenecks and cover very long lead time items, the military will not be in a good position to take advantage of this shrinkage. Production can initially rise rapidly to capacity levels. Subtier constraints, though, will retard acceleration and capacity bottlenecks will keep overall production increases between 30 percent and 60 percent over the first 12 to 15 months of a wartime surge.

These bottlenecks can be removed by presurge investment. Tripling all ten PGMs within six months would require $550 million, giving industry the ability to produce $5.5B more PGMs within the first 15 months. Total cost-effectiveness would be 10:1. If investment were concentrated on the higher payoff items, total cost-effectiveness could reach 15:1. Even if surge preparedness is paid for by reducing weapons procurement, figure 4-3 illustrates that total available assets would recover within months and be in much better shape within a year of surge. Thus, the Navy and Air Force would be better off investing in wartime surge if the value of a PGM delivered between months six and 15 were at least 10 percent of one available at M-day. For some programs, even lower valuations still favor investment.

As for implementation, two methods may be considered. The traditional model is to fund a distinct surge program. The alternative model is to build the requirement into the procurement process.

To fund a distinct surge program, investment requirements are calculated in advance, packaged as a weapon-specific program and forwarded through DOD's program process. If approved, the program funds a group of specific expenditures at chosen sites. Capacity expansion is provided by identified purchases of plant equipment and a Government-bonded inventory of components (rotated through current production to minimize obsolescence). This programmatic model facilitates cost control and post-expenditure auditing. However, direct funding of plant equipment is in potential conflict with policy direction against Service funding of production equipment. Worse, it involves the Government directly with potentially hundreds of subcontractors and requires a precise level of expenditure specification which, in practice, could prove unmanageable and intrusive. Worst, by investing at certain facilities and not others it unavoidably frustrates the objectives of competition.

Alternatively, capability can also be built in through contract clauses. Such clauses would require prime contractors (and GFE suppliers) to demonstrate their capability to increase production by so much (e.g., threefold) so fast (e.g., in six months). These contractors would then pay for these investments themselves, presumably reflecting such expenses in their bid prices. One key advantage of this method is that contractors who compete thereby have an incentive to keep costs under control in order to win the larger share of the production contract. Companies would have an incentive to limit the additional costs they pay for meeting surge requirements; otherwise they face hard choices between absorbing such costs themselves or seeing them reflected in prices which might prove uncompetitive. Government-industry negotiation over costs may still be necessary in cases where prime or GFE contractors are sole sources.

In dual source contracts some rules will be needed to govern the rate charged by one contractor to its competitor to retain capacity which is idle until needed. Two contractors may collectively have capacity to triple production, but the winner, by virtue of winning would be likely to have higher capacity utilization then the loser. In surge preparations, the most cost-effective plan would have the winner rent the option on the loser's excess capacity but this may be frustrated if the charge for such rentals is deliberately set high so as to raise the renter's production costs and so make it less competitive.

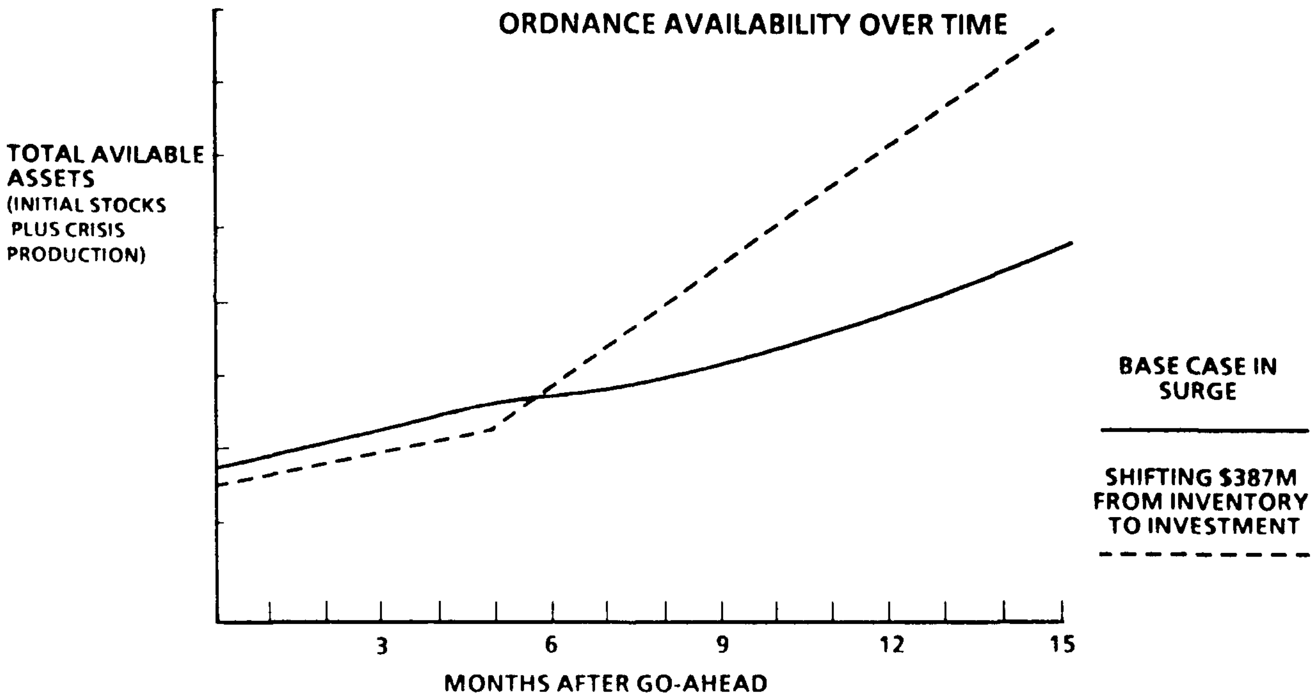
The latter model is also less intrusive. Government would only have to deal with primes, who in turn would pass capability requirements through the subtier level. The subtiers, with their multiple programs, would know, from the list of programs for which they must retain expansion capacity, what their priorities would be in a wartime context. Over the long run subcontractors will have an incentive to spread their work among PGMs, other DOD programs, and commercial work so as to be able to meet surge requirements through displacement rather than underutilizing their current plant.

The disadvantage of the policy model is that it introduces uncertainty in cost planning and makes the auditing job more complicated (although the planning job is made easier). The issue would not be whether certain expenditures were made, but whether industry could, in fact, do as well as they say. In the end, however, such a contract would make both industry and Government more conscious of wartime surge requirements than would the programmatic we-plan-and-you-buy model.

DOD should support this investment by funding engineering work on alternative product specifications for wartime conditions as well as innovative methods of stretching capacity and reducing

FIGURE 4-3

IS A LARGE GAIN IN LONG-TERM SUSTAINABILITY WORTH A SLIGHT REDUCTION IN INITIAL ASSETS?



lead times in emergencies. The current wartime priority planning system should also be redesigned to reflect both demand and supply information on a real-time basis.

5

FOREIGN-SOURCE DEPENDENCE

Most major weapons, such as PGMs, cannot be made without overseas inputs. Access to such inputs would be imperiled in a major war. However, if foreign-sourced subcomponents were prestocked in sufficient quantity, producers would have the time to develop alternative domestic sources for such inputs. $15 million dollars worth of buffer stocks suffices to protect the entire PGM industry; another $5 million more than suffices to protect their surge schedules.

Using foreign sources in weapons production can offer many benefits, from lower costs and better technology to increased competition and better allied integration. Such use, though, carries risks. If shipments of critical parts are cut off, then the production of weapons which use them would cease until domestic sources could be found to replace them. How long and how deep the disruption is would vary with several factors. Among these are what percentage of part supply is cut off, how critical the part is, when it is needed in production, how long it normally takes to make it, and not least, whether domestic suppliers know how to make the part. These factors vary widely among components. For this reason, no blanket statement on foreign source vulnerability can be made without a detailed look at the systems which incorporate foreign parts.

The Foreign-Source Dependence Problem

Most major US weapons, and all PGMs, use foreign parts. A total unanticipated cut off from the rest of the world would stop PGM production for at least weeks and up to more than a year. While such an event is unlikely, it is possible that any given overseas source would be inaccessible. Most parts sourced overseas come from only one country. Ensuring production against any foreign-source contingency is tantamount to ensuring production against all foreign-source contingencies at once.

The key question is whether such insurance is possible at all for any weapons as complex as precision-guided munitions. Hitherto there have been two opinions on the topic. The first held that the magnitude and the complexity of the problem effectively prohibited action. The costs would be outrageous because foreign sourcing was so ubiquitous. The second held that the problem could be managed with a blanket restriction barring everyone in the great chain of PGM producers and subcontractors from buying any part overseas. While this prohibition would raise costs, this increase would be impossible to measure and more specifically, impossible to audit. Nevertheless, it responded to the higher good of protecting the domestic industrial base. This appeared to be the position taken by the authors of a predecessor study on foreign-source dependence for the Joint Logistics Commanders in 1985.

It was the author's suspicion that the ubiquity of foreign-source dependence, which was undeniable, was too often confused with the value-added provided from overseas, which was much less impressive. The old saw that blamed the loss of a kingdom on the loss of a nail may be true, up to a point. PGMs are so complicated that the loss of any one of a thousand parts could have unpredictable effects on performance. Everything has to be in place. However, to return to the metaphor, a box of nails is cheap, and if foresight is sufficient, no loss need be suffered. Mitigating dependence might be complex but not very expensive.

PGMs were used as a case study of foreign source dependence, because of their criticality and the rich data base that had been collected on their production base. The key question was to determine and cost the cheapest method of protecting existing production schedules from an unexpected foreign-source cutoff. What percentage of the five billion dollars spent annually for PGM acquisition would have to be set aside to ensure continued deliveries in a crisis?

The principal assumption made in estimating costs is that a foreign-source cutoff would occur only in the context of an actual or imminent large-scale conventional war. Why? As it turns out, almost all PGM components sourced overseas come from allies. Their manufacturers are unlikely to withhold components during peacetime; only war would prevent our access. Such a cutoff would most likely occur when the need to surge production was most acute.

The methodological implications of this assumption follow. A foreign-source cutoff, if it occurs, is likely to coincide with a shift in production from peacetime to wartime regulations. The urgency of accelerating production, or, at minimum, maintaining it, would be very high. Normal lead times for components would be expected to shrink as rules were eased and money were spent in the interest of getting war materiel to the forces as rapidly as possible. As the previous chapter pointed out, wartime lead times are likely to be shorter than peacetime lead times. The surge assumption therefore says use the shorter wartime lead times to calculate the impact of a cutoff (at least where domestic sources exist), not the longer peacetime lead times. Where there is no domestic producer at all, the pertinent question is how fast one could get on line if cost were no object.

The second implication follows from the likelihood that few if any of the identified parts from overseas would take more than a year to replace with domestic production. The previous chapter suggested that, in the absence of surge investment, it would take roughly 15 months to expand PGM capacity. By then virtually all foreign-sourced subcomponents could be available from domestic sources. In that case, the cutoff would affect only the peacetime schedules, or the surge schedules, but not the higher schedules which would come from added capacity. This fact limits the potential harm from a foreign-source cutoff; in no instance would an unresolved foreign-sourcing problem prevent the utilization of new capacity.

Finally, references to a cutoff implicitly assume that it is unanticipated. If industry knew it would have a year's warning, it could purchase additional supplies during that period, and it would not have needed prior preparations to ride out the crisis. An unanticipated cutoff, of course, affords no such opportunity and must be insured against beforehand.

Theory

It is characteristic of PGM production that the loss of any foreign component necessitates its exact substitute by a domestic one. Unless the technological specifications of the part are known beforehand to be flexible, the substitution of a non-specification part may create severe problems in systems integration and performance. It is for this reason that the aforementioned Joint Logistics Commander's report argued that the cessation of parts deliveries from overseas meant a cessation of domestic production.

This establishes the basic questions. What is the extent, nature, reason, and length of this disruption? What can be done beforehand to prevent it, and how much will this cost?

To answer these questions requires first knowing the extent of foreign-sourcing in the PGM industry. Where foreign-sourcing has been determined, does this sourcing create a dependence? The two are not the same. Companies may choose to buy parts overseas which they can get as easily, if not as cheaply, here. In a crisis, if domestic capacity is sufficient, companies can return to domestic sources. For other components, however, there is either no qualified source, no domestic source with enough capacity, or a substantial production lead time that would interfere with the prompt replacement of overseas supply. These latter components are the ones of interest.

Assuming the existence of such components, the next task is to estimate what it would take to buffer the production schedules against the risks of a cutoff. What kind of insurance would the industrial base need to minimize its exposure to overseas events? Policies to protect production schedules are many and varied. Among them are eliminating the foreign-sourcing to begin with, creating the standby capability to pick up production in emergencies, and creating a buffer stock of components large enough to bridge the gap between a cutoff and a domestic production recovery.

The last method, creating a buffer stock, is used here as an upper limit to the cost of ensuring production schedules.

Figure 5-1 illustrates how buffer stocks might work. Normally, a domestic producer gets shipments from overseas. An unexpected cutoff stops these shipments. The factory then begins to draw components, no longer from shipments, but from a stock of component inventories specially created in quantities calculated for this emergency. At the same time, domestic manufacturers are asked to produce the affected components as quickly as possible. After a period, which would vary according to the item, domestic producers would begin shipping such components to compensate for lost shipments from overseas. A correctly sized buffer stock would be drained just as the user switches to a domestic supplier.

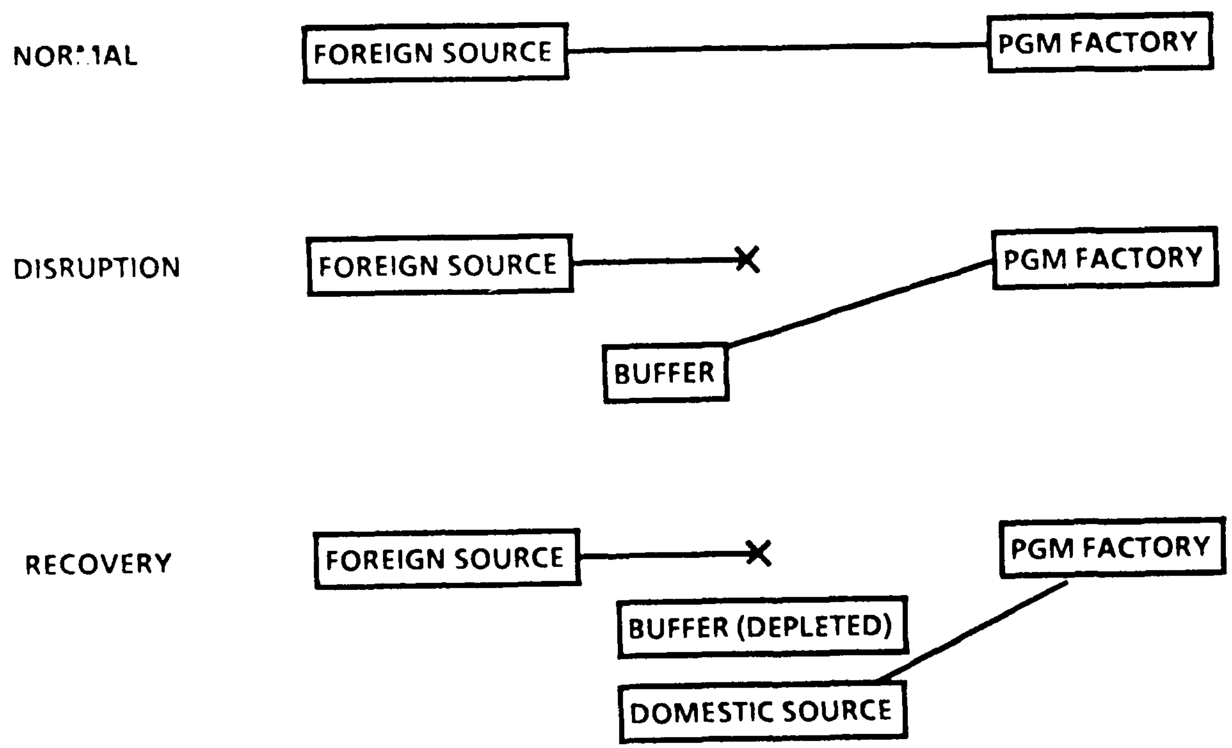
One advantage of buffer stocks is that they can be applied to almost any foreign-source dependence at the subcomponent level, and can be implemented in a straightforward way. The acquisition of such stocks is usually the lowest cost alternative, particularly when the overseas part is either inexpensive or used infrequently. Indeed it is often cheaper to buy the inventory than it would be to study the problem to find a lower cost alternative. In many cases costs can be offset if such stocks can be used in the final production run of the affected PGM. But there are also instances (e.g. rocket motor cases) when buying standby capacity is cheaper than buying the inventory required to support downstream production until capacity is adequate.

The last advantage in using buffer stocks is that is alternative means to eliminate the dependence or shorten the onset of domestic production can be evaluated by how much they reduce the buffer stocks that would be needed.

Buffer stocks are calculated from two data. One is how many dollars worth of components are imported each month; where imports are only a fraction of supply, the value of imports equals the value of usage multiplied by the percentage imported. The other is how many months it would take for a domestic source to ship product at rates previously supplied from overseas. This time would be shortest where there is a producing domestic source. If the product is simple, and/or the most likely domestic sources have produced comparable items, the time is reasonable. Otherwise the time is longer, particularly if domestic firms have to be qualified to appropriate quality control standards.

FIGURE 5-1

HOW BUFFER STOCKS WORK



It may be wondered why PGM production is so rigid that a drop off in component delivery means a similar drop off in PGM delivery. Is it impossible to make up production at a later date? The best answer has to be that the two are probably not very tightly coupled. Late component deliveries can partially be overcome by using residual component supplies and juggling production schedules so as to accommodate the later deliveries of some modules. The degree of flexibility in PGM lines, though, is difficult to measure short of an actual disruption, by which time it is too late. In the meantime, lost production early in the production process is hard to make up. Most PGMs face bottlenecks at the end of their production line because of a lack of spare test equipment. If production is halted, the build-up of modules awaiting the missing parts will not result in a burst of production once the dependent parts are replaced because production will be paced by the bottleneck at the end of the line. Thus, lost production is gone forever, or at least until new test equipment arrives a year or more later.

If the recovery time extends past six months, then additional inventory may be required to support not only current production rates but also the higher rates for surge. The latter inventory is what it would take to keep the dependence from hobbling acceleration schedules under crisis conditions.

Methodology.

The cost estimation method entailed unearthing all possible cases of foreign subcomponents in PGMs, determining which ones represented dependencies, and costing the buffer stocks required to protect existing and also surge schedules.

As noted in chapters two and four, the cases of foreign-sourced subcomponents were culled from data generated for both phases of the JCS study of PGMs, the Navy PBA study, and subsequent studies of specific PGMs (the HARM and Sparrow missiles). A list of specific cases was then generated from the data

The next step was to segregate dependencies which characterized the integrated circuit (IC) industry in general from those which affect PGMs in particular. Dependencies in the IC industry were common over all sectors. In most cases there were domestic sources for products purchases overseas but the problem was whether the domestic economy would have the capacity to support military production in the event of a cutoff. As noted below, PGM specific dependencies, in general, were not capacity- sensitive because the relevant industry was generic even if the particular product was specific. If it could be made at all then it could be made in the right quantity.

Investigating specific instances of foreign-sourcing required contacting firms which cited these instances to inquire into the source and nature of these dependencies. This, when coupled with calls to selected producers, provided a basis for estimating how much inventory would be required to buffer the domestic base from a cutoff of overseas supplies. Similar methods were used for other problem solutions where appropriate.

Specific Findings

(NOTE: In order to protect industry-proprietary information the names of specific contractors which supplied information have been replaced by numbers. Government officials who need this information may contact MCDC for the list.)

Although only one to two percent of a typical PGM's value is generated overseas, the industry's reliance on overseas sources is widespread. Of the almost 300 vendors examined in the various PGM studies, over a quarter claimed to be dependent on overseas components or processing. After close examination of their claims, they were reduced and consolidated into 22 separate dependencies, forming five groups.

The first group, <u>subsystems</u>, were defined as foreign-sourced products purchased directly by the prime PGM contractor, or which otherwise constituted an individually large item.

The second group, pervasive dependencies, were so defined because they were common to many PGMs.

The third group, integrated circuit dependencies, as noted above, were generic, and affected users across the board.

The fourth group, individual dependencies, were instances where it appeared that a single user, so far as known, had decided to use overseas sources.

The fifth group, mineral based dependencies, occurred largely because the United States lacks certain types of minerals in sufficient quantity. No separate estimate was made of the cost of relieving such dependencies because the National Defense Stockpile is supposed to cover these problems. For an overall discussion of the Stockpile's adequacy see chapter four of the MCDC study, US Industrial Base Dependence/Vulnerability: Phase II--Analysis.

Subcomponents which were incorrectly cited as dependencies are also noted.

Subsystem Dependencies

Of the five categories, the subsystem dependencies would cost most to fix. A buffer stock of almost $9 million would be required to buy enough subsystems (and, in some cases, their subcomponents) to fill the gap between a cutoff and when domestic sources could make up for the loss of its overseas competitor. Although many of these subsystem items are dual sourced (and thus not dependencies, strictly speaking) the inability of domestic producers to increase shipments immediately would mean reduced PGM deliveries in the interim.

Subsystems may be divided into two categories, components purchased directly by prime contractors, and rocket motor cases, a dependence which occurred in several instances.

Of the over 1000 major components purchased directly by prime contractors for PGMs, five are purchased in part from abroad. Table 5-1 shows the PGM, component, source, unit cost, the percentage sourced abroad, the replacement time in months, and the inventory necessary to offset a foreign-source cutoff.

Table 5-1
Subsystems Sourced Overseas (dollar costs in thousands)

Program	Item(s)	Country	Cost	Months	Pct	Stock
Stinger	Launch Tube	Israel	.11	3	75%	100
Harpoon	Extrusions	Australia	*	2	*	300
HARM	Actuator motor	U.K.	4.5	2/1**	60%	1,100
HARM	Gear motor	U.K.	.5	2/1**	60%	100
Standard 2	Castings	Israel	.25	3	50%	50
TOTAL						1,650

* Represents $150,000 a month worth of various extrusions.

** Two months of assembly, plus one month of parts (prestocking parts saves 75 percent of costs).

In general, US sources could replace overseas components in two to three months provided they were operating under wartime conditions, and that, in at least two cases, they had sufficient subcomponent inventories of their own.

Three separate programs use foreign producers for rocket motor cases. Table 5-2 lists the program, the foreign country, the alternative US source, the unit replacement cost, and the cost parts required to offset an unanticipated cutoff.

For the Harpoon booster rocket motor case, Company #1 was an active source, but did not receive any FY 86 contracts. If they were provided with prestocked inventory (four months' worth at $800 per ship set) it is believed they could begin shipping rocket motor cases in three months under wartime conditions.

Table 5-2
Rocket Motor Cases
(dollar costs in thousands)

Program	Country	US Company	Unit Cost	Inventory
Harpoon	U.K., Australia	#1	4.0	600
Skipper	U.K.	#1	.9	1,600
HARM	U.K.	#2	12.0	4,800*

* Includes $800,000 for capacity expansion to accommodate increased production to substitute for overseas sources.

Currently, the Skipper rocket motor case is completely sourced overseas but Company #1 is believed capable of producing the motor once formally qualified. It is estimated that they could start shipping motor cases within nine months under expedited conditions.

The HARM rocket motor case is sourced 40 percent domestic, and 60 percent in the U.K. Although Company #2 is fully capable of producing the entire lot, they do not currently possess the capacity to do so and their representatives do not believe they could expand in less than a year or two. Under wartime conditions, additional HARM rocket motors could probably be accommodated by shifting Company #2's Patriot work to Company #1 and the latter's Standard Missile, Extended Range rocket motor case work to Companies #3 and #4. Company #1 itself only runs a shift and a half and has commercial work which could be displaced. However, $800,000 would be needed for certain equipment specific to rocket motor cases. An alternative way of solving the dependence problem would be for Company #2 to modernize their plant with the help of an Industrial Modernization Incentives Program. Such a program was proposed to the Navy.

It is interesting that this one part, rocket motor cases, should be bought overseas so frequently. This may be because the chief overseas source, Royal Ordnance Factory (U.K.) has established itself as cost-effective over the years.

The list of dependencies is not permanently fixed. As an example, the rocket motor nozzle in the Standard Missile, Medium Range, a $4,000 item, was until recently sole sourced by Company #5 from Schwarzkopf, an Austrian firm. Cognizant of this dependence, the Navy is trying to expedite deliveries under the FY 86 contract and is currently qualifying a domestic source for the FY 87 contract. In its absence, a buffer stock of about two million dollars would have been required to cover the year that, so it is claimed, it would take to qualify a domestic source. Conversely, it now appears that one of the sources for the Stinger rocket motor case could be Israeli.

Finally, it had appeared as though a 1985 purchase of Patriot missiles by the Dutch would have created additional foreign-source dependencies in missile production when both prime contractors, Companies #6 and #7, were required to offset the quarter billion dollar purchase on a dollar for dollar basis. Company #6 chose to enter into coproduction agreements for power supplies and radar modules on the ground-support equipment for a certain fraction of their item buys. This arrangement would not have affected the sourcing of missile parts. Company #7 chose to offset the sales by reviewing its corporate buying to shift business to the Netherlands, or by creating counter-trade arrangements. Again, these offsets would not have been used to affect the sourcing of missile subcomponents.

Pervasive Dependencies

The most critical problems come from a cutoff of those subcomponents common to multiple systems, requiring a buffer stock of $2.8 million to mitigate.

A cutoff of these sources could disrupt schedules for at least a year on some parts (field-effect transistors, ferrite cores) and six months to a year on others (gallium arsenide transistors, sapphire, butane triol). Two items, precision glass and high-purity silicon, could be produced domestically without significant disruptions but entail risks due to the uncertain viability of their supplier base. Table 5-3 summarizes the basic sourcing problems, their applications, their current countries of origin, and the cost of inventory necessary to offset a potential foreign-source cutoff.

Field-Effect Transistors (FETs, also known as radio frequency transistors) come in two types, silicon and gallium arsenide (GaAs). The world market for high frequency silicon FETs is roughly $40 million, $20 million in the US. $10 million of that belongs to NEC;$ 6 million of their US sales are military. Based in part on usage by specific microwave producers, perhaps a fourth of that total, $1.5 million, is used to make PGMs. Potential domestic producers could include Hewlett-Packard, Harris, Micro-Semiconductor, Avantek, Rockwell, General Electric, and Raytheon. However, the particular geometries of NEC transistors are design unique. As a result, it may take up to a year for potential domestic sources to design and prove out NEC's geometries. It would take equally long to alter the basic microwave subsystem configurations to accept domestic geometries. This time would vary greatly by system and geometry. Two companies (#8 and #9) claim that they could replace some types quickly but others may take over a year.

Table 5-3
Pervasive Dependencies
(dollar costs in thousands)

Item	Application	Source	Buffer
FETs (silicon)	High frequency radar	Japan	1,500
FETs (GaAs)	High frequency radar	Japan	200
Ferrite cores	High frequency radar	FRG	150
Glass	Target detectors	Japan, FRG	250
Sapphire	Infrared	Switzerland	100
Butane triol	Rocket motors	FRG	600
High-purity silicon	Target detectors	FRG	0
TOTAL			2,800

Within the last year, gallium arsenide (GaAs) has started to replace silicon as the favored material for making FETs. US producers appear to be more competitive here, but dependencies still exist. One user feels that US producers can make similar devices but with disadvantages in economics, delivery, and to a smaller extent, quality. Another user was dependent but has since gone domestic, except for a $100 GaAs FET supplied by Toshiba ($30,000 annual purchase). MA/COM claims to be the largest GaAs substrate producer in the world; Avantek recently finished a $25 million facility and is still growing.

Although there are many domestic producers of ferrite cores, the market, particularly at its high end, is dominated by Company #10. Their advantage stems from the development and use of superior magnetic materials in the gigahertz inductance range. One particular geometry, the low permeability double-aperture U-60 hexagonal core appears to be virtually irreplaceable by domestic sources at this time. Company #10 sells roughly $7 million worth of cores into the United States at this time, but military sales as such are only a small percentage of the total. They sell about 1.5 million U-60 cores at ten cents each. No firm estimate is available on how long it would take a domestic company to replace their products, but a year is a fair guess.

Precision glass parts, roughly $500,000 worth, are used in detectors for the Sidewinder, the HARM, and certain laser guided missiles. A Japanese company and a German one are the two leaders in the area. The German one (Company #11) has a US plant which makes $5 million worth of precision optics. Many users agree with Company #11's assessment that they can make everything currently supplied by the Japanese one. Their representatives, at the same time, note that their US plant can produce everything that the West German plant can (certain low volume domestic orders are sent to West Germany to exploit scale economies). The domestic plant however, depends on overseas sources for $40,000 worth of foreign feed stocks. Company #11 estimates that it could handle all the overseas glass business within current facilities and could ship within two to three months. However, this capability is dependent on their maintaining a business base for glass optics. Business had been declining by as much as 15 percent a year and its future viability is open to question. If this source is lost, the domestic dependence on glass will be much harder to fix.

Synthetic sapphire is used to make optical elements in the Sidewinder missile, and may have other PGM uses as well. Although there are some domestic sources for finished sapphire, all of the raw feed stock comes from Europe; most in the form of crackle (scrap material). One source, Company #12, believes that a domestic plant can be built and in operation within six to eight months. It would require roughly seven metric tons of crackle ($400,000) to cover the interim feed stock requirements for the three companies which convert crackle to finished sapphire (Union Carbide, Tyco, and Crystal Systems). Allocating $100,000 of that for PGM production is probably generous.

Butane triol is the primary feed stock for BTTN, used in making rocket fuel mixtures. Although some US sources are in development, the current sole supplier is a West German firm, Company #13. They claim that the basic formula is simple, but separating the various isomers and maintaining high purity is a difficult art. If the small ICBM gets built, Company #13 may source its product domestically; otherwise, in an emergency, they could probably do so in six to eight months. Domestic usage of butane triol, all now for PGMs, is roughly 50,000 pounds at $20 a pound. Covering an unexpected foreign-source cutoff would thus require roughly 30,000 pounds or $600,000 worth.

Roughly $500,000 worth of high-purity silicon is used in the production of detectors. Potential requirements for power switching devices may increase military demands significantly in the future. The world's two major producers (which concentrate on semiconductor grade silicon) are Wacker (West Germany) and Topsil (Denmark). A large percentage of DOD's requirements are now being met by domestic sources. Martin-Marietta buys from overseas but possesses a stockpile of indeterminate size. Texas Instruments mostly serves their own needs and Company #14 buys most of theirs from Amorphous Silicon. The latter came on stream quickly a few years ago, but some time was required for buyer and vendor to work towards acceptable quality. This problem is now solved and overall process yields have returned to what they were when Wacker was the sole supplier of the domestic market. The continuity of domestic high-purity silicon supply may be imperiled in two ways. The first is that neither source is guaranteed to stay on-line; Texas Instruments may not maintain production if the volume of Paveway laser guided bomb work dwindles. The second is that the supply of polysilicon rods, the feed stock for high-purity silicon, is intermittent. Current supplies are being drawn from inventories created from a one-time purchase of small diameter (25-mm to 50-mm) rods. When this runs out the only way to get small diameter surfaces used in PGMs would be to process the occasional (roughly once a year) large diameter rods which happen to pass tight purity specifications. It is not clear that such processing will not itself introduce impurities. At present DOD is working a purchase guarantee for small diameter rods so that they can be produced on demand and forestall a potential foreign-source dependence. In the absence of this capability, the supply of small diameter plate (from which rods are made) of adequate specifications may take several months to recover. An inventory of $100,000 of polysilicon rods at that point would be adequate insurance.

Integrated Circuits (ICs)

ICs, used in all PGMs, have dependency problems all their own, generic to all users, not just PGM producers. The analysis assumes that, in crisis, defense would have the first priority in competing for limited production resources. That being the case, the question was whether the few domestic assembly plants would suffice to fit military demands.

The IC industry now depends on overseas facilities to assemble its finished chips from domestically produced wafers. Also sourced from overseas are ceramic packages, plastic feed stock and metal parts for nonceramic packages, silicon wafers and all the raw glass used to make glass masks. Assembly capacity is the most salient. All other problems could be handled by stockpiling piece parts and materials; costs would be pennies on the dollar. The assembly operation, since it occurs almost last in the process, could only be mitigated by prestocking the entire chip. This would cost a lot more.

Calculations for the entire industry, however, show that the industry could meet military needs in isolation (some packaging materials perhaps aside) without further investment. A cutoff would still leave enough industry to cover current military needs three times over. The dependence issue, however, cannot be dismissed so easily because of its pervasiveness and the adverse trends now being observed.

Almost all domestic IC operations, while based on domestic wafer fabrication, assemble chips overseas where labor is much cheaper. Most military circuits are also packaged overseas. The rest, called JAN chips, correspond to Military Specification 38510, which, by regulation, must be packaged in the United States. There is domestic capacity, but how much? Current military demand, 14 million units, was estimated by multiplying the nation's monthly chip sales, 300 to 350 million, by DOD's four percent share. This percentage comes from analysts at Texas Instruments and was generally confirmed by others.

The first place to look for such capacity is the JAN assembly shops. Most such operations are working well below capacity now and could easily expand production in emergencies. Many companies surveyed, could, in fact, meet their own requirements in this way and have room for other requirements besides. Among those surveyed, Company #15 could do about three million a month; companies #16, #17, #18, two million a month; and companies #19, and #20 combined could do one million a month. The total for these six facilities is 10 million a month. Adding companies making military chips but not surveyed, such as Fairchild, National, Signetics, Raytheon, suggests that the current JAN facilities could get to at least 14 million a month, by themselves. Capacity is also available from the few commercial producers who have stayed put. The independent domestic assembly business could probably handle 11 million a month based on the capacity of its leading independent, Company #21. Other potential sources include Company #22 at 15 million a month and Companies #23 and #24 at 9 million a month each as well as a number of Japanese firms which repackage memory chips for the US market. Sixty million chips a month capacity thus appears attainable at home in an emergency. IBM, which accounts for roughly 20 percent of all domestic production, assembles most of their circuits in-house. Their capacity, however, relies on a proprietary flip-chip process which is largely incompatible with the wafers produced by the merchant semiconductor houses. Some convergence between the two is likely in emergencies but not without a lead time of six months. Beyond that, most respondents indicate that they could reestablish domestic packaging capability in six to 12 months.

Using such capacity, almost needless to add, requires that military chips could be assembled on domestic lines. By and large this was no problem for the JAN facilities which already make military chips. The commercial facilities would be similarly capable if the military would accept plastic rather than ceramic packaging for an interim period. Amassing 14 million chips worth of MILSPEC burn-in and test capacity is more problematic and may not be possible. Most industry respondents, however, maintain that MILSPEC standards are overstated and may even result in lower quality than is available commercially.

Almost all MILSPEC ICs have to be packaged in ceramic, most of which comes from two Japanese companies. The larger, company #25, has a facility in the United States. Both headquarters and domestic representatives claim that its US facilities, coupled with those of other domestic sources, have enough capacity to support the ceramic package needs of Government in an emergency. Furthermore its US facility could be operated without requiring materials from overseas and can produce all package types required. Figures provided suggest that their gross capacity to make ceramic packages exceeds the capacity of domestic assemblers to use them. Another solution, particularly for assemblers not doing military work now, would be to package circuits in plastic as commercial operations do. While circuits so packaged may perhaps sacrifice some moisture-tightness, crisis conditions may remove the worry of PGMs sitting around long enough to get spoiled. A large share of both plastic and metal leads also comes from overseas, however. Only one of the three major US plastic-using assemblers surveyed used a domestic source for its plastic and then for only part of its needs. Roughly half of the metal leads used by the three were domestic. Neither plastic nor leads are impossible to make and US capability, if not sufficient, could quickly be made so. At roughly a cent per chip for plastic and leads, some prestocking to cover the several million chips used in PGMs would be an alternative insurance policy.

Another possible package dependence is metal-can packages for transistors. Two respondents originally reported a dependence for metal-can packages. One has eliminated its foreign-sourcing, but the other still buys at least part of its line overseas. At least two domestic sources have been located which are now producing these metal cans, one of which could expand production many fold by displacing commercial business. Another two producers could do so easily (if not immediately) but are making more sophisticated devices at present.

The domestic IC industry imports a high percentage of its raw silicon. There are now two domestic sources, Monsanto (which was reported looking for a buyer) and Siltec, which has been recently purchased by a Japanese concern. In addition, both Wacker (German) and Topsil (Danish) have domestic facilities but import feed stock to run them. One supplier to the HARM missile reported to the prime contractor that it was dependent on foreign silicon wafer; a follow-up call established the presence of domestic alternatives though.

At present all the feed stock glass used in making the masks is produced in Japan, mostly by Hoya. Glass masks are the medium on which an IC design is etched so that it can be used in photolithography. A typical chip uses eight to 14 different masks in its production. Since the annual market is roughly $50 million, one can estimate that the military market requires roughly $2 million, and PGM production perhaps $100,000 to $200,000. Were Japanese sources cut off, however, the effect would not be immediate. Glass masks can be used over and over again; they are needed only when bringing out new designs or expanding production to new photolithography lines. There is no inherent reason why current PGM circuits cannot continue using the glass masks they are now produced with. New glass is required for new designs; but domestic producers, such as Corning, are capable of producing raw glass masks and moving down the learning curve in quality. Nevertheless, some prestocking for contingencies may be prudent.

It is noteworthy that no ICs used in PGMs were reportedly produced, as opposed to packaged, overseas. This may be partly explained by the sampling methodology for prime contractors, which did not include many low cost items. But, in general, overseas IC producers have not penetrated military markets to any major extent. There is currently a lot of worry that this may quickly change should the domestic industry fall behind the Japanese industry in technology. This possibility is discussed in chapter five of the MCDC study, US Industrial Base Dependence/Vulnerability: Phase II--Analysis.

Individual Dependencies

The individual dependencies are scattered and diverse. To ensure production against their cutoff, only $400,000 worth of subcomponents need be prestocked. Listed in table 5-4 are the buyer, item, foreign-source, and buffer stock cost associated with seven items.

Table 5-4
Individual Dependencies
(dollar costs in thousands)

Respondent	Item	Source	Inventory
#26	Ball screws	U.K.	30
#27	Copper liner forms	Switzerland	250
#28	Bearings	N/A	100
#29	Molybdenum foil	Austria	2
#30	PWB plating bath	U.K.	50
#31	Springs, pivots	Germany, S. Africa	1
#32	Radome chemicals	Germany, Mexico	50
TOTAL			393

Ball screws, a $150,000 annual buy item for the Patriot missile program, were previously dual sourced on a 70:30 split between a British source and a domestic one (Company #33). The British source now has 100 percent of the current buy, but the domestic source could return to production within three months under emergency conditions.

Copper liner preform, a Copperhead component costing $100 each, is currently purchased from Switzerland. The impact of a cutoff is to return to drawn-and-carried liners made in-house. A transition could be made in six months; perhaps less since the respondent say this purchase is not really a dependence.

Foreign off-the-shelf bearings, costing $2 to $3 each, are used in making a slip-ring assembly for the Standard 2 missile program. In an emergency, American bearings would be quite acceptable, and could be delivered within two months.

Between $5,000 and $10,000 worth of foil from Austria is used on the Patriot program. Although there are domestic sources, foreign ones are cheaper. A cutoff could be domestically replaced in a few months.

The copper based printed-wiring board (PWB) operation of Company #30 buys its plating bath (roughly one million dollars worth) from a European source (probably British). Although such baths are, in general, produced domestically, the particularly chemistry is produced only by a foreign company (with US laboratories). Using US sources would mean lower yields but an acceptable product. No estimate was made of how long a transition would take, but it is probably short. Only a small fraction of their PWBs are used in PGMs. The buffer stock estimate of $50,000 generously estimates that PGMs account for a tenth of the total capacity, and assumes a six month replacement period.

Pivots and hairsprings are low cost ($5) items purchased from abroad to make the Phoenix missile accelerometer. The diamond pivot is made domestically but uses South African diamonds. The precision hairsprings are purchased from Germany for historic reasons but could be replaced by domestic sources in six months. Total usage of both items runs $100 a month.

Dependencies were reported for three chemicals, titania, arsenic pentoxide, and magnesium oxide. Titania, a particular grade of titanium dioxide, is now bought from German sources, but alternative facilities in Norway and Canada could start production within two to three months. Arsenic pentoxide can be purchased from Canadian plants, and thus is not foreign-sourced per se. Magnesium oxide is purchased from Mexico because of the particular purity available there. Domestic sources could be used but due to quality reasons, considerable retrofit would be needed first

Mineral Dependencies

Several respondents cited foreign-source dependence problems which arise because of domestic mineral deficiencies. Four of note are samarium, germanium, indium, and palladium. Such deficiencies are, by their nature, long-term, and can only be alleviated through product substitution and/or the development of domestic mineral resources (if such exist). Separate costs for supporting PGM production were not calculated for mineral dependencies in the belief that they are or should be covered in the National Defense Stockpile. PGM requirements alone for any of the four would be modest.

Samarium, a rare earth, is used by Company #34 to make permanent samarium-cobalt magnets used in motors and actuators. Military sales are a small percentage of the total business. Domestic resources of samarium are probably more than sufficient to cover military demand but less than required to meet the total demands of the economy. Effective domestic capacity is 90 tons versus domestic demand of 100 to 150 tons. Domestic capacity may rise somewhat as Molycorp gains experience with its new facility. There are no stockpile goals for the material.

Although the US is also dependent on cobalt, the other material used in the magnets, there are large stockpile goals for that mineral. Quality considerations aside, current stocks would suffice for three years of wartime usage for the economy.

Germanium is used by company to make interface actuators for the IR Maverick missile. Current supplies come from Africa via Belgium. A new stockpile goal has been established on germanium because two-thirds of all usage is military. A 30 ton purchase is requested for FY 87. Domestic mineral refining capacity, roughly 40 tons a year could handle peacetime domestic demand, roughly 35 tons a year.

Two respondents reported at least some indium based dependencies. One was partially dependent on overseas sources of indium antimonide; the other was completely dependent on indium arsenide but only for a PGM program (Rolling Airframe Missile) not yet in production. Canada is the world's largest miner of indium, and the United States also has domestic sources. Nevertheless, domestic consumption, at 700,000 ounces a year, exceeds total North American mining production by at least 20 percent. There are no stockpile goals for the material.

One capacitor producer, Company #36, uses $3 million worth of palladium in its electrostatic inks. Although the United States is roughly 90 percent dependent on sources outside North America, the National Defense Stockpile has enough palladium to cover several years' worth of wartime consumption.

Incorrectly Identified Dependencies

Several components were incorrectly identified as foreign dependencies. Much of the confusion was the failure to distinguish between foreign-owned but US-located facilities for facilities located abroad. Getters, which evacuate traces of gas from vacuum-sealed devices, were mentioned twice as a foreign-sourced item, but are actually produced in Colorado by the US subsidiary of the Italian firm, Saes Getter. Rocket motor chemicals were also misidentified as dependencies. Some, like TMETN, DEGDN, and Desmodur N-100 are produced locally, the latter by a domestic subsidiary of a German company. Zirconium carbide, although sourced abroad, could as easily be purchased in the United States. PBNA, a component of the Sparrow rocket motor, is produced only in Poland, but existing stockpiles at Naval Ordnance Station, Indian Head, Maryland cover current requirements through 1988. Beyond that requirements are sufficiently small to allow laboratory-scale production, given emergency environmental waivers.

General Findings

Table 5-5 summarizes the dependencies, the affected PGM systems, the overseas sources, and cost of buffer stocks required to shield current production schedules from disruption.

Table 5-6 groups costs by subcomponent type.

Several features of this estimate call for comment. The salient one is how low the total is. Twelve million dollars is roughly .2 percent of the annual production cost of PGMs. For just this, items most critical to the CINCs can have their current production ensured even if all overseas sources were cutoff. Also, most of the major expense is for parts for which domestic producers are active but have capacity for only a fraction of total component requirements. Those sourced only overseas are a small fraction of the total. Another interesting datum is that half of the cost is for the HARM missile alone.

Table 5-5
Foreign-source Dependencies Affecting PGM Production (dollar costs in thousands)

ITEM	SYSTEM	SOURCE	IMPACT (*)	BUFFER
Silicon FET	Radar	Japan	12 + mo (all)	1,500
Ferrite cores	Radar	FRG	12 + mo (all)	150
Rocket mtr case	Skipper	U.K.	9 mo (all)	1,600
Rocket mtr case**	HARM	U.K.	7 mo (60%)	4,800
Rocket mtr case	Harpoon	U.K., Austrl.	7 mo (all)	600
GaAs FET	Radar	Japan	6 + mo (all)	200
Butane triol	***	FRG	6 + mo (all)	600
Sapphire	Sdwr et al	Switzerland	6 mo (all)	100
Copper preform	Copper-head	Switzerland	6- mo (all)	250
PWB plating	HARM	U.K.	6 - mo (all)	50
Springs, pivots	Phoenix	FRG, S. Afr	6 - mo (all)	1
Ball screws	Patriot	U.K.	3 mo (all)	30
Precision optics	****	Japan, FRG	3 mo (all)	250
Actuator motor	HARM	U.K.	3 mo (75%)	1,100
Gear motor	HARM	U.K.	3 mo (50%)	100
Castings	Standard	Israel	3 mo (50%)	50
Radome chemicals	Radar	Mexico	3- mo (all)	50
Molybdenum foil	Patriot	Austria	2 mo (all)	2
Launch tube	Stinger	Israel	2 mo (75%)	100
Extrusions	Harpoon	Australia	2 mo (50%)	300
Bearings	Standard	Overseas	2- mo (all)	10
IC parts	All	E. Asia	varies	200
TOTAL				12,043

* percentage in parentheses refers to percentage of components sourced overseas

** includes $800,000 in additional tooling

*** Standard, Patriot, Maverick, Sidewinder, et al.

**** Sidewinder, Maverick, HARM, et al.

Table 5-6
Buffer Stock Costs by Component Type
(dollar costs in thousands)

Subcomponent	Buffer Stocks
Subsystems	8,650
Pervasive Dependencies	2,800
IC Dependencies	200
Individual Dependencies	393

Table 5-7
Buffer Stock Costs by Component Source
(dollar costs in thousands)

Source Country	Buffer Stock
United Kingdom	7,980
Japan (and misc. E. Asia)	2,025
West Germany	875
Australia	600
Switzerland	350
Israel	150
Mexico	50
Austria	2
South Africa	1
N/A	10
TOTAL	12,043

Vulnerability vs. Dependence

Since not all dependencies are vulnerabilities, an assessment of the latter would be heavily influenced by sources involved and the chances that the US would be cutoff from them. As it happens, virtually all of the foreign-sources are allies, or friendly neutral countries. Except for raw materials, no Third-World country is represented; virtually none of the foreign-source dependence risk is

Table 5-8
Buffer Stock Costs for Alternative Options and to Cover Surge
(dollar costs in thousands)

ITEM	SOURCE	BASE	OPTIONS NOT UK	OPTIONS 3W + CE	SURGE BUFFER
Silicon FET	Japan	1500	1500	0	1,000
Ferrite cores	FRG	150	150	150	100
Rocket mtr case	U.K.	1600	-	-	200
Rocket mtr case	U.K.	4800	-	-	1,100
Rocket mtr case	U.K., Austrl	600	300	-	0
GaAs FET	Japan	200	200	-	100
Butane triol	FRG	600	600	600	50
Sapphire	Switzerland	100	100	100	50
Copper preform	Switzerland	250	250	250	50
PWB plating	U.K.	50	-	-	20
Springs, pivots	FRG, S. Africa	1	1	1	0
Ball screws	U.K.	30	-	-	10
Precision optics	Japan, Germany	250	250	125	50
Actuator motor	U.K.	1100	-	-	0
Gear motor	U.K.	100	-	-	0
Castings	Israel	50	50	50	0
Radome chemicals	Mexico	50	50	50	0
Molybdenum foil	Austria	2	2	2	0
Launch Tube	Israel	100	100	100	0
Extrusions	Australia	300	300	-	0
Bearings	Overseas	10	10	-	0
Semiconductor parts	E. Asia	200	200	-	50
TOTAL		12,043	4,063	1,428	2,680

associated with the type of conflicts which have characterized the postwar era. Table 5-7 regroups the cost of buffering PGM schedules by the country which currently provides the relevant components and subcomponents.

Another way to view this data is to consider the cost of buffering against vulnerabilities rather than dependencies. For instance, most of the cost of relieving dependencies is borne by parts sourced in the U.K. If U.K. dependencies were not judged to be vulnerabilities, buffer stock costs, the NOT UK column, could be cut by almost two-thirds. Similarly, if the only vulnerabilities are limited to the Third-World and Central Europe sources, the requirement for buffer stocks, the 3W + CE column, could be cut further, to $1.6 million. Table 5-8 illustrates these alternative buffer stock options.

Preparing for Surge

Table 5-8 also indicates how much more buffer stocks would have to be held to guarantee that foreign-source dependencies would not get in the way of surge production. Reviewing the examples suggests that the additional sum to ensure surge schedules would be $2.7 million.

Why so little? The major reason is that domestic bottlenecks themselves keep surge production from rising so much in the absence of specific industrial preparedness measures. As chapter four illustrated, without surge investments, industry would begin accelerating production as early as nine months, but prime contractor and subtier bottlenecks prevent production from rising beyond 150 percent of the base rate. This limits the difference between surge and base schedules. Since most of the foreign-source dependencies are remedied in the first year, by the time production does rise, they are no longer holding back the rest of the system. Many of subcomponents sourced overseas are not on the critical path per se. Some subcomponents are so far off the critical path that the additional lead time required to find a domestic source can be afforded within the times required to accelerate the production of the longest lead item in the production flow.

Quality of the Estimate

As in all such exercises, the total estimate must be qualified by consideration of missing factors. The sample is not 100 percent complete. The original supplier list compiled from the prime contractors only supply 85 percent to 90 percent of the materials used in PGM production because they did not include all the minor piece-parts. Only 70 percent of the suppliers (85 percent by value-added) responded to the surveys and no separate surveys were done below the prime contractors' immediate suppliers (many suppliers, however, would be aware of dependencies among their own suppliers). Finally, some respondents were probably unable or unwilling to report their foreign-sourcing constraints.

Such coverage, however, was sufficient to capture almost all big subcomponent dependencies and most of the pervasive dependencies; only one respondent has to report a pervasive dependence for its total effect to be estimated. The study's coverage averaged 90 percent for subsystems, 80 percent for pervasive dependencies, 100 percent for the IC dependence problem, and 40 percent for individual subcomponents. Extrapolated to the nonrespondents, an overall figure of $15 million would be a comfortable ceiling on the total.

The more critical factor was the estimate of how long it would take for a domestic source to replace a foreign one. Where a domestic source was qualified, the current estimate of lead times under emergency conditions was probably reliable. Where no domestic source was capable of producing to a certain quality specification, any such estimate is necessarily soft. Until domestic sources actually have to replace foreign ones, no one will really know.

Finally, some of the quantity numbers for current production rates may be soft, particularly where some estimate had to be made of what the PGM sector's share of military usage was. In such cases estimates were probably generous.

Implementation

Rather than having Government purchase the buffer stocks outright it may be more effective for the prime contractors to demonstrate that they could continue production at scheduled rates even with a total overseas supply cutoff. Program costs would rise some in either case, but specifying a requirement through a contract rather than by line item purchase allows producers greater flexibility and moderates the increase. Government's role would be limited to spot checking compliance and specifying exceptions (e.g. assume withdrawals from the National Defense Stockpile is available or that IC assembly capacity will be allocated in a crisis).

Industry could demonstrate continuity by:

a. Adding inventories,
b. Requiring their distributors to keep inventories,
c. Demonstrating that its overseas sourcing does not create a dependence,
d. Showing that the affected item, though subject to schedule disruptions, is not on the critical path,
e. Evaluating all economies, imposed and extant, and deciding to buy domestic.

The latter solution may, particularly with subsystems, be significantly cheaper than buying inventory.

Conclusions

Notwithstanding the many differences between the PGM sector and the rest of the defense industry, this case study suggests several important points about the phenomenology of foreign-source dependence.

First, it is possible to get a handle on the entire foreign-source dependence problem, particularly when producers are aware of the legitimacy of the Government's concern. While a 100 percent coverage of the industry would not have been feasible, enough information was collected to demonstrate the pervasiveness and low cost of mitigating foreign-source dependence Further study to scope out general policy recommendations is not needed; it would not improve the estimate enough to matter. For systems not covered here, sufficient data can be collected without efforts significantly more complicated that those which have been tried to date Prior pessimistic conclusions (the JLC study, or a subsequent examination of semiconductor dependence by IDA) are exaggerated.

The most salient lesson, from a policy viewpoint, is that the cost of insurance is small, only a few percentage points of one year's production. Of the total five billion dollars spent a year for PGMs, only one to two percent is spent abroad $15 million to prestock critical subcomponents would ensure the continuity of current production in the face of an unexpected total foreign-source cutoff, the most severe condition.

The greater surprise is not how much foreign-source dependence exists, but how little Compared to the one to two percent figure cited above, the commercial manufacturing sector, in general, probably gets 10 to 20 percent of its value-added from abroad. Comparable figures are 15 percent for automobiles, ten percent for test equipment, and a similar ratio for non-MILSPEC ordnance such as sonobuoys

Why so little dependence? One reason may be that the requirement to qualify component producers makes it much easier for prime contractors to deal with domestic suppliers, most of which are military oriented to begin with The military market, even at the subtier level, requires a long learning curve before entrants are sufficiently steeped in the way the Department of Defense does business. Such investment is infeasible for most potential overseas sources at the second tier and for many even at the third tier, where DOD's direct influence is muted Another reason is that most producers do not, themselves, want to be dependent on overseas suppliers and have said so explicitly Not all producers feel this way, however, and so the insurance provided by one supplier is vitiated by the lack of insurance from another supplier not so bothered by foreign-sourcing.

No one reason dominates as the cause of what foreign-sourcing exists but several individual reasons recur For those dependencies where domestic substitution would be lengthy, the primary cause is the inability of domestic producers to meet required quality control standards, particularly where materials purity matters. Examples of this problem occur in ferrites, silicon FETs, and IC materials (especially packaging). A second cause is that domestic volume--or world volume, for that matter--for some items is too small to interest domestic manufacturers. Where there is only one world producer, it is no more likely that the producer is domestic than foreign. Examples of this include sapphire, butane triol, and titania.

Cost savings, a third cause, accounted for foreign-sourcing in those areas where business is dominated by commercial markets and considerations. Examples included GaAs FETs, glass, IC assembly, and bearings. Finally, some overseas defense firms-- Royal Ordnance (U.K.), Lucas (U.K.), Schwarzkopf (Austria), and IMI (Israel)--have found profitable niches in the domestic military market, and are frequently second sources on selected subsystems. Although the latter is not a dependence, per se, an unanticipated cutoff would interrupt production schedules just the same.

Not to be overlooked is the dynamic nature of the dependence problem in both directions. Several subcomponents which were sourced overseas a year or two ago are now or will soon be purchased domestically. Examples include the Standard Missile rocket nozzles, high-purity silicon, and certain transistor packages. In other cases movements go both ways; at least one IC producer was moving its assembly back home, while several others were dismantling assembly capacity and preparing to go offshore. In yet other cases, such as rocket motor cases, foreign-sourcing appeared to be a growing trend. Where some producers are busy trying to qualify domestic sources to eliminate potential dependencies, others are reevaluating foreign suppliers to improve product economics.

The overseas sourcing of PGM subcomponents, while it is a relatively small percentage of total value added, is nonetheless capable of leading to sharp schedule disruptions in the event of a foreign-source cutoff. The overwhelming bulk of the foreign-sourcing takes place in what are currently allied or friendly neutral countries. Many of them, particularly those situated near the Iron Curtain, may be considered at risk in a large conventional conflict.

The more general impact of foreign-sourcing, of reducing domestic surge capacity, has a relatively minor impact on surge compared to all the other constraints on capacity. A sector, for instance, which is at full capacity for peacetime deliveries is, in the end, no more responsive than one which is supplying only half the military's needs but is working at half capacity. In general, industry's ability to expand quickly is not assured. Too many critical sectors are working at or near capacity to satisfy current military demand; the knowledge and resources required to shift production to alternative sources will not be instantaneous.

6

A DOCTRINE FOR SURGE

> Correct surge preparedness policy requires a sound doctrine. In surge, DOD's first priority should be to accelerate the several years' worth of production in-process; investment in the base is required to do so in volume. Surge production targets should give industry a maximum feasible ramp-up path. Surge investment, however, should be concentrated on scenarios where DOD is willing to grant waivers and pay more for faster production.

Most of why so little is done to foster surge potential is a lack of doctrine for surge itself. The concept itself is simple and powerful. Beyond the basics, though, there is little understanding of its place in warfighting, how it works, the basic policy questions that its consideration drives, and issues to be resolved before it can be made into policy. In place of doctrine is confusion, a black box of levers and gears which connect to very little.

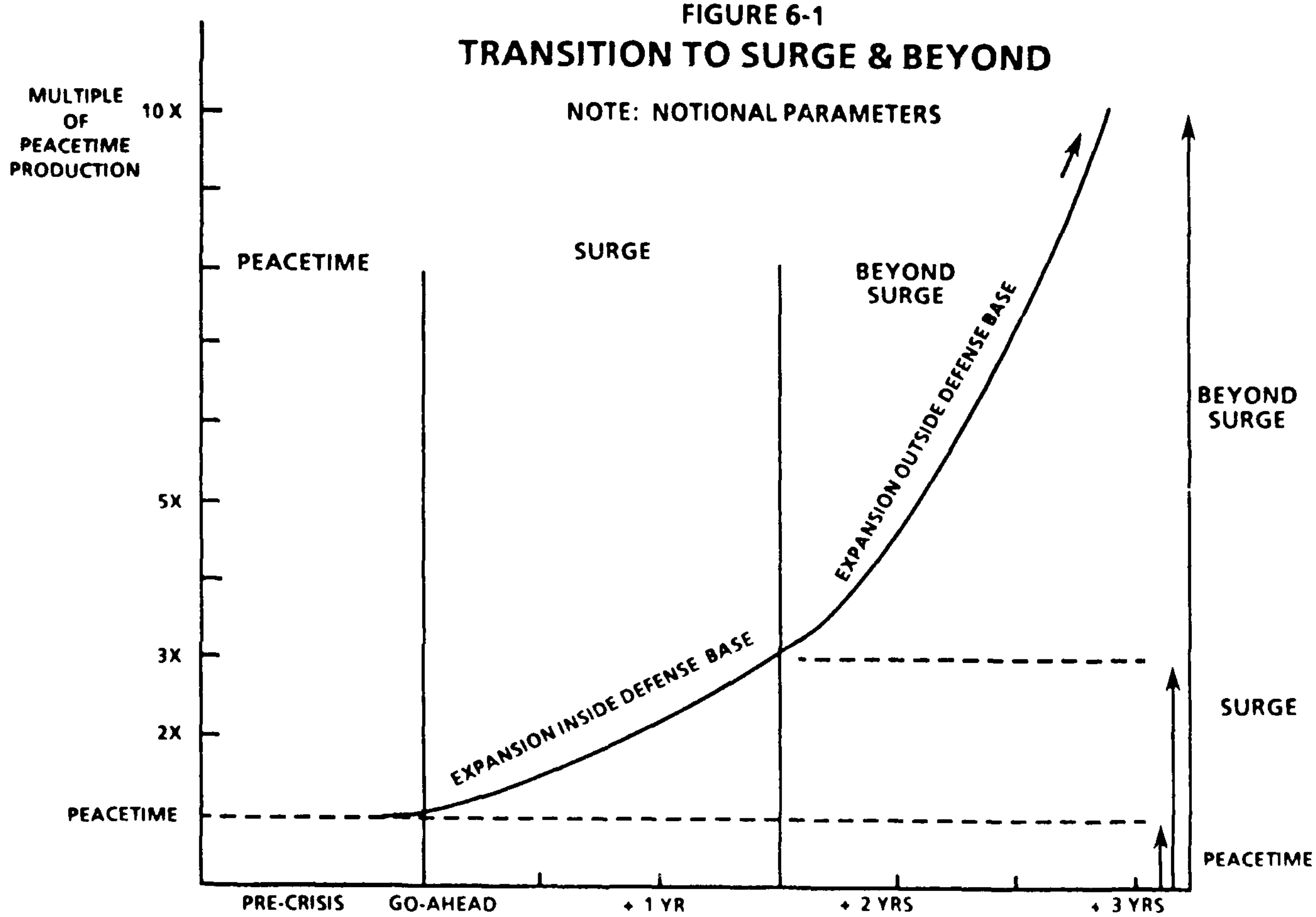
A few simple concepts can help clarify the current debate and let industrial surge assume its rightful place in the grand hierarchy of DOD's resources. Most of the ideas below are not themselves original or even particularly subtle. Many are foreshadowed by studies cited in chapter two. But what remains missing is a structure within which these ideas can fit, and through which their merits can be consistently evaluated. There remains a tendency to see the uses of surge as universal, with the constraints on its effectiveness equally numerous. Problems which advertise themselves as unsolvable stay unsolved.

DOD's concern with industry's reserve power lies with its ability first to surge and then to go beyond. Surge may be defined

FIGURE 6-1

TRANSITION TO SURGE & BEYOND

NOTE: NOTIONAL PARAMETERS



as a time-urgent increase in production largely within the defense industrial base. Going beyond surge entails the widespread conversion of commercial facilities into war-goods production. Roughly put, surge may be thought of as the act of tripling production by the second year of crisis; moving from there to perhaps tenfold rate increases lies beyond surge. Figure 6-1 illustrates this. The base is what would have been peacetime production. The first increment comes from maximizing the defense base. The next, but larger increment comes from converting the civilian sector to producing military goods. Seen thus, peacetime, surge, and beyond differ not so much in their timing as in the problems that each is designed to address.

This chapter explores three facets of surge. One is requirements, how best to assess industry's capability against emergency military needs. Two is how to surge, that is, to move the defense industrial base to maximum production in minimum time in war. Third is how to adapt the exigencies of wartime surge to contingencies short of war. The next chapter discusses yet another facet, the far different problems beyond surge.

Requirements

It is not requirements, but consumption and attrition forecasts which DOD generates as part of its war planning process. The latter, though, even when accurate rarely tells industry what to do, how fast to do it, or in what order.

Take PGMs. War plans may call for the expenditure of tens of thousands of PGMs within the first 60 days. No one expects industry to build these weapons in 60 days. In most cases it took industry ten years to build the reserves required to destroy the large percentage of the threat called for in war plans. If supplies are short, and most PGM inventories are, some build-rate short of consumption has to be generated in order to close the inevitable supply gap. This rate must respond to warfighting needs and still be within industry capabilities.

Even if replacing attrition were scheduled over a longer period, though, its achievement would not end industry's questions. Clearly, the United States will expand forces in wartime. But how much has to be calculated, translated into monthly production rates, and transmitted to industry before one can know how well industry could respond.

Finally platform and munitions requirements are functions of each other. A war with shots but no more shooters is not going to last very long. Some platforms may thus have a higher marginal urgency than their munitions depending on what happens in conflict.

Production Targets as Requirements

As a result of such weaknesses, the Navy in 1984 developed wartime production targets against which to measure industrial capabilities. These targets replaced requirements based on consumption estimates, or in the case of platforms, on physical plant capability--a circular definition actually used. Rather than require that a lump sum shortfall be made up as soon as possible, industry was given a target expansion rate. This rate was a feasible production expansion path whose achievement would have industry making as much contribution to warfighting as could reasonably be expected.

Targets are based on considerations of both supply (industry's ability to expand quickly) and demand (the need to replace attrition and build a suitably large force). Typical targets for aircraft production, for instance, require reaching existing factory limits within a year and a half and expanding over the next year towards whatever rate is required to build a force of a given size within three to four years. At the outset, ramp-up rates for various aircraft are similar because they face analogous supply constraints. As the build-up continues and these supply constraints are worked out the ramp-up rate would be increasingly governed by the rate of attrition and the desired force structure for specific aircraft types.

Those who used production targets as yardsticks had to understand that these were not alternative measures of war requirements. Meeting them does not solve the problem, which, is much larger than industry can solve in the first months of crisis production, anyway. But doing do would be much better than one might expect industry to do under their current state of preparedness.

Determining a feasible goal will always be a matter of trial and error. Initially, the acceleration of PGMs was thought to be a long drawn-out process. Then, CNA's Mk-46 study showed how industry could hasten this process. Navy's first production targets, a 50-percent increase in six months, proved too easy, and might have been achievable without further preparation. But it would still leave large sustainability shortfalls. New targets, tripling PGM production in six months, were instituted and tested in the Navy PBA (discussed in chapter four). Would the Navy support the investment required for industry to be capable of meeting targets? If not, would some lower goal be more realistic? All this remains to be seen.

As noted, build-up rates will be determined by ultimate force requirements. Navy production targets calculations used the JCS Planning Force as its force goal, for lack of a better one. But the Planning Force is that pre-conflict level required on hand to better afford the United States reasonable retaliatory capability against attack. It was never calculated for extended war. Indeed, both the size and composition of an extended force could be quite different from that of the Planning Force. Its size could vary depending on how successful the Soviet build-up was as well as the relative usefulness of weapons over the course of the conflict--deep-water mines, for instance, perhaps being useful earlier, and carrier-based attack aircraft later.

An example illustrates how level-off rates can be calculated from initial and desired stocks together with initial and continual attrition. If the Navy has 600 F-18s at the outset, it might have 300 left after six months. Say the desired force is 1,200. Thus the delta is a build of 900 aircraft. Meanwhile, the first serious production increase is month 24, and the aircraft are needed by month 42. Thus, a build rate of 50 F-18s a month between months 24 and 42 is required to achieve the desired force. If, at the same time, steady-state attrition rates are 2 percent a month, then builders must replace 24 aircraft a month (2 percent of 1,200) just to keep even. Total production targets are 50 for force replacement/expansion and 24 to cover continual attrition replacement for a total of 74 aircraft as the level-off target.

One of the largest difficulties in getting Navy concurrence for these numbers was that staff officers objected that the attrition rates were too low, or the onset of production increases was too soon, or the when-required date too far into the future, or the target force goal too low. Unfortunately these numbers are linked together; any change towards perceived realism in one has to be reflected in a change away from perceived realism in another.

This and similar processes applied to the Navy's production targets suggested increases of 20X to 50X for conventional ordnance, 5X to 10X for PGMs and aircraft, and 2X to 5X for ships and related platforms.

In contrast to steady-state wartime rates, the initial surge rate is best defined as the best ramp-up schedule from current production. For the hypothetical F-18 example, this would be the maximum feasible ramp up rate which falls between the current rate, now about 10 a month, and the putative target rate of 74 a month. Targets for smaller but equally urgent conflicts would use the same surge ramp-up factors but level off sooner and lower than in a large conflict. If the degree of urgency is less for a mid-sized war or for pre-war surge, a slower pace of surge may be appropriate as a target of support for surge investments. The scenario makes a difference in which weapons are surged. A land based Korean War requires a different mix of weaponry than a marine based Philippine War.

For conventional ammunition, spares, and troop support, the notion of a consumption based requirement makes more sense as a level-off production rate, although not necessarily when applied to surge requirements. In theory, this problem does not exist. The Services are supposed to have prescribed amounts of conventional ammunition and other consumables, and the base is supposed to take over from there. In practice, however, the Services do well to have a portion readily available. Some facilities, particularly those laid away, cannot react in as little as six months. Many so-called consumables are really very complicated pieces of electronics and cannot be produced rapidly under any circumstances. A base which might be asked to reach one production level if it could get there fast enough might be asked to reach a higher level if delays in raising production lead to an under-filled pipeline which has to be restocked to allow the logistics system to operate smoothly.

With experience in surge planning and more attention from warfighters, production targets should be even better guides to planning. It is yet capable of major improvement but already represents a substantial increase in realism over its current proxies--consumption requirements or current production capacity.

Priorities

Many factories could boost some of their weapons programs at multiple rates but not all of them at once. Prioritizing among competing programs requires both demand-side and supply-side considerations.

In 1982 the JCS took a major step in this effort and assembled a prioritized list of weapons which represented the CINCs' best judgment as to which weapons they needed most. The initial exercise was quite valuable, and established that PGMs, as a class, had the highest priority among competing weapons systems.

JCS recognizes that the basic list needs work. Other less well recognized issues concern the relative priority of spares versus their end items, strategic versus conventional systems, and demand-side versus supply-side considerations.

Working the list should address several issues. Is it meaningful to average the rankings of individual CINCs when some are more important than others, and some pay more attention to priorities than others? Would combining separate lists create an amalgam of material that fits no one warfighting approach very well? Finally, are all weapons on this list in production, in need of greater production, and capable of being produced in greater amounts in a reasonable time?

As for spares, the CINCs' list contains only Air Force war reserve spares kits. But putting the right priority on spares compared to their end items is sensitive to the ratio of missions to attrition. Spares requirements rise with the tempo of operations and decline with attrition. In a Central Front war, where attrition would be high, spares requires may dip below peacetime levels once the initial intense phase of combat ends (in six months?). In a Vietnam type conflict spares requirements started high and stayed high because most platforms survived. Accelerating spares production before war began would be important to maximize the number of usable platforms available six months later. Once war started, however, anticipated attrition levels might reduce the urgency of supply six months out. Hence the problematic wisdom of trying to surge spare parts in a no warning scenario.

It may also be necessary to adjust priorities to accommodate a build-up of strategic systems, both offensive and defensive, and/or civil defense during a period of conventional warfare. War between us and the Soviets automatically raises the prospects of nuclear exchange, and thus the importance of on-going strategic preparedness. Conversely, if a tacit agreement not to use nuclear weapons and/or abide by overall arms limitations holds, the urgency and scope of such efforts would be mitigated. Also relevant are the very long lead times involved in surging strategic systems.

Supply-side factors have a powerful influence on transforming demand-side priorities into real-world allocation decisions. Consider a factory which can make a 1000 missile parts and a 1000 engine parts a day. Its total capacity is 4000; it could double both lines, or increase one line threefold and keep the other one constant. Perhaps missiles are needed first. However, further supply-side data shows that missile production overall is limited to 1500 because of bottlenecks in producing another missile component. Meanwhile there are no bottlenecks for any engine parts. If the factory produces 2000 missile parts, a quarter of them will just pile up as inventory down the line. The smart thing to do is to build 1500 parts for missiles and the rest for engines, despite demand-side priorities, until the bottlenecks in the other missile part plants are resolved.

Similarly, programs whose bottlenecks are removed beforehand to facilitate surge should get priority over programs with unresolved bottlenecks, because the former programs can use the material and the latter ones cannot. But a distinction is needed between programs which are ready for surge and those which are "planned" by the standard bureaucratic process. The conventional ammunition base is "planned" with great thoroughness if not accuracy. Several constituent facilities serve both low value conventional ammunition plants and high value PGM warhead lines. In the past there has been a tendency to allocate the entire plant to "planned," that is, low value, munitions because high value munitions are not "planned." Enforcing such planning would prevent even programmed PGMs from getting built.

Supply-side considerations are not always straightforward. At times there may be several multi-product plants, all of which limit production, creating mathematically interesting allocation problems. In practice, this is rare; data from the Navy Ordnance PBA suggests that the worst bottlenecks are in plants which specialize in one or two programs.

Other complications could arise in a factory making parts needed at different stages in the production process. Some parts are put into final assembly just before shipment; others have to traverse a long production process afterwards. Since bottlenecks emerge differentially over time, a sophisticated allocation process has to take this into account. Finally, surge priorities which favor easy to accelerate items, such as ordnance, over others, such as platforms, should be aware that hard to accelerate items that are near completion, by that fact, merit allocation priority.

Navy's rough guide for priorities in the first year of surge put PGMs first, followed by other ordnance, spare parts, troop support supplies (including medical), small platforms, upgrades to large platforms, large platforms, fixed C^3I/physical infrastructure, and, last, strategic forces.

Allies

The current policy on allies' requirements for US- made materiel is mixed. Guidance calls for including Allied requirements where appropriate. The Services, though, assuming that US requirements themselves are unattainable, rarely bother with adding requirements of allies on top. Munitions requirements, which have to be matched with physical capacity, only count South Koreans as allies (under the WRSA program).

Allied requirements do matter. If they have platforms that cannot be used because they lack munitions, spare parts, etc. then our war effort is no less crippled than if our own platforms were so idled. Would the US tempt its allies to cede more of their responsibilities by stepping in with wartime material to overcome their lack of surge capacity? Probably not; the allies expect this of us in a long war regardless of what the United States may say is or is not policy.

Estimating production requirements for allies has to take many factors into account. Munitions and spares are determined by the number of platforms, the latter is a function of the size of the armed forces. But what percentage of either will be available by the time US production can kick in? Allies that lie in or near combat zones can expect attrition rates higher than ours. They will have fewer platforms to maintain, and/or fewer fighting units to equip. Unless surge starts with warning, rather than war, their requirements would be thereby reduced. Their inability to employ everything we make also lowers their demands on our base.

For complete weapons, the best approach seems to be to keep allied requirements in mind when determining level-off production targets, but to postpone the hard questions until it comes time to apportion production, particularly work in progress here which was originally committed to foreign customers.

In some cases domestic firms supply components to overseas weapons manufacturers; e.g. the target detector on the Sidewinder missile. For these, one should attempt to guess how much of the overseas industrial base is likely to be left functioning over time and plan to allocate and/or expand capacity accordingly.

The Limits of Requirements

No set of requirements, regardless of how well crafted, will survive intact for more than a few days into a conflict (any requirements for pre-war surge, contingent on opportunity). War is a tremendous source of information on the efficacy of weapons systems. Some weapons will prove useless; others useful and vastly under supplied. Still others, although good, may be usable only with platforms which have been mostly been destroyed. And, despite the fact that boosting production rates is somewhat incompatible with rapid design changes, the latter will often be necessary in many cases if our weapons are to work at all.

Production targets are guidelines, not absolutes. They let industry know what kinds of actions are necessary, and their magnitude and direction. They also give a rough accounting of who will get what common components and other resources. But they are not meant to be followed blindly. Such expectations jeopardize their entire worth.

Surging Production

To surge production is to trade money for time. What matters is when extra quantities are delivered. Current lead times represent the least cost production schedules that can be derived from the industrial base given current order levels. If faster production costs less, industry would produce faster now. Thus, to get deliveries faster, one has to be prepared to pay more. Money will go a long way towards speeding deliveries if capacity is there.

Paying a premium for faster deliveries in surge should be as acceptable as investing in long lead items to shorten lead times. Conversely, surge investment is not warranted unless a price premium is an alternative possibility. Why? Precisely because surge investment is itself a premium for faster deliveries.

For instance, a program to accelerate the production of Sidewinders ($60,000 each) may seek to reduce the lead time for new deliveries from 12 to six months by pr stocking long lead components equal in value to half of a Sidewinder. This program would allow faster deliveries under a wide variety of peacetime contingencies. Since long lead inventory would be recovered when the surge preparedness program ends, the cost of such investment would be just the annual rental cost of this inventory. For purposes of this example assume the annual rental rate to be 5 percent, Government's real interest cost. Thus, the cost of an option to buy additional Sidewinders within the first year of surge is the rental value of the inventory. Half of $60,000 times the annual rental cost, 5 percent, is $1,500.

This $1,500 buys a year's option on faster deliveries. For the next year, of course, another $1,500 must be paid. Assume that the chances that surge begins is known to be 10 percent in any particular year. If $1500 is an acceptable price to pay for a 10 percent likelihood that faster deliveries may be needed, then the premium for faster deliveries has to be at least $15,000. DOD, if consistent, should also be willing to pay $15,000 extra per missile at the time of surge if this can buy comparable delivery schedules with or without a declared crisis. If it is not, then DOD is saying that faster deliveries are not that important, and thus surge investment for peacetime surge is not justified.

The odds of surge, the carrying cost of surge preparedness measures, and the potential inability to get faster deliveries with a premium may still leave surge investment a better buy then surge premiums. But data from the JCS Phase II study (on the added cost of faster deliveries) suggests that surge premiums are usually more cost-effective than most surge investments, regardless of scenario, even if the latter are themselves cost-effective on their own.

Surge may be put to many uses, not just a war with the Soviets. But this is not to say that DOD should invest money in the industrial base for all sorts of surge, because there are scenarios for which it is not willing to pay a premium. Surge planning, when used to identify worthwhile investments, properly concentrates on the more urgent scenarios. A good rule of thumb, therefore, is to invest only to accelerate production in circumstances for which a contract premium is also justifiable. In short, spend money beforehand only for problems that cannot be solved with money when the time comes.

Of course, if surge brings higher production volumes, costs may be lower even after a premium is paid for acceleration. This is nice if it happens, but largely beside the point. The point is the willingness to pay as an incentive to speed things up.

Surge Is a Bridge

The importance of accelerating production is best appreciated in the context of a full-scale conventional war. At its start the military would expect to fight with platforms and munitions on hand. As war continued, stocks would be swiftly reduced and reach very low levels until the whole economy could be converted from peacetime production to war goods.

Calculations made in computing the Navy's production targets indicate that the highest vulnerability of US forces would occur between months six and 24; munitions shortages would be worst between months three and 18. Full recovery would occur not before the third year. If attrition is symmetric the same would be true for the Soviets.

This trough is precisely when surge could make a difference. Surge production may be smaller than either initial stocks or subsequent production beyond surge. The extra weapons arrive, however, at a particularly critical moment and help determine which side has the momentum when both economies are converted to war production. The amount of added production early in the war from a prepared industry can be significant. A sonobuoy industry that can double or triple production (as it now can, thanks to Navy money) can meet most buoy requirements over the course of the conflict. Without preparation, large supply gaps would appear after a few months, the difference between losing and keeping contact with Soviet submarines in a critical period. In PGMs, the difference between a responsive industrial base and the current one is producing two-thirds vice less than half of the requirements within the first 15 months. Surging platforms may mean being 20 percent ahead rather than 20 percent behind after a year.

Surge Works by Shrinking the Pipeline

Within the first 18 months of surge, most of the output of PGMs, platforms, and complex spare parts (in contrast to conventional munitions) are deliveries from orders placed before surge starts.

Why? PGM production typically takes two years, now. At the beginning of FY 88, for instance, industry will have started delivering the FY 86 production run; three years of production, FY 86's, FY 87's and FY 88's, will be sitting in the procurement pipeline. Even a vigorous production increase, tripling production at the end of six months, would require 16 months to ship three years worth of output. Month 17 and later represent new orders. For aircraft, which typically have four years on order, and take twice as long to accelerate, shipments of new orders start in the third year.

The relationship between reducing lead times in surge and increasing production is immediate and direct. An immediate and sustainable surge is possible even without prestocked subcomponents if conditions are right. Assume, for a moment, that no PGM prime or subcontractor does any work over the weekends (mostly but probably not entirely true now). In an emergency everyone starts working weekends, and lead times are proportionately cut. A process that done in parallel. The best changes in crisis may come from workers who become sensitized to steps which slow shipments down, or engineers who are motivated to change their habits in the interest of greater or faster flow.

Time can also be saved outside the main production plant. Defense houses often complain of extended lead times for minor components. Often the lead times are extended not because the production process is long, but because their customers schedule small military batches around 'arger commercial orders. In crisis, defense orders would take priority even if it costs more. Parts deliveries may be speeded by cutting the paperwork built into the shipping/receiving process or by shipping in smaller lots even if trucks do not run full.

Acceleration would move more assuredly, however, if people were asked to think about it ahead of time. There will be methods which, although thought to be useful in theory, may in practice be counterproductive. If not tested beforehand, shortcuts in manufacturing may lead to higher reject rates. It is only some tests which can be cut short and only some processes which can be skipped.

It is precisely this sort of planning which has been sorely lacking in DOD's approach to surge. It is not that industry could not come up with such innovations but that they have not been asked to do so. Too often, industry volunteers a number and the planners meekly accept it, little questioning the basis for such estimates, or whether in fact, industry had exhausted all possibilities for doing better. Not infrequently, the simple query, "Is this the best you can do?" elicits answers which indicate that they in fact can do better.

To excite the changes which make surge work, DOD must be willing to pay the price for acceleration, both in money spent and in terms of a willingness to throw out the rule book or at least wink at the right time. Current rules are designed to shift direct responsibility away from deliberate choices made by people and towards adherence to procedures themselves, to discharge them as one would discharge static. Why should not producers have the freedom to alter the innards of their boxes as long as these boxes work and interface with other subsystems predictably?

Starting Surge

What should trigger surge? Some believe a trigger should be built into the DEFCON process. Others would have a separate set of industrial alert conditions (INDCONs) to do the job. All this is besides the point. Money starts surge; muscle eases the course. Money is necessary to start new work or hasten existing contracts. Muscle can be brought in afterwards, if Government has to compel cooperation. Two laws, the Selective Service Act of 1940, and the Defense Production Act of 1950, have more than enough muscle. Neither needs a declared war.

With a limit of one to two billion dollars (it varies each year) money may be reallocated from previously appropriated funds into current or standby contracts for items needed most quickly. This could be used to accelerate deliveries of existing orders, or start buying items, such as conventional munitions, for which no active orders exist. Money would be funneled in the usual ways to program managers who, in turn, would invoke or create appropriate contract clauses. Money could also be used for additional capacity to accelerate production (as is now done for test equipment). Along with this reallocation, DOD would presumably prepare an urgent supplemental appropriations request to Congress.

A useful piece of planning would be for DOD to figure out where and how much extra contractors are to be paid in order to accelerate deliveries. This would save valuable time otherwise spent in writing, haggling over details, or deciding how much premium is needed to engender an appropriate response.

Worrying about emergency budgets is a less useful piece of planning, provided production targets are already established. Budgets can be overhauled in a weekend. By contrast, additional weapons (conventional munitions aside) which this budget would pay for are unlikely to reach the forces until at least a year and probably two years later at best. If the budget is truly an emergency, DOD should be focused on buying weapons and not long lead items for weapons. Failure to buy the whole weapon is justified only if the anticipated crisis is several years away and fiscal constraints are unyielding.

As money affairs are settled, work should have begun on production specs which inhibit production and test specs which can be waived without loss of quality. New subcontractors will also be needed beyond those formally qualified on specific programs. Some rules are encoded in the Federal Acquisition Regulations and cannot be altered except at high levels. Others, particularly the technical specs, may or may not be applied at the discretion of project managers. The latter, without guidance, could easily waive specs in random, confusing, conflicting and counterproductive ways. Some will be more comfortable than others giving up known production/testing procedures to speed production. Defense contractors who deal with many programs could easily find their managers each taking a different approach. This means that high level, early, or best of all, predetermined decisions are needed.

Allocating production components and other resources also has to start early. The current allocation structure, represented by the Master Urgency List, is slow, cumbersome, and virtually useless for real-time decision making. No alternative structure exists even in theory. Clearly, the Services do not know the magnitude of the allocations problem. In Exercise Port Call, the Navy's buying commands combined only asked for 20 additional priorities and allocations officers, low by perhaps a hundredfold.

Preparing Industry to Surge

To move the next 18 months of deliveries in six months requires that flow volume be tripled. Lower lead times are useless without the capacity to take care of higher flow-through rates; in most cases this requires preparations prior to crisis.

Chapter four demonstrates that the capability to produce more missiles may be purchased ten to 15 times more cheaply than buying the missiles themselves. But this estimate does not come easily. It results from painstaking discrimination between essential costs and those required only to maintain production practices which characterize peacetime operations.

There are many ways to cut surge investment costs, only some of which were actually used in the Navy PBA. For many test sets, for example, it would be more cost-effective to stretch the existing capacity than it would be to buy standby equipment. Alternatives include eliminating multiple test cycles, culling tests which are performed on sequential workstations, using statistical rather than 100-percent testing in places, or reviewing existing tests to see which are routinely passed and therefore needless. CNA's Mk-46 study showed that two-thirds of the money said to be needed to support a tenfold increase, most of which for test equipment, could be eliminated. The remaining one-third had to stay.

Buying test set module components in advance rather than test set modules also saves money. In general, it is said to take six to nine months to buy test set modules and an equal time to make a test set from the modules. Hewlett-Packard, which makes most of the modules, builds them in one to two weeks after its gets components. Having Hewlett-Packard prestock parts (which cost 10 to 20 percent the cost of a full module) and ensuring military priority would halve the delivery time for a small fraction of the cost. Lead times for follow-on test sets should reflect the lessons learned in building the originals.

Other savings are possible. Buying empty buildings may be avoided if "tilt-ups" or similar prefabricated structures can be purchased in open economy quickly. Many serviceable machine tools can be procured in the second hand market as can other gear.

Capacity can also be extended by off-loading work to local subcontractors or to competitors; commercial work is assumed to have been displaced by the crisis. Two firms work on one part; one is working on it at full capacity, the other at a very small fraction. If both tripled, the first would need more capacity. If the first off-loaded work to its competitor in a crisis, total output could be tripled without pre-crisis investment.

Many worry that such investments might be wasted because additional workers needed for surge will not be available. The labor problems of war may not resemble today's very much. Most complaints have to do with skills which are employed in competing commercial industries, which defense houses, with their roller coaster production schedules, have a hard time bidding away.

In a macro sense, however, work force skills are not a problem in surge. The total numbers involved initially are small and the skill requirements not demonstrably higher or different from those of competing sectors. Getting critical skills assumes that the crisis is felt deeply enough to draw workers willingly from commercial pursuits, and that they will put up with very long hours. Money may buy 50 hours a week, but for key skills this may not be enough; work levels of 80 hours a week for several months may be required until new people are trained. If this happens, work hours can be met easily. Nevertheless, critical shortages may be expected for test engineers and microwave technicians, a critical but manageable problem worth DOD's attention.

As to whether the recall of reserves will hurt production, the overlap between the defense industry work force and the reserves is small, one or two percent on average. Sectors which may experience more trouble are military equipment maintenance facilities such as depots and shipyards, and those relying on skills primarily acquired through military service.

As chapter four notes, there are two ways to fund surge investments. The current method is to fund a surge investment purchase through the budget process, a method which has been easy to cut. An alternative would be to put surge capability requirements directly into the production contracts. Just as a contractor would have to demonstrate technical capability to win a contract, it would have to demonstrate rapid expansion capability. How it finances this is its own business; DOD, of course, would pay in the end, but competition would tend to force contractors to seek methods which do least financial damage to their overall bid prices. Government's role would be limited to spot checking compliance with contract requirements and establishing exceptions--e.g., reducing the burn-in requirement for electronics in a crisis, or assuming that materials are available from the National Defense Stockpile.

Getting Information

Industry information is not just nice to have. It is needed to guide surge investment decisions prior to crisis, and allocation decision afterwards. Information admits of two issues, what should be collected and who should do the collecting.

Four types of data are needed: requirements, capabilities, technical specifications, and the health of industrial sectors.

Production targets, as noted, require both warfighters and industrial planners. The former need to think about how much of what is required to compel the Soviet Union to stop fighting. Once gross quantities and priorities are determined, industrial planners can fine tune these needs into production targets.

Information on industrial capabilities is the most critical data and this is where the most has been done. As chapter two brings out, DOD now has detailed data on industries which produce PGMs, turbine engines, ships, armor, ammunition, and certain aircraft. OSD needs to consolidate this information, find the gaps, and direct appropriate collection efforts. The Navy PBA questionnaire (in appendix B) is as good a guide as any.

With that, the current planning form, the DD 1519, would be ready for burial. The DD 1519 is an egregious source of irrelevant distinctions (between so-called planned producers and everyone else) and poor information. Its existence has justified no shortage of lazy minds and feet (perhaps accounting for its long survival), but has probably lessened DOD's understanding of the base through its promulgation of systematic error. Defenders of the form say that it does not prevent good information from being added. Neither does a blank sheet of paper, and the latter at least forces planners to think about what they need to know and why.

Information on the value and impact of regulations and specs helps tell which can be waived in emergencies. Such information needs the cooperation of factory engineers and the various Service labs. This in turn requires that they understand the role and meaning of surge.

Finally, information on troubled sectors should be available from Commerce or FEMA if they are doing their jobs. Often the Services will have more reliable information based on their day-to-day interaction with companies in their procurement programs.

It is not important exactly who collects this information so long as competency pervades the process. There should be no doubt on who is responsible for the information collected. That is OSD, because of their central role in promoting surge investment and making the allocations system work. FEMA is not the place. Surge preparedness has enough trouble in gaining credibility without trying to be the primary rationale for an organization with so fuzzy a mission.

Where in OSD is less important. What matters is that the cadre in charge be intelligent and curious, and led by someone capable of gaining the ear of decision makers without becoming mired in day-to-day fire fighting. A direct link to the Defense Resources Board or the JCS Vice Chairman would be useful.

Surge Without War

Save Preparedness for Where it Counts

Prior chapters discussed surge as an activity restricted to actual or imminent war with the Soviets. Other contingencies have been used also as potential surge justifications. TASC's INDCON report suggested:

a. Local disasters
b. Economic crises
c. Demonstration of national will
d. Replacement of client war losses
e. Reactions to warnings of Soviet aggression
f. Technological breakthroughs by the Soviets
g. Soviet production surge
h. Conventional war against US client states
i. Civil defense preparations

It is one thing to justify surge at the time, and quite another to justify investments for a surge yet to come. Efficacy in accelerating production may be nice, but is it nice enough to spend money to get? How important is saving time? Important enough for a premium? If the frequent cases when premiums are rejected, is the desired acceleration important enough to merit pre-crisis investment, which, in effect, constitute a real cost paid for accelerated deliveries one may never need?

Such questions may help explain why it does not pay to prepare for a surge for "selectively increasing our stocks of spares and munitions . . . [as] a prudent response to a . . . Lebanon or Falklands crisis." The support of these client states hardly justifies surge either. US stocks were reduced to support both crises but only to levels extent only a few months prior. The urgency of rebuilding stocks was modest and consequently DOD was not prepared to pay a premium to accelerate deliveries which would do so. So why invest money just in case? Client requirements may justify premiums in some cases, but the size of the draw-down and/or the urgency of the threat to US forces has to be a lot larger.

This may be extended to most of the other crises cited above. Take technological breakthroughs as an example. By their very nature, they are unpredictable, and it would be impossible to specify those investments which best prepare us to respond to a Soviet breakthrough. If investment is to be justified, the surge scenario must be plausible, sufficiently critical, and has to call out specific investments.

Surge on Warning

Should industry be prepared to surge for situations short of actual or imminent war with the Soviets? The best justifications for this are scenarios which bolster weapons supplies against a heightened probability of their use.

Surge may support lesser conflicts so that they can be conducted without draining supplies needed to deter the Soviets in other theaters. Such conflict would have to be sizable, though, before stocks are drawn below levels which can be safely replaced in the normal course of business. Excursions to Grenada or Libya should have been supportable out of pocket; if they cannot be, the problem is not production, but grossly deficient or maldistributed war reserves.

Surge may also be called for if the probability of attack by the Soviets rises above background levels, raising the relative priority of filling material shortfalls quickly. The Berlin Crisis of 1961 prompted such surge. Again, the nature of this surge would vary with the likelihood and imminence of conflict. A medium likelihood of war within six months may require the next two years of PGM deliveries to be hastened. A greater likelihood of war but at the end of two years may mean compressing the next five years of aircraft deliveries.

Notwithstanding the greater likelihood of lesser surge scenarios, success of the wartime surge scenario is of far greater criticality. DOD's focus on the lesser scenarios at the expense of the greater scenarios would be poor policy (not that either are well supported now). Preparing primarily for lesser scenarios is both misleading and expensive. It is better to prepare for the greater scenario and then use money and muscle to make it work, then to spend too much money on the lesser scenario, achieve limited results and leave it inadequate for its greater tasks.

A planning system which is predicated on getting warning may be confounded by the probability of warning's not coming until too late. Of the last four wars with US participation, two were a surprise to initial combatants (Korea and World War II) while World War II cast a long shadow and the Vietnam War was a slow escalation. Apart from guerrilla conflicts, few of the smaller wars of the last forty years were presaged by more than a few weeks, even though they mostly occurred in known trouble spots.

Its High Cost

Accelerating production without raising prices or changing rules may cost less at the time, but the investments required to make it happen cost more beforehand. The results also take longer to achieve. The JCS study of PGMs showed how expensive preparing for a business as usual surge can be. For Navy-managed PGMs, getting another dollar's worth of production between months six and 24 required roughly 60 cents worth of inventory and production equipment ($1.03 for the AIM-7M).

Without a crisis, serious labor force bottlenecks become another constraint to surge, expressed as a difficulty not in finding sufficiently qualified workers but in drawing them from their current employers. With war, or its perceived imminence, workers go into defense work on their own and are more willing to put in very long hours that they would be reluctant to commit to even with overtime rates.

A similar sense of crisis is also required for professional employees to alter habits of mind developed to conform to military specifications and instead explore innovative production techniques which may not always be by the book. Finally, it may take more than ambiguous warning for industry to take the priorities of the Defense Production Act to heart, particularly if preparedness planners themselves believe commercial production should not be disrupted in surge.

How to Use Warning

To take full advantage of warning time it helps if some surge preparations are ready, even if these are designed for wartime use. Using surge correctly demands a solid understand of what surge is meant to accomplish--getting war material faster, and nothing but.

Surge has been touted as a way to demonstrate national will or illustrate the prowess of our industrial base. Will is demonstrated not so much by results but by costs; one may bear costs with or without preparation. Anything the United States does which prepares us for war and costs us resources demonstrates will. By contrast, the prowess of our industrial base is only demonstrated by a successful surge. However, the Soviets have not forgotten that the American industrial base is still robust, and, in fact, they may think more highly of our industrial base than its performance warrants. Demonstrating its capabilities for real only helps us if it <u>increases</u> their estimate of its capabilities. If their estimate is exaggerated, then any such demonstration <u>decreases</u> their estimate and for deterrence purposes, such information is best kept to ourselves.

As for the warning itself, it may be ambiguous when received but it must be communicated unambiguously if surge is to work. Why? For the same reasons, money and muscle. Beyond the threshold, congressional supplementals are needed to pay for all this accelerated production. Congress has to be brought into the decision making process before it appropriates money. As for muscle, it is needed to get resources allocated to defense work quickly. An air of urgency is needed before workers and engineers are persuaded to alter their production processes away from minimizing costs and towards minimizing lead times. Both need explicit justification, and one which is inevitably public.

(Sonobuoys, by contrast, <u>can</u> be surged quietly, and used without much notice. They can be assembled within weeks in a handful of rural locations and their parts are cheap enough to prestock in complete ship sets. In fact, hundreds of thousands already have been.)

Indeed, a surge program should need to force changes in work place attitudes. It tests the degree to which the working public takes warnings seriously and prepares them for necessary changes in habits in case war actually commences. It also makes the acquisition bureaucracy aware of how it too must change. By contrast, a surge predicated on changes not taking place will leave people unprepared for changes that must happen if anything beyond surge is to succeed.

Graduated Response

Within the last few years, DOD has shown interest in a Graduated Mobilization Response system, GMR, which could adjust the conditions of industrial production in to changes in the degree of likelihood and imminence of conflict. Under the originally named INDCON (industrial conditions) concept, the industrial base would crank up from its current deep peace status (INDCON 6) and progress in stages towards all-out mobilization (INDCON 1) as needed.

The GMR system has a theoretical neatness which may, in fact be appropriate, were there a well articulated set of acquisition practices and some systematic way of assessing the likelihood of war. But DOD is a long way from that state, having only recently begun to understand the production implications of wartime versus peacetime production practices. Procedures which out-run their knowledge base are apt to confuse decision makers by persuading them of the illusory precision of their policy instruments.

Three basic flaws may be cited. One is the false analogy between DEFCONs and INDCONs. A change in DEFCON is associated with a virtually immediate change in military posture. A change in INDCONs, however, leads only to a gradual change in military posture because it takes time from any change in production (itself a delayed reaction to changes in operations) to lead to a change in assets. Subtlety in DEFCON setting may be required to convey a precise message in terms of capabilities. Because the effects of INDCONs translate so slowly into capability, precision in message-sending is not nearly as useful.

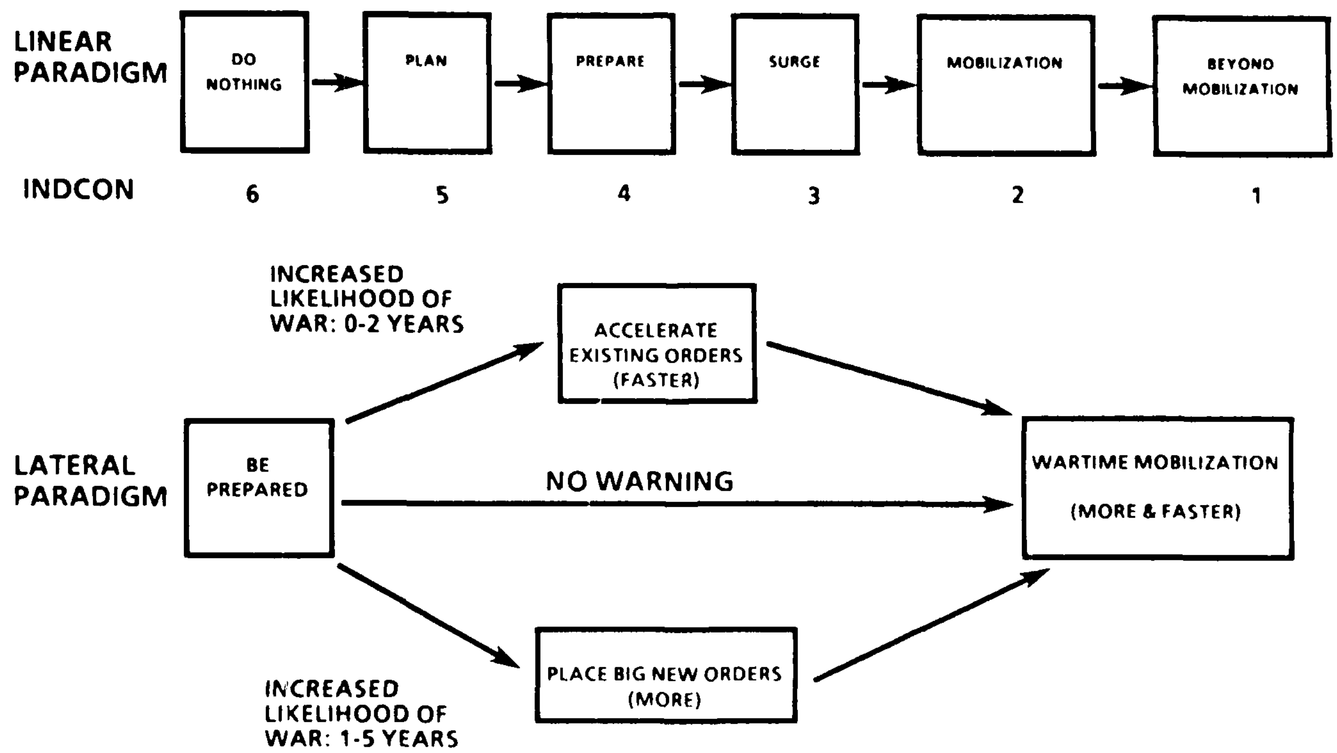
Two is the lack of data required to measure the relationship between cause and effect. DOD now knows that a change in rules will lead to a change in production response. But the gross relationship between rules and responses is understood, and only partially, in the production of PGMs. The relationship between particular rules, the costs of imposing such rules, and the responses from such rules is totally unknown in other sectors. Any justification for intermediate INDCON states (between peacetime and wartime) that would imply the selective or partial application of changes in production rules has to rely on pure conjecture. Proponents argue that the US should be able to respond to ambiguous warning without putting the whole economy into full mobilization. Given that the surge base (that share of DOD procurement which can be surged at all) is only one percent of the nation's GNP, the argument is disingenuous.

Three are the psychological traps. Even if a perfectly understood increase in subtlety is valuable, an imperfectly understood system may lead to worse decisions if it feeds the wrong tendencies in decision makers. GMR could easily do this. One way is to misread the pallid industrial response to a peacetime surge as the best that industry could do, when the vigorous response of a wartime surge is still untried. The other is to put the burden of proof on those who would free industry of production constraints as soon as possible without having tested intermediate conditions first. INDCONs do not have to proceed in lock step order, but it is instructive that the minimum time required to move from deep peace (INDCON 6) to mobilization (INDCON 2) is 13 months if each step is traversed according to the defining document. Other pernicious side effects is to justify discouraging planning (INDCON 5) and preparedness (INDCON 4) since the quiescent world only calls for deep peace production rules (INDCON 6). The INDCON system also helps perpetuate the myth that peacetime surge (INDCON 3) must precede wartime production (INDCON 2).

This same implementation, by imposing a linear solution to a lateral problem, ignores the multiple choices available in response. A crisis which presages a midsize conflict in six months would require a different production response from one which presages a large conflict in five years. The first may stress accelerating existing orders, emphasizing near term deliveries. The second may concentrate on

FIGURE 6-2

GRADUATED INDUSTRIAL MOBILIZATION RESPONSE: ALTERNATIVE PARADIGMS



the efficient expansion of the industrial base, emphasizing longer term deliveries. Different choices mean different trade-offs (e.g.repair machinery more or less frequently). By contrast, a decision to prepare for surge in INDCON 4 as a response to crisis implicitly assumes that the crisis is years away and of fairly low likelihood. If it were closer one would want to accelerate existing orders; if it were a littler farther one would order more, not make elaborate preparations to maybe do so later.

A better implementation might be illustrated by figure 6-2, where six linear stages are replaced by various parallel responses to various types of crises. One path would lead to quick surge, another to long surge, and a third directly to wartime mobilization.

Conclusions

The essence of surge is to force orders and money in one end of the system, remove the internal constraints (both procedural and mental) to its operation, and receive products out the other end fast enough to matter in the field. Surge will subject Government to the pressure of making decisions on rules, regulations, and allocations. It will have greatly helped if there were prior attention to the possibility of surge. Crisis decision making would proceed more reasonably. Troubling production bottlenecks which take time to resolve regardless of money would be removed in advance. In the end, clarity in thought, and attention to the details of information and execution can make a tremendous difference in what it gets from industry when it has to.

7

BEYOND SURGE

> Beyond surge, DOD reaches past the defense industrial base to the larger commercial economy. Taking advantage of this base will require that DOD adapt its practices to commercial norms, something best done prior to crisis. Assuring that sufficient domestic capability exists in all key defense technologies requires better knowledge of key sectors, notably their trade position and defense role.

Fifty years ago, when the US geared up for a big war, it had to start virtually from scratch. As late as Fiscal Year 1940, defense spending was 1.5 percent of GNP; in five years terms, spending peaked 40 times higher. Now, were the United States to do so, it would start with a much larger base, roughly 6.5 percent of GNP, 40 percent of which is spent buying things. Procurement would, roughly speaking, triple twice. The first tripling, surge, would fill out the defense base; the second tripling, beyond surge, would expand to fill out the durable goods sector of the commercial base.

Using the Commercial Base

It is not certain, however, that converting the commercial base would be easier if done today. The difference between practices for military and civilian production has grown. Moreover, the United States is on the verge of losing many key sectors entirely.

The Production Schism

In building the defense industrial base DOD has created an industry increasingly distant from the commercial world. Twenty years ago, for instance, defense contractors routinely built consumer electronics; no longer. Today, the only major overlap between specifically defense work and civilian production is with commercial airliners. Otherwise, the two do not meet except well below the prime contractor level. Even there, the two markets do not converge, despite producing virtually identical products. As an example, military integrated circuits (ICs) are only nine percent of the total demand (by value), but 40 percent of all military circuits are made by producers whose DOD work is at least 30 percent of their business. Many civilian IC producers with military work segregate their MILSPEC business far away from their commercial plants.

The increasing divergence between military and commercial work has stemmed from the independent evolution of defense contracting away from commercial considerations. Over time, DOD has insisted on higher and higher levels of embedded technology in each weapon system. These levels, in turn, have raised unit costs, leading to smaller buys. With buys so low, DOD has rationalized a system of rigorously defined system design parameters so that every unit could document (but not necessarily ensure) 100 percent standard operation. Specifications and contract requirements blossomed. Defense houses specialized in their ability to market to DOD and work to arcane specifications.

Technology alone would not have accounted for the difference. Within the world economy one can find high volume high-technology productions, such as Japanese VCRs, American personal computers. Many sectors also work in low volume high-technology markets driven by commercial considerations. Take medical equipment or instrumentation. Like weapons, these are characterized by high technology, precision machining, high value, and low volume. One might expect defense houses to be among the market leaders here, but they are not. The world's leader in instrumentation, Hewlett-Packard, has made a point of not doing defense contract work.

The key difference has been the pursuit of esoteric performance characteristics without an equally strong attention to cost and large scale producibility. Derived from this is a pervasive role of design specifications in the production process. During design, the match of specifications to performance has a use in giving producers a basis from which to control manufacturing for results. Once this is done, though, the primary features of the design are fixed to remove auditable sources of performance variation.

Worse is that the military's desire for reliability documentation (as opposed to reliability itself) multiplies the volume of paperwork which must accompany production. Both inhibit a willingness to experiment with design to enhance produceability, and lead to practices in the defense industry which would not survive in the civilian market. Observers may point to the frequency and number of change orders as evidence of flexibility, but perhaps they are better indicators of the paperwork required to change anything at all.

An unknown but probably high percentage of the specifications exist to fix problems that might easily have gone away on their own as technology evolved. IC producers, for instance, argue that the DOD's testing regime is based on antiquated views of the industry and may even produce chips less reliable than their commercial counterparts. Many IC producers now guarantee their chips to all customers to below 150 defects per million; military tests are said to be incapable of testing better than 1,000 defects per million. Meanwhile, producers of military ICs have to invest in burn-in ovens for military work, which are then run at capacity, leaving no room for surge.

Design aside, there is also little harmonization between weapons designs and the production capability of the commercial base. Building the M-1 tank, as designed, requires a singularly large metalworking machine, only one of which exists in the world. This may be efficient, but only so long as tank production never has to leave the original facility.

The production of gyroscopes and accelerometers (used to guide PGMs) might illustrate what a combination of low volume and high specifications do. Such units run $5,000 to $25,000 depending on their accuracy and range. By comparison, Japan makes similar units in the millions for portable compact disc players and spends a few dollars each doing so. There are differences between the two, with the military units being more accurate and made in much smaller volumes. In war one might want to go from thousands to millions of these. Is it obvious that expanding the production of military units is a better path to affordable quality in volume than scaling up the technology of commercial units? To the extent that converting industry involves firms such as Maytag making products that defense houses such as General Dynamics, now make, would it be better for the former to make defense goods, or have the latter run Maytag's capacity?

Military equipment does not have to be bought this way. Sonobuoys, anti-submarine acoustic devices, are made to commercial specifications. Rather than document every sonobuoy (on the theory that one can always drop another buoy in the same place that a failed buoy landed), much less every sonobuoy part, the producers and the Navy rely on statistical testing. In practice, 95 to 98 percent do function, a rate similar to those of PGMs, all of which are tested prior to shipment. Freedom from design specifications let producers vary their production practices so long as performance specifications are met. Combined with production rates in the hundreds of thousands which low costs make possible, this makes the industry competitive in a commercial sense. Every year, each producer redesigns their sonobuoys to cut costs and compete. Prices stay down, and buoys cost what they look like they should cost, a few hundred dollars.

In the last decade, DOD has deliberately purchased fighter aircraft, such as the F-16 and F-18, that have been designed for affordability as well as performance. These are the so-called low end of the high-low mix; F-15s and F-14s are the high end. As one result, foreign military sales are a high percentage of production, further holding down costs. It is also likely that the production habits conditioned by higher volume rates would make it easier to bring these models to the very high production rates that would be needed beyond surge.

In general, though, the norm is a defense base polarized in facilities and outlook to high cost, low volume, specification dominated production. This orientation is antithetical to production changes entailed in tenfold or higher increases.

Alternative Production Strategies

The farther apart commercial and military production practices are, the less success each side has penetrating the other, and the harder it is to see how the two can be melded into one industrial base beyond surge. Strategies for making conversion possible would have to focus on changes in production practices under peacetime conditions if the difficulties are to be resolved efficiently in anything approaching real time. Steps in this process would involve accelerating the nascent moves towards using more commercial products, reducing the proliferation of military specifications, promoting modularization to achieve economies of scale, and lastly, spreading defense work throughout the commercial sector. All are consistent with the current thrust to greater competition; together they realize sufficient economies to justify themselves in the absence of any consideration of wartime roles and missions for industry. Such arguments have picked up support from the Packard Commission and within the Office of the Undersecretary of Defense for Acquisition, both pushing for DOD to use more commercial grade products and shift from testing quality to building quality.

On oft misunderstood notion has arisen, which argues that, when war comes, industry should immediately shift to a lower-spec form of current weapons in order to increase production faster. Opponents of this notion wonder how useful lower-spec weapons would be or even whether they would work at all.

This debate confuses two alternative PGMs which may be referred to as son-of-PGM and grandson-of-PGM. Son-of-PGM, the surge version, is essentially the same weapon produced in peacetime, but with subtle changes. Some tests are dropped or shortened in the interest of stretching limited capacity or saving some lead time. A few operations relevant to long shelf life only are eliminated. Subcontractors who are capable but have not gone through formal qualification are used anyway. Sons-of-PGM would not be cheaper, certainly not if they are produced without regard to cost. But, by avoiding tight spots in the production process, they can be accelerated faster.

By contrast, grandson-of-PGM is a complete redesign but one which appears only beyond surge. Redesign has two purposes. One is to optimize around producibility so that thousands can be made where hundreds were before. The other is to bring the production process closer to the standards of commercial industry and so allow the larger civilian sector to take part in war production. Grandson-of-PGM needs to be prototyped and tested quickly before production decisions are made. Specification reduction for its own sake is not what happens.

A related problem is how to redesign weapons quickly under wartime conditions. It is virtually certain that the first few weeks of combat will show some weapons to be useless or easily neutralized, others which need to be restored to usefulness with minor fixes, and some unexpectedly versatile and, for that reason, under-supplied. One of industry's most urgent tasks therefore would be to redesign weapons and get the new versions manufactured as soon as possible. There should be some techniques for emergency weapons redesign which could parallel emergency weapons production acceleration, but such techniques have yet to be implemented or tested.

Systems can be re-engineered for higher volumes. In the presence of static budgets, more steps could be taken towards greater subsystem commonality among weapons. A generic gyroscope or engine fuel regulator, communications module, etc., may be designated the relevant subsystem for a wide variety of weapons. This would have to be imposed from above. Program managers on their own will not have the buying clout to create common modules. Until such modules are developed, they are unlikely to give up particular performance characteristics to save a few dollars by linking up with another program. Linking with ten other programs offers a much better tradeoff.

One step may be to consolidate the modules from the nine antiaircraft missile systems being purchased for the four Services. Greater economies of scale would create opportunities for real competition, and lower costs would facilitate marketing US designed weapons worldwide to allies. This in turn would legitimize international competition, further widening the base.

It may be argued, as Edward Luttwak does (in his book, On Strategy), that concentration on a limited number of models creates too much risk. If countermeasures are developed against common features of many PGMs then a large percentage of the weaponry would prove useless at once. This is a real concern, but it should not stand in the way of developing common functional subsystems whose mission is the same from one PGM to the next. That is, gyroscopes, accelerometers, rocket motors, etc., would be good candidates for common modules. What about seekers and target detectors? Perhaps differentiation there would be useful for its own sake.

Alternatively, one could use software to differentiate PGMs. Changes in software would not affect manufacturing economics but it would allow PGMs to be differentiated in the field and would thus admit of a virtual infinity of types.

There is no easy way, however, to get defense producers into commercial work and vice versa. Attempts by aerospace houses in the early 1970s to build transportation systems, for instance, have not been notable successes. Some push in that direction, however, might arise from requiring defense contractors to prove that they could expand production quickly in emergencies. Ordinarily, this might lead to excess capacity held deliberately idle against emergencies. Producers, however, might come to understand that filling such capacity with commercial work allows them to meet imposed requirements and earn money on that capacity besides.

Ensuring Industrial Capacity

Beyond surge, capacity bottlenecks may be expected for two reasons. Some sectors are dominated by defense work now and have little commercial work which can be displaced to make room for defense. Others have cut back in the face of foreign competition. If access to overseas producers is restricted, their customers face long waits until the domestic industry is rebuilt. If access is not restricted, DOD should know how to tap these foreign sources and make them mesh with the current base.

During surge it is the capacity of the current producers that matters. Speed is critical, and only firms which have proven able to build particular parts will be able to demonstrate their continued ability in a short time frame. Beyond surge, it is often faster to qualify potential competitors than add capacity to existing ones. Then, it matters how much capacity there is to convert.

Predicting Capacity Bottlenecks

It is not easy to predict which sectors would be swamped by higher orders. There is little good data on either the defense share of sales or the ratio of total capacity (168 hours a week) to domestic demand (production adjusted for foreign trade). If a sample war economy is run through a input-output matrix, only a few problem sectors--forgings, for instance, arise. That cannot be right. Part of the problem is that the current Commerce Department data base is too grossly defined for conversion planning. A system that mixes commercial aircraft, military aircraft, and helicopters into one sector is a poor guide. Desultory data have informed DOD of many problem sectors including precision bearings, engineering plastics, and microwave tubes. But lacking better information; DOD cannot rank its problem areas or even know that it has accounted for all of them.

Much effort has been wasted determining which civilian sectors would be displaced by war. For gross totals, figure that civilian consumption will have to drop by the extent to which higher defense expenditures exceed the ability of a higher GNP to accommodate them. Housing and consumer durables are the sectors most likely to be affected; even in peacetime they are the first hit when interest rates rise, or disposable consumer income falls. This leaves only a few details to be resolved, reasonable differences in which are unlikely to make a large difference in assessing the country's conversion capability.

One area where industrial requirements do need work is industrial investment; can conversion can be supplied by the capacity inherent in the capital goods industries: machine tools, cranes, turbines, etc. Machine tool requirements are critical, given the parlous state of the industry and the fact that wars produce sharply increased demands in that sector. Input-output techniques cannot themselves predict investment requirements; data on conversion, expansion and modernization needs of war have to be calculated explicitly.

Foreign Dependence

It is quite common to hear industries asking for import relief cite their value to national security. True, many sectors of the economy have been so decimated by imports that they do not have the capacity left to support war requirements if these imports are cut off. But not every such sector is so entitled.

Two criteria should be met. One is that the industry supplies DOD to a significant extent in peacetime. A high proportion of import-impacted sectors fill consumer durable needs almost exclusively; such needs will, no doubt, decline under wartime conditions. Sectors which supply DOD (whose demand will jump) and, to a lesser extent, industrial investment (whose demand may rise) are generally in better shape.

Two is the speed at which capacity could grow in a wartime environment. Figure that the pacing bottlenecks are likely to come from industries like non-ferrous forgings which are so dependent on defense work, that they cannot meet war needs by cutting back on civilian production. Modest increases in production cannot be met without significantly more capacity. By contrast, sectors which can expand faster than the primary bottlenecks do not deserve as much national security attention. The remaining critical sectors are a small proportion of those which claim preference.

The final concern is for sectors whose capacity takes a long time to expand, such as metals and chemicals. MCDC's foreign source dependence study suggests that the National Defense Stockpile has enough surplus to meet its modest needs for new and upgraded materials via swaps and sales rather than new funding. Similar data are needed on which key chemicals could fall short.

A related concern is for industry's losing its technological edge, forcing DOD to a difficult choice between creating a new foreign dependence, or buying second rate technology from domestic vendors. So far, only in scattered subsectors does the United States lack a technological basis for reconstituting lost sectors in emergency. Others such as piezoelectricity, digital displays, key materials (electronic and high purity) and optics may reach that status soon if current trends continue. They, and others like them, should be watched lest a combined loss of capacity and increasing technological backwardness create an <u>irreversible</u> dependence on foreign technology. Perhaps an index can be developed to measure technology absorption of domestic firms compared to overseas ones.

That said, not all dependencies are vulnerabilities. Vulnerabilities involve the disposition and geography of the overseas source, as well as the extent to which the domestic economy can substitute for or work around the affected sources.

In many cases, creating competing overseas sources for military weapons and components helps rather than hurts a transition to war production. The United States would probably not be alone fighting the Soviets. Our allies would either be converting their economies at the same time, or, at least, be willing to sell military products to us. The more other countries know how to build military goods, the more easily they can supply us parts, subsystems, and weapons. This transfer would allow our forces access to a base which is several times greater than domestic base alone, at least for items whose technology we could transfer without security fears.

Conclusions

DOD's strategy for accelerating beyond surge should have two elements. The first would focus on whether the general economy has the capability to accept defense work; the second would see whether it has the capacity. The needed capability may be assured either by training commercial firms to think like DOD or by having DOD think commercially. The latter is preferable and should be started now. As for capacity, DOD, like everyone else, knows too little about the impact of higher defense expenditures on the rest of the economy, particularly on those sectors ravaged by import competition. DOD and/or Commerce should attend to the data requirements of this task.

8

THE FUTURE OF SURGE

Despite lagging defense budgets, DOD is coming to understand the proper place of surge and attendant considerations. Seven suggestions follow.

Amidst the enormous tasks undone to prepare industry, there are signs that DOD is moving toward policies which could make industry a real partner in the defense of the nation.

Of late, the credibility of nuclear deterrence as our primary strategy has become complicated by the proliferation of Soviet forces, and the potential elimination of certain theater nuclear weapons. The renewed interest in the capabilities of the military to undertake and sustain conventional conflict cannot fail to draw attention to industry's role. The recently completed Sustainability Policy Task Force Report should also help policy makers understand the importance of being able to finish wars that we only plan how to start.

Another impetus may stem from concerns for industry's ability to compete. A more modern production base has to help. So too, would a Government program that puts DOD in the lead for industrial strategies to regain competitiveness. Among its first acts would be to ensure that its production base employed manufacturing technology second to none. Implementing key parts of the Packard Commission report will help.

Within the planning community, the best vehicle for surge may lie with the Joint Industrial Mobilization Planning Process. Used as an instrument to rethink surge from the bottom up, it can link warfighting, procurement, and industrial strategy coherently. Surge planning will emerge as the analytic core, not a leftover branch. To do all this will require imagination and daring, but will repay its intellectual investment immeasurably.

Preparing for surge is not free, but, if done right, can be a bargain. Two trade-offs must be faced. One is trading resources (which might be used for buying weapons) for industrial capacity to make weapons quickly. The other is collecting information on industry to limit investments to those which industry could not support surge without. In the meantime DOD has work to do:

One: War planning should be revisited in order to change its orientation from the consequences of deployment to the prerequisites of successful outcomes. Budgets prevent us from building a force that can win or stop conventional wars on its own. This calls for ways to maintain, sustain, and build forces once need arises. The need for industrial surge would re-emerge and be thus integrated seamlessly into warfighting doctrine.

Two: Once a warfighting strategy has been determined, the material requirements of this strategy have to be determined. These requirements, coupled with a realistic understanding of what the base can provide, will be expressed as mobilization production targets. DOD needs a coherent set of production targets covering all services, as well as some allied requirements, as a basis for planning. These targets should include a methodology for prioritizing among competing claims.

Three: Prior to planning, DOD needs to develop a set of working rules which will govern wartime production. These rules should be optimized to ensure rapid production acceleration at the expense of cost, habit, and administrative convenience. For completeness, a list of current regulations to be waived must be compiled. Complementing these wartime rules should be wartime production specifications for individual weapons, a needed process, but one which should not hold up fixing the rules.

Four: OSD should impose a common basis for surge planning, specifying a uniform, but concise, set of data elements which directly support either pre-crisis investment or crisis allocation (see Appendix B). DOD should also specify a wartime environment consistent with its wartime production rules, and a softer environment appropriate for mid-sized wars or the imminence of major ones. The responsibility for good planning cannot be left to Service/program manager discretion; it is a command level function for command level decision making. A DOD-wide data base to hold this information follows.

Five: OSD should establish threshold criteria for judging the worth of investments to improve surge responsiveness under conditions of war, war's imminence, or a foreign-source cutoff. Weapons systems which meet the criteria would be required to have contract provisions which mandate prime contractors to meet certain production goals under specified contingencies. In addition, all weapons contracts should contain provisions which offer contingent incentives for accelerating delivery schedules which could be invoked in emergencies.

Six: DOD should undertake long range efforts to design weapons using components, parts, technologies, and producers from the commercial economy. Supporting this effort would be procurement changes which make its acquisition practices more akin to those of large US companies such as GM or IBM. Also complementary would be incentives, positive or negative, to push defense houses into producing high-technology products for the commercial marketplace.

Seven: No more studies.

APPENDIX A

HOW DOD SEES SURGE

DOD's current lack of action on surge, despite the increasing importance of being able to prevail in a conventional conflict, may be analyzed through both objectives and rhetoric.

Less than one-tenth of one percent of DOD's budget goes to preparing industry; virtually all other industrial base expenditures are used to support the current program. No more than a hundred DOD employees work preparedness issues (apart from facilities maintenance), if that; their grade structure must be described as modest. Industrial preparedness is given its due within defense documents, but mostly this is lip service, more akin to genuflection rather than commitment. And while industrial preparedness may be cited for relevant decisions, their true motivations are usually more immediate.

Objective Factors

DOD's attitude on preparing industry can be understood as an extreme example of its attitude toward sustainability in general. This in turn may reflect some key distinctions between conventional deterrence and warfighting. To the extent that deterrence works if it denies the aggressor the certainty of quick victory (qua Mearsheimer), defense policy will be geared to that end. Denying the enemy quick victory, of course, is not the same as denying it eventual victory. But many believe that the former is sufficient; nations will not commit aggression if they believe they have to face the costs of a long war, because no possible gains from victory would justify it.

Theories in turn imply policy choices. In particular, stopping a quick victory by the other side requires early striking power; it is keeping the aggressor stopped which requires sustainability. Deterrence places a high priority on being able to defend through inhibition. It emphasizes readiness (the ability to use credible force at any time) and mobility (the ability to do this anywhere). It also emphasizes the initial effectiveness of units by raising per-platform capabilities rather than counting on outlasting opponents through sheer numbers. By contrast, sustainability, beyond some initial amount, is irrelevant to the task of stopping aggressors quickly. It is thus ignored even though the lack of sustainability may mean that losing is the inevitable consequence of war.

Correspondingly, there is much more effort devoted to how to get into conflict expeditiously than to how to get out respectably. Operation plans of the CINCs have considerable detail on how to get forces to theater and then stop well within the first 180 days of combat, of which the first 60 days are paramount. With planning like that, laying up long-term supplies is less critical and gets only five percent of DOD's budget.

Can DOD's sustainability posture be otherwise justified with the argument that a large war is unlikely any time soon? This reasoning holds that we would have the time to buy supplies; but not necessarily to buy platforms and certainly not technology. Sustainability requirements would be important for the short wars which may arise on short notice. Perhaps. But this rationale, even if logical, is inconsistent with DOD's current spending levels for readiness and mobility into theaters (such as NATO's) which are unlikely to see any war other than a very large one

If sustainability, which affects forces over the second and third month of conflict, does poorly, is it any wonder that industrial preparedness, with its horizons beyond six months, does even worse? Ironically, planners find themselves most often fighting logisticians. The latter should be most sensitive to getting the most from industry but they are forced to worry about the very near term. As a class, they have a hard time seeing beyond their 60-day horizon and thus disparage the notion that extended warfare on our part is even possible. Industrial production is worth the worry only after the more acute first-order problem of insufficient reserves, a problem which never seems to get fixed.

Surge preparations are not helped by the fact that procurement is a Service responsibility. Many industrial investments, while benefiting all Services, must be borne by one. Services are also unlikely to spend money on war support capabilities, regardless of how useful, that lie outside their command. Most factors of war, after all, are subject to the hierarchy of orders. Industry is not; it can only be influenced and often in ways that are hard for the inexpert to grasp. It is easier to believe that industry's affairs are its own concern only. And last, the current military is most concerned with the beginnings of wars because that is when they and their units are most likely to be around to shape events. As wars go on, they are decreasingly fought by initial combatants and increasingly fought by ex-civilians. The attentions of the professional military wane correspondingly.

Rhetorical Factors

Those who would attempt to sell surge preparations to DOD officials have meanwhile run into a barrage of excuses for inaction, many of which seem logical but are flawed.

The first is a curious hybrid that holds, sometimes simultaneously, that the next major war will be too short for all industry to do anything or that it will be so long that industry would come through as they did in World War II. Some of this myth is left over from the dominance of nuclear warfare in strategic thinking. The rest bespeaks a misreading of both industry's performance in World War II for which it started earlier and took longer than remembered, plus the obvious difference that the US is now a front line power. It cannot start fighting at its convenience, and must engage itself credibly throughout the course of fighting, from beginning to end.

A related excuse is that industry is either so well equipped to surge that we need not worry, or so ill-equipped that fixing the problem would be prohibitive. No one in DOD now makes the first argument any more. Unfortunately the industrial preparedness planning community is only too eager to demonstrate how many problems there are and how difficult it is to fix them.

Much depends on how the industrial surge requirement, is defined. If surge has to replace all weaponry as fast as used, then the problem is impossible to fix affordably. If some lesser goals, such as production targets (see chapter six), are defined as the requirement, then the fix-up cost can be adjusted to whatever is affordable. The corresponding argument, that a lesser requirement provides inadequate capability, can be debated on its relative merits. As chapter three points out, the relationship between investment and added output can be as high as 15 to 1. Chapter four demonstrates that insurance against foreign source disruption can be bought for .2 cents on the dollar. The point is to concentrate on problems that have to be solved in advance (not those that can be bought off at the time) and set goals that can be met with reasonable resources.

A third excuse, peculiar to threat weapons (e.g. most PGMs), holds that if stocks are low, the United States will run out of weapons, and that the war will be over. If stocks are high, the need for additional procurement ends because weapons exist in sufficient quantity to kill every threat. In the small margin between too low and too high, surge is ill timed because programs are winding down. Hence, the system never needs surge.

This argument is hostage to its assumptions about platform deployment. The only way the Soviets could run us out of threat weapons (provided stocks are at least half of requirements) is to throw everything they have at US forces very quickly. Doing so entails taking very large chances. It is more likely that the enemy would not want to make such a large commitment except for strategic rather than logistic reasons. Sounder logic would argue for surge capability even when weapons stocks have a long way to go. Early in a conflict between two technologically advanced countries, kill ratios will be high--the battle envelope will be target rich and potential victims will not yet have learned how to avoid being hit. Later on, the kill ratios will fall. A stockpile which is oriented towards the first 60 days of war may be sufficient even if half full; but as war goes on, it may become increasingly inadequate as the ratio of hits to shots declines.

The next two rationales have also, unfortunately, been perpetuated by the industrial preparedness community in the false hope that they were making a complex problem simpler.

The fourth excuse is that the problems of wartime mobilization cannot be solved until the problems of peacetime surge are. This excuse results purely from semantic confusion. Surge, defined as the initial ramp-up, necessarily precedes mobilization. Surge, as DOD documentation has defined it, to be peacetime acceleration without civilian disruption, is only one possible precursor to mobilization. When planners say the problems of surge have to be solved first, they refer to the first definition; when they search for solutions they are invariably looking at the second official definition. The paradoxical result is that solving peacetime surge problems is perceived as too expensive, and solving wartime surge problems, which is cheaper, is stymied by the erroneous perception that the prior problem lies unsolved.

Finally, the fifth rationale is a by-product of graduated industrial mobilization conditions. Under its original INDCON version the need to plan and prepare for surge occupied steps on the crisis ladder which were one and two steps higher than current world conditions indicate. Such categorization only strengthens arguments against doing either now. Thus, while the notion of a graduated response has its uses, the implicit tendency is to assume that, because DOD would have a system for energizing itself in time, that it will in fact have the time to take advantage of the system.

APPENDIX B

INDUSTRIAL MOBILIZATION QUESTIONNAIRE

1. General product line (Defense oriented items)

____

   a. Approximate annual sales: __________ M$

2. What percentage of your production goes for:

________	Ordnance (components)
________	Other Defense Work
________	Other Government Work (e.g. NASA)
________	Commercial Civilian
100%	TOTAL

   a. How common is your Defense and non-Defense capacity?
      [ ] all common   [ ] all separate   [ ] N/A
      [ ] some operations are separate: ________________

   b. Can your non-Defense capacity be converted to Defense work within 30 days under mobilization conditions?
      [ ] Yes   [ ] No   [ ] N/A

   c. Do you produce parts for any of the following systems?

[ ] SIDEWINDER	[ ] SPARROW	[ ] PHOENIX	[ ] HARM
[ ] HARPOON	[ ] CRUISE MSL	[ ] STANDARD	[ ] MK-48 ADCAP
[ ] MK-46	[ ] IR MAVERICK	[ ] LASER MAVERICK	
[ ] HELLFIRE	[ ] SONOBUOYS	[ ] SKIPPER/LGB II	
[ ] FMU-139 FUSE		[ ] HAWK	

3. Production employees per work shift:

______ first shift
______ second shift
______ third shift
______ fourth shift (and/or weekends)

a. Capacity utilization of your first shift: ______ %

4. Does your production process require automated testing?

[ ] No
[ ] Yes, but only on a lot sample basis.
[ ] Yes, 100% testing is required for all units.

a. How many hours/week is your pacing test equipment run?

______

b. Does your production process require MTBF testing?

______

5. Your annual production (military items only) is usually produced:

[ ] in one annual batch
[ ] in smaller periodic (e.g. monthly) batches
[ ] on a continuous basis

6. Please supply the following information for products and/or product categories listed below:

Output and Capacity are measured in units; lead time in weeks, and make-buy ratio in percent. Capacity should assume a 24 hours a day, 7 days a week work pace and current product mix.

IN-HOUSE LEAD TIME is the minimum time required within the facility to produce the item. Now assumes 1986 conditions and product mix. War assumes around the clock production and maximum acceleration of Defense production without regard to cost or non-Defense work. TOTAL LEAD TIME includes subcomponent ordering.

MAKE-BUY RATIO: LONG LEAD refers to the percentage of selling costs accounted for by materials which cannot be acquired within 30 days even under highest priority conditions.

Product (category)	1986		LEAD TIME			MAKE-BUY	
	Output	Capacity	TOTAL	IN-HOUSE Now	War	All	Long Lead

7. Which critical components do you need that cannot be acquired within 30 days in sufficient quantity even under highest priority conditions? Include Government furnished items.

NOTE: Use weeks for ILT (installation lead time: how soon prior to your shipment is the product required) and PLT (procurement lead time). State refers to state, Canadian province, or country as appropriate.

[ ] general product line [ ] specific product ____________

			Primary Source			Alternative Source		
Name	ILT	PLT	Name	City	ST	Name	City	ST

8. MOBILIZATION. How much can your facility acceleration production under mobilization? Assume that production acceleration has absolute priority over all other objectives (cost minimization, regulations etc.). Your facility would work 24 hours a day, 7 days a week with all work stations filled. All nonessential commercial civilian production would be displaced in favor of defense production.

Can you meet the following five scenarios? If not, what is the minimum additional capacity that has to be in place for you to do so?

A: All DOD production would be doubled.
B: All DOD production would be tripled.
C: All DOD production would be increased fivefold.
D: Ordnance production alone would be tripled; other defense production would be maintained at current levels.
E: Same as Scenario D, but with alternative wartime product specifications whose adoption would not measurably affect the performance of the item in its first year of existence.

SCENARIO	Capacity Adequate	Capacity Inadequate, Need: Test Equipment	Tooling	Other
A (DOD 2X)	[ ]	________ $	____ $	___ $
B (DOD 3X)	[ ]	________ $	____ $	___ $
C (DOD 5X)	[ ]	________ $	____ $	___ $
D (Ordnance 3X)	[ ]	________ $	____ $	___ $
E (Alt-spec 3X)	[ ]	________ $	____ $	___ $
Months to get and install:		[ ]	[ ]	[ ]

a. How many weeks would it take you to get your facility's operations to full capacity levels <u>assuming the availability of material inputs</u>? ________________ Why? __________

____

____

b. Do you foresee difficulties in hiring up to full capacity operations? If so what skills would be potential bottlenecks? ______________________________

____

c. Which production and/or testing operations are likely to reach their capacity maximum rates, and in which order, as production expands?

1) ______________________________

2) ______________________________

3) ______________________________

4) ______________________________

d. How many weeks of production can you make from stocks on hand? ______________________________

e. How many weeks would it take you to ship ordnance at triple current rates <u>assuming you had the capacity and the work force in place</u>? ______________________________

9. How many weeks would it take you to double production of your defense items under peacetime emergency conditions?

Defense items in general ____________________

Ordnance items in particular ____________________

a. Would owning more capacity shorten this time any?
[ ] No [ ] Yes: ______________________________

____

10. FOREIGN SOURCE DEPENDENCE. If North America were cut off from overseas suppliers would you experience difficulties in any of the following areas? If so, please indicate what kind of problems, and their impact.

[ ] No known problems.

[ ] Problems in getting subcomponents and materials
[ ] Problems in accessing overseas production processes
[ ] Problems in repair foreign made machinery

Explain: ______________________________

____

____

____

____

____

____

____

Comments

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____

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APPENDIX C

REFERENCES

Note: Documents are listed in the order they were published.

US Congress. House of Representatives. Defense Industrial Base Panel of the Committee on Armed Services. The Ailing Industrial Base: Unready for Crisis. Report, 96th Congress, 2nd Session, December 1980

US Congress. House of Representatives. Committee on Armed Services. Capability of U.S. Defense Industrial Base. Hearings, 96th Congress, 2nd Session, December 1980

Office of the Undersecretary of Defense for Research and Engineering. Report of the Defense Science Board 1980 Summer Study Panel on Industrial Responsiveness. Washington D.C. January 1981.

Undersecretary of Defense for Research and Engineering. DOD Task Force to Improve Industrial Responsiveness: Summary Report. March 1982

McDonald-Douglas E2680. September 1983. Harpoon Missile Industrial Preparedness Planning Analysis Report.

Pratt & Whitney. Industrial Preparedness Planning Data for Aircraft Engines. September 1983. Contract N00019-82-C0216

Aeronautical Systems Division, United States Air Force Systems Command. Blueprint for Tomorrow. Joint Air Force/Industry Assessment of the Aerospace Industrial Base. January 1984.

Raytheon Co. The Industrial Preparedness Planning Study: Sparrow AIM/RIM-7M. May 1984. Contract N00019-83-C-0389

References

Office of the Joint Chiefs of Staff. Joint Service Production Base Analysis. Phase I: Prime Contractor Analysis. February 1985

R. T. Cheslow, F. Armbruster, G. W. Leonard, D. A. Perin, R. J. Ravera. A New Approach to Mobilization Planning: Case Study of Mk 46 Torpedo Production. Center for Naval Analysis Research Memorandum CRM 85-39. June 1985.

R. T. Cheslow, F. Armbruster, G. W. Leonard, R. J. Ravera. A New Approach to Mobilization Planning: Case Study of Sidewinder AIM-9M. Working Paper 85-1095. June 1985.

J.S. Hauger, J. Starns, D. Leech. A Study of the Effect of Foreign Dependency, Draft Final Report. Applied Concepts Corporation, The Analytic Sciences Corporation. October 1985. (Note: Classified Confidential)

Department of Defense. DOD Manual 4005.3-M: Industrial Preparedness Planning Manual. November 1985

Richard H. Van Atta., et al Technical Assessment of U.S. Electronics Dependency, Institute for Defense Analyses, November 1985

Office of the Joint Chiefs of Staff. Joint Service Production Base Analysis: Precision Guided Munitions. Phase II: Subcontractor Analysis. November 1985

McDonald-Douglas. Industrial Preparedness Planning Data for the F/A-18 Aircraft. June 1986. Contract N00019-84-C-0403.

MCDC Study, US Industrial Base Dependence/Vulnerability: Phase I--Survey of Literature Roderick L. Vawter, December 1986

R. T. Cheslow, D. R. Graham, P. H. Richanbach, K. L. Wilson. Mobilization Capability for the M-1 Abrams Tank and the Bradley Fighting Vehicle. Institute for Defense Analyses Paper P-1992. December 1986.

References

James H. Quinn, Frank E. Armbruster, John Thomas. Raytheon AIM/RIM-7 Sparrow Mobilization Study. Center for Naval Analysis. February 1987.

Aerospace Industrial Modernization Office (prepared by General Research Corporation) Gas Turbine Engine (GTE) Production Base Analysis Study: Final Report February, 1987.

TASC Corporation. Improving Intergovernmental Mobilization Planning: Preliminary INDCON and PERSON Systems. Volume 1: INDCON/PERSON Report. March 1987

Leonard Sullivan. Preliminary Report of the Sustainability Policy Task Force. March 1987

MCDC study, US Industrial Base Dependence/Vulnerability: Phase II--Analysis. Martin Libicki, Jack Nunn, William Taylor. November 1987.

APPENDIX D

ABBREVIATIONS

ADPA	American Defense Preparedness Association
ARA	Attitude reference assembly
CINC	Commander-in-Chief
CNA	Center for Naval Analysis
CNO	Chief of Naval Operations
DEFCON	Defense conditions
DINET	Defense Industrial Data Network
DOD	Department of Defense
FEMA	Federal Management Emergency Administration
FET	Field effect transistor
FMS	Foreign Military Sales
FRG	Federal Republic of Germany
FY	Fiscal Year
GaAs	Gallium arsenide
GFE	Government furnished equipment
GMR	Graduated Mobilization Response
GNP	Gross National Product
IC	Integrated Circuit
IDA	Institute for Defense Analysis
INDCON	Industrial conditions (now GMR)
IR	Infrared
IRA	Industrial Responsiveness Analysis
IRS	Industrial Responsiveness Simulation
JCS	Joint Chiefs of Staff
JIMPP	Joint Industrial Mobilization Planning Process
JLC	Joint Logistics Commanders
MCDC	Mobilization Concepts Development Center
MODSG	Mobilization and Deployment Steering Group (now MSG)
MTBF	Mean time between failure
NATO	North Atlantic Treaty Organization
OPLAN	Operation Plan
OSD	Office of the Secretary of Defense

ABBREVIATIONS

PA&E	Policy Analysis and Evaluation
PBA	Production Base Analysis
PGM	Precision-guided munition
PWB	Printed wiring board
RF	Radio frequency
SECDEF	Secretary of Defense
TASC	The Analytic Sciences Corporation
TFIRE	Task Force to Improve Industrial Responsiveness
USD(A)	Under Secretary of Defense, Acquisition
WRSA	War Reserve Stocks, Allies