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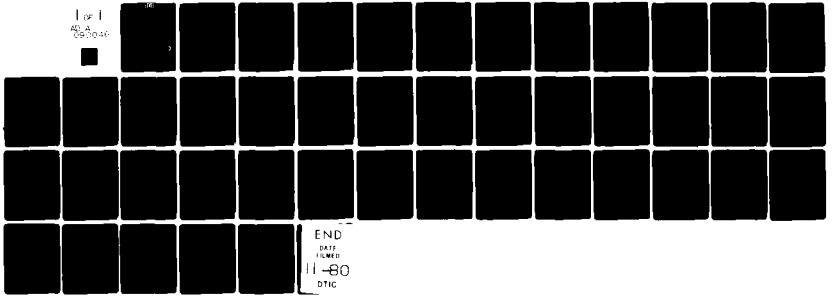

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U.S. ARMY COMMAND AND GENERAL STAFF COLLEGE

CURRENT TRENDS IN METRIC CONVERSION IN THE UNITED STATES: POTENTIAL TROUBLE FOR NATIONAL DEFENSE

By

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A RESEARCH STUDY SUBMITTED TO THE AIR FORCE FACULTY

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ABSTRACT

Conversion to the metric system of weights and measures in the United States appears inevitable, but is being prolonged due to present legislation which allows each industrial sector to convert voluntarily at its own desired pace. This study analyzes the impact of a prolonged dual-measurement system on military readiness and capabilities, and concludes that debilitating national defense problems will occur if the country does not soon embark on a course of authoritative centralized planning and leadership toward metrication in the shortest possible time. The study recommends that the Defense Department actively call on Congress to pursue such a course.

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EXECUTIVE SUMMARY

QUALIFIER: Part of the mission of the U.S. Army Command and General Staff College is distribution of student research products to interested DOD agencies to enhance the potential for new insights into Defense-related problems/issues. While the College has accepted this product as meeting academic requirements for graduation, the views and opinions expressed or implied are solely those of the author and should not be construed as carrying official sanction.

TITLE: CURRENT TRENDS IN METRIC CONVERSION IN THE UNITED STATES: POTENTIAL TROUBLE FOR NATIONAL DEFENSE.

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I. Purpose: To warn DOD of the potential deterioration of the nation's defense posture during a prolonged voluntary metric conversion period, and propose that DOD abandon its present "wait-and-see" policy by vocally appealing to Congress for immediate centralized government planning and leadership toward metrication in the shortest possible time.

II. Problem: Spurred by the automotive industry, voluntary conversion among major U.S. industries is snowballing while public resistance to metrication is stiffening. This confrontation threatens to indefinitely prolong a dual-measurement system which DOD could acceptably manage only for a relatively short, planned period of time. When the converting industrial sectors begin to overlap with those sectors avoiding metrication, DOD will be precariously caught in the middle because of its ongoing reliance on the overall industrial base. This dilemma, which could begin to adversely affect DOD inventories as early as the mid-1980s, could be resolved only by a centralized U.S. body given legislative authority for overall planning and leadership during conversion. To date, Congress has formulated no such body.

III. Data: Realities in the changing environment of international trade, paralleled by the profit-seeking characteristics of big business, have led to forecasts of inevitable metrication in the United States. Hesitation on the part of non-exporting industries, which have no profit incentive and fear U.S. consumer rejection of metric-dimensioned products, has stalled voluntary conversion. Related metrication issues were addressed to provide a framework of rationale for pro-metric and anti-metric sentiment. Then, a modelistic demonstration of the overall industrial base was developed and analyzed in an attempt to depict the eventual futility of DOD's present efforts to react to sector-by-sector metrication on a "wait-and-see" basis. Ultimately, two basic DOD alternatives were examined: 1) convince the nation to abandon metrication, or 2) convince the nation to proceed with a metric conversion program that is carefully planned and controlled to minimize conversion time, thereby reducing exposure to critical uncertainties associated with a prolonged dual-measurement system. In the final analysis, the first alternative was rejected.

IV. Conclusions: Based on the contention that the Defense Department cannot effectively manage the complexities of a dual-measurement system for an indefinite period of time, DOD must, in the interest of maintaining sufficient combat readiness, alert Congress to the immediate need for an authoritative, centralized metric conversion organization.

V. Recommendations: That the Department of Defense abandon its silent acceptance of the unacceptable status quo and implement a series of vocal and written appeals calling on Congress to recognize and act upon this potential threat to the nation's defense posture. In turn, DOD must prepare to accept its share of socioeconomic responsibility inherent in such a strategy.

CHAPTER I

INTRODUCTION

Background

> A system, by its very nature, is made up of interdependent elements. As such, actions which affect one element must affect others also. And actions of one element cause reactions on the part of others. The recognition of such interactions and interdependencies both within and without the organization is the essence of the systems viewpoint. (1:77)

The socioeconomic system in the United States consists of over 200 million people and a gross national product of over two trillion dollars. (5:592) It is a massive, complex phenomenon of interacting and interdependent elements; to even contemplate applying internal or external pressure to induce a comprehensive change on this system boggles the mind. Yet, such a change, the conversion of the U.S. customary system of weights and measures to the metric system (metrication) is presently in progress, although there has never been any direct internal or external mandate to do so. The change, viewed by opponents (and there are many) as radically revolutionary, actually appears to be evolutionary--an inevitable transformation spurred by international realities and the monolithic inertia of big business. As a result, the U.S. Department of Defense (DOD), a sprawling organization within the socioeconomic system (and long-time advocate of adherence to the "systems viewpoint"), is inextricably involved in this transformation.

The metric system has been legal in the United States since 1866, but has never been considered as usable as the customary system. In 1971,

largely due to prodding from economic, scientific, academic, and assorted "think-tank" groups, the U.S. National Bureau of Standards (NBS) conducted an intensive study to explore the supposed advantages of metrication in the United States. The Bureau's conclusion: ". . . it would be best for the nation to change to metric under a coordinated program that provides for flexibility and encourages the various sectors of society to deal with their particular problems voluntarily." (22:xvi) Subsequently, Congress conducted extensive hearings on the matter and, in 1975, passed the Metric Conversion Act, which established a national policy of planning and coordinating the increased use of the metric system in the United States, and formed a U.S. Metric Board to coordinate voluntary conversion. The Act and its legislative history show the national policy is not to prefer one system over the other, but to provide for either to be predominant on the basis of the voluntary actions of those affected. Thus, a national decision has never been made to begin compulsory conversion. (24:Ch 31, p 5)

Why, then, is metrication snowballing in the United States? There are two fundamental, interrelated reasons:

1) The United States is one of only four countries still using the customary system. (The others are Burma, South Yemen, and Brunei.) (10:8) Great Britain (the original source of the customary system) and all other industrialized nations have either completely converted to metric or are near completion. (16:23) U.S. imposition of an "obsolete" system in the international trade market is gradually becoming more difficult.

2) Seeing the economic drawbacks of jeopardizing trade with a world community that is growing unsympathetic to U.S. impositions, major U.S. industries and international wholesalers and retailers are increasingly manufacturing and marketing metric-dimensioned products. (9:61; 11:75; 17:49; 20:100)

The leading industry, not surprisingly, is General Motors (GM), whose overall influence is probably greater than any other single corporation in the United States; GM's goal: complete metrication by 1983. (8:22)

Due to GM's trailblazing, the entire U.S. automotive industry, including its suppliers (over 80,000), dealerships (about 32,000), and mechanics and other employees (over 1.3 million) are converting to the metric system. (24:Ch 11, pp 1, 30; 10:8) It is not difficult to predict the snowballing implications: in the mid-1980s, the automotive industry, its suppliers, and the massive webs of vendors (supplying the suppliers) will be becoming predominantly metric. Add to this (more appropriately, multiply) the array of nonautomotive-related industries that are presently converting (e.g., bottling, computers, construction, farm equipment), and the exponential evolution becomes quite apparent. (5:803) Unless a deliberate attempt is made to stop it, metrication in the United States is inevitable.

The Problem

A 1977 Gallup Poll revealed that 45 percent of the American people objected to converting, and that trends indicated this percentage was growing. (14:23; 15:77) Newsweek recently claimed an opposition margin of two to one. (10:8) The prognosis: it appears that the "irresistible force" (inevitable metrication) faces an "immovable object" (the people).

To deal with this imminent confrontation, either big business or the people must relent--or, more realistically, a mediator (logically the government) must negotiate mutual compromise. The problem, however, is that none of the above appear to be forthcoming, despite the fact that the U.S. General Accounting Office (GAO), following a lengthy study in October 1978, called on Congress to either mandate metrication or call the whole thing off, because ". . . the existence of a dual system for any length of time is impractical, inefficient, uneconomical, and confusing." (24:x) The Metric Board, as "coordinator," has no legislative power; its members are helpless to meaningfully arbitrate in the cross fire between

metric proponents and opponents. Jeffrey Odom, metric coordinator for the NBS (and one of the country's leading authorities on metric matters), used to be enthusiastic about conversion. (9:61) Now, he sees some tough problems looming: "If we just change where people think it's necessary, then we'll have an incredible mess. I'm afraid that's the way we're going." (7:B3)

The obvious reason why changes cannot be made only "where people think it's necessary" is because of the massive systems interactions and interdependencies involved. One example of literally millions: if new 1983 automobiles were to roll off the production line with only metric speedometers, all highway signs would have to include metric speed limits. This requires planning and implementation of exhaustive proportions--and this is only one example. In essence, U.S.-wide metric conversion is a systems management nightmare--an enormous conglomeration of interconnected elements--and there presently is no overall plan or leader! (6:7)

Significance of the Problem

This problem is significant to the Department of Defense because DOD is essentially in a precarious position between the two forces: inevitable metrication and public resistance. In its ongoing dependence on the industrial base, DOD must deal with two categories of suppliers: those proceeding with metrication, and those who resist metrication for fear of alienating and losing non-DOD customers. While metric conversion would be costly to DOD in many respects, studies have indicated that the costs would be manageable. (21:610) However, if the conversion period is prolonged due to the industry-consumer standoff, DOD costs will exponentially increase and could progressively threaten to adversely affect the national defense posture. Thus, the present voluntary, haphazard mix of two legal

measurement systems cannot be acceptable to DOD. Centralized government planning and leadership is essential.

Purpose of the Study

Following a tutorial of the substantive issues of metrication in the United States, this study will modelistically demonstrate the costly implications of a prolonged conversion period, warn of the potential dangers to national defense during such a period, and propose that DOD abandon its present "wait-and-see" policy by vocally advocating immediate centralized government planning and leadership toward metrication in the shortest possible time. While this proposal largely echoes the GAO call for Congressional action, it differs in two key respects: 1) it warns of potential trouble for the national defense posture, and 2) it rejects the alternative of abandoning metrication.

Scope of the Study

The metrication issue in the United States involves the whole socio-economic system. Virtually every tangible object, from raw material to finished product, is "measurement sensitive" (having one or a combination of standard dimension, weight, capacity, temperature, etc.), and is, when in use, related to other measurement-sensitive objects. These millions of interactions and interdependencies prohibit a segmented analysis of the problem. Therefore, the analytic approach must be broad--an overall look at a highly complex web and DOD's position within that web. Conversely, an analysis of the entire system in the necessary detail would be equally prohibitive. (The GAO study was several hundred pages long and exposed only the tip of the metrication iceberg.) As a result, very simplified models must be used to render the analysis manageable. This approach leads to the inherent risks of assumptions, generalizations, and abbre-

yiated parameters. Notwithstanding these limitations, the study strives to consolidate data gathered through research into a logical and intuitively acceptable comprehension of the "big picture." Toward this end, relevant variables and debatable points of view are interjected wherever deemed necessary in an attempt to fully support contentions and conclusions.

CHAPTER II

METRICATION: WHAT, WHO, AND WHY?

Changes Involved

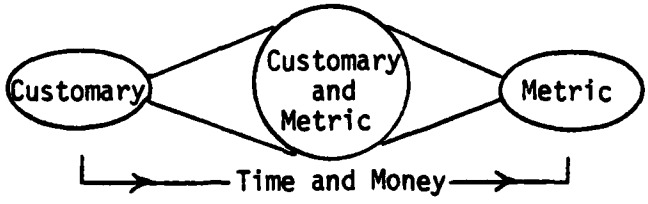
The international metric system of weights and measures consists of seven basic units: the meter (length), the kilogram (mass, or weight), the kelvin (temperature, which in common use is translated into the degree Celsius), the second (time), the ampere (electric current), the mole (substance), and the candela (luminous intensity). All other metric units are derived from these base units--e.g., the liter (volume, or capacity) is derived from the kilogram (one liter of water is exactly equivalent to the weight of one kilogram of water). Standard prefixes are added to give names for quantities of a particular unit that differ by multiples of ten. For length, a meter (slightly longer than a yard) multiplied by 1000 could be called a kilometer, as well as 1000 meters. If divided into 100 parts, each part could be called a centimeter, as well as 0.01 meter.

The U.S. customary system has base units also, but there are so many it would require several pages to list and define them all. For length alone, there are several base units--inch, foot, yard, and mile are the most commonly used. The reason each of these is considered a base unit is because there is no consistent reference point. While most people know how many feet are in a yard, few know how many inches, feet, or yards are in a mile. Metric equivalents can be readily converted by moving the decimal point; customary equivalents very often require a trip to the dictionary (e.g.,

how many fluid ounces are in a quart?).

Converting from customary units to metric equivalents (or vice versa) requires calculations. One yard is equivalent to 0.9144 meter, so to determine the metric equivalent of 15 yards requires multiplying 0.9144 by 15, or 13.716 meters. Therefore, changing everything in the United States that is measurement sensitive would require either mathematical computation (soft conversion) or physical change (hard conversion). For example, a basketball goal is ten feet high; a soft conversion would change the rule book to read 3.048 meters--a hard conversion would physically change the height of the goal to a more convenient (rounded) metric number, such as 3.0 or 3.1 meters (a two-inch change either way). Either conversion method is acceptable, but normally one is more practical than the other. It would be impractical (and unnecessary) to change the height of every U.S. basketball goal, so soft conversion would be preferable. However, many hard conversions would be practical and/or necessary, particularly among defense-related industries dealing in international markets.

Hard conversion of any measurement-sensitive element in the United States would involve three stages: sole customary, dual, and sole metric. Graphically:



For example, in 1960 all U.S. automobile engine bolts had customary dimensions. In about the year 1990, all (new and used) automobile engine bolts will be metric. In the interim, bolt suppliers are required to manufacture and maintain a suitable inventory of <u>both</u> types. The conversion period involves <u>time</u> and <u>money</u>, which further invlove:

--determining the best time to convert in order to minimize costs;
--agreeing on metric sizes;
--designing and producing in metric dimensions;
--training personnel in metric;
--obtaining metric supplies, tools, and machinery;
--changing laws, codes, ordinances, and regulations to accommodate the metric system;
--informing customers about metric products;
--remaining competitive in the market place; and
--putting up with the general inconvenience of using two systems.

Quite simply, converting to the metric system means thinking, hearing, and seeing things in metrics. The impact would surprise many Americans and affect them all in many and varied ways. (24:ii)

Purported Benefits

Why should the United States be embarking on such a mammoth undertaking? Why discard a tried-and-true system and start all over with a "foreign" one? Metric proponents have cited four primary reasons:

1. The metric system is a planned, more rational, simple, and coherent system. Prefixes or decimal movements allow expansion and contraction of all basic units to fit the full measurement range with a base number of ten. Calculations are made easier because there is no need to intermix unlike components such as feet and yards, nor to wrestle with fractions. As a result, the metric system is easier to teach (particularly to young students), learn, and use, ultimately providing benefits of less calculation time with fewer errors. (Refer to Appendix A for a typical example of a "scenario" demonstrating metric efficiency.)

2. Conversion would improve or help maintain the U.S. foreign trade position. The U.S. economy is becoming increasingly dependent on foreign countries for raw materials, manufactured products, and technological improvements. The United States puts itself at a competitive disadvantage by using a measurement system different from that of the world market. The

emerging nations of Asia, Africa, and Latin America represent vast new markets that, along with the established industrial countries, deal primarily in metric units. (Many of these countries now expressly prohibit non-metric imports.) The deteriorating U.S. balance of international payments would be aided immensely by metric conversion. (24:Ch 3, p 3) (This benefit will be analyzed further when discussing conversion cost in Chapter III.)

3. Conversion would provide opportunities for standardization, rationalization (reduction of items), and other worthwhile changes. Faced with the task of doing things differently, industry would take the opportunity to "clean house" of the unnecessary myriad of sizes, shapes, weights, etc., presently in existence. For example, the worker in the office or home who runs out of his supply of staples would not be faced with searching for the one of over 100 marketed staple sizes needed to fit the stapler. Done right, metrication would "start us over" with just two or three needed sizes. From an industry-wide standpoint, these collateral benefits of standardization and rationalization (both domestically and internationally), and replacement of obsolete machinery, equipment, and parts, would result in significant long-run improvements in trade, productivity, and efficiency. (24:Ch 3, p 3; 16:23)

4. Conversion will never cost less than it will cost now. The "ripple effect" of big business conversion is making conversion inevitable. Proceeding in a disorganized and divided fashion will prolong metrication costs. Clinging to the customary system will, in the long term, have only one predictable outcome: a profuse waste of time and money. (24:Ch 3, p 4)

These are persuasive arguments, and their validity tends to be borne out by the actions of GM and the growing conversion of overall U.S. industry. John Donnelly of the U.S. Metric Board concludes: ". . . about 300

of the Fortune 500 companies have changed in whole or in part to the metric system. Business doesn't do this for altruistic reasons. These companies are converting because they think there are bottom-line benefits." (8:Sect IV, p 22) Nevertheless, it is generally accepted that "there is no such thing as a free lunch." The next chapter will look at the major hurdles standing in the path leading to these benefits.

CHAPTER III

CONVERSION PROBLEMS AND OBSTACLES

Public Resistance

Metric conversion faces widespread opposition in the United States. Small businesses fear the short-term conversion costs; marketing experts predict consumer rejection of metric products; the packaging industry abhors the labeling nuisance. But the greatest howls of protest are heard from average, everyday citizens who have no rationale for their objections other than plain old "resistance to change." For example, consider the following excerpt from a "Letter to the Editor" in the February 1978 Science Digest: "It is a proven fact that the inch is more accurate (than the centimeter)." (14:89) While this faulty argument against metrication is humorous, it is, unfortunately, a typical example of Americans' inability to cope with change. Metric opposition is largely due to unfamiliarity with an alien "language" that is unjustifiably perceived as either inferior or too complicated, or both.

Jeffrey Odom of the NBS, while reviewing the anti-metric 1977 Gallup Poll, noted that 26 percent of those polled had never heard of the metric system. He observed: ". . . resistance to change is especially obvious in an area where people aren't quite sure what they're changing to." (9:61) Other events have not helped dissuade metric haters. At a meeting of the National Association of Consumer Agency Administrators, the metric topic was squeezed into the program in a last-minute movie entitled "The Metric

Threat," a description which some consumer proponents understandably critiqued as "a little sensational." (6:7) And, not to be outdone, members of the National Cowboy Hall of Fame have filed suit against the government for its conversion support, maintaining that the West was won "inch by inch, foot by foot, and mile by mile." (10:8)

Despite being laced with irrationality, public resistance to metrication cannot be disregarded. The law of supply and demand is still the driving force in American economics. For businessmen to ignore consumer attitudes, logical or not, could be disastrous to their financial survival. Therefore, better efforts toward metric education of the public appear to be needed.

Education

To date, metric education efforts in the United States have been dismal failures. Two notable examples:

> 1) During the mid-1970s, the Federal Highway Administration spent $100 million on highway signs that displayed distance and speed limits in both miles and kilometers. The objective: educate the public in preparation for a full conversion by 1982. The result: the project was abandoned indefinitely due to overwhelming public opposition. (3:522) Drivers had no conception of a kilometer, found the mathematical conversion too difficult to do mentally (this mental preoccupation and confusion also worried safety experts), and began to ignore the metric equivalents. The counterproductive consequence: displaying customary and metric values side by side began conditioning the public to regard metrics as a complicated nuisance. (2:116)
>
> 2) The National Weather Service withdrew indefinitely its plan to give forecasts and measurements in metric units, due to events similar to those experienced by the FHA. The consequence was the same: the public was being turned off to Celsius in specific and metrics in general. (7:B3)

These and other abortive attempts at metric education reveal one undeniable premise: metrics will be ignored as long as customary equivalents are available. It appears the only effective way to teach metrics will be

to go "cold turkey" whenever and wherever possible. (Refer to Appendix B for one version of a simple "metric guide" with no references to customary measurements.) This cram-it-down-their-throat method would not be easily sold, but there are areas where it would be extremely beneficial. For example, if all American sports were converted to metrics, the exposure would be immense, particularly through television. Moreover, the sporting events themselves would be unaffected, and the public would not be endangered or inconvenienced.

While effective metric education of the public is probably the single most critical challenge in overcoming the public-resistance obstacle, it is not a panacea for other conversion problems. As mentioned earlier, small businesses have a great fear of metrication--the fear that conversion costs (and/or loss of the big-business customer) will threaten their survival.

Cost

No country with the combined population and economic size of the United States has ever attempted metric conversion. The total monetary cost will be staggering--some estimates have put it at $100 billion. (10:13) However, many economists now contend that most estimates are way off, for two reasons. First of all, GM has found that actual metrication costs thus far have been only one percent of their original estimates. (8:Sect IV, p 22) Other companies have experienced similar overestimates. Part of the reason is that costs are passed on, through increased prices, to consumers, who must ultimately bear the burden of metrication costs. (To date, the government has not and does not intend to help absorb any private conversion costs.) Double, triple, and even quadruple counting had occurred in the original aggregate estimates, when only one buyer in the chain was

paying the conversion costs. Further, these costs have been so widely spread among buyers that the impact on each has been, thus far, virtually unnoticeable. Nevertheless, many small businesses do not have the means to bear the initial expense of dual customary/metric inventories, retooling, employee training, and other conversion start-up costs. And consumers are reluctant to pay increased prices for any reason, so their reaction to knowingly paying for a system perceived as worthless could be quite easily predicted.

The second reason it is difficult to predict conversion costs is because the time it takes to convert will affect estimates considerably. The NBS, in a report to Congress in 1971, stressed that metric conversion should not be prolonged, and pushed for a ten-year planned program. In an attempt to convince those who could not grasp the cost advantages of rapid conversion, it sought to quantify the dollar costs and benefits associated with conversion. Through exhaustive research and polling, the NBS provided a conservative estimate for U.S. manufacturing firms alone. Their data:

Aggregate Net Costs	With 10-Year Program	With NO Program
Conversion Cost per Year	$ 1.0 Billion	$ .2 Billion
Dual-Capability Cost per Year	.5 Billion	.5 Billion
Total Yearly Cost	$ 1.5 Billion	$ .7 Billion

Benefits in international trade per year, once the nation becomes metric: $600 million. Using a multiplier of 2 or 3 (obtained from Paul A. Samuelson's basic text, Economics), the benefit would be $1.2 to $1.8 billion. Remaining conservative, the NBS used $1 Billion as its yearly benefit, and constructed a cost/benefit chart similar to the one in Figure 1. (Note: the NBS assumed other benefits not included in Figure 1;

thus, the chart is even more conservative than that developed by the NBS.

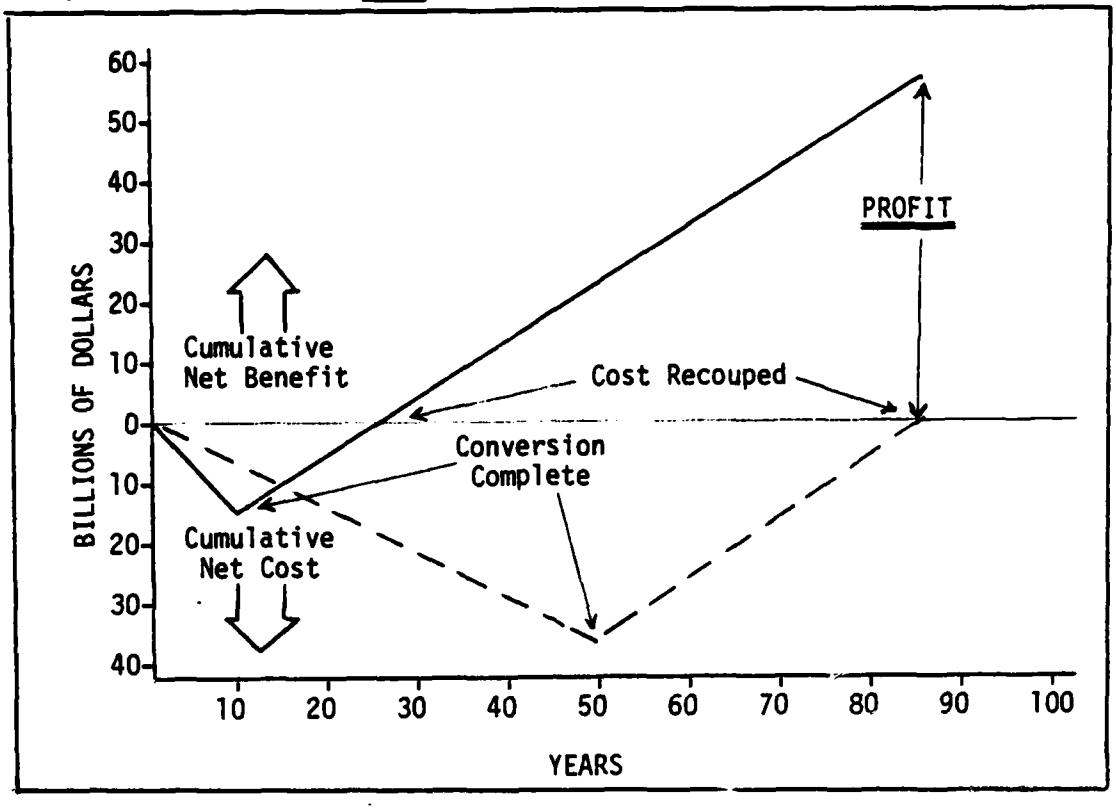


Fig. 1.--The Economic Advantage of Planned Metrication

The solid line on the chart shows that with a 10-year program, costs would total $15 billion, then benefits would begin to accrue at $1 billion per year until, after 25 years, the costs would be recouped and benefits would be totally realized thereafter. The dashed line shows that without a planned program (and assuming total conversion evolution would take a minimum of 50 years), costs would total $35 billion, and accrued benefits would not recoup these costs for a total of 85 years. By that time, the 10-year program would have shown a $60 billion "profit." (22:Ch IX, pp 98-110) To reemphasize: the NBS used very conservative data, for the manufacturing industry alone (not including construction, electrical, wholesaling, retailing, etc.). At the other extreme, metric proponents

have estimated that annual foreign market benefits could be as high as $10 to $25 billion annually. (4:937) While this may be unrealistically optimistic, it is a tempting panacea for the ailing U.S. balance of international payments.

It is obvious that aggregate conversion costs are indeed staggering in the short term--some small businesses could go under without government aid. In the long term, metrication costs are sunk and sizeable benefits would theoretically accrue. With a planned program, most medium and large businesses would have little financial difficulty converting. But with no plan, a larger proportion of business could be adversely affected. The bottom line: nation-wide voluntary conversion without coordinated planning is, to put it mildly, economically unsound.

CHAPTER IV

THE METRICATION IMPACT ON DOD: A MODELISTIC DEMONSTRATION

Hypothetical Case Study: "Company M" Goes Metric

A purported major benefit of metrication in the United States is expanding or, as a minimum, retaining present international trade markets. Metrication opponents argue that too few U.S. business firms will reap these benefits, and that too many U.S. consumers and taxpayers will incur the costs. Proponents counter by contending that while the firms reaping substantial benefits may be "few," their collective economic size is sufficient to effect export gains beneficial to the economy as a whole, thereby benefiting all. The following miniature case study and analysis of a hypothetical firm's venture into the metric world market will further examine the financial aspects of conversion. The case is purposely simplified to aid in grasping the economic benefits of metrication, yet is not so simplified that it will ignore important variables in the analysis process--these variables will be addressed at appropriate intervals.

In 1970, U.S. Company M manufactured and marketed Product M in customary dimensions. Foreign Company X used a product virtually identical in composition, price, and quality but, needing (or preferring) this product in metric dimensions, imported it from Foreign Company Y. Company M, realizing the necessity to penetrate this market to increase sales of its product, decided to produce it in metric dimensions. Before

proceeding, the company reviewed its monthly financial and market position, summarized in Table I.

Table I.--Company M Prior to Producing Metric Units

	PRODUCT M				
	$ Per Unit		Monthly Quantity Produced & Sold (maximum U.S. market)		Total
Sales	$ 200	X	1000	=	$ 200,000
Cost	$ 180	X	1000	=	180,000
Monthly Profit					$ 20,000
Profit Margin					10 %

The company determined it had the production capacity to produce 100 additional units per month. Since the U.S. market would not buy these units, they would be produced in metric dimensions for Country X, who would pay the same $200 price per unit.

Following production of the 100 metric units, the company discovered that the costs of retooling, capital investment, training, and reduced efficiency (caused by initial metric unfamiliarity), coupled with the inherent cost disadvantages of a limited production run, resulted in a unit cost of $250. Since Foreign Company X would pay no more than $200 per unit (it could still buy for that price from Foreign Company Y), M was forced to sell them at a loss of $5000 ($50 loss per unit X 100 units). But Company M did not in fact lose $5000; a look at the following month's financial summary reveals why (see Table II).

The company recovered the loss by increasing the price of its U.S. product to $205. The 2 1/2 percent price increase was not significant enough to adversely affect their market share--all 1000 units were sold.

(Actually, some drop in units sold would occur, resulting in a slight profit decrease. For simplicity, this probability was ignored because any decrease would be offset in later months due to reduced metric costs.)

Table II.--Company M After First Metric Production Run

PRODUCT M								
	U.S. Market (Customary)				Foreign Company X (Metric)			
	$ Per Unit	Monthly Quantity		Total	$ Per Unit	Monthly Quantity		Total
Sales	$ 205	X 1000	=	$ 205,000	$ 200	X 100	=	$ 20,000
Cost	$ 180	X 1000	=	180,000	$ 250	X 100	=	25,000
Profit (Loss)				$ 25,000				($ 5,000)
Monthly Net Profit				$ 20,000				
Profit Margin				8.9%				

Meanwhile, U.S. export sales increased $20,000 per month, and a multiplier of 2 to 3 promised an overall benefit of $40,000 to $60,000 to the U.S. economy, at a cost of only $5,000 (paid by the U.S. consumers). (A multiplier is an economist's coefficient showing the resultant increase in U.S. gross national product from each increase in export sales. A multiplier of 2 assumes 1/2 of M's new foreign income ($10,000) was spent by its ultimate recipients (e.g., M's employees and suppliers) in the U.S. market, the other 1/2 being saved or used to buy imported goods. Then, 1/2 of this spending ($5,000) was, in turn, respent by its recipients. This respending spiral continued in geometric progression which, when carried to its conclusion, totaled an additional $20,000. A multiplier of 3 assumes 2/3 was respent in the spiral, totaling an additional $40,000.)

Finally, Company M had borne the brunt of conversion costs; before long, the unit cost of the metric product fell to less than $200, and profits mounted. Ultimately, the company, due to its U.S. market power, announced plans to eventually produce Product M in solely metric dimen-

sions, with conversion to be complete by 1980. Why? Because production of 1100 metric units per month would cost only $175 per unit.

A re-examination of this analysis raises some questions. First, was not the price increase of $5 per unit inflationary? The answer could be yes in the short run, but probably no in the long run. The price increase paid for a temporarily high cost of production. While it is unlikely that the company lowered its price back to $200 when conversion costs were complete, it is equally unlikely that the company would be anxious to soon again raise the price to meet, for example, increased labor costs, because market demand could be adversely affected. In other words, the company would, in the long run, simply strive to re-establish the original 10 percent profit margin. Further, U.S. exports themselves lower the rate of inflation by increasing the demand for dollars abroad, thereby raising the value of the dollar and cutting the real cost of imports. (18:726)

Second, was not much of the conversion cost probably paid to foreign countries to obtain metric items, and, if so, did not imports offset the export benefits? This question typifies a valid argument against metrication, but is, again, applicable only in the short run. Even if the company paid substantial amounts to foreign markets for metric parts, thereby reducing the net export benefit, U.S. suppliers, in the interest of survival, would move rapidly to fill the void. Soon, those of Company M's suppliers who needed to maintain Company M as a customer would manufacture and supply metric parts.

To summarize to this point, Company M has penetrated a foreign market, increased U.S. exports with resulting macro-economic benefits, increased its own sales and profits, and, ultimately, seeing further profits to be gained by totally converting to metric, alerted its customers and suppliers

of its intent to do so.

The DOD Tie-In

(Refer to Figure 2.) Company M has three suppliers, S1, S2, and S3, who are converting to metric to retain Company M's business. The Department of Defense has an inventory item, Weapon A, which has a 10-year operating life remaining. Weapon A includes three interconnecting components requiring frequent replacement. These three components are supplied by S3, S4, and S5--S4 and S5 are not metric companies.

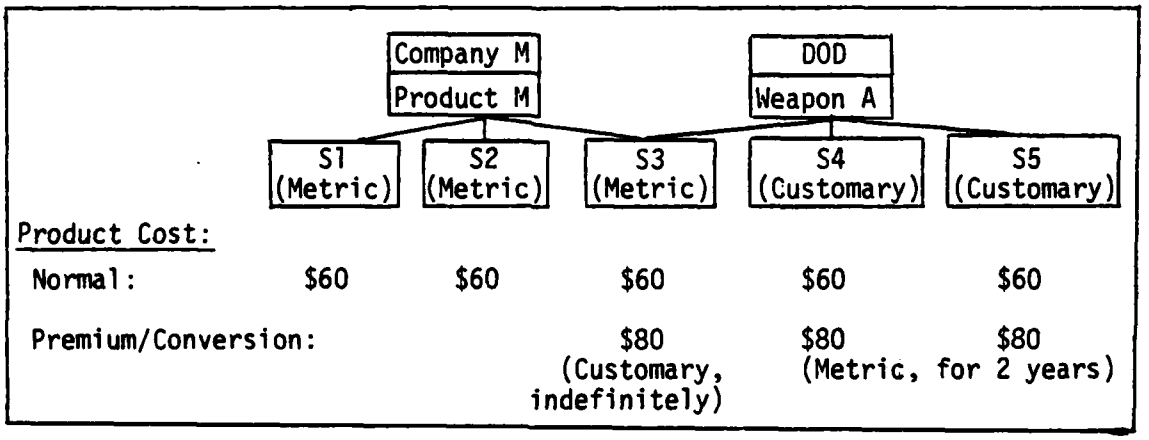


Fig. 2.--DOD Tie-In to Company M

In 1980, DOD finds that S3, now predominantly metric, is demanding a premium price for the customary version of its product. Faced with the unwanted increase in cost, DOD turns to S4 and S5 and requests them to convert to metric. S4 and S5 agree, but stipulate that their prices would increase during conversion, estimated to take two years. DOD has two choices: 1) pay S3 the premium price, or 2) pay S4 and S5 the conversion price.

The normal DOD cost of $180 for the three components would be increased $20 by remaining customary, or $40 by switching to metric. At first glance, choice number one appears best--but it is not best in the long term. If DOD purchases 10,000 components over the next 10 years (1000 per year), the total premium cost, paid to S3, will be $200,000.

On closer examination, DOD realizes that S4 and S5 can be fully converted in two years, at which time the $60 unit cost will be reinstated; total metric conversion cost to DOD: $40 X 1000 units/year X 2 years = $80,000. Result: DOD would save $120,000 by "paying" S4 and S5 to go metric. (A logical argument to this analysis is that DOD could find another supplier to replace S3. For the time being, this model assumes that either S3 is the only supplier, or that all other suppliers of this item have also gone metric.)

So far, it appears DOD has the situation in hand. While it will suffer an $80,000 cost increase due to metrication, it will have minimized long-term costs by avoiding the premium customary price.

However, consider a wrinkle in the model. (Refer to Figure 3.)

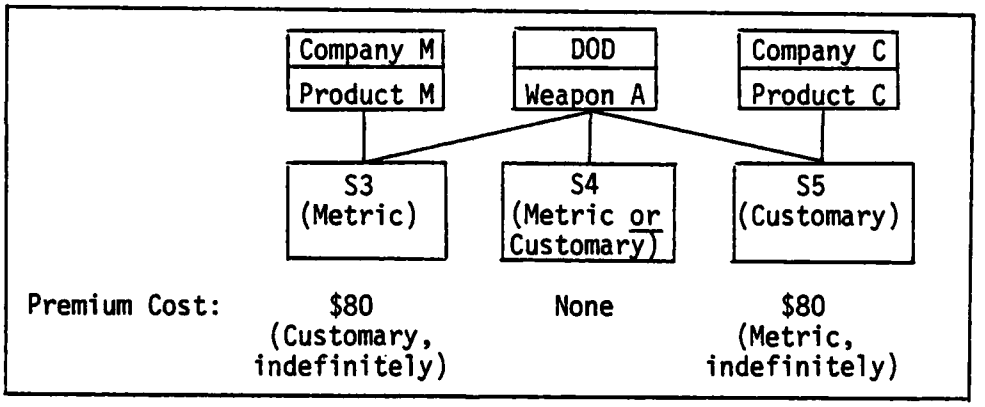


Fig. 3.--DOD Tie-In to Companies M and C

Assume that S5 cannot convert to predominantly metric, because it is economically dependent on the business of another customer, Company C, and the latter refuses to go metric. DOD's problem takes on a new twist: DOD must pay the $20 increased price indefinitely, no matter which choice it makes. DOD can pursue the matter in two directions: 1) try to convince Company M to return to customary, or 2) try to convince Company C to adopt metric. Company M refuses for financial reasons (they would

lose their enhanced profitability); Company C refuses because it has solely U.S. customers who, C fears, would reject a metric product and turn to C's competitors. DOD is now in the vice between "irreversible" metrication and "immovable" public opposition.

As if the cost burden in this dilemma is not bad enough, DOD is faced with other potentially serious problems as well. If DOD opts to remain with the customary unit, what will happen to the quality of the product supplied by S3? Will the reduced attention in production result in a degraded product? If so, how will reliability and maintainability be affected--or, even more ominous, will the safety of Weapon A be affected? Further, will S3 be able to produce customary units in the quantity DOD requires--will availability be affected? Finally, S3 may decide to disband customary production altogether, forcing DOD to find another manufacturer willing to produce the item, but at a prohibitive price. Would DOD, in a worst case, be forced to scrap Weapon A for lack of an essential component?

Conversely, if DOD opts to take the metric alternative (by finding a metric supplier to replace S5), reliability, maintainability, safety, and other critical operational effectiveness and suitability considerations will all have to be re-evaluated, just as they were in the original acquisition process. What if a significant deficiency is discovered? Can DOD live without Weapon A until it is resolved? If so, for how long?

DOD Alternatives

Given the collective costs and uncertainties revealed by the model and, in turn, the questions raised above, and spreading them over the entire DOD inventory, the potential implications become severe. How will overall readiness posture be affected?--deployability?--resupply?--sus-

tenance during crisis action relocation or actual combat operations? Simplistically, there is a way to avoid these dilemmas: prevent the situation predicted in the model from occurring in the first place--but how? There are basically two alternatives open to DOD: 1) convince the nation to remain with the customary system, or 2) convince the nation to proceed with a metric conversion program that is carefully planned and controlled to minimize conversion time, thereby reducing the exposure to premium costs and other critical uncertainties associated with a prolonged dual-measurement system. From a systems viewpoint, this second alternative would require centralized government leadership.

CHAPTER V

THE STRATEGY DOD MUST PURSUE

Rejection of Alternative Number 1 (Abandoning Metrication)

For DOD to attempt to convince the nation to remain with the customary system is neither feasible nor wise, for three fundamental reasons. First of all, DOD is not, nor has it ever been, opposed to metrication. As early as 1971 DOD concluded:

> Metrication within the DOD appears feasible provided sufficient and timely resources are made available and a national conversion schedule is adhered to by industry and DOD. It is imperative that close coordination be maintained between DOD and industry. Lack of such coordination will extend the conversion process and greatly increase the costs of conversion. (23:10)

While this conclusion erroneously assumed a national conversion schedule would be developed, it did correctly reflect DOD studies that, after careful weighing of estimated metrication costs and benefits, acknowledged the long-term advantages. Following further studies conducted through 1975, DOD still did not consider the direct dollar costs of conversion a matter of undue concern (although concern <u>was</u> beginning to mount over the uncoordinated proliferation of voluntary conversion, and the resultant specter of <u>prolonged</u> conversion). (21:610)

On 10 December 1976, DOD issued a formal policy directive favoring increased use of metric units and products for DOD and the individual services. (24:Ch 22, p 11) Significant long-term benefits such as increased operational efficiency and enhanced NATO standardization, rationalization, and interchangeability were deemed worth the short-term costs

and inconveniences of metric training, dual inventories, and the like. In essence, DOD has from the outset considered the metric system, once adopted, preferable to the customary system; to attempt a strategy involving reversal of years of pro-metric conclusions would hardly be credible.

Second, those industries pursuing voluntary conversion, from GM on down, would have to be asked or told to return to sole customary usage. This would require some very healthy "understanding" on the part of 300 or more large companies who would not be anxious to forego their "bottom-line benefits." It is not far-fetched to assume that legislation outlawing the use of the metric system in the United States would be required. It is highly doubtful that Congress could overcome the lobbying against such proposed legislation.

Third, and probably most important, is the international trade aspect. Over the long term, the economic advantages gleaned through exports of metric-dimensioned goods cannot be convincingly denied. Further, as noted in Chapter II, the United States no longer has tight control over international economic events--it is increasingly dependent on foreign raw materials, export markets, and technological cooperation. C. William Verity, Chairman of Armco, Inc., recently provided an analysis typical of many that have been stressed in recent months:

> The United States is still the biggest, most successful and most envied nation in the world. Yet no longer can we snap our fingers and change the course of events. We can't on our own reshape the world even to fit our most earnest and finest principles, much less our every whim and fancy. (18:723)

The adamant retention of the customary system is understandably perceived by many nations in the metric world as a "whim" of the United States; it cannot be freely imposed on the world much longer. When the U.S. aerospace industry, the last stronghold of global imposition of the

customary system (24:Ch 15, p 13), begins to meet foreign resistance, the metrication snowball will roll at unprecedented speed.

Turning back is not a viable alternative. Even if such a strategy was tried and proved temporarily successful, the changing international environment would not allow it to last. The whole conversion process would have to be re-initiated, and previously sunk costs would be wasted. The only sensible alternative is to forge ahead--but properly.

The Optimum Strategy: Alternative Number 2 (Centralized Planning, Leadership, and Control of Metrication)

In 1975, during hearings before the House Subcommittee on Science, Research, and Technology, Dr. Joseph L. Ryerson, Chairman of the DOD Metrication Panel, submitted in a prepared statement:

> Defense related industries are moving toward conversion to the International System of Metric Units (SI) at vastly different rates which are generally dependent upon economics of metrication in each industrial sector. For example, the automotive sector of industry has firm metrication plans and is moving in accordance with relatively firm milestones while the aerospace and armaments sectors are not formally moving to metricate and apparently have no plans to do so in the near future. This wide industry variance dictates that each sector be considered on an individual basis. (21:586)

Dr. Ryerson's observation correctly acknowledged the fact that the lack of a centralized government plan necessitated a concerted DOD effort to adapt to industry's uncoordinated metrication pace. However, it questionably concluded that DOD conversion should be accomplished on a sector-by-sector basis, apparently assuming that the national schedule, if ever developed, would also take this approach. A primary objective of the modelistic demonstration in Chapter IV was to warn of the eventual futility of such an approach. From an overall systems viewpoint, the various sectors cannot be so easily segregated--interdependencies and interactions are too prolifically interwoven to locate logical points of dis-

section. One case in point: General Motors recently received a $3 million Air Force contract for jet engine parts. (19:6) How can this transaction be neatly "sectored" into the automotive industry without regard for potential ripples in the aerospace industry?

The Department of Defense can no longer justify a "wait-and-see" strategy. Manageable conversion problems will become unmanageable if allowed to remain and build within a dual-measurement system. On the other hand, neither can DOD lead or direct U.S.-wide metrication. For example, recent Air Force specifications for the new MX missile required the use of metric units in system design and manufacture. When contractors complained about the retooling costs (the contract obviously stipulated that the Air Force was not required to pay these costs), the Air Force backed down from the metric requirements. (12:55) In this case, the Air Force attempted a "leadership" role by recommending conversion for companies not yet embarked on voluntary metrication. Dr. Ryerson was, in 1975, quite prophetic when he asserted: ". . . I've never, and I hope that no one in DOD has ever, recommended that we become leaders in this field." (21:610)

DOD must remain a willing metric customer, but not a demanding one. Leadership can come only from a disinterested, centralized government body given Congressional sanction to plan, direct, and control metrication throughout the overall socioeconomic system. DOD can only vocally appeal to Congress to take such action, but must do so before prolonged, uncoordinated conversion results in a deteriorated national defense posture. Without such action, this deterioration could begin to appear in the mid-1980s and become progressively more serious in the years that follow.

If this strategy is pursued aggressively, the Defense Department should not have undue difficulty convincing Congress of the dangers of having a

confused and cost-burdened defense force caused by a dual-measurement system. Nevertheless, to further assure the legislators that prompt action is highly advisable, the following summary from the 1978 GAO study (24:Ch 30) provides a formidable arsenal of reminders from the recent conversion experiences of Australia, Canada, New Zealand, and the United Kingdom. Their unanimous "lessons learned" (most of them the hard way):

> --A clear and firm government commitment on metrication is essential. Conversion problems will be extreme without such a commitment.
>
> --The country must have a centralized metric organization responsible for planning and coordinating conversion. A well-developed plan must be prepared and effectively implemented.
>
> --A voluntary conversion program eventually becomes mandatory. Delaying this inevitability leads to hardships and setbacks when the shock of mandatory conversion hits unprepared socioeconomic sectors.
>
> --Overall and specific target dates must be established and followed. (Most U.S. firms consider 15 years to be the optimum conversion period.)
>
> --Educating the general public is essential. The public must be taught metrics and be kept informed of metrication progress. The use of sports was one effective way to aid education of the public.

Hopefully, the United States will not have to relearn these lessons. However, if the metrication status quo is allowed to continue, "hard knocks" appear inevitable. The nation's defense community, with its sweeping global commitments, cannot afford to bear these unnecessary hardships. DOD must begin sounding the alarm.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

William C. Norris, founder, chairman, and chief executive officer of Control Data Corporation, recently wrote a thought-provoking article expressing his diagnosis of today's U.S. socioeconomic system. Some excerpts:

> Roaring inflation, persistent unemployment and underemployment, a weakened U.S. dollar, an eroding standard of living, and other woes are due in large part to a paralysis of fortitude in our society. Too few of us are ready to take the risks necessary to solve our problems. We lack the will to accommodate the changes that creative approaches to our social and economic ills demand. . . . everyone is out for himself. Perhaps the best one-line summary of our society today is that the pioneering spirit epitomized by the phrase "go west, young man," has been replaced with the shortsighted negative implications of the question, "What have you done for me lately?" (13:20)

Recent trends in metrication in the United States have revealed a "paralytic" unwillingness on the part of individual segments of the U.S. socioeconomic system to bear some short-term inconvenience for the long-term benefit of the system as a <u>whole</u>. Many sectors of big business have voluntarily begun metric conversion, but for only one reason: profit incentive. Other sectors, fearful of widespread public resistance and probable consumer rejection, have wisely chosen to avoid metrication. This wisdom, however, applies only to each <u>individual</u> sector; <u>collectively</u>, the same profit incentive exists in the long term. Congress has recognized this potential benefit to the aggregate U.S. economy but, through the <u>voluntary</u> nature of the Metric Conversion Act, has chosen to allow metrication to evolve on its own.

This study has sought to alert the Department of Defense of its vul-

nerability to the looming problems inherent in this unplanned, uncoordinated, and leaderless national policy. While the analyses and forecasts were simplified and mostly abstract in nature, it does not require an over-active imagination to apply them to any array of specific procurement, maintenance, logistic, or operational activities and predict their synergistic degradation if disrupted for a prolonged period of time due to a dual-measurement system. The potential combat readiness deterioration becomes inevitable and irreversible.

In order to avoid these problems, the Defense Department must, without delay:

1) Abandon its "wait-and-see" strategy of reacting to metrication events on a sector-by-sector basis. Although DOD has neither the means nor the position to be the leader in national metric conversion, it cannot ignore the interactions and interdependencies that render impossible a clean segmentation of the U.S. socioeconomic system.

2) Develop and implement a series of concerted vocal and written appeals calling on Congress to give the U.S. Metric Board (or similar centralized body) the legislative authority to plan, implement, and control a formal conversion program designed for completion in the shortest possible time. These appeals should conclusively forecast the potential threat to the nation's defense posture caused by prolonged voluntary conversion.

3) Attempt to budget and pay its "fair share" of conversion costs. As industry's customer, DOD must pay part of the tab or many industries will be unable to financially bear initial metric expenses. Further, this would spread and dilute the cost among all the taxpayers rather than the relatively few customers in each industry.

4) Stand prepared to resist counter-efforts to abandon metric conversion

in the United States.

To be sure, the obvious side effect of such a prescription cannot be ignored: DOD would arouse and incur sharp criticism from millions of metric opponents, primarily those among the general public. DOD already deals with its share of criticism, and would understandably shudder at the prospect of another chink in its public-relations armor. Nevertheless, the only alternative, remaining silent about the problem, is not acceptable. The potential trouble for national defense is too ominous, and must be averted before it is too late.

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APPENDIX A

CARPETING PROBLEM

You have a hallway in your house that you want to carpet. A friend in a distant town says he has five scraps of carpet he doesn't need, and offers them to you. He tells you the scraps have the following lengths:

9 feet, 3 5/8 inches
7 feet, 9 3/16 inches
6 feet, 3 1/2 inches
5 feet, 9 3/4 inches
2 feet, 1 1/4 inches

You measure the hallway and determine it is 31 feet, 3 inches long. (For simplicity, width is assumed to be satisfactory.) Before you commit yourself to the long drive, you want to be sure the scraps will do the job. Will they? If so, how much will you have left over? If not, how much will you be short?

Solution: First you have to convert all the fractions to the lowest common denominator of 16; then you have to reduce all the foot measurements to inches by multiplying by 12; then you have to add the odd inches to those figures to get:

111 10/16 inches
93 3/16 inches
75 8/16 inches
69 12/16 inches
25 4/16 inches

375 5/16 inches

This figure must now be converted back to feet and inches by dividing by 12. That comes out to 31 feet, 3 5/16 inches, or 5/16 of an inch left over.

****

Now, assume the same problem in a metric world. Using a meter stick, your friend gets the following figures:

2.835 meters
2.367 meters
1.918 meters
1.772 meters
0.641 meters

9.533 meters

Measuring your hallway with a meter stick, you get 9 meters, 52 centimeters, and 5 millimeters, or 9.525 meters. You can readily see that you have 8 millimeters (0.008 meters) left over.

Result: You have obtained the same result with a meter stick as you would with a yard stick in perhaps one-third the time and with considerable less chance for error. (2:56)

APPENDIX B

METRIC GUIDE

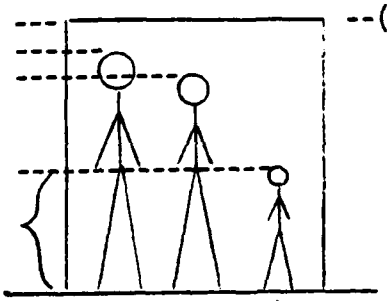
LENGTH: 100 meters ---  --(Football Field)

HEIGHT: 3 meters ----------  --(Basketball Goal)

2 meters --- --(Household Doorway)
1.8 meters ------
1.6 meters ------

1 meter ----------

100 centimeters
(paper clips)



MAN WOMAN CHILD (Age 4)

WEIGHT: 80 55 20 kilograms 1 kilogram

CAPACITY: 1 liter ----------  (Water) ---------

TEMPERATURE:

Air	Celsius	
Very Hot ----	37^{o}	--(Body Temperature)
Hot ----	30^{o}	
Warm ----		
IDEAL --	20^{o}	
Cool ----	0^{o}	--(Water Freezes)
Cold ----	-15^{o}	
Very Cold ----		

VELOCITY:

Air	Kilometers Per Hour	Driving In
Breeze	0-30	Parking Lot
Wind	30-60	Town
Gale	60-90*	Country
Storm	90-120	(Speeding)
Hurricane	over 120	Race Track

*National Highway Speed Limit

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Conversion to the metric system of weights and measures in the United States appears inevitable, but is being prolonged due to present legislation which allows each industrial sector to convert voluntarily at its own desired pace. This study analyzes the impact of a prolonged dual-measurement system on military readiness and capabilities, and concludes that debilitating national defense problems will occur if the country does not soon embark on a course of authoritative centralized planning and leadership toward

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metrication in the shortest possible time. The study recommends that the Defense Department actively call on Congress to pursue such a course.