THE PRESIDENT'S SCIENCE ADVISORY COMMITTEE
EXECUTIVE OFFICE BUILDING
WASHINGTON, D.C. 20506

MAY 10 1971

May 5, 1971

MEMORANDUM FOR

Members and Consultants-at-Large
President's Science Advisory Committee

The enclosed draft report on the U. S. Metric Study will be discussed with Dr. Branscomb and Mr. De Simone at the May meeting of PSAC (May 18 at 8:30). Please note the policy issues treated in the summary of the report which should provide a focus for the discussion.

David Beckler
David Beckler
Executive Officer

Enclosure

No. PSAC 17

To: K.H. OLSEN

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REPORT ON THE U.S. METRIC STUDY

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DRAFT

APRIL 30, 1971

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An Act

To authorize the Secretary of Commerce to make a study to determine the advantages and disadvantages of increased use of the metric system in the United States.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of Commerce is hereby authorized to conduct a program of investigation, research, and survey to determine the impact of increasing worldwide use of the metric system on the United States; to appraise the desirability and practicability of increasing the use of metric weights and measures in the United States; to study the feasibility of retaining and promoting by international use of dimensional and other engineering standards based on the customary measurement units of the United States; and to evaluate the costs and benefits of alternative courses of action which may be feasible for the United States. Metric system. Study.

SEC. 2. In carrying out the program described in the first section of this Act, the Secretary, among other things, shall— Investigation and appraisal requirements.

(1) investigate and appraise the advantages and disadvantages to the United States in international trade and commerce, and in military and other areas of international relations, of the increased use of an internationally standardized system of weights and measures;

(2) appraise economic and military advantages and disadvantages of the increased use of the metric system in the United States or of the increased use of such system in specific fields and the impact of such increased use upon those affected;

(3) conduct extensive comparative studies of the systems of weights and measures used in educational, engineering, manufacturing, commercial, public, and scientific areas, and the relative advantages and disadvantages, and degree of standardization of each in its respective field;

(4) investigate and appraise the possible practical difficulties which might be encountered in accomplishing the increased use of the metric system of weights and measures generally or in specific fields or areas in the United States;

(5) permit appropriate participation by representatives of United States industry, science, engineering, and labor, and their associations, in the planning and conduct of the program authorized by the first section of this Act, and in the evaluation of the information secured under such program; and

(6) consult and cooperate with other government agencies, Federal, State, and local, and, to the extent practicable, with foreign governments and international organizations.

SEC. 3. In conducting the studies and developing the recommendations required in this Act, the Secretary shall give full consideration to the advantages, disadvantages, and problems associated with possible changes in either the system of measurement units or the related dimensional and engineering standards currently used in the United States, and specifically shall— Results of changes in measurement system.

(1) investigate the extent to which substantial changes in the size, shape, and design of important industrial products would be necessary to realize the benefits which might result from general use of metric units of measurement in the United States;

(2) investigate the extent to which uniform and accepted engineering standards based on the metric system of measurement units are in use in each of the fields under study and compare the extent to such use and the utility and degree of sophistication of such metric standards with those in use in the United States; and

(3) recommend specific means of meeting the practical difficulties and costs in those areas of the economy where any recommended change in the system of measurement units and related dimensional and engineering standards would raise significant practical difficulties or entail significant costs of conversion.

SEC. 4. The Secretary shall submit to the Congress such interim reports as he deems desirable, and within three years after the date of the enactment of this Act, a full and complete report of the findings made under the program authorized by this Act, together with such recommendations as he considers to be appropriate and in the best interests of the United States. Report to Congress.

SEC. 5. From funds previously appropriated to the Department of Commerce, the Secretary is authorized to utilize such appropriated sums as are necessary, but not to exceed $500,000, to carry out the purposes of this Act for the first year of the program. Funds.

SEC. 6. This Act shall expire thirty days after the submission of the final report pursuant to section 3. Expiration date.

Approved August 9, 1968.

AUTHOR'S NOTE For President's Science Advisory Committee, Commerce Technical Advisory Board, and Others

There are a dozen volumes of detailed reports in the U.S. Metric Study series, prepared by experts on the Study Team and covering surveys on international trade, manufacturing, education, national security, and almost every other activity in the U.S. economy.

This volume evaluates and distills all of that, and also covers what has been learned from the British, who are just past the midpoint of their metric changeover; the Australians, who are beginning theirs; the Canadians, who have decided to go that way, too; the Japanese, who finished ten years ago; and the thousands of individuals who spoke and corresponded with us during the course of the Study.

The principle that guided the writing of this volume was that it be kept simple, yet be a faithful account. It is written for Americans in literally every walk of life, for a metric change would affect them all. Most of them are not acquainted with the nuances of international trade, technology, and the many other factors that were considered in the Study. Nor need they be to understand the essential issues.

The main reason going metric has been so controversial in the past is that it was never clear to most people what the debate was all about. This time, as many Americans as possible should understand what is really involved and what the choices really are. That is the purpose of this volume.

I would be grateful for any suggestions you may have on how it might be improved and for your general reactions when we meet.

Daniel V. De Simone

DANIEL V. DE SIMONE, Director
U.S. Metric Study

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REPORT ON THE U.S. METRIC STUDY

Appendixes (to be done later) -- Bibliography, how Study was done, participants, etc.

Illustrations and Sidebars -- Sketches of the important ones are on the yellow sheets in this draft. More to come later.

Special Terms -- Side bar, Single page, multiple columns, facing Chapter I (ochre background)

SPECIAL TERMS

Metric System: Developed in France during the French Revolution, this measurement system was originally based on the meter, a length defined as a small fraction of the earth's circumference. Since then it has been refined in many ways. The up-to-date version, to which the nations of the world have agreed, is called Systeme International d'Unites. When this report refers specifically to this version of the metric system it will be called the International Metric System.

International Metric System: At this time, the whole system is founded on six base units. The unit of length is the meter. The unit of mass is the kilogram. The unit of time is the second. The unit of electric current is the ampere. The unit of temperature is the degree kelvin (which in common use is translated into the degree celsius, formerly called centigrade). The unit of light intensity is the candela. All other units, such as those for speed and volume, are derived from the base units.

Customary System: The measurement system most commonly used in the U.S. It includes: inch, foot, yard, mile, pint, quart, gallon, peck, bushel, ounce (fluid and dry), pound, ton, and numerous other units. The Customary system may also be said to include the metric system to the extent that it is used in the U.S.

Going Metric, Metric Conversion, Metrication: As used in this report these terms are synonymous. They mean a national changeover that would result in acceptance of metric as the preferred system of measurement and, untimately, thinking primarily in metric terms instead of primarily in Customary terms. Metrication is the term the British apply to their own conversion program.

Transition Period: The length of time needed for a nation to become primarily, though not exclusively, metric.

Engineering Standards: Broadly speaking, they are agreements that specify characteristics of things or ways to do things -- almost anything that can be measured or described. They cover an enormous range: e.g., the diameter of wire; the length and width of typewriter paper; the purity of aspirin; the fire resistance of clothing; the meat content of frankfurters; the symbols on highway signs; the way to test for sulphur in fuel oil; local building codes; the strength of a safety belt; the wattage of light bulbs; the weight of a nickel. Taken together, engineering standards serve as both a dictionary and a recipe book for a technical society.

I - SUMMARY

In the last few years more than 100 million people all over the world have started using a new language when they speak of the speed of an automobile, the weight of a bag of flour, the height of a ceiling, the distance to the moon, and other things that can be measured. They have joined more than two billion who were already talking this language: the metric system of measurement.

The United States today is an island in a metric world. We are the only major nation that clings to "pounds," "inches," "gallons," "acres," and a host of other measurement units so numerous that no one fully comprehends them all. They make up what has been called the "English" system, but since the British and almost all other English-speaking countries are abandoning it, this report will call it the "Customary" system.

In the U.S. the use of the metric system is gradually increasing. Automobile mechanics have added metric tools to their toolboxes, because most foreign cars and even some American cars have metric parts. Home movie enthusiasts load their cameras with 8-millimeter or 16-millimeter film. Doctors prescribe drugs in milligrams and milliliters.

Swimmers in outdoor meets compete in meter-distance events. Skiers buy skis that are measured in centimeters. Soldiers interviewed on television speak naturally of advancing "three kilometers to Hill 803," an unnamed hill that is 803 meters high.

Most school children are taught at least a little about the metric system. When the papers or television stations report pollution levels in the air, they talk of micrograms per cubic meter. In fact, the metric system is the measurement language of science throughout the world, and American scientists use it almost exclusively in their work.

It is impossible to say just how metric the U.S. is, but a rough estimate would be about 10 percent. Nevertheless, most Americans have very little familiarity with using metric units.

What is the impact on the U.S. of the worldwide swing to metric? What does it mean to our international relations and balance of trade? How does it affect the American workingman and his employer? What does it mean to teachers and students? The farmer? The housewife? The small businessman? Government officials? Athletes? Scientists and engineers? Warehousemen? Lawyers and doctors? Plumbers and electricians? Carpenters? Broadcasters? Servicemen?

Would it be desirable for the U.S. to use the metric system more widely? Should this be done deliberately in some coordinated way? Or should we let nature take its course, since the U.S. is already drifting toward metric? Or, as another approach, should we try to turn back the tide by persuading the rest of the world to make more use of our Customary system? What can be said about the costs and benefits of deliberately changing our measurement system or doing nothing at all?

These are the kinds of questions that Congress wanted answered when it passed the Metric Study Act in 1968. (See inside front cover for a copy of this Act.) And so, a sweeping study was made by the National Bureau of Standards with the help of literally thousands of people from all walks of life.

The questions, at first, seemed fairly straightforward. Actually, they proved extremely difficult to cope with. This is a subject that involves technology, economics, sociology, international relations -- and plenty of emotions and prejudices. The choice of a measurement system affects so many people in so many different ways that the questions about going metric cannot possibly be reduced to a simple issue and settled to everybody's satisfaction. As with most major controversies, the answers depend largely on subjective thinking and personal preference, on balancing future gain against current inconvenience. There is yet no way for drawing up a reliable balance sheet in dollars and cents for deciding complex social issues. Going metric is one of these.

Over the course of the Study almost every American had a chance to speak up or be spoken for. Representatives of business, labor, trade groups, consumers, and the professions answered thousands of questionnaires, engaged in thousands of personal interviews, and participated in a series of hearings that were widely publicized in advance. And the opinions of the general public were solicited by interviews with a representative sample of American households.

A dozen reports have been published on the detailed results of these inquiries (see Appendix One). This volume pulls together and evaluates the entire Metric Study experience.

It is perhaps surprising that any general pattern of agreement should have emerged from the Study, considering the great diversity of the participants. They ranged from engineers and scientists who make measurement their life's work to people who simply take measurement for granted and, in some cases, neither know nor really care if a meter is shorter than an inch or longer than a mile.

Outlooks varied widely, but in most sectors of society there emerged substantial agreement on these points:

- The impact on the U.S. of the increasing worldwide use of the metric system appears slight at present.

Increasing use of the metric system in the U.S. is inevitable and in the best interests of the country. Eventually the U.S. will be primarily metric. It would be futile to try to persuade the rest of the world to abandon their International Metric and to adopt our Customary system.

- A crash conversion would be so costly and disruptive as to be out of the question, but a changeover period dragged out over too many years would also be unduly expensive.
- A carefully planned and coordinated national effort is the preferred method for going through the transition.
- Only essential changes should be made; there is no good reason for taking a fanatically pure approach. It is enough to have metric measures eventually predominant.
- The target date for achieving this predominance should be about 10 years from the beginning of the coordinated national effort.

The main reason going metric has been so controversial in the past is that it was never clear what the debate was really all about. Some people assumed that it would mean an instantaneous and mandatory changeover: at some specific date in the near future the inch and the pound would be outlawed. People at the other extreme viewed it as a painless and casual drift toward the use of more metric measurements.

The truth is that we shall certainly not go metric in either of those two ways. An instantaneous, mandatory changeover would so greatly dislocate our lives that it would be a national calamity. If we were to rely on drifting, on the other hand, our experience since Congress legalized the metric system in 1866 suggests that we would not join the ranks of the metric nations before the end of this century.

Mere approval or legalization seems not enough. This Study, plus the experience of other industrial nations, shows that success in going metric depends on careful planning, coordination, and scheduling, backed up by a national consensus.

For industrial engineers, factory workers, butchers, school teachers, and people in almost every walk of life, going metric would mean acceptance of metric as the preferred system of measurement and, ultimately, thinking <u>primarily</u> in metric units instead of <u>primarily</u> in Customary units.

What does "going metric" really mean then? If schools were to give greater attention to metric than to Customary, if a large number of industries were to convert to metric, if our traffic signs were to read in kilometers instead of miles, if a man buying a shirt were to be shown a 40 or 41 centimeter collar instead of a 16 inch collar, if milk were sold by the liter and meat by the kilogram, then our national measurement language habits might, in not many years, become close to 50 percent metric.

From that point on metric habits of speech and metric ways of thinking would gain momentum like a snowball rolling downhill. And after a couple of generations, "inch," "gallon," and other common Customary units would sound almost as archaic as "cubits" or "leagues." We would then unquestionably be a primarily metric nation.

In even a concerted program for going metric, some things would be changed rapidly, some slowly, and some never. In most cases, machines would be replaced with new metric models only when they wore out or became obsolete. For example, new buildings, aircraft carriers, railroad locomotives, power generating plants, and hair dryers might be built of metrically dimensioned parts; but old ones in good working order would continue to be used.

The fact is that we experience this process of change and renewal all the time. Superior technologies encourage the housewife to remodel her old kitchen when the appliances begin frustrating her work, steel companies to retire old furnaces in favor of new ones that promise better profits, and telephone companies to introduce the latest in electronic switching and transmission whenever old devices stop pulling their share of the traffic. Going metric would be approached with the same level-headed pragmatism.

Some convenient measurements might never be changed. It would be preposterous to tear up all our railroad tracks in order to relate them to some metric gauge, although we might describe the distance between the rails as 1,453 millimeters instead of 4 feet, 8 1/2 inches. Similarly, it would be quite unnecessary to change the length of U.S. football fields, even if our kind of football ever became an international sport. And keeping them as they are, no sports announcer in his right mind would ever seriously say: "Notre Dame has the ball; first down and 9.144 meters to go." Yards would cling to football just as furlongs have clung to horse racing. And why not?

A practical program for going metric would thus call for making changes only in those things that make sense to change, when it makes sense to change them. This was the principle that guided the U.S. Metric Study.

The Metric Study Act did not ask that specific plans and timetables for a metric conversion be developed -- and for a good reason. This would have to be done after a national decision to go metric and after joint planning by all groups to be affected by the change. Nevertheless, Congress did ask for an evaluation of the courses of action that might be feasible. And so, the thousands of individuals and organizations participating in the U.S. Metric Study were asked, in broad terms, how a transition from a primarily Customary measurement system to a primarily metric one could best be accomplished.

There are many different ways in which nations have gone metric. The British decided on a ten-year program, which was initiated by industry and then supported by government. The Australians, with the government taking the initiative, are also on a ten-year schedule. New Zealand decided on a transition period of seven years. Japan, after several starts and stops, finally reached its goal in 40 years. The Canadian Government last year announced its intention of going metric but put off setting any target date.

There was no reason to presume that any other nation's specific program would be appropriate for the U.S. There is an almost infinite number of conceivable programs and variations on them, because there is such a wide choice of target dates, sequences of transition among various sectors, and ways to handle special problems. In order that all the diverse groups in our society could prepare considered opinions on the metric question, the choice of ways of going metric had to be reduced to a reasonable number. The study thus focused attention on three modes of transition:

- The first said, in effect, that each entity in society -- firm, organization or individual -- would go metric as it pleased. Society would follow no overall plan.
- The second set a ten-year target date for the entire society, acting in concert, to become primarily metric.
- The third asked each company or other organization to figure out what would be its own "optimum" period in a coordinated national program -- that is to say, to convert at a pace which would be most convenient and least costly for itself.

The clear consensus for the length of the changeover period was ten years, at the end of which the society would be primarily, though not exclusively, metric. Some people wanted to change much sooner; a few later. Nevertheless, all could be accommodated by a ten-year transition. Those who could move faster would do so as soon as their customers and suppliers were ready. And those who needed more time could take it, since society's goal in a ten-year program would be to become mostly, but not entirely, metric.

A coordinated national program would indeed be a monumental undertaking. Groups of industries would have to coordinate their efforts with the help of trade associations and regulatory agencies of Federal, state and local governments.

State weights and measures agencies would cooperate in making the changeover through their National Conference on Weights and Measures. Other groups, including educators, labor, standards-making bodies and consumers, would have to be brought in at the start. A hierarchy of definitive plans would have to be developed by all these participants for themselves. And each plan would have to provide for contingencies such as failures to meet deadlines.

All the detailed plans would fit into the framework of an overall national program. This overall program, too, would have to allow for contingencies. Some might be of major consequence. It is conceivable, for example, that parts of the program might be suspended or stretched out if the nation were involved in an international conflict.

Because of the scope of such a program, the Federal Government would, at the very least, have to stand behind it. There would have to be a central coordinating body. It would work with all groups in the society that were formulating their own plans so as to insure that the plans meshed. It would advise government agencies, at all levels (state, local and federal), of changes that would be needed in codes and regulations. It would help decide how the public could best be familiarized with the new measurement units. And it would anticipate other special problems such as those described below.

Congress would decide when the program would begin and also the target date at which the society could expect to be mostly metric. At the target date, or possibly earlier, the coordinating body would have completed its work and would cease to function.

In any coordinated national program a number of special problems would warrant special treatment. Not all of them could be anticipated in the early planning stages. But those that could be provided for in advance include the following:

- Small businesses and self-employed craftsmen might be at a temporary disadvantage, as some have been in Britain. Special programs of education and technical assistance could be provided for these people.
- The few laws and regulations that involve measurement would have to be reexamined and possibly amended.
- Consumers might be apprehensive about price increases linked to metric conversion. For instance, the price of a liter of milk would have to be greater than the price of a quart (.946 liter). But how much more? A consumer education program would be needed to allay fears. Unit pricing would help.
- Engineers would have to reassess many designs before agreeing on new metric standards. This would require

expanded cooperative effort among businessess and standards-making bodies.

- If competitors cooperated, antitrust considerations would arise. Although Federal leadership in a coordinated national program would minimize this problem, some accommodations would have to be made to permit cost-saving coordination while avoiding illegal collusion. These problems would have to be resolved by business and industry, on the one hand, and the Department of Justice and the Federal Trade Commission on the other.
- Canada, our major trading partner, has not yet started metric conversion, although it has announced its intention to do so. As much as possible, the U.S. program would have to dovetail with Canada's plans.
- Costs of going metric would have to be apportioned and in such a way as to minimize the overall cost to society and to avoid bureaucratic waste. The British seek to attain this end by "letting the costs lie where they fall," although a few minor exceptions have been made where government has a clear responsibility -- e.g., citizen education. As a result, British metrication has been coordinated by a small group at insignificant cost to the

taxpayer. The general rule is that everybody in the society, including government agencies, must share in the temporary costs, as they will in the continuing benefits.

What can be said about the costs and benefits of going metric? This proved to be the most difficult question that the U.S. Metric Study asked the thousands of participants. It amounted to asking: "How would you plan and budget for a once-in-a-lifetime change unlike any you had ever made before?"

The ideal outcome of this phase of the Study would have been a simple figure, in dollars and cents, representing the net benefit or cost of going metric. It would have come from adding all the costs and all the benefits and finding the difference between the two totals. If this could have been done in the straightforward manner of a profit-and-loss statement, the U.S. Metric Study would have concluded with one of these two simple statements. Either, the nation would make a profit by going metric. Or, it would take a loss.

This ideal is unattainable. The costs and benefits are not comparable. First of all, in any metric program that has been tried or contemplated, they occur at different times. Virtually all the costs are incurred during the transition period, at a time when the benefits are just beginning. Most of the benefits come after the transition period, at a time, perhaps a decade after the start, when the costs have already been written off. Assuming that a dollar value could be put on each cost and benefit, it is theoretically possible to calculate the present value of a future benefit, provided it was also known exactly when it would occur. But practical people who make cost estimates and draw up budgets seldom look more than three or five years into the future -- and with good reason. So many economic, social, and political factors can change in the space of a few years. Even today, leading economists disagree in their forecasts for next year.

What kinds of costs were considered? They include out-of-pocket payments for hard changes, e.g., buying new scales, changing gasoline pumps, replacing or adjusting machinery, repainting highway signs, rewriting plans and specifications. They include also the often-hidden expense of confusion and inconvenience, e.g., having to learn new words and how to use them, having to work more slowly in order to avoid mistakes, having to do arithmetic in order to understand an item in the newspaper, wondering which kind of wrench to use on a bicycle or lawnmower.

It is even harder to put price tags on the benefits. Some are directly rewarding: metric calculations are easier; school children learn the metric system more quickly; travelers abroad would be spared petty annoyances if they were at home with the measurement language. Many of the potential benefits would be by-products of a changeover. They would come about because people, while making the metric change, would seize upon opportunities to do other worth-while things that are actually not directly related to any measurement system.

Thus, there might be many dividends that hitched a ride on conversion. The growth of modular housing might go faster. Translating textbooks into metric terms might provide opportunities for curriculum improvements. And in thinking out new metric standards, engineers would weed out superfluous sizes of nuts, bolts, and many other common items. Taking advantage of these opportunities would, in effect, be benefits and thus would be a way of recouping the costs of going metric.

Firms, groups, and agencies participating in the Study were on shaky and uncharted ground when they came to evaluating the metric question in terms of dollars and cents. Most of them declined to make estimates. Those that did came up with cost figures that were so inconsistent and disparate that they could not all be valid.

In the mechanical products industries the highest estimate was 900 times the lowest. And for all industries many of the cost estimates were so high they were probably based on an approach analogous to "tearing up all the nation's railroad tracks," or in any case on a serious misunderstanding of what going metric would really mean. This did not surprise one authority on statistical surveys, who noted that in studies of this kind costs tend to be exaggerated and benefits virtually ignored. As a matter of fact, with almost no exceptions, no one was able to put a dollar value on the benefits of going metric.

Nevertheless, if the cost figures can be taken at face value, something less than $60 billion of economic activity would be ascribed to a ten-year changeover to the metric system in the U.S. This would amount to roughly 1/2 of 1 percent of the gross national product during the transition period.

All the cost figures were based upon speculation about a hypothetical change. What is to be learned from industries and nations that have actually gone through the experience of converting to the metric system? In the U.S. the pharmaceutical and anti-friction bearings industries have made extensive metric changes. The changes they made proved much less costly and difficult than had been expected. The British, who are more than half way through their metric conversion program, are solving their problems satisfactorily. Again, in their case, the change to metric is turning out to be much less costly and difficult than some had anticipated.

A crucial question is whether a change to the metric system would put the U.S. in a better position to cope with the world of the future. Many of the participants in the U.S. Metric Study believe that the Customary system is already becoming a burden in our international relations -- a burden that is easy to bear now but will become heavier with time.

The main source of trouble is that things (e.g., nuts and bolts) that are made to metric standards often are not compatible with corresponding things made to Customary standards. This looms as an obstacle to our foreign trade, cooperation with our military allies, and our relations with developing nations (almost all of whom are metric). Even today, nations of the industrial world are getting together to develop compatible standards. European nations are especially vigorous in using international standards negotiations to further integrate their economies and in their insistence on the use of metric language in these standards. We participate in this international standards making, but are hampered to some extent because we alone use a different measurement system.

This problem is becoming more and more troublesome. Imports of materials and equipment are increasing, and overseas subsidiaries of U.S. companies are having to develop standards programs that are independent of the parent company, because U.S. Customary standards do not meet their needs. Alluding to these complications, one participant in the U.S. Metric Study remarked that these are now "little clouds, no bigger than a man's hand," but they point up the urgency for the U.S. to strengthen its position in world standards-making before they grow much larger.

In the give and take of international standards making, compromises would tend to result in all parties giving a little ground and therefore sharing in the costs of changes. These costs are usually reflected in the price of products. Thus, the costs of making U.S. standards compatible with those of other nations would not be borne solely by the U.S. And our products would not be burdened by a competitive price disadvantage.

As a matter of fact, U.S. industry is already influential in setting international standards. This is particularly true where U.S. technology has taken the lead -- e.g., integrated electronic circuits, commercial aircraft, automobile wheels, computers, oil drilling machinery, and videotape.

Our opportunity to exert further influence is great. To date, relatively few international standards have been adopted. But in the next decade the number on the books is expected to multiply roughly tenfold. The standards that exist today are but a few patches in a mosaic that an increasingly interdependent world will need to exchange products, materials, and ideas.

The urgency for the U.S. to participate more vigorously in world standards making was stressed in the first interim report of the U.S. Metric Study. Entitled International Standards, it was sent to the Congress in December 1970. The most important recommendations were:

- That Federal and non-government standards organizations develop together a firm U.S. policy about effective participation in international standards activities.
- That this action should be taken as soon as possible, regardless of any decision about the nation's going metric.

Almost all the participants in the U.S. Metric Study stressed the importance of education in any change to metric. Citizens would need to be informed of what the change would mean in their jobs and everyday lives. Metric measurement would be taught more vigorously in the schools. Speaking for almost two million members, the National Education Association has urged that, as early as possible, all children be taught metric as the primary language of measurement.

Through newspapers, magazines, radio, television, and other media, the British Metrication Board has tried to tell people about kilograms, meters, degrees celsius, and a few other metric units they are likely to encounter in everyday life, trusting them to pick up on their own any further details they desire to know.

A U.S. national program could presumably rely on a similar low-key approach to adult education. The American Association of Museums has volunteered to display popular exhibits on the metric system. And the Advertising Council, which helped greatly to publicize the Peace Corps and the campaign against cancer, has offered its services in connection with going metric.

Planning for the Inevitable

The clear consensus of the participants in the U.S. Metric Study is that the U.S. will ultimately become a mostly metric country, along with the rest of the world. It is indeed an idea whose time has come. The question is how should the U.S. plan for this eventuality. The participants narrowed the options to three, each of which has substantial support.

Option 1:

Let nature take its course. The large multinational corporations are already going metric at their own pace. The rest of the society can follow on its own.

Option 2:

Go metric according to plan, everybody together. This would call for an overall national program with an overall target date. Within this framework, segments of the society would work out their own specific timetables and programs, dovetailing them with the programs of other segments. But concentrate initially on what needs to be done anyway: education and international standards. Then, when these aspects are well under way, move ahead on all other fronts until the nation is primarily metric.

Option 3:

A coordinated national program based on mandatory legislation. Although this would not be a crash program, participants would have less freedom to choose what steps to take and when to take them.

Which of these three options appears to be the most reasonable and the most acceptable to the participants in the Study? On both counts, Option 2 is the choice, by the process of elimination. There was vociferous opposition to Option 3 from people who felt that a forced change would impinge on their freedom of action and would be wasteful, although some favored it as the only way to keep everybody in step.

There was even more opposition to Option 1. Some feared the cost of a prolonged period of metric and Customary duality in the U.S. Others were apprehensive about the attendant confusion in the absence of national coordination. Still others doubted that conversion could be accomplished this way and felt that it would be shirking a responsibility that this generation should assume for the sake of all future generations.

But there was very little opposition to Option 2. Time and again, participants in the U.S. Metric Study stressed the urgency of coming to grips with the problems of international standards and of preparing Americans, through education, to live in a metric world. There was a strong feeling that, with these problems under control, the inevitable change to metric could be accomplished with a minimum of cost and disruption.

UNITS

	Length	Mass	Volume	Temperature
METRIC	meter	kilogram	liter	Celsius
CUSTOMARY	yard foot inch fathom rod mile	ounce pound ton grain dram	fluid ounce teaspoon tablespoon cup pint quart gallon barrel peck bushel	Fahrenheit

Names and symbols for metric prefixes

Prefix	means
tera	One trillion times (10^{12})
giga	One billion times (10^{9})
mega	One million times (10^{6})
kilo	One thousand times (10^{3})
hecto	One hundred times (10^{2})
deca	Ten times (10)
deci	One tenth of (10^{-1})
centi	One hundredth of (10^{-2})
milli	One thousandth of (10^{-3})
micro	One millionth of (10^{-6})
nano	One billionth of (10^{-9})
pico	One trillionth of (10^{-12})
femto	One quadrillionth of (10^{-15})
atto	One quintillionth of (10^{-18})

II - TWO CENTURIES OF DEBATE

One of the powers specifically given the Congress by the men who framed the Constitution was to fix the standard of weights and measures. It comes as one of the very first of the responsibilities assigned to the legislature.

From the early days of the Republic, the United States has repeatedly faced the question of going metric. Yet today, on the eve of the nation's second centennial, the question remains unsettled.

The changing role of measurement in what has come to be a virtually metric world has dictated a fresh look at this old and perplexing problem. The Congress therefore authorized the U.S. Metric Study to assay the social and economic implications of measurement systems and to gauge the consequences to society of courses of action that the U.S. might take. Many of the facts and opinions that have been gathered during the Study are new in the context of their times. But others have changed so little in a century or two that a reader of history might feel as if he were walking through a revolving door.

Is the measurement controversy finally about to be resolved? Is this an idea whose time has come? The following historical account casts light on why, up to now, the metric question has not been settled.

* * * * *

Our Customary system of measurement is part of our cultural heritage from the days when the thirteen Colonies were under British rule. It started as a hodge-podge of Anglo-Saxon, Roman and Norman-French weights and measures. Since medieval times commissions appointed by various English monarchs had reduced the chaos of measurement by setting specific standards for some of the most important units. Early records, for instance, indicate that an inch was defined as the length of "three barleycorns, round and dry" when laid together; a pennyweight, or one Tower ounce, was equal to 32 wheatcorns from the middle of the ear.

The U.S. gallon is the British wine gallon, standardized at the beginning of the 18th century (and about 20 percent smaller than the Imperial gallon the British used to measure most liquids).

(SKETCH OF QUEEN ANNE WINE GALLON IN MARGIN)

In short, as some of the founders of this country realized, the Customary system was a makeshift based largely on folkways.

In his first message in 1790 President Washington reminded Congress that it was time to set our own standards of weights and measures. The matter was referred to Secretary of State Thomas Jefferson, an inventive genius, who soon proposed two plans. Both involved adoption of a standard of length based on a natural phenomenon that was more nearly reproducible than a barleycorn or a wheatcorn. His own preference was for a simple pendulum: a round iron rod of such length that it would swing once each second.

Jefferson's first plan was to use this pendulum as a standard to "define and render uniform and stable" the weights and measures of the English Customary system. With length firmly established, units of area, volume, weight, force, and other measurements could be consistently derived.

His second plan was more far-reaching. He wanted to establish a new system of weights and measures based on decimal ratios, which the U.S. had recently adopted for its coins. He suggested retaining some of the old names for frequently used units, and he felt also that the sizes of the new units should be as close as possible to the sizes of the old ones. His new "foot," based on the pendulum, would be about as long as an old foot, but it would be divided into ten new "inches."

Jefferson's report was accepted by Congress and discussed by select committees on several occasions over the next six years. But despite prodding from President Washington in two subsequent messages, neither plan was adopted.

Meanwhile, a brand new measurement system, strictly based on natural phenomena, had been born in the intellectual ferment of the French Revolution. In 1790 Talleyrand, Bishop of Autun, got approval to proceed with formulating a new system of weights and measures. The Paris Academy of Sciences constructed a system based on the most scientific principles of the time and radically different from commonly used measurement systems in that it was wholly rational, quite simple, and internally consistent. Its keystone was the "meter," a unit of length defined as a specific fraction of the earth's circumference.

All other elements of the metric system were derived from the meter, and they were related to larger and smaller units by decimal ratios. Originally time and angles were divided decimally, and for a while during the Revolution Frenchmen lived on a ten-day week.

Neither the design nor the implementation of the new metric system was instantaneous. But it took hold rapidly, considering the chaos existing then in French political and social life. By 1795 provisional standards had been fabricated, and laws had been passed making the system compulsory. At the end of the century, an international conference was held in Paris to bring other nations up to date with what had been done and to show them the new standards.

The metric system was not an unqualified success at first - not even at home in France. Use was not enforced, partly because commercial and household weights and measures remained scarce. Acceptance came so slowly, in fact, that in 1812 as a practical measure Napoleon Bonaparte issued a decree partially reinstating the old system while retaining metric standards. Only after a hiatus of 25 years was the metric system officially restored in France by passage of a law in 1837 making its use compulsory throughout the country after January 1, 1840.

After that the metric system began to spread internationally at an astounding pace. By 1850 the Netherlands, Greece, Spain, and parts of Italy adopted it. By 1880 seventeen other nations - including Germany, Austria-Hungary, Norway, and most of South America - had climbed on the bandwagon. And eighteen more were added to the list by 1900.

After Jefferson's early attempts, the U.S. had shown little concern for standardizing measurement until 1816. Then President James Madison again reminded Congress that the lack of provision for uniformity in weights and measures constituted an important piece of unfinished business. In response, the Senate the next year passed a resolution asking the Secretary of State to reinvestigate the situation. The result was John Quincy Adams' Report Upon Weights and Measures, submitted four years later.

The Adams' report was the first systematic consideration of the metric system by the U.S. Government. In eloquent language, it covered the pros and cons of both widely used measurement systems in the context of the time and in scrupulous detail. And for many years to come it inspired participants on both sides of the metric controversy.

Adams called attention to five features of the metric system that could be considered distinct advantages: the invariable standard of length taken from nature; the single unit for weight and the single unit for volume; the decimal basis; the relation of weight units to French coinage; and its uniform and precise terminology.

On the other side, he found disadvantages - notably, that the system had not actually become popular in France. And so, he presented Congress with a choice of four courses of action which, taken together, are not unlike the goals the current U.S. Metric Study is charged to explore. While extolling the virtues of the metric system, Adams suggested the following possibilities:

- "To adopt, in all its essential parts, the new French system of weight and measures . . .
- "To restore and perfect the old English system of weights, measures, moneys, and silver coins . . .

- "To devise and establish a [combined] system . . . by adaptation of parts of each system to the principles of the other.
- "To adhere, without any innovation whatever, to our existing weights and measures, merely fixing the standard."

Adams' own preference was a two-stage approach. First, he would have the familiar English units standardized and approved without change. Later, he would have the President begin negotiating with France, Britain, and Spain to establish a uniform international measurement system.

The recommendations were in keeping with the times. By 1821 most states had already enacted laws providing for weights and measures and specifying the English units. At a time when the constitutional rights of states were just beginning to be examined by the Supreme Court, any attempt to upset these laws by imposing the metric system might have been disturbing. Secretary Adams was aware of this point. He was also aware that the most pressing need was for agreement on uniform standards of any sort.

In addition, he stressed international harmony of measurement. The preponderance of American trade at that time was still with Britain, and the U.S. was bounded on one side by British Canada and on the other by Spanish possessions. He, therefore, deemed it wise to consult both Britain and

Spain before making any such radical change as adopting the metric system.

Congress took no action in response to the Adams' report, although in 1832 the Treasury Department did adopt English standards to meet the needs of customs houses. Thus, until the metric controversy was renewed some 40 years after the Adams' report, the U.S. industrial society took form and grew large. A brief flurry of interest in the metric system, coinciding with its rapid spread from France to other nations, was cut short by the Civil War.

Then in 1863 the subject again came to the fore. President Lincoln had formed the National Academy of Sciences to advise the government on all technical matters. A committee led by Joseph Henry, an eminent physicist, was appointed at the request of the Secretary of the Treasury to reconsider weights, measures, and coinage. After two years of deliberation, it issued a report favorable to the adoption of the metric system. This met with the approval of Congressman John A. Kasson of Iowa, chairman of the newly appointed House Committee on Coinage, Weights, and Measures.

In 1866 the Kasson Committee reported favorably on three metric bills that were eventually passed by Congress. The most important legalized the use of metric weights and measures, and it also specified English-system equivalents of metric weights and measures. One of the other bills directed the Postmaster General to distribute metric postal scales to all post offices exchanging mail with foreign countries; the other directed the Secretary of the Treasury to furnish each State with one set of metric standards.

Congressman Kasson made clear the intentions of his committee. The metric system was not being made compulsory, for the nation was not prepared to accept so drastic a change. Rather, Congress was to permit the use of metric, while stimulating interest in reform. And this was to remain the goal of metric advocates for several more decades.

Congressman Kasson had stressed the importance of educating the "rising generation" to the simplicity and utility of the metric system. Appropriately, educators themselves staged the first public set-to over the question of adopting metric. The adversaries were Professor Charles Davies of Columbia College and the President of the College, Frederick A. P. Barnard. Davies had been asked by the University Convocation of New York to head a committee to investigate what might be done to improve knowledge of the metric system. His report, submitted in 1871, recommended that nothing be done. Instead, it raised numerous objections to the system and prophesied dire consequences to the nation if it were to be adopted.

Barnard delivered a rebuttal refuting all of Davies' objections and outlining a strategy for educating people in the use of the metric system. He wanted it taught in the schools, used in legislating tariffs and assessing customs duties, and put to use in a variety of other government activities, including public surveys, military and naval establishments, and post offices. Having advanced this plan, Barnard created an organization to push ahead with it: the American Metrological Society, founded in December 1873 with Barnard himself as president.

In its early years, especially while Barnard remained as its head, the Society attracted many influential members, among them: Congressman Kasson, a dozen other U.S. Representatives and Senators, and eminent scientists and educators from the colleges and universities. In addition to its interest in advancing the metric system, the Society was concerned with internationally uniform coinage, standardized time zones, and several other reforms.

So much of the Society's energy was being taken up by other matters that it spawned a special group to promote the metric system through education. This was the American Metric Bureau, founded in 1876 with headquarters in Boston. Barnard was president of this organization also, and its executive director was a young librarian, Melvil Dewey, who later became known for his development of the decimal system of classifying library volumes.

The American Metric Bureau remained active for only a few years. During this time its most ambitious project was the purchase of metric hardware - scales, rules, and capacity measures - for resale to educational institutions at reasonable prices. When funds ran low, and particularly after Barnard's death in 1889, the Bureau's influence dwindled.

Yet the American Metrological Society and the American Metric Bureau did manage to spark some interest in measurement. Between 1877 and 1886 Congress considered several pieces of legislation dealing with increased use of the metric system. One resolution was passed in 1877 resulting in an executive-branch investigation of the desirability of making the system compulsory in all Government transactions. By and large, the survey showed, the idea had little public support.

Another result of the early pro-metric activity was the fostering of the first organized opposition. While many individuals and groups objected to changes in the measurement system, the first to adopt opposition to the metric system as its main objective was the International Institute for Preserving and Perfecting Weights and Measures. It was founded in Boston in 1879 by a Cleveland engineer, Charles Latimer, and it made clear that the weights and measures to be preserved and perfected were strictly Anglo-Saxon.

The International Institute's thinking was greatly influenced by a contemporary movement known as "pyramidology." The main contention was that the Great Pyramid at Giza, Egypt, had been constructed by the hand of God in such a way that it contained all of His scientific gifts to mankind. By elaborately manipulating the pyramid's dimensions, pyramidologists "proved" that the Anglo-Saxon race was one of the ten lost tribes of Israel and that Anglo-Saxon weights and measures, represented by the customary English system, were of divine origin. The Institute was naturally opposed to any other measurement system and even wanted to "purify" the English system by eliminating all non-Anglo-Saxon influences.

One of the Institute's main targets was U.S. adherence to the Treaty of the Meter, which had been signed by seventeen nations after five years of meeting (1870-1875) in Paris. The convention and the treaty that followed it accomplished several objectives. They reformulated the metric system and refined the accuracy of its standards. They provided for the construction of new standards and distribution of accurate copies to participating countries. They established permanent machinery for further international action on weights and measures. And they set up a world repository and laboratory - the International Bureau of Weights and Measures near Paris - with land and buildings donated by the French Government.

Less than ten years after the Treaty of the Meter was signed, the U.S. became an <u>officially</u> metric nation, even though the Customary system continued to be used predominantly in industry, commerce, and the home. The standards, including meter bars and kilogram weights, were finished in 1889 and the U.S. received its copies. Four years later the Secretary of the Treasury, by administrative order, declared the new metric standards to be the nation's "fundamental standards" of length and mass. The yard, the pound, and other customary units were defined as fractions of the standard metric units.

In the Treaty of the Meter the U.S. had joined with every other major nation in the world in endorsing the metric system as the internationally preferred system of weights and measures. Yet there was no immediate and concerted effort to convert the nation practically to the system it had approved officially.

An attempt was made in 1896, and for a short while it appeared that it might succeed. Representative Dennis Hurley of Brooklyn introduced a bill providing that all Government departments should "employ and use only the weights and measures of the metric system" in transacting official business and that in 1899 metric would become "the only legal system . . . recognized in the United States." Ardently supported by the Committee on Coinage, Weights and Measures, the bill passed the House by the bare margin of 119 to 117. But immediately, opponents forced a reconsideration and launched an attack stressing the difficulty of making a change. Foreseeing defeat, the Committee chairman had the bill sent back to his Committee, and there it died quietly.

One contemporary report said that the Hurley bill failed because other Congressmen had not been fully briefed. Another claimed that too many Congressmen were afraid of adverse reaction from farmers and tradesmen in an election year.

Over the next ten years, more than a dozen bills dealing with the metric system were proposed and many were debated. Support for the metric system continued to come from scientists, educators, and some government officials. And members of the Committee on Coinage, Weights and Measures kept the subject alive in Congress, though to little avail.

During this time, Congress established the National Bureau of Standards as a successor to the old Office of Weights and Measures. Its first director, Samuel Wesley Stratton, took such a vigorous interest in the metric system that he was charged with lobbying for it.

In general the arguments, both pro and con, changed little. It was said that the U.S. would inevitably have to go metric and that the transition would become no easier as time went on. Britain and Russia seemed ready to make the changeover, thus leaving the U.S. isolated. And the intrinsic simplicity and utility of metric units and decimal arithmetic were reiterated. Opponents continued to stress costs and confusion.

The opposition was better organized and more effectively led than ever before. It was spearheaded by two men: Frederick A. Halsey, a New York engineer, and Samuel S. Dale, the editor of a Boston textile magazine. They rallied the support of engineers, manufacturers, and workmen and claimed to be "practical men, not closet philosophers or theorists." They charged that the metric system had been a practical failure in countries which had adopted it -- i.e., that customary weights and measures were still the ones most commonly used even in those countries. Other arguments, some of which are still heard today in one form or another, included:

- Industrial standards (e.g., for nuts, bolts, and machine tool sizes) would have to be abandoned at great cost and inconvenience.
- The alleged simplicity of the system was illusory, because errors would be made through misplacing of the decimal point.
- Most of the world's commerce was being carried on in the Customary system.

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- The Government had no right to tell a man what weights and measures to use. And in any case, such laws would be unenforceable.

Most of the metric legislation proposed between 1896 and 1907 would have required the Government to adopt the metric system first, with the rest of the country following within a few years. At first, the pro-metric factions had the momentum, but the tide turned about 1902, when Halsey and Dale managed to stir up such an outcry from a few manufacturers and influential engineers that further proposals were bottled up in Committee. They were, in fact, so successful that advocates gave up trying and decided to await a more propitious time.

The next phase of the metric controversy, which began before the U.S. got embroiled in World War I and lasted until the Great Depression set in, took place mostly outside Congress. The anti-metric forces continued to be led by Halsey and Dale and this time they had the backing of a formal organization, the American Institute of Weights and Measures. Its council included such leading industrialists as Henry D. Sharpe, treasurer of the Brown and Sharpe Manufacturing Company, a leading machine tool maker; D. H. Kelly, secretary of the Toledo Scale Company; Edwin M. Herr, president of Westinghouse; and Henry R. Towne, chairman of the board of Yale and Towne Manufacturing Company.

With financial and political backing from a large portion of the nation's major manufacturers and manufacturing associations, the Institute was able to overwhelm each pro-metric proposal with broadsides of organized protests and adverse publicity. In addition to publishing its own journals, bulletins, and pamphlets, the Institute enjoyed the support of some leading professional and trade journals.

The main anti-metric arguments, though not radically changed, were embellished with inflammatory flourishes. One series of articles in 1920 carried such titles as What Real He Men Think of the Compulsory Metric System, Metric Chaos in Daily Life, and A Metric Nightmare. Newspaper and magazine articles sympathetic to the metric system were methodically rebutted, and those refusing to publish the Institute's replies were often charged with suppressing the facts.

In the face of this continuing barrage of opinion, two newly-founded pro-metric organizations began speaking out. In 1916 the American Metric Association was formed with headquarters in New York, and about a year later the World Trade Club opened in San Francisco. Of all the adversaries, only the American Metric Society has survived until today. Its supporters included Director Stratton of the National Bureau of Standards, William Jay Schiefflin of

New York, Professor Arthur E. Kennelly of Cambridge, Massachusetts, and the long-perservering Melvil Dewey.

The Association drew most of its support from groups that had tended to be pro-metric in the past -- e.g., scientists, educators, and members of such closely related professions as medicine, engineering, and pharmacy. It was also endorsed, and to some extent supported financially by several professional societies, notably the American Chemical Society, the American Pharmaceutical Association, and the American Association for the Advancement of Science. In fact, the Metric Association eventually affiliated itself with the AAAS. A few companies also were represented in the Metric Association, including General Electric and Goodyear Tire and Rubber, although they by no means exerted as much influence there as the industrial representatives that virtually dominated the anti-metric American Institute.

Complementing the activities of the American Metric Association on the west coast was the World Trade Club, which later changed its name to the All-American Standards Council and then to the World Metric Standardization Council. It was funded and organized by Albert Herbert, a wealthy manufacturer, who preferred to remain in the background.

The actual campaign was directed by a San Francisco advertising agency owned by Aubrey Drury, who worked hard at promoting the metric system until the 1930's and thereafter remained active as a member of the Metric Association. The World Trade Club devoted much of its effort to lobbying; it retained a Washington lawyer to make sure that a metric bill was introduced in every session of Congress and urged the Committee on Coinage, Weights and Measures to hold hearings. Through Drury, it countered the American Institute's tactics by issuing some inflammatory flourishes of its own, including a pamphlet entitled Keep the World War Won, and it published lists of "practical" men who urged adoption of the "meter-liter-gram" system.

In the post-war, pre-depression years, only two Congressional hearings were held on the subject, although 40 bills were introduced. Then, with the onset of the prolonged financial crisis, the metric question was shoved into the background. When times got better, the U.S. was in an isolationist mood and still in no economic shape to consider the capital outlays that would be required to change machinery over into the metric system -- although the time would come when metric advocates would propose a crash metric changeover as a cure to recession.

In fact, the metric controversy remained dormant for almost three decades. The nation was too busy to consider the question during World War II, and after the peace, the

U.S. so dominated the world's production and exchange of goods that there seemed to be no need for a change.

Then came an event that suddenly focused America's attention on science and technology: the launching of the Soviet Union's first Sputnik satellite. Students flocked to science courses; firms and government agencies poured money into research; and along with this resurgence of faith and interest in things scientific, the U.S. Government again began to consider seriously the desirability of increasing the use of the metric system, the predominant measurement language of science.

In 1957, the year Sputnik soared, a U.S. Army regulation established the metric system as the basis for weaponry and related equipment. A committee of the Organization of American States proposed that the metric system be adopted throughout the Western Hemisphere. The following year the major nations still using the Customary system, including the U.S. and Britain, agreed to use the same metric equivalents to define their inch-pound units. This dramatized the fact that the metric system is the basis of the inch and the pound.

And two years after that, in 1960, the metric system was itself refined by a General Conference of Weights and Measures, in which the U.S. participated. Although the metric system had been the common measurement language of the 43 nations that adhered to the Treaty of the Meter, like other languages, it was spoken in various dialects. Prior to 1960 there were subtle differences in the use of metric; none caused confusion in everyday use, but where the highest levels of scientific and engineering precision were required, the metric system was not really standard and there was room for misunderstanding and error.

The General Conference of Weights and Measures ironed out these differences by agreeing on a standard metric system that might be compared with "the king's English." The result was the International Metric System (Systeme International d' Unites), from which today all the U.S. Customary measurement standards are derived. International Metric, known in technical circles as "SI," is open to further refinement; nevertheless, it is providing the world of measurement with a common language as useful and as nearly universal as was the lingua franca, spoken widely through Europe and the Orient in the Middle Ages.

In May 1959, in an address to the American Physical Society, the Secretary of Commerce announced his intention to throw his Department's weight behind an in-depth study of the costs and difficulties which might be involved in changing the entire U.S. to metric. The action was inevitable, he implied; the only issues were when and how the change was to be brought about. Accordingly, he proposed that the Director of the National Bureau of Standards establish an advanced planning group to "assemble all available documentation and to identify possible courses of action."

Congress, however, decided that the question should first be given Congressional attention, and three bills were introduced to deal with it. Two specified a metric study; the third took the form of a concurrent resolution stating that it be the sense of Congress that the President take steps to adopt the metric system as the nation's official system of measurement.

None of these bills was acted upon, but the idea of going metric or at least authorizing a metric study gained momentum in Congress. Hearings were held, although in the House none of the proposals ever reached the floor. A sense of urgency was still lacking.

Finally, on May 24, 1965, an event occurred which American advocates had hoped for since at least 1870. On that day the President of the British Board of Trade announced in Parliament the United Kingdom's intention to adopt the metric system over the course of the next ten years.

Britain's action made it clear that the U.S. would soon be the only major industrialized nation on earth that still clung to the Customary system. After a series of efforts to mold a bill that would be acceptable to all parties, Public Law 90-472 was enacted and signed into law in 1968. (For the text of the Act, see the inside front cover.) It authorized the Secretary of Commerce to make a study "to determine the advantages and disadvantages of increased use of the metric system in the United States" and to make such recommendations as he considered appropriate and in the nation's best interests. Thus began the three-year U.S. Metric Study that is summarized in this report.

The climate in the U.S. has never been more conducive to a serious evaluation of the metric question. Never throughout the Study have the issues been obscured by the kind of emotional opposition exemplified by the pyramidologists and their successors. Confronted with the realization that the U.S. may soon be the only non-metric nation in the world, participants in the Study faced up to the fact that now is the time for the nation to chart its course.

When the Study started, only a handful of countries remained non-metric. Since then, in just three years, several of these have taken steps to go metric. Australia and New Zealand are already on the way with scheduled conversion programs. Canada, Malawi, and Guyana have committed themselves, without setting a definite date. And KOMING have said they are considering the matter. As a glance at the map in Chapter I shows, the U.S. has become an island in a world committed to the metric system.

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III - MEASUREMENT SYSTEMS

Today, as regards the language of measurement, the United States is a Tower of Babel. Men and women in every industry, every vocation, even every sport speak their own special dialects. The two "pure" tongues, Customary and International Metric, are often intermingled and also enriched with such special-purpose "slang" units as: barn, furlong, board-foot, pica, face-cord, therm and electron volt.

Generally speaking, people who must communicate with one another regularly can do so readily enough and with a minimum of confusion. But the proliferation of measurement terms has indeed caused some difficulties. In certain highly technical industries, for example, research scientists think wholly in terms of metric, whereas product engineers work with Customary units. Before an idea can be reduced to application, measurements must first be translated.

Clearly there would be less chance of confusion if everyone agreed to talk measurement in some consistent way -- preferably in Customary, International Metric, or some other language if it were already widely accepted.

We agree on a common alphabet; we accept the dictionary for the spelling and meaning of words; standard nuts are manufactured to fit standard bolts; if we live in the same time zone, we set our clocks the same. These conventions for making life simple are now taken for granted, yet in the past each of them was adopted in the face of strenuous objections.

Can we, and should we, seek similar harmony in the way we measure? If so, which of the two major measurement languages is better? This is not an easy question to answer, because each has intrinsic or practical merits.

No other system of measurement that has been actually used can match the inherent simplicity of International Metric. It was designed deliberately to fill all of the needs of scientists and engineers, although laymen need only know and use a few simple parts of it. It is logically streamlined, whereas other systems developed more or less haphazardly. At this time there are only six base units in the International Metric System. The unit of length is the meter. The unit of mass is the kilogram. The unit of time is the second. The unit of electric current is the ampere. The unit of temperature is the degree kelvin (which in common use is translated into the degree celsius, formerly called centigrade). The unit of light intensity is the candela. These units are described more fully in Table ___.

(Insert Table)

All other units of measurement are derived from these six base units. Area is measured in square meters; speed in meters per second; density in kilograms per cubic meter. The newton, the unit of force, is a simple relationship involving meters, kilograms, and seconds; and the pascal, unit of pressure, is defined as one newton per square meter. In some other cases, the relationship between the derived and base units must be expressed by rather more complicated formulas--which is inevitable in any measurement system, owing to the innate complexity of some of the things we measure. Similar relationships among mass, area, time and other quantities in the Customary system usually require similar formulas, made all the more complicated because they can contain arbitrary constants. For example, one horsepower is defined as 550 foot-pounds per second.

The third intrinsic advantage is that metric is based on the decimal system. Units of different sizes are always related by powers of 10. There are 10 millimeters in one centimeter; 100 centimeters in one meter; and 1,000 meters in one kilometer. This greatly simplifies converting larger to smaller units. For example, in order to calculate the number of meters in 3.794 kilometers, multiply by

1,000 (move the decimal point three places to the right) and the answer is 3,794. For comparison, in order to find the number of inches in 3.794 miles, it is necessary to multiply first by 5,280 and then by 12.

Multiples and subdivisions of all the fundamental International Metric units follow a consistent naming scheme, which consists of attaching a prefix to the unit, whatever it may be. For example, kilo stands for 1,000: one kilometer equals 1,000 meters, and one kilogram equals 1,000 grams. Micro is the prefix for one millionth: one meter equals one million micrometers, and one gram equals one million micrograms. For the meaning of the other prefixes, see Table ___.

(INSERT TABLE OF PREFIXES)

Metric calculations are so much easier, in fact, that one authority is convinced the U.S. aerospace industry alone would save $65 million a year in engineers' time by converting entirely to metric.

In contrast, the Customary system seems to be devoid of logical patterns. But on the other hand, it does have its own practical merits, although they are somewhat more subtle. In some ways, Customary units are still closely related to everyday human experience and even human anatomy, from which they were derived centuries ago. The foot is roughly the length of a human foot; the yard is approximately the distance between a grown man's nose and the fingertips at the end of his outstretched arm; a mile is about 2,000 paces.

The seeming multiplicity of units is in reality often a convenience for those who use them. Most people find it easiest to comprehend numbers that are between 1 and 1,000 -- preferably between 1 and 10. By picking from the wide assortment of Customary units, it is usually possible to wind up with a convenient number. The householder buys a few tons of coal for the winter. The farmer delivers a few hundredweight of produce to the market. The grocer sells potatoes by the pound. Some pipe tobacco is sold by the ounce, and diamonds by the carat.

The multiples in the Customary system are frequently based on powers of 2 and 12. Therefore, they do not harmonize with decimal arithmetic. Nevertheless, intuition easily grasps binary fractions -- i.e., halves, and halves of halves. The number 12 also has a special practical virtue in doing arithmetic. It is conveniently small, and it is divisible by 2, 3, 4, and 6 -- twice the number of divisors of 10. Even the French, fathers of the metric system, recognize the handiness of 12. A few years ago a British building contractor, specializing in partly prefabricated construction, decided to convert his plans to modular units of 40 inches on the theory that this length was close enough to one meter (39.37 inches) so that he could bid on some school buildings in France. He was surprised to learn later that French schools were being designed to modular units of 1.2 meters, because these could be divided into 200, 300, 400 and 600 millimeter subunits.

With both systems accepted and in use in the United States, people in different walks of life have compromised in different ways to take advantage of the convenience and handiness of the Customary system and the logical simplicity of International Metric. The Customary system still predominates, but metric is gaining ground, especially in highly technical industries, in education, in pollution standards, and in international trade and relations.

In addition there remains a host of miscellaneous units, which belong strictly to neither the Customary system nor International Metric, but which are used by certain groups of people almost as part of a private language. Printers still talk of picas and points. Racing fans are committed to the furlong. It seems almost as if every commodity were measured in a different way; there are eight kinds of ton, 56 varieties of bushel, to say nothing of such oddities as cords and board-feet of wood.

(ALONG BOTTOM OF THIS PAGE SHOW VARIETIES OF BUSHELS DISAPPEARING IN DISTANCE LIKE RAILROAD TRACKS).

There is obviously plenty of chance for confusion. In the construction industry, for example, the quality of concrete is sometimes described in terms of gallons of water per bag of cement. But near our northern border misunderstandings are likely to occur, because Canadians speak of the Imperial gallon, which is 20 per cent larger than the U.S. gallon, and they also market cement in a different sized bag. Even scientists and engineers speak special measurement dialects. There are, for instance, more than a dozen units of energy, including ergs, electron volts, frigories, horsepower-hours, joules, kilowatthours, therms, watt-seconds, British Thermal Units, metric tons of TNT, and six kinds of calories. Whether in Customary or metric, a few things are still measured crudely. You cannot trust a shoe to fit unless you try it on. A "mile down the road" may be as much as three miles; to be told a "kilometer down" may be just as vague. And housewives throughout the world add a "pinch" of this or a "dash" of that, whether they use metric or Customary recipes.

The metric system is advancing in our society under its own power, albeit sporadically and in piecemeal fashion. By and large, these changes have taken place in activities and disciplines which are more or less self-contained. The pharmaceutical industry more than a decade ago gave up the apothecary's traditional drams, grains, and minims and converted to milligrams, grams, and milliliters (see Chapter V). They had no serious interface problems with other industries; nor is it necessary to package pills in metric-sized boxes and bottles.

(PHOTO-MONTAGE OF METRIC THINGS IN U.S., INCLUDING, FOR EXAMPLE, INSTRUCTIONS AFFIXED TO AUTO).

Physicians, whose medical school training in chemistry is metric, learned easily enough to write prescriptions in metric units, and pharmacists learned to fill them.

With few exceptions, the language and tools of U.S. science are entirely metric. In schools throughout most of the country the metric system is taught to some extent, even to very young children. Soldiers interviewed on television speak casually of "advancing 3 kilometers to Hill 803," an unnamed hill that is 803 meters high. Their ammunition is measured in metric. One of the largest government agencies, the National Aeronautics and Space Administration, decided last year to use International Metric in its documents and reports.

The electric current that flows into our homes and the radio waves in the air are measured in units that are the same in both the metric and Customary systems.

Some automobiles made in the United States have engines, transmissions, and other parts built to metric specifications. The width of photographic film is expressed in millimeters, even though sprocket holes are spaced six to an inch. Statutory standards for automobile emissions of hydrocarbons, carbon monoxide and oxides of nitrogen read in "grams per mile," another metric infiltration. Most pipes manufactured for export have metric diameters, but the very large oil pipelines are measured in inches.

Swimming pools for outdoor competition are being built to metric dimensions so that our swimmers can practice for international metric-distance events. American skis, made to standard feet and inch lengths a few years ago, are now sold in centimeter sizes.

These examples, though far from exhaustive, do indicate that metric measurements and practices have established a beachhead in the United States.

(INSERT CONVERSION TABLE. METRIC TO CUSTOMARY AND CUSTOMARY TO METRIC. COMMONLY USED LENGTHS, AREAS, VOLUMES, WEIGHTS. SHOW THAT ELECTRIC AND TIME UNITS ARE SAME IN BOTH SYSTEMS.)

Many other measurement systems have been conceived. As far back as 1790, Thomas Jefferson considered basing measurement on a foot determined by the length of a pendulum that swung once per second; he suggested dividing it, decimally, into ten inches. Albert Einstein once proposed that the diameter of the hydrogen atom and the speed of light be the primary units of measurement from which all other units could be derived. Others have argued that, no matter what base units are used, they be related by binary fractions -- i.e., 1/2, 1/4, 1/8, 1/16, etc. -- and the powers of 2.

(VISUAL AIDS DEPICTING JEFFERSON'S AND EINSTEIN'S SCHEMES.)

In principle, almost any precisely defined and consistent measurement system could serve us well. In practice, however, it is unrealistic to consider for general use any choice of measurement system that is alien to our culture or to that of the rest of the world. We therefore really have only two practical alternatives: either to allow our own measurement system to develop without overall design, or to elect as a society to adopt the measurement system that has virtually achieved worldwide universality and to work out a policy and program for changing to it.

Comparing the Commonest Measurement Units

How to convert approximately from customary to metric and vice versa

	When you know:	You can find:	If you multiply by:
LENGTH	inches	millimeters	25
	feet	centimeters	30
	yards	meters	0.9
	miles	kilometers	1.6
	millimeters	inches	0.04
	centimeters	inches	0.4
	meters	yards	1.1
	kilometers	miles	0.6
AREA	square inches	square meters	0.09
	square feet	square meters	0.8
	square yards	square centimeters	6.5
	square miles	square kilometers	2.6
	acres	square hectometers (hectares)	0.4
	square centimeters	square inches	0.15
	square meters	square yards	1.2
	square kilometers	square miles	0.39
	square hectometers (hectares)	acres	2.5
MASS	ounces	grams	28
	pounds	kilograms	2.2
	short tons	megagram (metric tons)	0.9
	grams	ounces	0.035
	kilograms	pounds	2.2
	megagram (metric tons)	short tons	1.1
LIQUID VOLUME	ounces (U.S.)	cubic centimeters (milliliters)	30
	pints (U.S.)	cubic centimeters (liters)	0.47
	quarts (U.S.)	cubic decimeters (liters)	0.95
	gallons (U.S.)	cubic decimeters (liters)	3.8
	cubic centimeters (milliliters)	ounces (U.S.)	0.034
	cubic decimeters (liters)	pints (U.S.)	2.1
	cubic decimeters (liters)	quarts (U.S.)	1.05
	cubic decimeters (liters)	gallons (U.S.)	0.26
TEMP.	degrees Fahrenheit	degrees Celsius	5/9 (after subtracting 32)
	degrees Celsius	degrees Fahrenheit	9/5 (then add 32)

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IV - ARGUMENTS FOR AND AGAINST GOING METRIC

Perhaps the longest running debate in the history of this country is whether the United States should convert to the metric system. In the course of almost two centuries dozens of arguments have been advanced, attacked, and defended with a passion inspired by a topic with implications that are both intensely practical and intellectually stimulating.

A main goal of the U.S. Metric Study has been to collect these arguments and to evaluate them with as much detachment as possible. During the last three years, literally thousands of people and organizations have been asked to contribute their knowledge and their opinions. The remaining chapters of this report review and weigh most of the age-old arguments, along with some new ones that have been evoked by current trends or by the simple fact that the question of going metric has been studied in great depth for the first time.

In this chapter are catalogued the arguments, pro and con, that are most frequently stated. Some are thought-provoking, even compelling; a few may seem frivolous. Many reflect the prejudices of particular groups or individuals.

Out of all the conflicting arguments, however, one fact emerges: neither those who favor going metric nor those who oppose it have a monopoly on pure reason -- or on bias.

Not a few of the common arguments are demonstrably false, even a bit frivolous. It is said, for instance, that the metric system, because it has roots in science, somehow makes measurement more accurate. (A similar claim is stated for Customary.) But measurement depends entirely on the accuracy of the measuring tools and the skill of the person who uses them.

Some people maintain that the U.S. has achieved its status as an industrial power through the use of inches and pounds. This is clearly beside the point: our excellence is due to technological skill and high standards of design and workmanship.

Other advocates of Customary insist that the metric system is a hideous complexity that pure scientists are trying to foist on the rest of the public. This can hardly be taken seriously, for our Customary system is presently defined by wavelengths of light and other natural constants on which the metric system is based. Besides, the public will never need to master the technical intricacies of any measurement system. In truth, whether we use one system or the other (or some of each) depends on which is most convenient and makes greatest sense over the long run.

There are, however, many serious arguments advanced by both pro-metric and anti-metric spokesmen. The choice of a measurement system affects so many people in so many different ways that the questions about going metric cannot possibly be reduced to a simple issue. Like most major controversies in politics, economics, and foreign affairs the answers are going to depend largely on subjective thinking and personal preference. There is yet no way for drawing up a balance sheet of hard numbers for deciding complex social issues. Going metric is one of these.

Although the following list of arguments is representative, it is by no means exhaustive. By and large, the arguments fall into four categories:

-- The convenience, utility, or intrinsic merit of the metric or Customary systems in everyday life as well as in industry, commerce, and government.

-- The problems that a metric changeover would entail and also the opportunities it would afford for improving many activities of society.

-- The ways in which going metric might affect the United States' relations with the rest of the world.

-- The implications for the future wellbeing of this country.

Which System Makes Calculations Easier?

Pro-Metric:

"It's easy to compute with metric units. All you have to do in many cases is add a zero or move a decimal point. Moreover, all our office machines are designed to handle decimals."

(INSERT METRIC - CUSTOMARY CALCULATIONS ON CARPETING AND FUEL COSTS FOR GAS, OIL, COAL, ELECTRICITY.)

"There are only a few units and the relationships among them are pretty simple. No need to remember how many drams in an ounce or whether the ounce is fluid or dry measure."

"Decimal relations are intellectually more satisfying."

"The modern metric system has different terms for mass and force, eliminating a confusion between pounds of mass and pounds of force that has perplexed generations of students."

Anti-Metric:

"Practically speaking, it's often easier to do simple arithmetic in your head with Customary units, because both the duodecimal and binary bases are handier. The duodecimal (base 12) has more factors than the decimal (base 10), and binary (base 2) is the natural arithmetic for making yes-no choices or designing computers."

"If we are going to change, let's look for some combination of number bases that are better than either decimal or duodecimal."

"This is an age of computers. If you have a really complicated problem, the machine can handle any units."

Which System is Personally More Convenient?

Pro-Metric:

"Customary units pretend to be related to human measurements -- e.g., the foot and the yard (or pace). But this is actually confusing because people vary so greatly in size."

"The metric system has a much more important relationship to human anatomy. It is based on the number 10; we have 10 fingers; and from antiquity people have learned to count on their fingers."

"It would be easy to calculate unit prices in a supermarket if soap powders, for example, were packaged in 1, 1.5 and 2 kilogram boxes."

Anti-Metric:

"Your foot may not be exactly one foot long, but it's pretty close and, in general, Customary units are related to everyday experience. To describe many things simply, you need the inch and the foot; the millimeter is too short and the meter too long."

(Pictorialize Stiehler's "man as a measuring rod": digit, palm, span, cubit, inch, foot and yard.)

"Even some scientists argue that units like the candela are artificial."

"The purported logic of metric unit names is violated by the use of the kilogram as the basic unit of weight. Why not the gram?"

"Modern metric advocates pride themselves on using only six basic measurement units. Yet the derived units with hard-to-remember names -- such as the pascal, the siemens, the weber, and the tesla -- are proliferating."

"Aren't they really proposing to substitute one jumble of names for another?"

The very fact that many such arguments tend to contradict one another shows how easy it is to take sides. Chapter III tries to analyze these contentions and place them in perspective.

Problems and Opportunities Within the U.S.

Anti-Metric:

"Changing would cause chaotic confusion. Consumers would not know whether they were getting their money's worth for things sold by length, weight or volume. It would take a generation to rewrite public records. For a while you might not understand what you read in the newspaper or heard on television."

"Conversion costs would be enormous to the manufacturing industries, and many companies would have to carry double inventories of spare parts during the transition period."

"The task of retraining people in most every sector of society would be enormous. For some people unlearning a familiar system would be even harder than learning a new one."

"During the retraining period people would be deprived of invaluable experience -- the intuitive feel for measurements on which craftsmen, mechanics, and engineers depend. The result would be a temporary loss of productivity that the country cannot afford."

"Dealing with unfamiliar quantities would result in safety hazards due to mistakes."

"Everybody would have to pay for the changeover, because industry would have an excuse for higher prices, labor an excuse for higher wages, and government bureaucracies an excuse for higher appropriations."

"A coordinated conversion program, even if purely voluntary, would be simply another government encroachment on free choice."

"Conversion might be all right for big firms with engineering staffs and foreign trade departments. But small businesses would suffer an additional competitive disadvantage."

"During transition almost every industry would have problems dealing with repairs and replacement of parts. Our industrial progress would be reversed, with a partial return to custom jobbing on a large scale."

Pro-Metric:

"Experience has shown that conversions of this kind turn out to be much easier and less costly than anticipated. For example, the Swedes managed to change overnight from driving on the lefthand side of the road to the righthand side -- with no increase in traffic accidents. And individual British firms have found from actual experience that full productivity was regained within a very short time after changing to metric."

"Metric is so much easier to learn that schools would have extra time to teach some of the new subjects now being introduced into the curricula."

"Metric is so much easier to use that engineers would save plenty of time and make fewer errors."

"The necessities of conversion would be a widespread blessing in disguise. While adjusting to the new measurements, we would have an incentive to clean house and eliminate many of the superfluous varieties of paper sizes, nuts and bolts, and other common goods. Manufacturers' inventories might actually be reduced."

(Photograph or drawing showing fasteners, both metric and inch-based, presently used in U.S. contrasted with metric set proposed by IFI.)

"A changeover would compel us to reexamine many codes and practices long overdue for revision. We could improve our engineering standards and building codes. We might well agree on modular units which would help make mass-produced housing a reality. And schools would have added incentives to revitalize textbooks and curricula."

"Many changes would probably go far beyond what was utterly necessary. Faced with the task of doing things differently, creative people would exploit the opportunity to do things better. Conversion to metric could stimulate invention and innovation."

"Small businesses and self-employed craftsmen would benefit from a coordinated conversion program. As it is, they are being left behind by some big firms that have the expert staffs and international connections to adapt independently to the increasing worldwide demand for metric goods."

"Speaking a common measurement language, scientists, engineers, businessmen, educators, and government officials would communicate with one another more freely and with less risk of misunderstanding."

"A changeover to the metric system would be a stimulus to the economy comparable to the space program."

In summary, these arguments strongly indicate that in the event of a changeover to the metric system the problems and costs would reach a peak during the transition period. The opportunities and benefits, on the other hand, would be enjoyed mostly in the late stages of transition and indefinitely thereafter. Whether short-run pain outweighs long-run pleasure is perhaps the key issue in the whole question of going metric. It will be explored in greater detail later in this report, chiefly in Chapter VII.

The U.S. and the World

Anti-Metric:

"Let's not risk our industrial success with a measurement system contrived by countries that have not done as well as the U.S."

"Going metric would open the way to a flood of imports from countries that do not now make products to Customary specifications. American workers would be thrown out of jobs."

"Our export trade is so small compared with our Gross National Product that the advantage of manufacturing according to metric standards would be insignificant."

"The solution to the balance of payments problem lies in tax, tariff and export policies, not in measurement language."

"Within our borders the customary system works all right. It's all very well for small, struggling nations to go metric; they don't have to make many changes. But we would have to disrupt a trillion dollar economy."

Pro-Metric:

"We would fortify our position as a leader by joining the rest of the world in a common and clearly better measurement system. Almost all the other English-speaking nations have converted to metric or are in the process of doing so."

"Travelers, traders, and all other U.S. citizens who have dealings abroad are handicapped to the extent that they are unfamiliar with the commonly accepted measurement language."

"Having two legal systems, Customary and metric, is already a bit of a burden. It would be better to settle on one or the other. Since we could not convert the rest of the world to Customary, there is only one way to go."

"Though small in relation to the total economy, our exports are crucial to maintaining a favorable trade balance, and a changeover to metric would be bound to increase exports."

"Our economy today, as never before, depends on trading raw materials, manufactured products, even technological ideas with countries committed to the metric system. We put ourselves at a competitive disadvantage by using an outmoded measurement system."

"We want to have our say in setting international standards of all sorts, especially those concerned with industrial products. Going metric would help to win acceptance for our ideas."

"The overwhelming majority of our military allies are committed to the metric system. Converting to metric would simplify coordination and logistics."

"We can better do our part to aid the development of other nations if we use the measurement language that is familiar to almost all of them."

"U.S. companies making metric designed products for sale abroad may find it easier to build the plant abroad and train foreign workers than to retrain inch and pound thinking U.S. workers. Export of jobs to metric countries is already a serious problem."

The Impact on the Future

Anti-Metric:

"If we decide to go metric, we are likely to pick the wrong time. What if we should have a war or runaway inflation during the difficult transition period? The measurement conversion would complicate all our problems. No economic wizard is smart enough to tell us the right time."

"Even in normal times society is faced with too many complex problems. Why add to them a troublesome change in measurement. In any list of economic priorities, going metric belongs near the bottom."

"The same can be said about intellectual priorities. There are many worthier goals to focus on -- e.g., making English spelling phonetic, introducing a universal language more acceptable than Esperanto, or making laws uniform throughout the nation."

Pro-Metric:

"We are already heading toward the metric system, although slowly and in an unorganized way. It would be cheaper and more efficient to do so deliberately and on a reasonable schedule. It's a shame we did not make the conversion 150 years ago, when there was so much less to change. Conversely, 20 or 50 years from now the change may be even more difficult than today."

"The costs and inconveniences of metric conversion would be temporary; they would stop at the end of the transition period. The benefits would be everlasting."

"No one can seriously say that the U.S. will not, someday, be mostly metric. All the costs and problems anticipated by those opposed to metric conversion are going to be visited upon us anyway. The important thing is to avoid a prolonged, confusing, expensive period with two measurement systems by planning as painless a changeover as possible."

V - GOING METRIC: WHAT WOULD IT REALLY MEAN?

The main reason "going metric" has been so controversial in the past is that it was never clear what the debate was really all about. Some people assumed that it would mean an instantaneous and mandatory changeover: at some specific date in the near future the inch and the pound would be outlawed. People at the other extreme viewed it as a painless and casual drift toward the use of more metric measurements.

The truth is that we shall certainly not go metric in either of those two ways. An instantaneous, mandatory changeover would so greatly dislocate our lives that it would be a national calamity. If we were to rely on drifting, on the other hand, our experience since Congress legalized the metric system in 1866 suggests that we would still be painfully straddling two measurement systems at the end of this century. Mere approval or legalization seems not enough. This study, plus the experience of other industrial nations, shows that success in going metric depends on a national consensus backed up by the sorts of planning, coordination, and scheduling described in the next four chapters.

When we talk about going metric, we really have to talk about making two kinds of changes, called "soft" and "hard."

A soft change is simply a trade of one language for another. Example: the weather announcer who begins reporting the temperature in degrees celsius instead of degrees fahrenheit is making a soft change. Hard changes involve altering sizes, weights, and other dimensions. Example: say that the dairy industry starts distributing milk by the liter. The milk carton manufacturer has to modify his machinery to produce a slightly larger container. And on the back porch, new milk boxes might be needed. These are typical hard changes.

A hard change is almost always preceded by a soft change. Suppose that new cookbooks are written with recipes in metric language -- i.e., convenient fractions of kilograms and liters. At first, the American housewife follows these recipes by making soft changes. If a recipe calls for 250 milliliters of oil, she looks at a conversion table for translating liters to quarts, then measures out slightly more than eight ounces (one cup) of oil.

So far she has made only a soft change. Suppose then she breaks her measuring cup. Since her cookbook reads in metric units, it would be foolish to buy a new cup graduated in ounces, and so she buys one marked off in milliliters. This is a hard change. In this case, the cost of the hard change is zero; she had to buy a new cup anyway. But if the use of the conversion table confuses her and she throws away her ounce-marked cup in frustration, the price of the new metric measure is an "extra" hard cost of conversion.

For industrial engineers, factory workers, carpenters, surveyors, building inspectors, butchers, school teachers, and people in almost every walk of life, going metric would mean acceptance of metric as the preferred system of measurement and ultimately, thinking <u>primarily</u> in metric terms instead of <u>primarily</u> in Customary terms.

The use of metric units has already made considerable headway in the U.S., as was pointed out in Chapter III. In a few fields-- notably the physical sciences and medicine-- people have converted much of their thinking, talking, and writing to metric units. In some others--electronics and broadcasting, for example--the two measurement systems are virtually the same anyway. Nevertheless, our national measurement language is still probably no more than about 10 percent metric, although it is hard to estimate this figure accurately.

If schools were to give greater attention to metric than to Customary, if a large number of industries were to convert to metric, if our traffic signs were to read in kilometers instead of miles, if a man buying a shirt were shown a 40 or 41 centimeter collar instead of a 16 inch collar, if milk were sold by the liter and meat by the kilogram, then our national measurement language might, in not many years, become close to 50 percent metric.

From that point on metric habits of speech and metric ways of thinking would gain momentum like a snowball rolling downhill. And after a couple of generations, "inch," "pound," and other common Customary words would sound almost as archaic as "cubit" or "league." We would then unquestionably be a primarily metric nation.

Every person making the change to metric units would make an assortment of soft and hard changes, as necessary either to do their jobs or to keep up with what was being said in the newspapers and on television. Some changes would be made rapidly, some slowly, and some never. In most cases, machines would be replaced with new metric models only when they wore out or became obsolete. For example, new buildings, aircraft carriers, railroad locomotives, power generating plants, and hair dryers might be built of metrically dimensioned parts, but old ones in good working order would continue to be used.

In many instances industry and commerce would make metric changeovers much as the housewife did when she broke her non-metric measuring cup. A pump in a chemical factory, for example, might with careful maintenance last ten years before it wore out and had to be replaced. But if a critical part failed after, say, five years, the user might well decide to buy a new pump of improved design and lower running cost, rather than fix the old one. And if he was going metric and metric pumps were available, the new pump would, of course, be built to metric standards.

Somewhat analogous is the problem of rewriting real estate deeds in metric dimensions -- meters instead of yards and hectares instead of acres.

(HANDWRITTEN IN MARGIN WITH LIGHT OCHRE BACKGROUND: A HECTARE IS 10,000 SQUARE METERS. DO YOU KNOW HOW MANY SQUARE YARDS ARE IN AN ACRE?)

There would be no good reason to do this until the property changed hands and was resurveyed. As a matter of fact, some deeds in New Orleans are still written in terms of the French foot of pre-Napoleonic times, and in the Far West there are still tracts that are described not in acres but in square varas, a holdover from the Spanish grant days.

In parts of France to this day, after almost 200 years of the metric system, consumers still order une livre de beurre (one pound of butter). They get a half-kilogram package, to be sure, but the point is that no one has forced them to give up an old familiar name. And manufacturers continue to make concessions to non-metric thinking; until recent years in Germany, butter was packaged in 125-gram bars for people accustomed to buying it in quarter pounds. And many Germans call the half kilogram ein pfund (one pound) like the French.

In even a concerted program for going metric, some measurements and some dimensions would never need to be changed. It would be inconceivable that we would ever tear up all our railroad tracks in order to relate them to some round-number metric gauge, although we might describe the distance between the rails as 1,453 millimeters instead of 4 feet, 8 1/2 inches. We would not be likely to translate into metric such sayings as "a miss is as good as a mile," and we would not rewrite the words to the song I Love You a Bushel and a Peck.

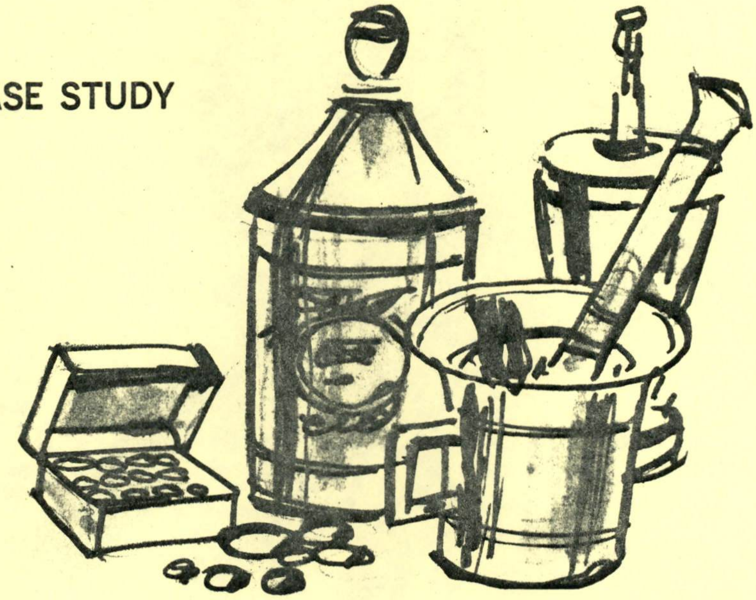
In sports, going metric is not likely to present much of a problem. Soccer is the most internationally popular game by a wide margin, and fortunately there is no standard size for a soccer field. Cricket is played throughout the old British Empire, but although most of the nations that play it have either gone metric or are doing so, they will presumably cling to the traditional Imperial dimensions of the cricket pitch. Similarly, it would be quite unnecessary to change the length of U.S. football fields, even if our kind of football ever became an international sport. And keeping them as they are, no sports announcer who wants to keep his audience would ever seriously say: "Notre Dame has the ball; first down and 9.144 meters to go."

Some unorthodox units of measurement will continue to be used wherever they make communications and calculations clear and easy. Meteorologists speak of "bars," one bar being roughly normal atmospheric pressure, and of the "millibar," which is one-thousandth of a bar. Chemists use the "mol," a unit of weight so contrived that most chemical equations can be written with small whole numbers. Astronomers prefer to talk of distance in "light years," instead of many trillions of kilometers. Such convenient units as these are not likely to be discarded.

Even if it were to be specified that only pure metric units were to have full legal standing, many non-metric measurement terms would persist in our culture -- perhaps forever. And why not?

A practical program for going metric would call for making changes only in those things that make sense to change, when it makes sense to change them. This was the principle that guided the U.S. Metric Study. Thousands of individuals, companies, trade associations, professional societies, unions, government agencies, and other groups were asked to contribute their thoughts and cost estimates about the best way to change to metric.

A METRIC CONVERSION CASE STUDY



Pharmaceuticals

About fifteen years ago the major U.S. drug manufacturers changed their internal operations and most of their products to metric. They did it with dispatch, and they found it surprisingly painless.

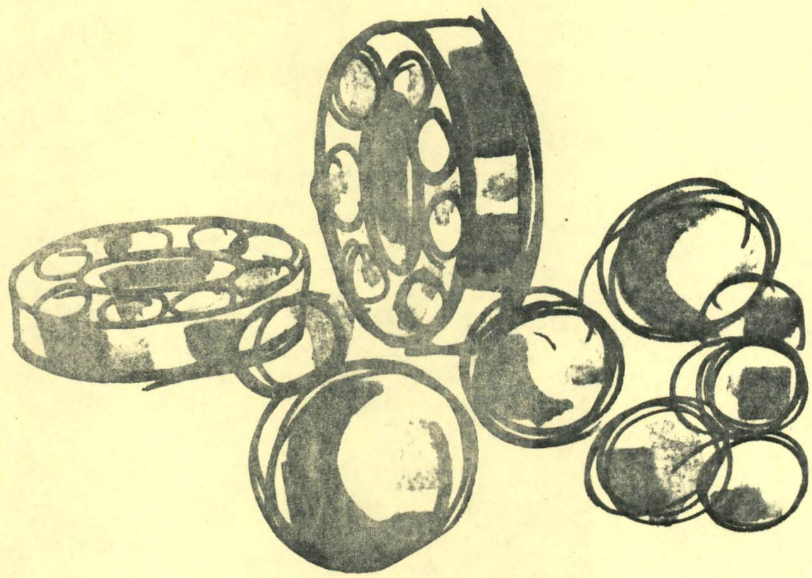
In their judgment, they have more than recouped the costs of changing over. The advantages they gained include: easier training of personnel; economies in manufacturing; reduction in errors; simplified specifications, catalogs, and records; and improved intracompany communications. There have been no apparent disadvantages.

Rather than divorcing themselves from the Customary environment, the pharmaceutical companies changed only what they had to change in order to make and market products in metric units. It was possible to limit the scope of the change because the industry deals primarily with volumes and weights of substances, hardly at all with lengths. Each firm could deal independently with its own problems, and so industry-wide coordination was not needed.

Here is how the changeover is regarded in retrospect:

- Costs were actually low—less than anticipated. One large company says that costs in terms of employee time and equipment modification came to $250,000, which was only ½ to ⅔ of its pre-conversion estimate.
- The same company believes it easily recovered the costs, although it has not tried to put a dollar value on the benefits that have accumulated since conversion.
- Retraining workers was no problem and took less time than had been anticipated. The industry was already using metric units for a few products; thus most workers were not confronted with something entirely new. A program of dual labeling and marking (first Customary with metric in parentheses, then the reverse) helped workers become gradually familiar with metric units.
- Only scales and volume measuring devices were modified. Most process machinery did not need to be changed at all. Many scales were changed simply by affixing a metric dial or indicator; some needed new weights or beams. In all cases, needed parts were easily supplied by scale manufacturers.
- Some suppliers were originally reluctant to furnish their products in metric quantities, but since the whole pharmaceutical industry was changing, they soon complied with the demand.
- Users (pharmacists and physicians) presented no problem. They had already been educated in metric units.
- An odd problem arose with alcohol. Federal regulations require that alcohol must be stored, sold, and taxed in Customary amounts. In this area, one of the few that demanded coordination outside the drug industry, conversion to metric has yet to be achieved. In contrast, Federal narcotics reports must be in metric units.
- Each firm converted at its own pace. One of the largest took about one year; a competitor took twice as long. Both felt that they could have moved faster.
- Careful planning assured a smooth transition.

A METRIC CONVERSION CASE STUDY



Anti-Friction Bearings

Metric units usually prevail in technologies that first developed on the European continent. Customary units have the upper hand in technologies first developed in the U.S. and Great Britain. The anti-friction bearing industry represents a mixture of both.

Ball bearings and parallel roller bearings, originating in Europe, are designed to metric standard sizes. These sizes are also used in the U.S., although they may be described in terms of inches.

Tapered roller bearings, on the other hand, originated in the U.S. and were therefore designed to Customary standard sizes. Now, many U.S. manufacturers are beginning to design their new tapered roller bearings to metric standard sizes. These firms are concerned about expanding their overseas operations and increasing their exports to an otherwise metric world.

The companies involved in this changeover say that it has been on the whole rewarding. They have been able to produce complete lines of tapered roller bearings with a reduction of superfluous types, and they have improved their competitive positions in the world market. They report no noteworthy disadvantages. Here is how they regard the changeover:

- No substantial costs can be attributed directly to going metric. With different parts of the world using different measurement systems, they have to pay the costs of labeling drawings in both Customary and metric units, but this was a cost they paid before anyway.
- Since the conversion involves design alone, only the engineering staff has had to be retrained. At one of the largest companies the engineers learned what they needed to know informally.
- It has not been necessary to replace or even greatly modify a single piece of Customary manufacturing machinery to produce to metric standard sizes. With dual labeling and conversion charts, any worker in any plant has been able to produce any bearing on any suitable piece of equipment.
- While going metric, one manufacturer has developed a new line of tapered roller bearings that incorporates the best features of both Customary and metric technologies. The company hopes that this line will win acceptance in the U.S. and ultimately throughout the world.
- Until this new line is widely accepted, there is no need for the industry to coordinate its efforts or set a conversion timetable for the entire field of tapered roller bearings. In the meantime, each company is applying metric to new designs only.
- Some customers still need bearings in Customary sizes, and these are being supplied. By and large, however, U.S. industry has readily accepted the new metric designs.

VI - GOING METRIC: THE BROAD CONSENSUS

The U.S. Metric Study has been one of the most thorough examinations of public attitudes toward a proposed social, economic, and technical change that has ever been attempted. During the last three years almost every American was spoken for. Representatives of business, labor, trade groups, consumers, and the professions answered thousands of questionnaires, engaged in thousands of personal interviews, and participated last summer and fall in a series of hearings that were widely publicized in advance. And the opinions of the general public were solicited by interviews with a representative sample of American households.

In August of 1968, Congress set forth broad goals for the Study in Public Law 90-472. This Act asked the Department of Commerce to do the following:

(1) Determine the impact on the United States of the increasing worldwide use of the metric system.

(2) Consider the desirability and practicability of increasing the use of metric weights and measures in this country.

(3) Also study the feasibility of retaining and promoting engineering standards based on the Customary system.

(4) Examine the effects on international trade, foreign relations, national security, and also the practical difficulties that might be encountered should the metric system be more widely used in the U.S.

(5) Evaluate the costs and benefits of alternative courses of action which the United States might take.

The rest of this volume is mainly a summary and analysis of views regarding these major points. Here, in Chapter VI, the extent of metric use and the attitudes toward increasing it are examined. Chapter VII is devoted to estimates of tangible and intangible costs and benefits associated with retaining our present measurement practices or becoming a primarily metric nation. Chapter IX outlines what would need to be done if the U.S. were deliberately to convert to the metric system. And Chapter X assays the metric question to try to fit it into the world of the future.

Appendix One in the back of this book lists detailed reports on segments of the Study, which are now available for those who want to explore particular aspects to a greater depth. Appendix Two describes how the Study was conducted and explains the roles of many of the people and organizations who contributed their time and expert knowledge to the planning and carrying out of the work.

It is perhaps surprising that any general pattern of agreement should have emerged from the Study, considering the great diversity of the participants. They ranged from engineers and scientists who make measurement their life's work to people who simply take measurement for granted and, in some cases, neither know nor really care if a meter is shorter than an inch or longer than a mile.

Moreover, opinions came from many different cross-sections of society. On the macro scale, for example, whole industries and groups of labor unions were asked for their collective views and estimates of costs and benefits. On the micro scale, individual citizens expressed their personal thoughts. And in between, ideas were collected from large and small firms, professional and technical societies, and other groups with special interests.

The public hearings alone included representatives of: manufacturing and non-manufacturing industries, organized labor, small businesses, engineering and scientific disciplines, education at all levels, advertising, publishing, law, medicine, public health, agriculture, forestry, fisheries, agencies of Federal, state, county, and local government, real estate, college athletics, finance, insurance, warehousing, transportation, construction, communications, retailers, wholesalers, chiefs of police, fraternal organizations, exporters and importers, home economists, and consumers.

Outlooks varied widely, but in most sectors of society there emerged substantial agreement on these points:

- The impact on the U.S. of the increasing worldwide use of the metric system appears slight at present.
- Increasing use of the metric system in the U.S. is inevitable and in the best interests of the country. Eventually the U.S. will be primarily metric. It would be futile to try to persuade the rest of the world to abandon their International Metric and to adopt our Customary system.
- A crash conversion would be so costly and disruptive as to be out of the question, but a changeover period dragged out over too many years would also be unduly expensive.
- A carefully planned and coordinated national effort is the preferred method of going through the transition.
- Only essential changes should be made; there is no good reason for taking a fanatically pure approach. It is enough to have metric measures eventually predominant.
- The target date for achieving this predominance should be about 10 years from the beginning of the coordinated national effort.

In a study of this sort, some groups present vexing problems to those attempting to get answers to questions. For one thing, the level of sophistication covers an enormous range, even among industrial firms. Some who deal in high-precision products -- e.g., automobiles and electronics -- maintain special departments that work full time on measurements, composition of materials, and other standards. One large automotive company, for instance, keeps a file of 61,000 different standards that are continually augmented and revised. Other companies, such as those who sell bulk materials by the lot or the carload, need seldom worry about measurements to the thousandth of an inch or the hundredth of an ounce.

Thus the U.S. Metric Study adopted several different approaches, some complex and some simple, all with the hope of letting each sector of society express itself on its own terms and on its own level of sophistication. Some people filled out questionnaires; others were interviewed in person or over the telephone; still others presented and discussed their views at the public hearings. As can be seen in the following paragraphs, there were some differences of practice, opinion, and judgment. But they were not nearly so great as had been anticipated.

Manufacturing Industry

The information for this sector came from answers to detailed questionnaires mailed to almost 4,000 firms and followed up in some cases by personal visits or telephone interviews. The companies were chosen to be a representative sample of some 300,000 U.S. firms that manufacture products, and they ranged from tiny operations employing only a handful of people to giants with payrolls of more than 2,500.

About 10 percent of these companies reported that they made some use of the metric system. But metric measurements and standards have pervaded U.S. manufacturing much more widely than this figure would indicate. A disproportionately large number of the big and very big companies use metric in at least some of their operations; metric users actually account for nearly 30 percent of employment in manufacturing.

Metric use has been increasing since 1965, and the current trend appears to be upward, especially among companies engaged in world trade. A principal use is in connection with research and development, which is to be expected, since the metric system is the universal measurement language of science. Also, more than 25 percent of the users print metric dimensions on their shop drawings, generally side by side with Customary units.

Manufacturers who now use metric to some extent were queried about the kinds of advantages and disadvantages that they might expect in a national changeover to metric. They were asked about such factors as: the training of personnel, engineering design and drafting, inventories of parts and products, manufacturing operations, exports and imports, domestic sales and competition, communications and records. Most were unable to explain where greater use of the metric system would be either a help or a hindrance.

Sentiment for or against going metric varied greatly even within the same kinds of industry. For example, large firms tended to be more in favor than small ones, although some small businessmen were among the most outspoken advocates of a metric changeover. Companies substantially involved in international activities tended to be more favorably disposed to metric. The aluminum industry was, on the whole, pro-metric; the steel industry was not.

As to whether a further proliferation of metric would benefit their own industries, manufacturers were about evenly divided. But as to whether conversion would be good for the country as a whole, an overwhelming majority voted "Yes." About 70 percent of those answering this question (representing 80 percent of the total employment) said that more use of metric would be in the best interests of the U.S. Then the companies were asked, if it is found that increased metric usage is in the best interests of the U.S., what course should be followed? More than 90 percent of those who responded preferred a coordinated national program based on either voluntary participation or mandatory legislation over no national program for going metric.

(THREE SETS OF BAR CHARTS ON MANUFACTURING INDUSTRY ATTITUDES)

Manufacturing companies were alerted in advance and requested to present considered opinions. Months before the survey was begun, the American National Standards Institute had drawn up and distributed a set of guidelines to explain what would, and would not, be involved in metric conversion. The main points were that change would be applied only to new products or to old products that were being redesigned. Products and major components would be converted only after new metric parts and materials became available at reasonable cost. Thus, the changeover would not be a costly and confusing revolution, but rather an orderly transition as products and tools became obsolete or other technical and economic considerations favored a change. Thanks largely to these guidelines, which were adopted by the U.S. Metric Study, manufacturers who answered the questionnaires were better prepared to deal with the issues.

Non-Manufacturing Businesses

Representatives of the non-manufacturing businesses were, in general, not so well informed beforehand on the major questions of metric use and conversion. For that reason efforts were made to brief them by advance mailings and phone calls. Then, members of a professional research organization, under contract to the U.S. Metric Study, conducted extensive telephone interviews with more than 2,500 spokesmen designated by the non-manufacturing companies. In more than 80 percent of the cases they talked with persons high in management, many times the president. The rest were technical specialists designated by their companies.

The companies in this sector are engaged in such a variety of activities that gross figures of metric usage would mean little. Nevertheless, some general conclusions about attitudes could be drawn. Few companies saw reason to change their measurement system unless the whole country were to do so, although 6 percent of those interviewed said they intended to increase their own use of metric in the near future, chiefly to enhance their prospects in world trade.

The non-manufacturing businesses were in favor of a national conversion program. In fact, this was true across the board, from agriculture to utilities. And 62 percent of these businesses preferred a mandatory program based on legislation.

(INSERT THREE CHARTS SHOWING NON-MANUFACTURING BUSINESS ATTITUDES)

But the vast majority of the companies saw no reason to change their system of measurement unless the whole U.S. does so. As to the anticipated difficulties of a metric change-over, the remarks of a trucking industry representative are illustrative. Pointing out at one of the public hearings that his industry has made a number of more-or-less drastic technical changes in recent years -- 6-volt to 12-volt electrical systems, gasoline to diesel engines, tube to tubeless tires -- he added: "No metric conversion could approach the difficulty of doing what is now being demanded of us for safety's sake." Indeed, most non-manufacturing businesses foresaw no particular problems, except possibly for the training and retraining of workers.

Organized Labor

A special public hearing devoted to labor heard reports from unions representing 7,783,000 workers. Those speaking for slightly more than two-thirds of the workers testified that part or all of their members made at least some use of the metric system. Representatives of almost 40 per cent were in favor of a planned national program, but only in the event that the U.S. should decide to adopt the metric system.

Generally, a substantial majority of the unions were not apprehensive about the possibility of a changeover. In a typical comment, the Communications Workers of America stated: "Although it is generally agreed that conversion would be of help to engineers in the telephone industry, it is difficult to envision any immediate advantages for the worker." In a similar vein, a representative of the Textile Workers of America said: "No significant advantages or disadvantages would result to our members, on the job. It can be expected that the average individual will find the metric system simpler, after a short adjustment period."

Some labor spokesmen expressed serious concern, however, that workers in certain crafts where an intuitive feeling for measurement is an asset would be deprived of much of the value of their experience by a change to an unfamiliar measurement system. More will be said about this in later chapters.

Education

No other sector was so nearly unanimous in its endorsement of the metric system as was education. A public hearing devoted to education was attended by representatives of all leading teacher and school administration societies as well as many firms in the educational field. They represented a total of 1,600,000 people.

Speaking for more than one million of these, one participant said in a prepared statement: "The National Education Association believes that a carefully planned effort to convert to the metric system is essential to the future of American industrial and technological development and to the evolution of effective world communication." He further urged that, starting with the upcoming school year, all teachers should teach metric as the primary system of weights and measures in the U.S.

Virtually all the individuals in the educational system and the firms associated with it make some use of the metric system and are in favor of a planned conversion program. This finding was supported by a special survey conducted as part of the U.S. Metric Study. It was pointed out, however, that little of this sophistication and enthusiasm has yet filtered down to the students, aside from those taking science courses. Although about 10 per cent of the boys and girls in elementary and intermediate grades are taught something about metric units, they still, like their parents, think primarily in terms of inches, pounds, and degrees Fahrenheit -- inevitably, since they live in a mostly non-metric environment.

Nevertheless, the survey reveals that all parts of the education system are ready and even eager to convert. They are far ahead of the rest of U.S. society in their awareness of problems and opportunities and in outlining a program of transition (as will be described in more detail in Chapters VII and IX).

Government

Since Congress had expressed a special interest in the possible effect of more metric usage upon national security, the Department of Defense conducted a survey of its own operations. The result was a report prepared by a task force of 50, who were assigned to subcommittees that focused on various aspects of military affairs: operations, logistics, research and development, construction, personnel and training, legal, and financial.

The overall conclusion was that the armed forces could make a changeover to metric without impairing their functions, assuming that industry would first convert through a coordinated national program. The Department of Defense would not take the lead by writing metric units into its specifications, but would follow industrial practices, and it would expect considerably higher appropriations to cover their estimated costs of conversion (see next chapter).

As to whether conversion might benefit the military, the committee concluded: "Although the use of a simpler system would have no outstanding military advantage, the slight advantage expected would be amplified because of its widespread nature. The compatibility of U.S. and foreign equipment will enhance combined military operations and simplify logistic support requirements."

This conclusion is consistent with one reached by General John J. Pershing more than 50 years ago, shortly after he had commanded the U.S. Army in World War I. He wrote in a letter: "The experience of the American Expeditionary Forces in France showed that Americans were able readily to change from our existing system of weights and measures to the metric system .... Not the least advantage ... is the facility which that system gives to calculations of all kinds, from the simplest to the most complex. I believe that it would be very desirable to extend the use of the metric system in the United States to the greatest possible extent; but I can readily see that there would be many practical obstacles in the attempt entirely to replace our existing system by the metric."

(IN MARGIN NEXT TO ABOVE PARAGRAPH, A PHOTO OF GENERAL PERSHING)

The views of 55 other Federal Government agencies were collected in a separate report. The results roughly paralleled those of the manufacturing industry survey. More than half the agencies make some use of metric -- generally in medicine, electronics, physical sciences, and other fields where it is already the dominant measurement language -- and one-fifth expect to use metric more extensively regardless of national policy and trends. As was mentioned earlier in this volume, one of the largest agencies, the National Aeronautics and Space Administration, last year began entirely on its own to convert to metric language. (IN THE MARGIN A SATURN V) Forty of the 55 agencies estimated that long-term advantages of going metric would outweigh disadvantages, and almost all of these favored a coordinated national conversion program.

A survey was undertaken by the State-County-City Service Center, which represents such groups as the National Governors Conference and the National League of Cities. The indication was that only a coordinated national program would persuade state, county, or local governments to go metric. Nevertheless, some government agencies at these levels are already making some use of the metric system, especially in connection with pharmaceuticals, laboratories and testing, and the purchase and repair of certain metrically designed equipment, such as foreign vehicles. In addition, the American Association of State Highway officials has begun to publish recommended tests in both metric and Customary units. And in California the engineering designs for water resources use metric units because they conform with European design models. These accommodations to metric have been made smoothly and with few problems.

Public Opinion

In order to probe public information and attitudes, the U.S. Metric Study enlisted the help of the Survey Research Center of the University of Michigan. The staff of the Center selected a sample of 1,400 families representative of the 62 million family units in the United States and then proceeded to interview the individuals in person.

The general public, it is apparent, knows little about the metric system. Only 40 percent could name a single metric unit, and only half of those were familiar with relationships among metric and Customary units. Consequently, it came as no surprise to the Survey Research Center that in answer to the question, Would a changeover to metric benefit the nation?, the vote was 25 percent "Yes" and 59 percent "No."

Among those who favored metric conversion, 34 percent did so because of a desire to conform to world practice; 47 percent believed that a decimal measurement system would make price comparisons easier; and 55 percent thought that children could more readily learn the metric system. But a great many of those interviewed anticipated specific troubles in the event of national metric conversion. Considerable majorities were worried about the confusion that might result if speed limits were posted in kilometers per hour and temperatures in degrees Celsius, and although few thought that conversion would cost them much, many were worried about the cost to business and industry.

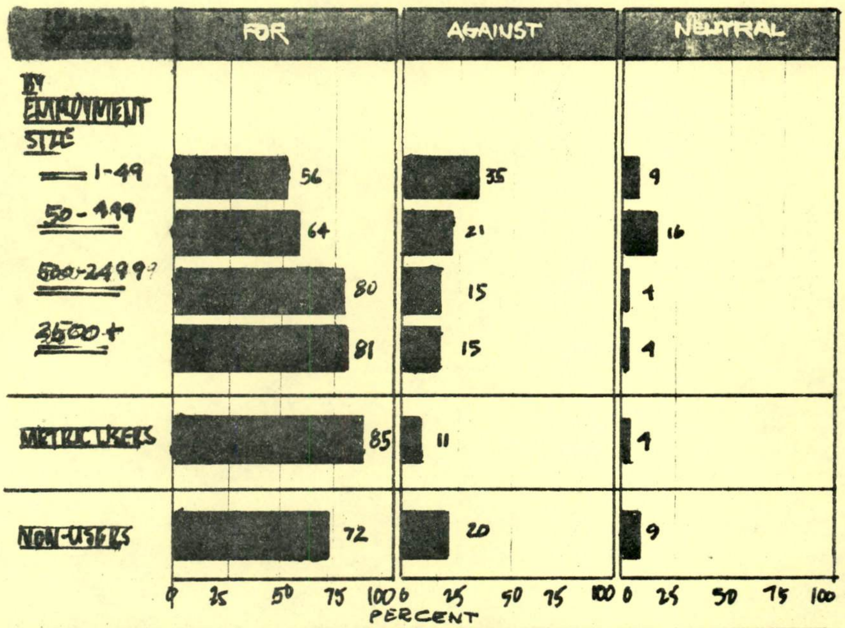
The surveyors were surprised that, considering the generally low level of public knowledge, so many people were favorably disposed toward the metric system: about one-third were in favor of converting to it. Rather consistently, those with more formal education or more experience using metric units seemed the most confident that they could master it with little difficulty and believed that metric conversion was in the best interest of the U.S. For these reasons the surveyors judged that a program of public education would win many converts to the metric system.

(INSERT IN THIS LAST SECTION THE 3 SETS OF BAR CHARTS INDICATING THAT "THE MORE PEOPLE KNOW ABOUT METRIC THE MORE THEY LIKE IT")

* * * * * * * * * * * *

Manufacturers attitude toward more metric use in the United States as a whole

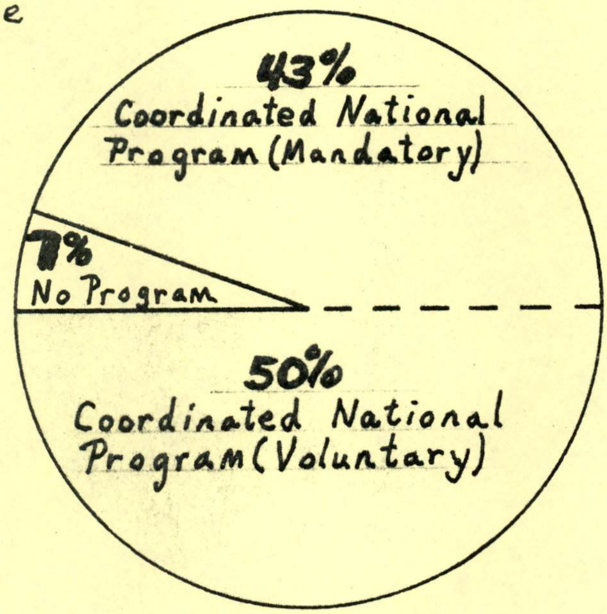
(~~Weighted by size of company~~)



Manufacturing Businesses

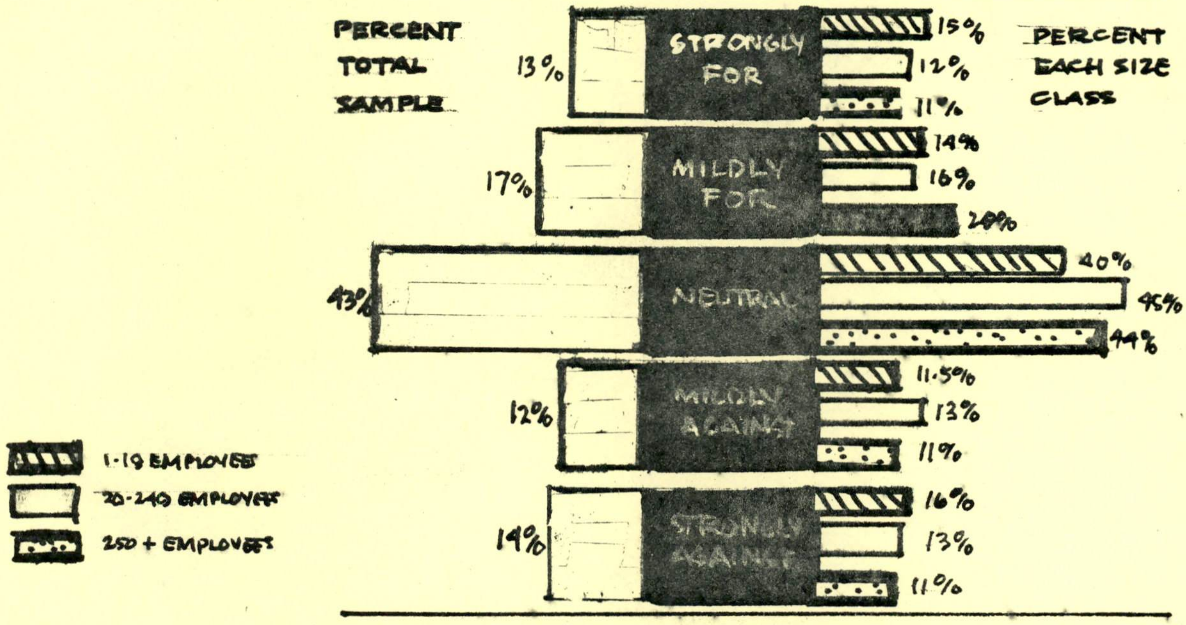
If Increased Metric Usage is in "Best Interests of U.S.," What Course of Action?

Percent Total Sample



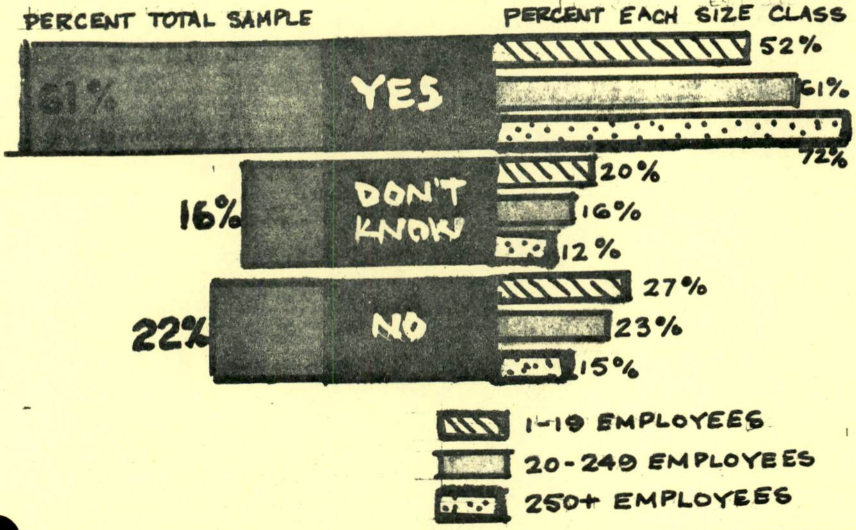
Non-Manufacturing Businesses:

Attitude Toward Increased Metric Use in Own Company



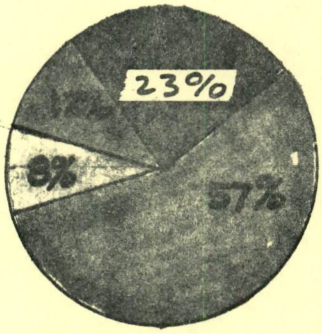
Non-Manufacturing Businesses:

Is increased Metric Usage in the Best Interests of the United States?

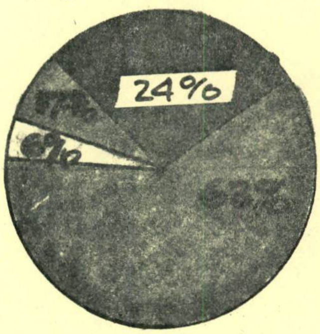


PERCENT EACH SIZE CLASS

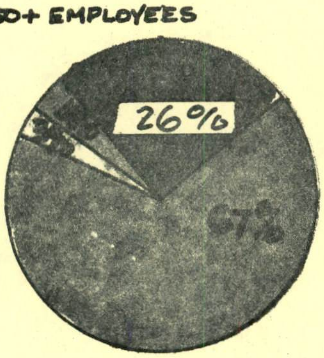
1-19 EMPLOYEES



20-249 EMPLOYEES



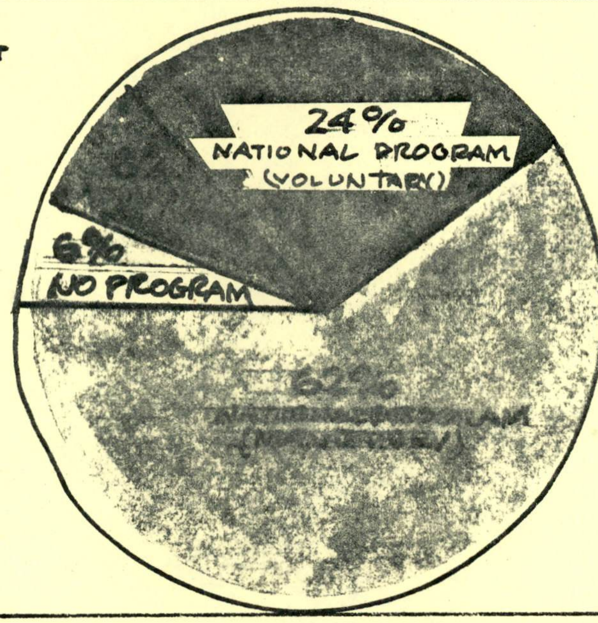
250+ EMPLOYEES



Non-Manufacturing Businesses:

If Increased Metric Usage Is in "Best Interests" of U.S," What Course of Action?

PERCENT TOTAL SAMPLE



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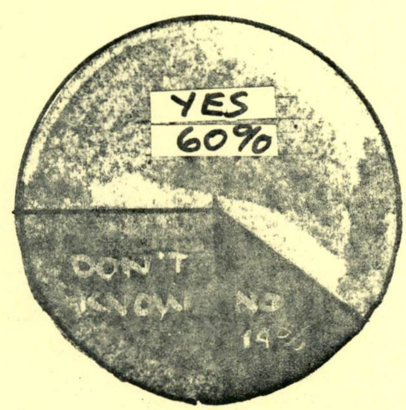
VIEWS OF FEDERAL CIVILIAN AGENCIES

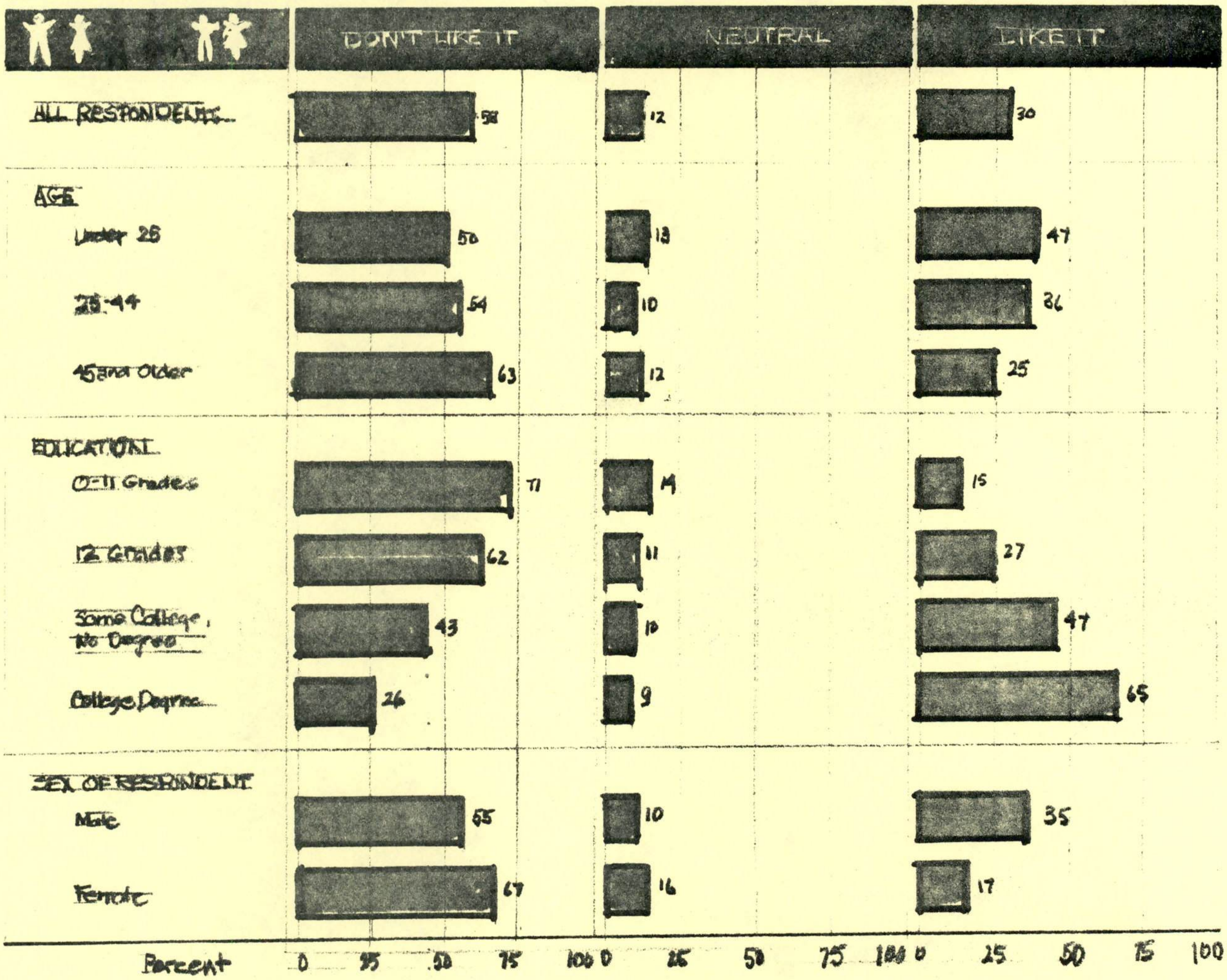
Favor Concerted National Change to Metric



Long Term Advantages Would outweigh Disadvantages cl vi

Public Attitudes Toward Metric

~~Public Attitudes Toward Using Metric~~



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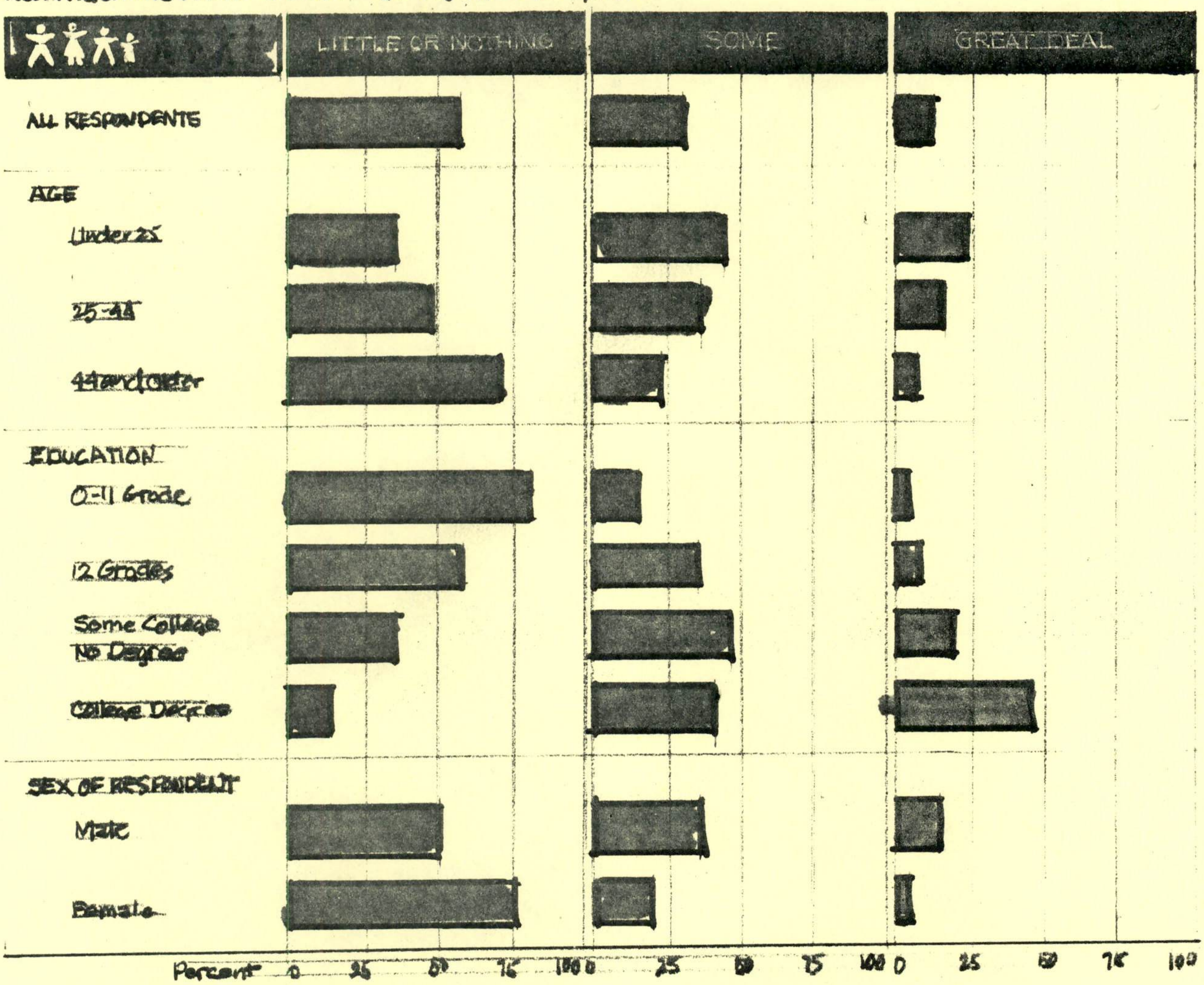
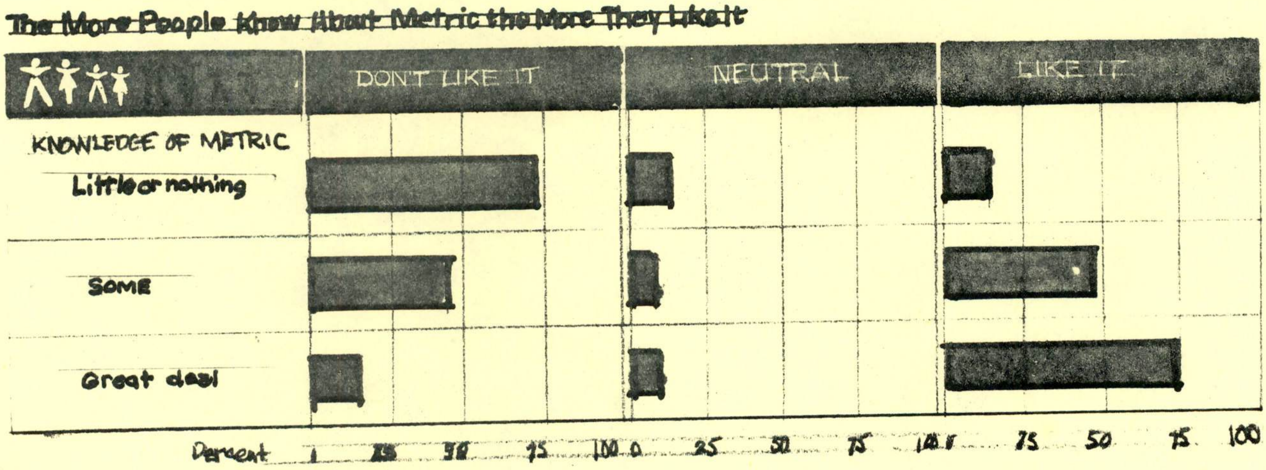
How Much the Public Knows About the Metric System



The More People Know About Metric the More They Like It



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VII - COSTS AND BENEFITS

How would you plan and budget for a once-in-a-lifetime change unlike any you had ever made before? This, in effect, was the problem confronting the thousands of people whom the U.S. Metric Study asked to estimate the costs and benefits of converting to the metric system. No nation has ever tried to make such an estimate before.

Firms, groups and agencies had relatively little difficulty reporting on their use of metric units and giving their opinions as to whether conversion would benefit them or be in the best interests of the U.S. But when they came to discussing the subject in terms of dollar values, they were on shaky and uncharted ground and some of them quite understandably became apprehensive and hypercautious.

Most of them declined to make dollar estimates. A typical reply said, "We don't know whether metric would help or hurt us, but if our customers want metric products, we will do what it takes to satisfy that need."

Men experienced in interpreting broad surveys of this kind were not surprised that cost-benefit estimates were often highly conservative and sometimes even inconsistent. One expert who played a leading role in the Manufacturing

Industry part of the U.S. Metric Study was Morris Hansen, formerly Associate Director of the U.S. Census Bureau and an authority on statistical surveys. In his review of the Study's survey of manufacturers he wrote:

"There is a general tendency in planning and budgeting to avoid overestimating income or benefits, and to avoid underestimating costs.... We have no basis for evaluating the survey results in this regard, but it would seem, as a judgment, that the net impact could reasonably be that benefits could be greater in relation to costs than would be elicited in a survey of this type. If this was true, it would be consistent with experience observed in some other statistical surveys that involve estimating income and costs that are not matters of record."

Similar observations were made by Australia's Senate Select Committee that spearheaded that country's decision to go metric. It noted in its 1968 report: "In only a few cases would the costs of conversion, or the compensating benefits, be capable of even approximate assessment.... Experience from countries where conversions have been made or are being made confirms that costs have been overestimated, in some cases drastically. In India the cost of converting petrol pumps to measure in litres proved to be only one percent of the estimate. Many sources in Japan confirm that industry and commerce were very happy with the change, which had proved less difficult and less costly than was expected."

Prudent planners are naturally reluctant to venture out on a limb. In addition, the estimating task in the U.S. Metric Study was complicated by the realization that numerous important costs and benefits are not really tangible enough to be evaluated on any sort of balance sheet. Examples include: the inherent simplicity and convenience of metric, possible confusion during changeover, the weighing of considerable and immediate costs during the transition period against delayed long-term benefits thereafter.

The ideal outcome of this phase of the U.S. Metric Study would have been a simple figure, in dollars and cents, representing the net benefit (or cost) of going metric. It would have come from adding all the costs and all the benefits and finding the difference between the two totals. If this could have been done in the straightforward manner of a profit-and-loss statement, this chapter would have concluded with one of these two simple statements. Either, the U.S. would make a profit by going metric. Or, the U.S. would take a loss by going metric.

This ideal is unattainable. The costs and benefits are not comparable. First of all, in any metric program that has been tried or contemplated, they occur at different times. Virtually all the costs are incurred during the transition period, at a time when the benefits are just beginning. Most of the benefits come after the transition period, at a time, perhaps a decade after the start, when the costs have already been written off. Assuming that a dollar value could be put on each cost and benefit, it is theoretically possible to calculate the present value of a future benefit, provided it was also known exactly when it would occur. But practical people who make cost estimates and draw up budgets seldom look more than three or five years into the future -- and with good reason. So many economic, social, and political factors can change in the space of a few years. Even today, leading economists disagree in their forecasts for next year.

Moreover, the majority of costs and benefits are basically elusive -- perhaps even unknowable in dollar terms. As the rest of this chapter will show, there was a wide disparity in the cost estimates by firms and others who participated in the study. And with very few exceptions, no one was able to put a dollar value on benefits.

What kinds of costs were considered? They include out-of-pocket payments for hard changes, e.g., buying new scales, changing gasoline pumps, replacing or adjusting machinery, repainting highway signs, rewriting plans and specifications. They include also the often-hidden expense of confusion and inconvenience, e.g., having to learn new words and how to use them, having to work more slowly in order to avoid mistakes, having to do arithmetic in order to understand an item in the newspaper, wondering which kind of wrench to use on a bicycle or lawnmower.

It is even harder to put price tags on the benefits. Some are directly rewarding: metric calculations are easier; school children learn the metric system more quickly; travelers abroad would be spared petty annoyances if they were at home with the measurement language. Many of the potential benefits would be by-products of a changeover. They would come about because people, while making the metric change, would seize upon opportunities to do other worthwhile things that are actually not directly related to any measurement system.

Thus, there might be many dividends that hitched a ride on conversion. The growth of modular housing might go faster. Translating textbooks into metric terms might provide opportunities for curriculum improvements. And in thinking out new metric dimensions, engineers would weed out superfluous sizes of nuts, bolts, and many other common items. Taking advantage of these opportunities would, in effect, be benefits and thus would be a way of recouping the costs of going metric.

In order to increase the accuracy, or at least the consistency, of all estimates, participants were urged to heed guidelines based on those set forth by the American National Standards Institute (and outlined in the preceding chapter of this volume). In brief, these stated that during conversion, measurement system changes would usually be phased into new products and old products ready for redesign and that products and major components would be converted only when new metric parts were ready at reasonable cost.

Although these guidelines were drawn up specifically for estimating the out-of-pocket costs of manufacturing, the intent could be translated broadly to the varied problems of education, labor, consumers, and other sectors of society. And so, they served as the U.S. Metric Study's basis for estimating costs and benefits of all kinds.

Education

In addition to being generally enthusiastic about increasing the use of the metric system, educators and the firms that work with them are not greatly concerned about costs of conversion. The education survey, conducted as part of the U.S. Metric Study, indicated that changing textbooks and equipment would cost about $1 billion spread over three to five years. If they were changed for no other reason than going metric, the cost could be attributed to a metric changeover. But, in fact, most textbooks are replaced anyway after a few years of use and, thus, most of the $1 billion could be completely absorbed and would not appear as an extra item in school budgets.

Training teachers who are still not familiar with the metric system would represent another expense. But since most teachers these days pursue programs of continuing education, the cost would probably be inconsequential if the conversion were made over a period of several years. It was suggested that much teacher retraining could be done through programs on educational television.

The intangible benefits of going metric might well be substantial. Some teachers pointed out, for example, that it is very difficult for small children to learn to interpret the graduations on a Customary ruler; centimeters and millimeters are conceptually much simpler than small fractions of an inch.

Much more important, though, is the time that could be saved if students did not have to be drilled in the intricate fractions necessary to cope with the Customary system. Estimates varied, but mathematics teachers said that in elementary school they spend from 15 to 25 percent of their class time driving home the details of adding, subtracting, multiplying, and dividing common fractions. If the metric system, with its simpler decimal relationships, were taught, they could rapidly give their pupils the basic principles of fractions and then move on to other parts of mathematics. This change would be in harmony with the philosophy of the "new math," which tends to minimize drilling and to emphasize the teaching of underlying concepts.

The Australian metric study arrived at an almost identical conclusion: "There seems no question that considerable time would become available for valuable new work if metric units were taught in place of the Imperial. The arithmetical procedures required for use with the metric system would be no different from those of ordinary decimal work and money sums, which would give a unity to this phase of mathematical education.... Various estimates have been made of the actual saving in time which would result from the adoption of the metric system. The British Association for the Advancement of Science and the Association of British Chambers of Commerce estimated in 1960 that there would be a saving of 20 percent in the teaching of arithmetic or 5 percent in the total school time for children between seven and eleven years."

Citing a study it had sponsored, the American Association for the Advancement of Science mentioned an additional intangible benefit. It has been found that slower children learn metric more readily than the Customary system -- a factor that could not possibly be expressed in monetary terms.

Business and Industry

The almost 4,000 companies selected for the manufacturing survey were asked also to carry out detailed studies of possible costs and benefits to themselves. Only a few more than 100 volunteered to undertake this troublesome and expensive task. Each company adopted its own "optimum period," the time in which it could convert most conveniently and at least cost, and each was asked to follow the American National Standard Institute's guidelines.

On the average, ten years was chosen as an optimum period for the changeover. If the findings of the volunteers can be taken at face value and are assumed to represent the U.S. manufacturing industry as a whole, the total cost of conversion would be about $25 billion. Put in perspective of the productivity of U.S. manufacturing industry over the ten year period, this estimated cost amounts to less than 1 percent of value added by manufacturing processes.

About one-fourth of the companies anticipated some long-term savings, although they did not expect to recover transition-period costs for twelve to fifteen years. However, no dollar estimates were given for benefits.

The charts (WHERE) show a striking disparity among the estimates of the individual companies. Within some industries, the highest estimate was over 100 times greater than the lowest. The results varied so greatly, despite the use of a common set of guidelines, that other factors must have crept into the estimates. The $25 billion total was based on the assumption that all manufacturers would arrive at a similar assortment of cost estimates. This overall figure was greatly influenced by the findings of a single large mining and refining company, whose cost estimates were much higher than those anticipated by similar firms. If, purely by chance, this one company had been omitted from the computation, the total estimated conversion cost for all manufacturers would have been $3 billion less.

In addition to the gross $25 billion figure, it was suggested that it would cost about $5 billion to carry extra inventories of standard parts and materials during the transition period. As a matter of fact, some of this cost is already being incurred, owing to the gradual increase in the use of metric in the U.S. As dual inventories of metric and Customary parts and materials build up, their cost will endure, and will reach the rate of roughly $500 million a year, until the country settles on a single measurement system.

Being both metric and Customary is not the only reason for dual inventory costs. Unnecessary varieties of things now exist. In a metric program these varieties could be reduced. In Britain, for example, one manufacturing company is well on its way to reducing its stock of fasteners (e.g., nuts, bolts and rivets) from 405 sizes to less than 200, and another is replacing 280 sizes of ball bearings with only 30 types made to metric standards.

(INSERT CHART ON TABLE OF ITEMS FROM COST QUESTIONNAIRE -- MFG. SURVEY)

Part of the disparity in cost estimates is due to the fact that few U.S. companies have had much experience in changing to metric. But some have made the conversion at least part of the way. It is suggestive that in the overall survey a majority of those firms that currently make some use of metric did not mention retraining of workers as a drawback to conversion. Presumably, they had not found it difficult or expensive. And one of the large pharmaceutical manufacturers, which took part in that industry's metric conversion program a few years ago, reports that its costs were one-half to two-thirds of careful estimates made as part of their actual conversion plan.

Non-manufacturing businesses were asked to judge their costs on a somewhat different basis, because their problems would often be quite different from those of manufacturers. For them, generally, metric conversion would require considerably fewer "hard" changes; that is to say, in many cases they would continue to use the same parts and machinery, although they might translate Customary dimensions into metric dimensions.

Non-manufacturing companies were asked, therefore, to estimate how greatly metric conversion would increase their annual cost of doing business. A majority speculated that their expenses would rise by about 1/2 of 1 percent during the transition period. Applied to the country as a whole, this would mean a total cost of roughly $10 billion spread over ten years for the non-manufacturing businesses -- or roughly $1 billion a year during transition to metric.

However, no dollar estimates were given for benefits.

Labor

Labor unions were greatly concerned about possible costs to their members for new tools and also for retraining. They suggested that these expenses would have to be borne by employers, and industrial participants did, indeed, view retraining and tools as major cost items in their own estimates. On the other hand, some craftsmen are self-employed and might have to spend up to several hundred dollars for new tools.

Some labor leaders are more deeply worried about a much subtler cost, which can be termed "loss of experience." Take the automobile mechanic who, after years on the job, instinctively reaches for the right wrench to tighten a bolt. When working for the first time, or even the tenth time, on a metric engine, he cannot rely on his instinct. He works more slowly, less surely, and is therefore not quite so productive. If he is a senior craftsman, he may even be at some disadvantage with respect to a metrically trained newcomer. Such examples are easy to envision for many crafts and industries. No dollar estimate was given for this "loss of experience." In any case, it would be important to ensure that this problem is dealt with equitably.

Government

The Department of Defense study team estimated conversion costs on the basis of maintaining national defense at a constant level during a conversion period assumed to begin in July 1972 and to be effectively completed ten years later. The cost items included in the estimate were based on a number of factors. The Defense study team foresaw extensive change orders in weapons systems already in the development stage. Men would have to be taken off the job and retrained. More lead time would be required for new weapons and for maintenance. Industry would suffer temporarily from a decrease in efficiency and the Defense Department would have to pay more for its purchases (these additional costs, however, are accounted for in the estimates for industry, above). Manuals, regulations, orders, and other documents would need rewriting in metric language. And the Armed Services would need more warehouse space for dual inventories.

For all these changes the Defense study team estimated that appropriations for the Department of Defense would have to be increased by $18 billion over the ten-year conversion period. In terms of the present military budget, this would amount to about 2.5% per year, which is about three times the increase anticipated by U.S. manufacturing industries. The British military agencies, in contrast, intend to absorb the added costs of metrication within their normal budgets.

The Department of Defense report also listed a number of long-term advantages. Going metric would contribute to a worldwide harmonization of measurements, and this would save the time now spent in converting from one system to the other. The compatibility and interchangeability of equipment between the U.S. and its allies would expedite repairs, make possible support in areas where support is now nonexistent, simplify procurement across national boundaries, and increase the communication of all data, including design, operations, and training. Use of the metric system would reduce the total training time of mechanics, engineers, and others. It would also reduce the chance for error in computations. Conversion would encourage a "general modernization and updating of individual plant equipment, ground equipment, and shop hand tools." And the need for fewer conversions and difficult programming would reduce computer time.

Metrication Board: "All firms will, because of the metric change, be called upon sooner or later to review the design of their products. They have to consider whether it is timely to change the whole design or to change individual components of it. All this should be done in ways which will make possible the most economical use of materials to metric specifications and the incorporation of metric fasteners.... A firm's review of its activities should also cover purchasing policies for materials and components, the organization of production, stocking policy and control, and, not least, a critical examination of marketing policies." In short, metrication gives such companies an unprecedented impetus to clean house.

The effect of metrication on the engineering industries has been heightened by their customers who must themselves rely on engineering to further their own metrication. The Defence Department, in particular, has taken the lead in discussing the problems of metric change with its suppliers. In 1969 the Ministries of Defence and Technology jointly prepared an outline target program for the introduction of the metric system throughout the defense procurement field, envisaging that all new designs should be metric. The completion of the changeover will depend, however, on the retirement of existing designs, some of which still have a long life.

Various segments of the engineering industries have responded to metrication in different ways. Aircraft manufacturers, for example, agreed to make every effort to comply with the Defence Ministry's program. But they pointed out that unless the U.S., the world's largest manufacturer and operator of civil aircraft, changes over to metric, two sets of units are likely to be current for some time to come.

In the earliest days of metrication the Council of Machine Tool Trades Association accepted a recommendation that its members consider the metric system for new designs. This would not only familiarize designers and machine shop workers with the new units but would start a gradual decrease in the manufacture of strictly Customary machine tools, thus reducing servicing problems when conversion was completed.

The British Bolt, Nut, Screw and Rivet Federation confirmed that it can meet the basic program of the British Standards Institution and began last year to produce preferred sizes of metric fasteners.

The automotive industry, on the other hand, while welcoming metrication in principle, has announced there will be no immediate and comprehensive change in the industry as a whole. Its plan is to continue conversion gradually as parts, components and new models are redesigned out-of-pocket payments. They would be absorbed in normal operations, such as existing personnel training programs, regular revision of textbooks and documents, and replacement of things that wear out or become obsolescent.

Compared with the total gross national product of the U.S. over a ten-year period, the estimated cost of going metric would hardly be a major factor in the economy. Over the next ten years, for example, economists estimate a total GNP of $10,000-15,000 billion. Thus if $60 billion were actually allocated to going metric, this would amount to only about 1/2 of 1 percent of the total national output of goods and services. This is roughly in line with the costs estimated by business and industry.

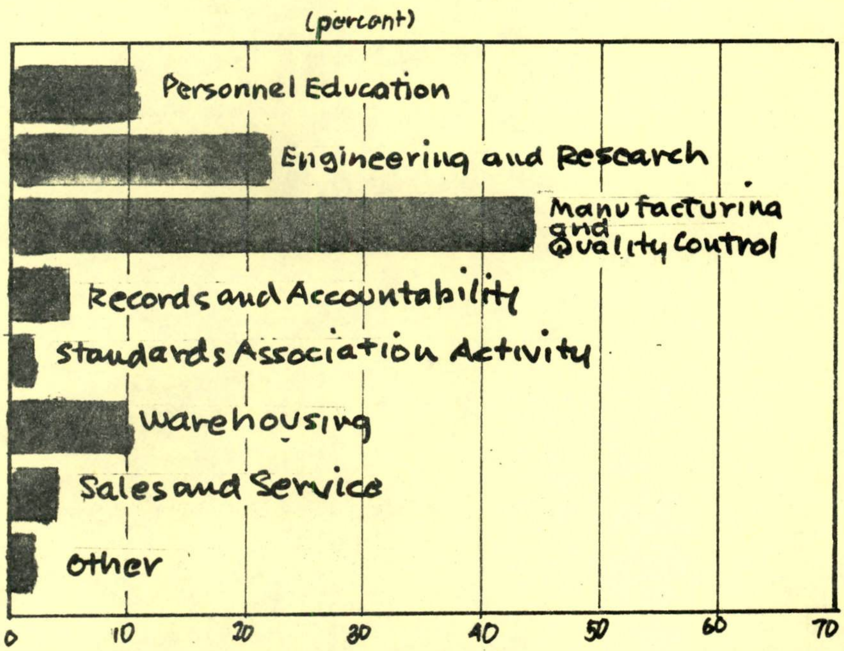
The cost would be considerably less if, instead of converting entirely to the metric system, the nation set a goal of becoming primarily metric. In Chapter V it was pointed out that going metric would really mean becoming primarily metric.

To these already nebulous economic costs must be added some that are still harder to evaluate: the loss of experience and temporary loss of productivity cited by labor, confusion caused by a change in the weights and measures used in everyday life, the uncomfortable feeling that somehow part of each person's cultural heritage has disappeared. These intangible costs may seem slight, but multiplied by 200,000,000 people....

The overall dollar value of benefits could not be estimated. Nevertheless, some are clearly tangible. As is discussed in Chapter X, going metric would have some favorable effect on our balance of trade, which is a major and continuing concern. But what is the book value of a healthy balance of trade? Then there are the pervasive benefits that would result from doing away with a dual measurement system and the duplicate inventories that go with it. No one has suggested a figure for the economic benefit of uniformity in measurement. And no one is likely to put a price on the value of 200,000,000 uncluttered minds.

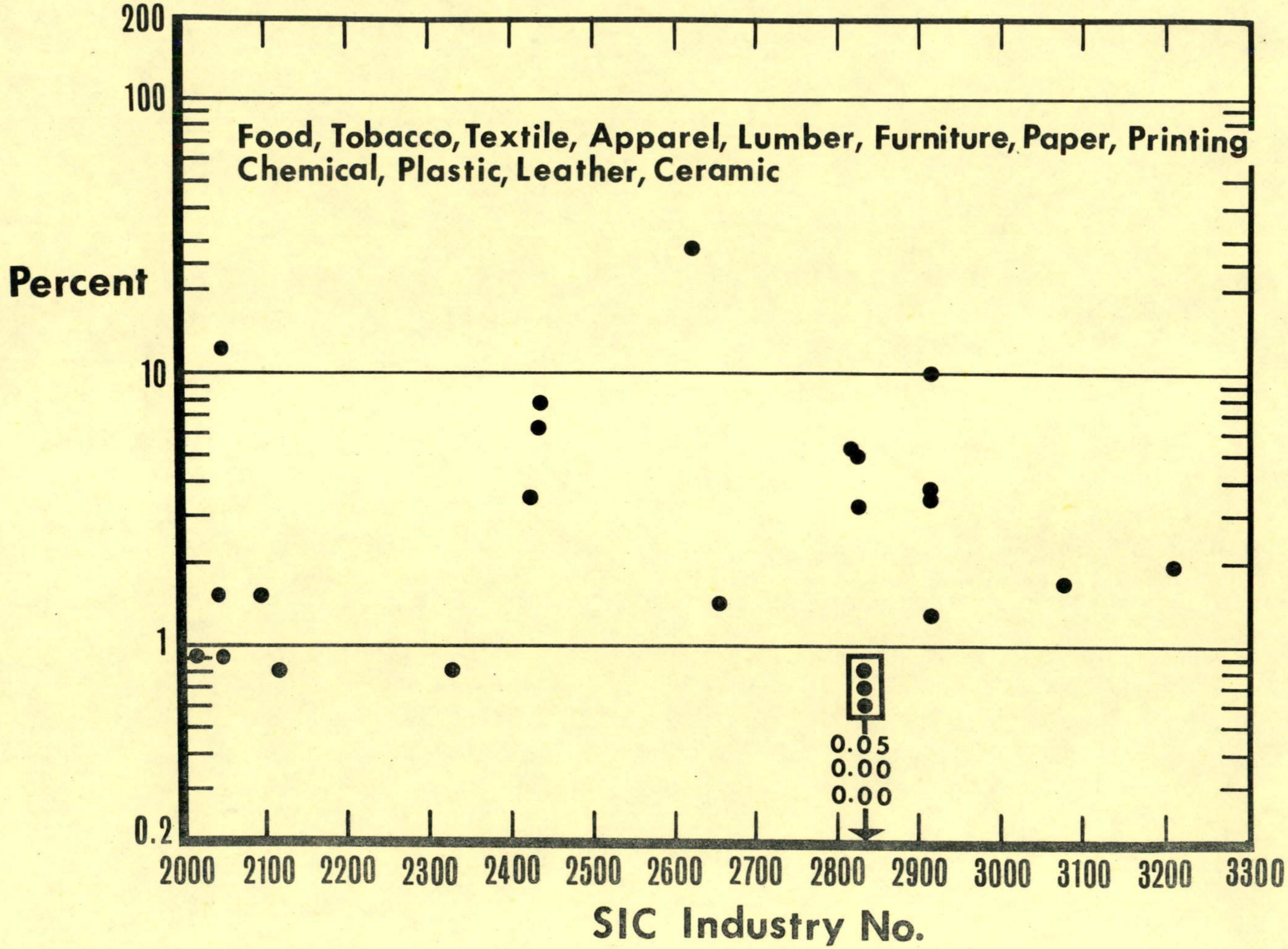
* * * * *

Manufacturing Industry Survey: Allocation of estimated costs of going metric



ESTIMATES BY MANUFACTURERS

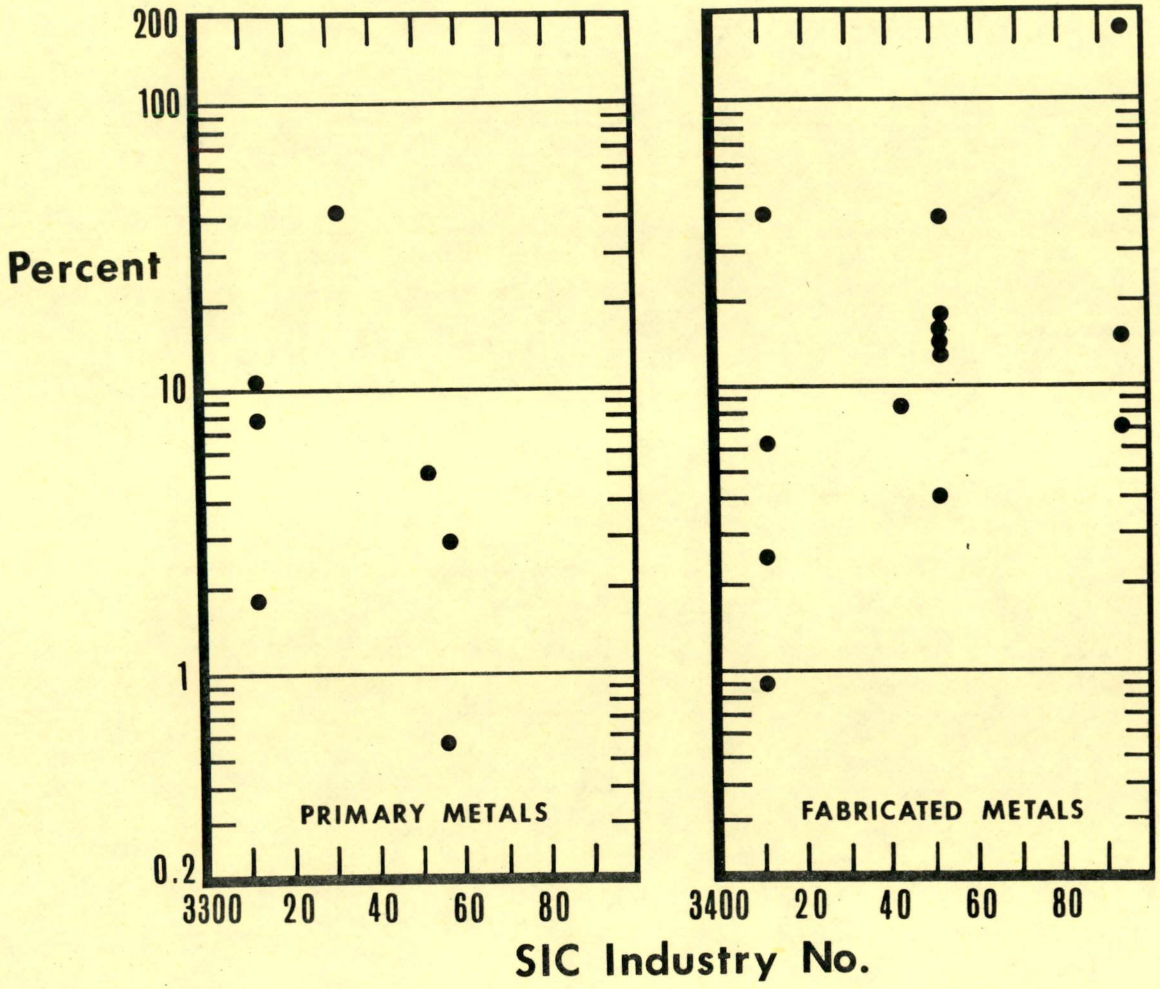
Total Cost of Metrication as Percentage of Value Added by Manufacture in 1969



(Industry Type according to Standard Industrial Classification Code)

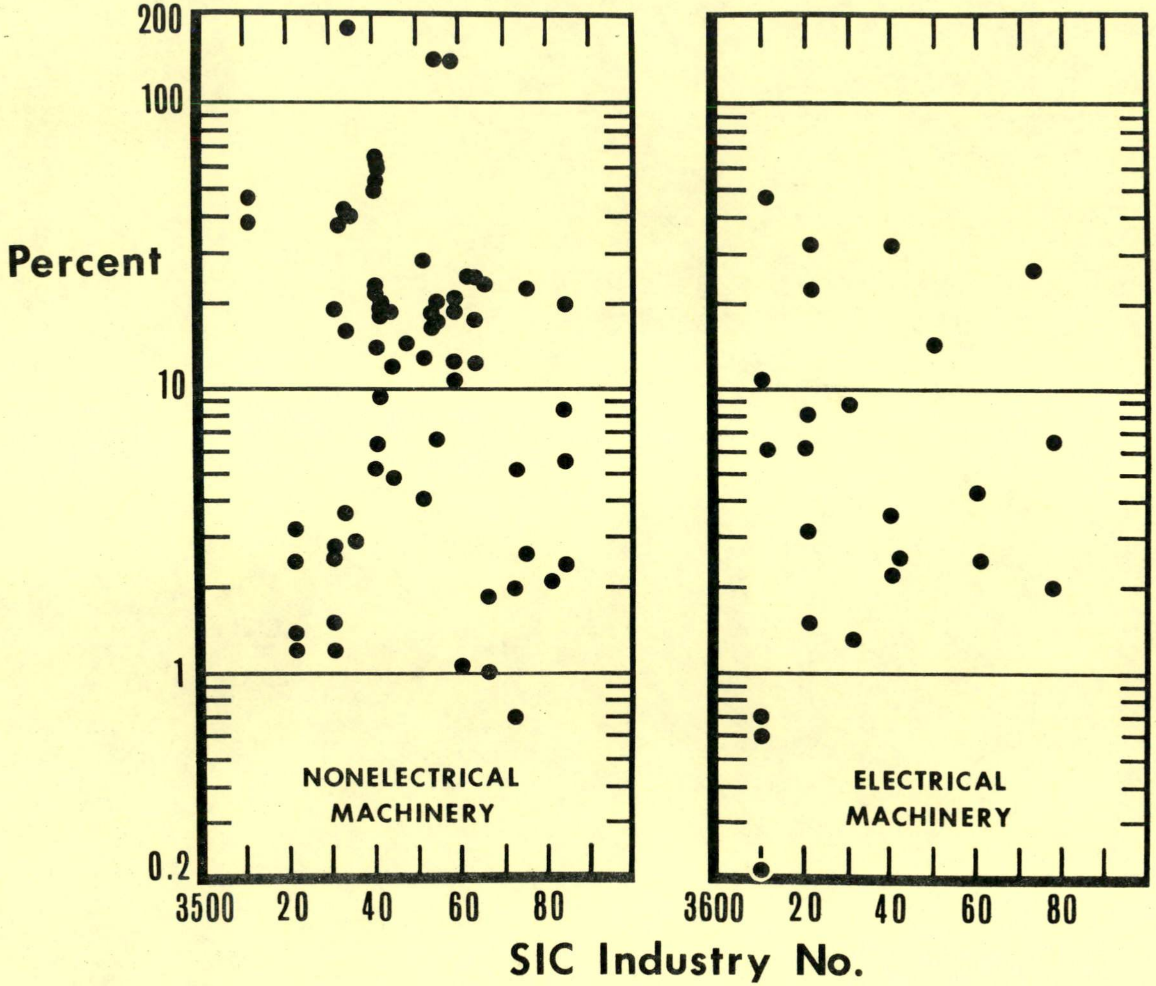
ESTIMATES BY MANUFACTURERS

Total Cost of Metrication as Percentage of Value Added by Manufacture in 1969



ESTIMATES BY MANUFACTURERS

Total Cost of Metrication as Percentage of Value Added by Manufacture in 1969



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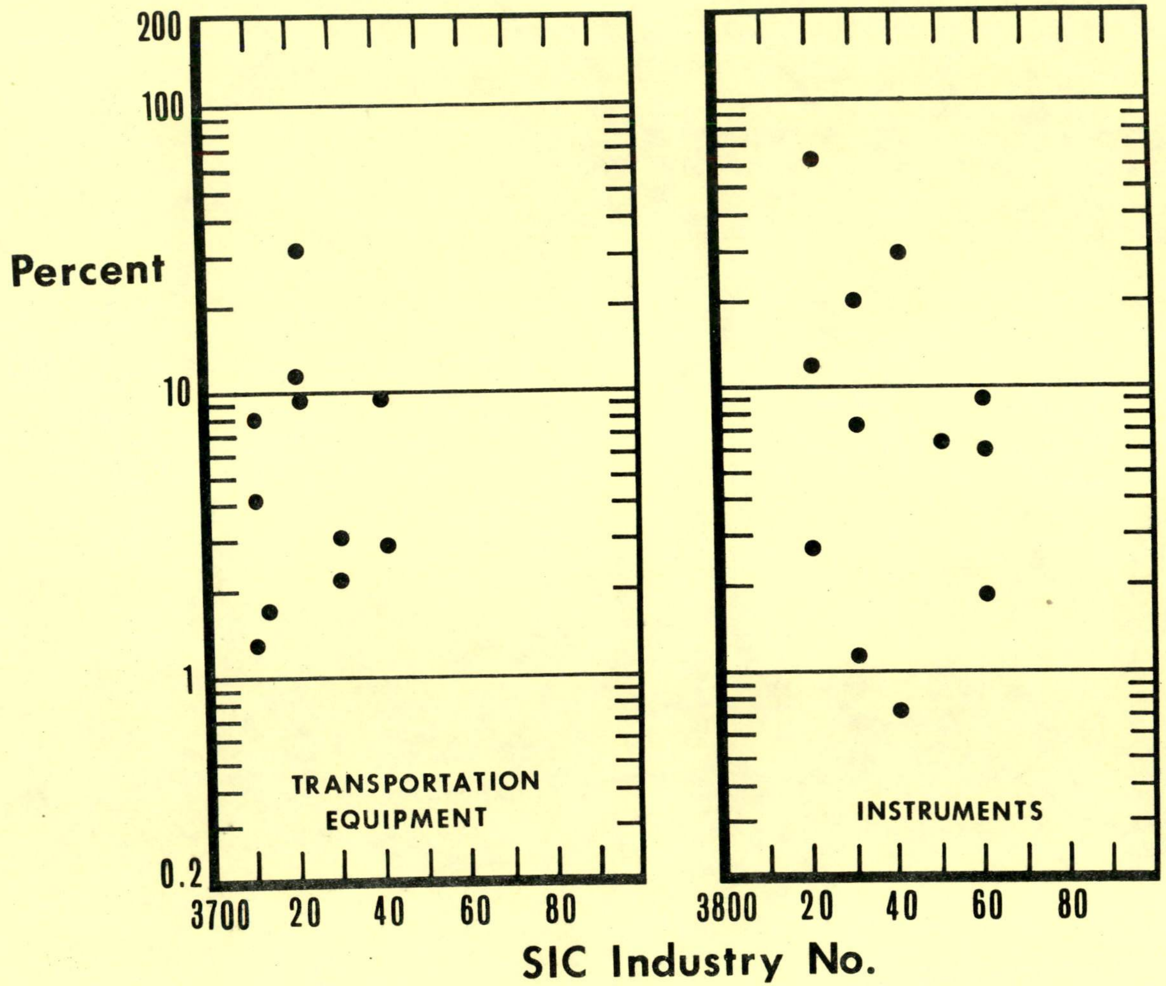
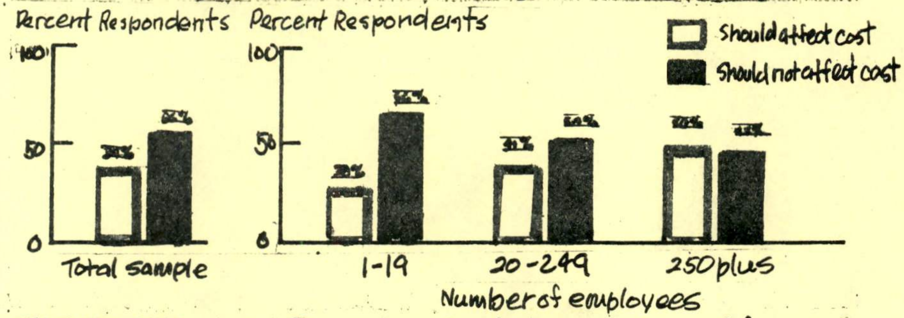
ESTIMATES BY MANUFACTURERS

Total Cost of Metrication as Percentage of Value Added by Manufacture in 1969

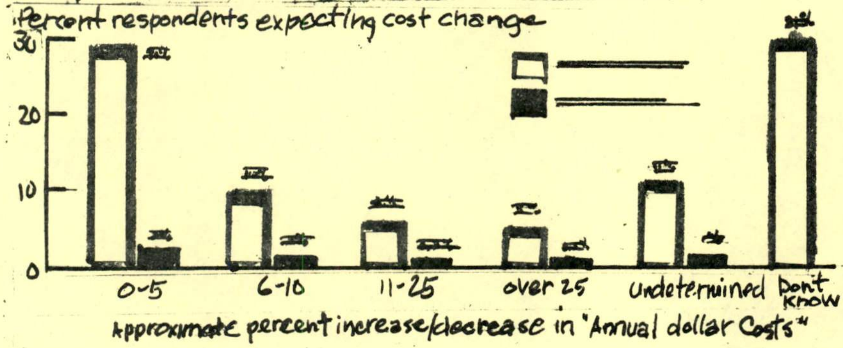


Non-Manufacturing Businesses:

Effect of Concerted 10-Year Changeover on Operating Costs



Of 39% Minority Expecting Cost Change, Direction and Magnitude of Change:



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VIII - TWO PATHS TO METRIC: BRITAIN AND JAPAN

No nation the economic size of the United States and at a comparable stage of industrial development has ever contemplated changing its measurement system. Thus, there is no exact model for the U.S. to follow in considering this possibility.

Since World War II, ______ countries have gone metric or committed themselves to do so (ref. to map in Chapter I).

> Insert list plus Canada status; also, give credit to India, the second most populous nation, for leading the Commonwealth in going metric after World War II.

Only two of the newly metric countries, Japan and Britain, are among the major industrial nations of the world. Each approached conversion in its own way. Although neither program would be likely to prove appropriate in the U.S., there are lessons to be learned from both in the event that this country does decide to go metric.

Japan began the approach to the metric system years before it had emerged as an industrial power. Interrupted first by the depression and then by the war, the program proceeded so haltingly that the goal was not reached for fully 40 years. In 1921 Japan had three officially recognized measurement systems: metric, English, and a traditional system based on the shaku (11.930 inches) and the kan (8.267 pounds). In that year the use of the metric system was extended by law, at the expense of both other systems, and introduced into primary schooling. Plans were made for public utilities, government agencies, and a few industries to convert to metric over a ten-year period. Other sectors of the economy were allowed twenty years to make the change. But conversion progressed slowly and the periods were lengthened by 50 per cent.

In 1939 a new law restored the shaku-kan system to equal footing with metric and also postponed final conversion to metric until 1958. Then at the end of the war, during the occupation, the U.S. Customary system came into wide use. Finally, in 1951 still another law affirmed the 1958 target date for metric conversion, and although the schedule was not met, the changeover was completed by 1962. The Japanese made the metric system compulsory by edict of the Diet.

Much of the final planning was directed by a Metric Promotion Committee, a quasi-public agency, which worked closely with the Ministry of International Trade and Industry. As it turned out, the educational effort begun in the schools more than a generation earlier greatly facilitated the final changeover.

It is conceivable that if the U.S. elects to go metric, we may follow a zigzag course like Japan's. We are, of course, faced with an entirely different set of circumstances: we are already a huge industrial power, heavily involved in trade with a predominantly metric world. Still, while we might decide on principle that metric is the way to go eventually, we might not choose the discipline of the kind of thoroughly planned transition described in the next chapter of this report.

The British took much longer to make up their minds, but once they decided to go metric, they moved steadily forward. Oddly enough, a century ago Britain very nearly became one of the early metric nations. In 1871, Parliament considered making the metric system compulsory for all purposes after a two-year crash conversion program; the motion was defeated by only five votes.

Going metric, or as the British now say "metrication," was not seriously reconsidered until the middle of this century, although in 1897 it became lawful to use metric measurements for most purposes. During the World War I era, when a member of Parliament raised the question, Prime Minister Lloyd George dismissed it facetiously by replying: "Do you expect the British workingman to go into a public house and ask for .56825 litre of beer?"

Renewed interest in metrication dates from a 1950 report of a departmental committee on weights and measures. After detailed study, the committee arrived unanimously at a number of conclusions. The metric system was inherently better than the Imperial (Customary) system then in use. A change for all trade purposes was sooner or later inevitable. Meanwhile the dual use of both systems would in the long run cause extra inconvenience. The long-term advantages of an organized conversion would far outweigh the inconveniences of making the change. Besides, the committee made two important provisos: that change should be made in concert with the United States and British Commonwealth countries, and that prior to metrication British currency should be put on a decimal basis.

The report had little immediate impact. At that time British industry and commerce were against making a change while the U.S. and most of the Commonwealth, which were then Britain's main trading partners, still adhered to Customary. Ten years later a committee of the British Association for the Advancement of Science and the Association of British Chambers of Commerce reported that a majority of industry still considered the time not ripe to make the change.

Then as more and more countries, including several members of the Commonwealth, shifted to the metric system and as the proportion of trade with metric countries increased, the balance of opinion shifted rapidly. By 1963 the British Standards Institution made a broad survey of industrial opinion and found a large majority of British firms in favor of starting metrication immediately, without waiting for the U.S. and the rest of the Commonwealth.

British industry itself took the initiative. In 1965 the president of the Federation of British Industries (roughly equivalent to our National Association of Manufacturers) informed the Government that a majority of firms favored adoption of the metric system as the primary and, ultimately, the only method of measurement to be used. The Federation asked the Government to support the principle and to aid the scheduling of conversion.

The Government's reply to this proposal was prompt and favorable, although it left most of the initiative with industry. It said in part: "...the Government consider it desirable that British industries on a broadening front should adopt metric units, sector by sector, until that system can become in time the primary system of weights and measures for the country as a whole... We shall also encourage the change to the metric system as and when this becomes practicable for particular industries, by seeking to arrange that tenders for procurement by the Government and other public authorities shall be in terms of metric specifications."

Britain had chosen the road to metrication, although more than two years of study were required before the program could be launched. In the summer of 1968 the Minister of Technology again reported on the subject. He made three major points: that manufacturing industry can make the change efficiently and economically only if the economy as a whole moves in the same direction on a broadly similar time-scale, and in an orderly way; that a Metrication Board should be established to guide, stimulate, and coordinate the planning for the transition; and that any legal barrier to the use of the metric system -- e.g., tariff and other regulations written in Customary -- should be removed. Every sector of the economy need not move at the same pace, he said, but central machinery -- the Metrication Board -- was needed to coordinate the change.

Thus, the stage was set for metric conversion, British style. The Metrication Board was made a purely advisory body with representation reflecting the interests of industry, distributors and retailers, education, and the general public. No compulsory powers were sought or granted. As for the expense of conversion, the Minister stated: "There can be no question of compensation; the costs of adopting metric must lie where they fall." Finally he confirmed 1975 as a target date for conversion, with the possiblity that some sectors of the economy might aim at somewhat earlier or later dates.

As this report of the U.S. Metric Study is issued, the British Metrication program is one year past the halfway point. Almost all the planning has been done, and in some sectors conversion is nearing completion. The chart (WHERE) shows in some detail the scheduling for most of the major British industries. The next several pages summarize accomplishments and problems in certain crucial areas.

Education

From the start the British have counted heavily on the educational system to make metrication smoother and lasting. The children now entering primary schools are learning to think in metric terms, as naturally as their mothers and fathers thought in terms of inches and pounds. Those in higher education are breaking the habit of thinking Customary.

Teachers in primary schools are satisfied that the metric system will save time and effort. They will not have to spend valuable hours on the intricacies of the Customary system, which makes arithmetic harder. British schools are more independent in their choice of curricula than are U.S. schools. But regional and national examinations will by 1973 be written entirely in metric terminology, and headmasters who want their pupils to do well will train them accordingly.

Publishers and makers of educational equipment are already well ahead in the production of texts and apparatus that conform to the metric system.

Future teachers now enrolled in colleges and schools of education are already being trained to teach in the metric system and should be familiar with it by the time they take their first jobs.

Vocational Training and Retraining

Here again, in this special area of education, the emphasis has been on teaching people to "think metric" on their own, rather than to rely on converting measurements from the more familiar inches and pounds. For the majority, the amount of new knowledge and reeducation needed has proved slight and easy to acquire on the job in a short time. Firms are finding that retraining for metrication is not the formidable obstacle it was feared to be at the outset of the program.

Vocational schools and technical institutes design their curricula to the needs of specific industries, and they are generally pacing their change to metric training according to the industries' metrication plans. The Council for Technical Examining Bodies, for example, has already published proposals for "metricating" examinations for trainees and workers in the leading industries: construction, industrial materials, engineering, mining, forestry, paper and printing, and shipbuilding.

The Industrial Training Boards have been active in preparing guidance for their industries on training needs. The Construction Industry Training Board, which has led the way in metric retraining, found itself with an exceptional problem. This stemmed partly from the decision of the industry to press forward with dimensional coordination and partly from the nature of the industry itself, with its large proportion of small firms.

For the most part, individual firms were not prepared to handle the necessary retraining as larger firms have generally been doing. Accordingly the Construction Industry Training Board has taken on a major role in providing training aids. In most other industries, the training boards are playing a more modest role in connection with metrication, and some have adapted to their own needs the training aids prepared for the construction industry.

The Government Training Centers, a central government agency for retraining unemployed workers, planned for half the machine tools used in their programs to be metric by mid-1970. They also began revising documents to metric terms for trainees in bricklaying, carpentry, woodworking, plastering, and machine operating. All construction trades get some knowledge of metrication.

Construction

British metrication got off to a flying start when construction, one of the most complicated industries to change, led the way. Its activities are closely interlocked with those of a host of manufacturing industries -- e.g., steel, glass, plastics, and timber. It employs a wide variety of skilled and professional people, including architects, civil engineers, electricians, steamfitters, and experts in heating and ventilation, and building maintenance. The conversion to metric materials and components, begun in January 1970, is expected to be substantially completed by December 1972. All the major materials manufacturers have now arranged their own metrication programs and these mesh with that of construction.

The construction industry decided from the outset to combine metrication with the adoption of a series of standardizing dimensions and thus to create new opportunities for modular design and building. Almost paradoxically, in rationalizing sizes the British construction industry has tended to favor a module of 300 millimeters. This is a seemingly peculiar number, but it happens to be very close to the familiar length of one foot.

It was decided not to delay the metric design of buildings until new metric dimensions have been decided for all components. For a limited time some components made to Customary standards will still be fitted into the new designs, in much the same ways that up to now most new buildings have had to make do with what was available. Old buildings have always been repaired with the materials available at the time.

By the end of 1972 the transition period will be virtually over, and Britain should be industrially capable of designing and constructing completely metric buildings. Meanwhile, most small private contractors have stuck to the old methods except when they have found some cost advantage in changing or where their clients or their consultants require metric design. On the other hand, larger "systems" builders are having little difficulty in switching to metric, and their customers are benefiting from the advances in standardization.

Transportation and Communications

These industries, which affect the lives of almost everyone, are less commonly privately owned than they are in the U.S. The British Government, for example, owns the electric power industry, the railroads, the major airlines, and, through the Post Office, the telephone and telegraph service. Whether publicly or privately controlled, most of these industries have had to face much the same problems, but each of them has had to work out its own timetable within the framework of the general target date of 1975.

Tariffs for delivering goods, people, and messages are generally based on combinations of weight, dimensions, and distance. Thus, with little effort old tables can be converted to new ones that are almost exactly equivalent. The change will hardly affect the individual citizen.

Many people, however, will have to adjust their thinking to revised traffic regulations, notably speed limits, when they are introduced. The Department of Transport Industries decided against posting speed limits in both miles per hour and kilometers per hour during a transition period. In the interests of safety they recommended an abrupt switch. The timing of this change has not yet been decided, although there has been a good deal of preparatory work by the authorities.

So far as the traveler is concerned, metrication of the railroads will mean little, except that timetables including distances will be revised at some convenient time for reprinting. But the people who run the railroads will have to become accustomed to new operating manuals with speeds, distances, weights, pressures, and other dimensions expressed in metric terms when the change is made.

Metrication of shipping and navigation is primarily a matter of rewriting in new units various acts, rules, and regulations. This process is well advanced, as is the provision of metric training for mariners. However, the knot and the nautical mile are internationally recognized units and will continue in use. Revised metric charts for British waters will be available in 1972; the Navy Department will then begin issuing tide tables in metric units; and the port authorities will convert their tide gauges accordingly.

The airlines have long dealt with a mixture of metric and customary units and will continue to do so until there is a comprehensive international agreement to change. Since they already weigh freight and baggage in kilograms, conversion to customs and other regulations to metric will be an added convenience.

There is unlikely to be any early change in air navigation practices, particularly in units used for air-to-ground communications in traffic control or for the calibration of flight instruments. International civil aviation uses two different sets of standards; both include the knot and nautical mile, but one set measures speed and vertical distances in metric, the other in Customary.

In the transportation and communications industries, metrication seems to have assumed a definite pattern: only those things that need changing will be changed, and then only when the change becomes necessary.

Engineering

In no other group of industries does metrication represent so profound a change. Precise measurement is a basic activity of engineering firms, and the use of new units of measurements affects every aspect of the firm's business. To change in an orderly and efficient way, the British engineering industries have relied greatly on a metrication program and guide published in the summer of 1968 by the British Standards Institution -- one of the first programs to be agreed upon.

For many products of the engineering industries the availability of metric standards has been an essential prerequisite of the changeover. These standards, prepared by the British Standards Institution, go far beyond a mere arithmetic change from Customary to metric dimensions. They have also eliminated unnecessary varieties of products and components and brought production into line with international standards where these exist. The task was imposing, but essential standards were made available in metric terms by the end of 1970.

While considering the changes dictated by metrication, engineering companies also linked these to still other and more far-reaching changes. According to a 1970 report of the

Metrication Board: "All firms will, because of the metric change, be called upon sooner or later to review the design of their products. They have to consider whether it is timely to change the whole design or to change individual components of it. All this should be done in ways which will make possible the most economical use of materials to metric specifications and the incorporation of metric fasteners.... A firm's review of its activities should also cover purchasing policies for materials and components, the organization of production, stocking policy and control, and, not least, a critical examination of marketing policies." In short, metrication gives such companies an unprecedented impetus to clean house.

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Many British engineering firms, especially those who export to the rest of Europe, are accustomed to producing to metric standards. Metrication has hardly taxed their technical ability, but it has challenged their planning skills. In fact, a number of the purely technical problems have proved less troublesome than had been anticipated.

The Metrication Board's 1970 report points out: "Although most inch-based machine tools can be used without modification to produce metricated components, some users will be faced with the need to convert their machines to a dual role or to metric working, and in some instances to replace them. Most machines can be readily converted, and conversion kits are now generally available.... Most firms will not be involved in major expenditures for reequipment and adaptation."

Industry, Trade, and the Consumer

Consumer trade and industry embrace such a wide variety of disparate products and problems that they have not been incorporated in any comprehensive plan or timetable for metrication. Nevertheless, some fragments of this sector have already worked out their programs, and in the pharmaceutical field British law now stipulates that all prescriptions be dispensed in metric units. Cosmetics, toothpaste, and similar drugstore items have followed suit.

In general, manufacturers in this area have the same metrication problems. Although they need not make elaborate technical changes in their production processes, they have to make timely adjustments in packaging, weighing, and labeling without disrupting their businesses. Throughout Britain many thousands of weighing machines will have to be converted and in some cases replaced. This alone is a complicated task, both for technical reasons and because the work cannot be done all at once.

As long as they are going metric, food manufacturers are considering changing the weights of the contents of packaged foods so as to provide a sensible series of quantities that will soon be familiar to the consumer, e.g., 125 grams as a close approximation of 1/4 pound; 250 grams for 1/2 pound; 500 grams for 1 pound; and 1 kilogram for 2 pounds.

For the most part, standardizing in ways such as this requires only that containers and filling machines be slightly modified. The cost is proving slight. The consumer will not have to contend with so many odd-sized packages and, combined with Britain's new decimal currency, will make the calculation of unit prices much easier.

Other consumer-related industries, however, will have to make more sweeping technical production changes. Some carpet looms, for example, will require rebuilding, although there is no problem in supplying metric widths even now. The bedding industry also intends to become thoroughly metric this year, and to eliminate odd sizes. The single mattress has been standardized at 100 x 200 centimeters, and the double mattress at 150 x 200 centimeters. In scheduling this change, the mattress makers were helped by the fact that existing sheets, blankets, and quilt sizes will fit the new beds.

The British clothing industry also intends to clear up the long-standing confusion of sizes and to join other metric nations in international standardization based on the centimeter. An international scheme for the metric sizing of footwear has been agreed upon in principle.

In its dealing with these parts of trade and industry the general public is being progressively confronted with the reality of metrication. To be sure, much retail trade involves measurement only incidentally. Many goods are sold by number or are pre-packed in familiar containers. Although packages generally are marked with metric as well as Customary volumes or weights, few consumers consistently read quantities on the labels.

Still, the British anticipate complaints from customers who do not think they are getting their money's worth when, for example, they pay slightly more for 500 grams of butter than they did for one pound, which is only 453 grams. The problem would be simplified if retailers could convert for all commodities overnight, but this will be impossible since suppliers will change over at different times.

Problems of Small Business

The mixed situation that is likely to prevail for a time at the retail level points up in general the problems of small businessmen, many of whom are also retailers. Most large companies have the technical, financial, and managerial resources to spare for planning their own metrication and dealing with it over a long period. Also, they purchase in such quantity that they can bring pressure on suppliers to meet their schedules.

The British Metrication Board has been studying companies that lack these resources and leverage and has expressed concern on two grounds. The small businessman is seldom in complete control over the decision of when to go metric; large companies tend to set the pace. Moreover, during the transition period some suppliers are loath to maintain full stocks of both metric and non-metric items, and if the small businessman runs short of some item they are unlikely to produce a special order of the limited quantity a small businessman may require; large companies may very well be able to get whatever they order.

These problems are of continuing concern. Nevertheless, they are not a burden peculiar to metrication; rather, they are the usual problems of most small businesses confronted by market and technical changes of any kind.

Still seeking for a workable solution, the Board states in its 1970 report: "Our present view is that a constructive attitude toward these problems by large firms is the main way of helping. Major producers and users can greatly ease the position by making their intentions widely known to those affected in good time." And this is a strong argument for carrying out metrication according to schedules carefully drawn up well in advance, with the government providing assurance that everyone gets a fair opportunity to participate.

Special Problems

One of the most interesting aspects of the British metrication program is the ingenuity with which a number of minor but bothersome technical problems have been solved.

Even before metrication was well under way, the gasoline industry realized it was soon going to encounter a two-pronged problem: service stations were going to have to dispense gasoline by the liter and price it in the new decimal currency, which was due to be adopted in February 1971. They anticipated both difficulties by having designed a price-computing pump with an important new feature: a convertible head that could be easily adjusted for changes in both money and measurement. All gasoline pumps installed since October 1968 have been of this kind.

When pharmacy went metric there was some reason to worry about medicine to be taken in liquid doses. Few consumers at that time had anything but the vaguest notion of the size of a milliliter. So, to avoid possibly disastrous confusion, drug manufacturers supplied pharmacists with quantities of cheap plastic spoons with a capacity of exactly five milliliters, one to be given away with each bottle of medicine.

Not all the knotty little problems of metrication have yet been solved. The dairy industry is still worried about the size of the metric milk bottle. The British householder is accustomed to having his milk delivered at the door every morning in one-pint bottles, and if milk is sold in the comparable metric size -- 500 milliliters -- he is not likely to change the number of bottles he orders. Unfortunately, 500 milliliters is about 10 percent less than a British pint. Milk companies have reason to fear that consumption would slump, because this did in fact happen in Kenya where the 500-milliliter milk bottle was adopted.

Fortunately, if the U.S. were to go metric, this would be no problem for our dairy industry, because the U.S. quart is about 5 percent smaller than one liter. Thus, if the same psychology were to apply, milk consumption would rise by roughly 5 percent when Americans begin buying their milk in liters.

Informing the Public

Throughout the metrication program a main goal has been to persuade the British people to "think metric," rather than to go through the tedious process of converting inches and pounds through arithmetic calculations. In addition to encouraging education and formal training, the Metrication Board has enlisted the cooperation of journalists and broadcasters to reach the general public. Posters, exhibitions, advertising campaigns, local meetings and study groups have also been encouraged.

How well has this extensive program worked? Generally, at this stage the British people have a pretty clear notion of metric lengths, a less clear one of weights and volumes. The conversion to metric temperature apparently went remarkably fast. Early in the program, British news announcers began quoting the temperature in both Fahrenheit and Celsius.

Then abruptly in 1970 one television station entirely stopped using Fahrenheit. Not one listener complained.

The Board has no intention of trying to teach all the intricacies of the modern metric system to everyone. As one member has stated: "I would begin by crying halt to those enthusiasts who would wish every man, woman, and child drilled in all theory and detail." For most people it is enough to become accustomed to the gram, the kilogram, the meter, the liter and a few units they need for everyday use.

Repeated surveys have indicated that the British public is becoming increasingly aware of metrication and more favorably disposed to it. The British decimal currency change has provided encouraging evidence of the readiness of people to accept such a change when the need arises.

According to a public survey completed early this year, public education has already been fairly successful. About 3/4 of the people questioned knew that a kilometer measures distance, and 2/3 of these knew it is less than a mile. Two-thirds knew that a liter is a measure of volume, and 2/3 of these knew that it is larger than a pint. About 2/3 knew that a kilogram is a measure of weight, but only 2/5 of these knew that it was more than a pound. More than 70 percent thought that metrication would be easy or fairly easy.

If the U.S. decides to go metric in a coordinated program, as the British have done, what lessons can be gleaned from their progress? It is manifestly foolhardy to attempt to translate British experience directly to U.S. problems. For one thing, the British economy is much smaller and less complex -- in dollar volume comparable only to those of our largest states. For another, we do not have under consideration joining a regional economic union such as the Common Market, which is wholly metric.

On the other hand, Britain is, like us, an advanced industrial nation and one with which we share many common traditions. At least to this extent, their metrication effort serves as our pilot program.

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COST of GOING METRIC : How Much Depends on How and How Long

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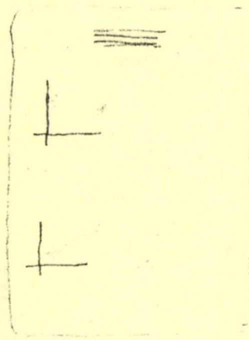

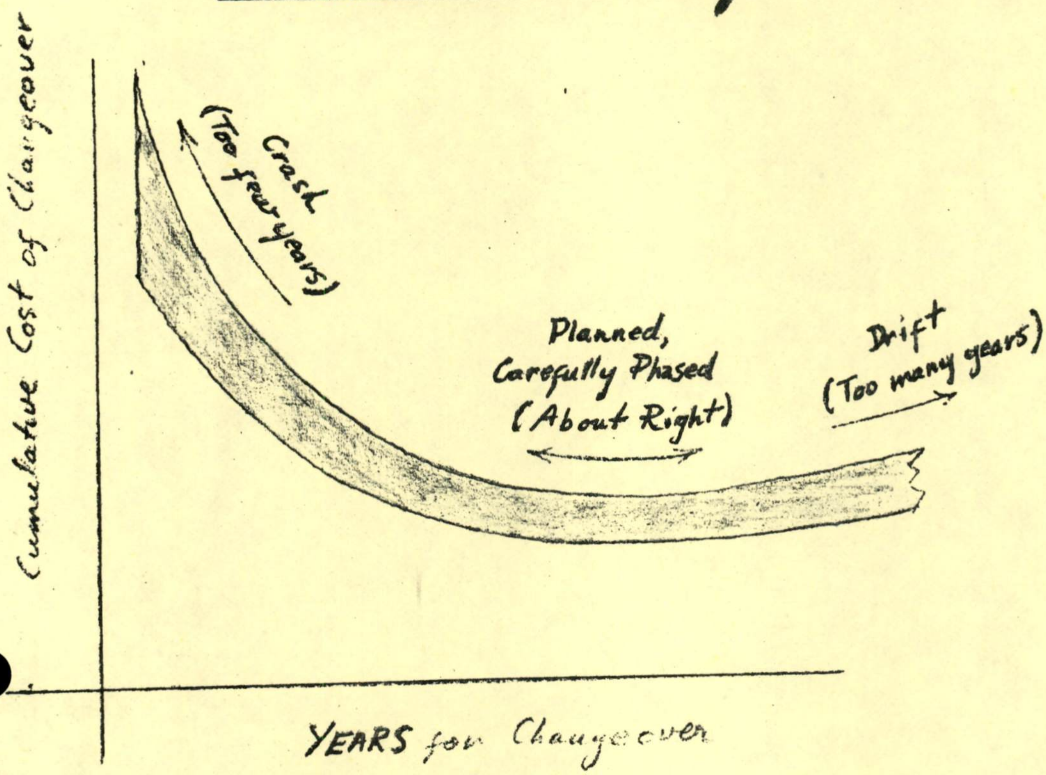

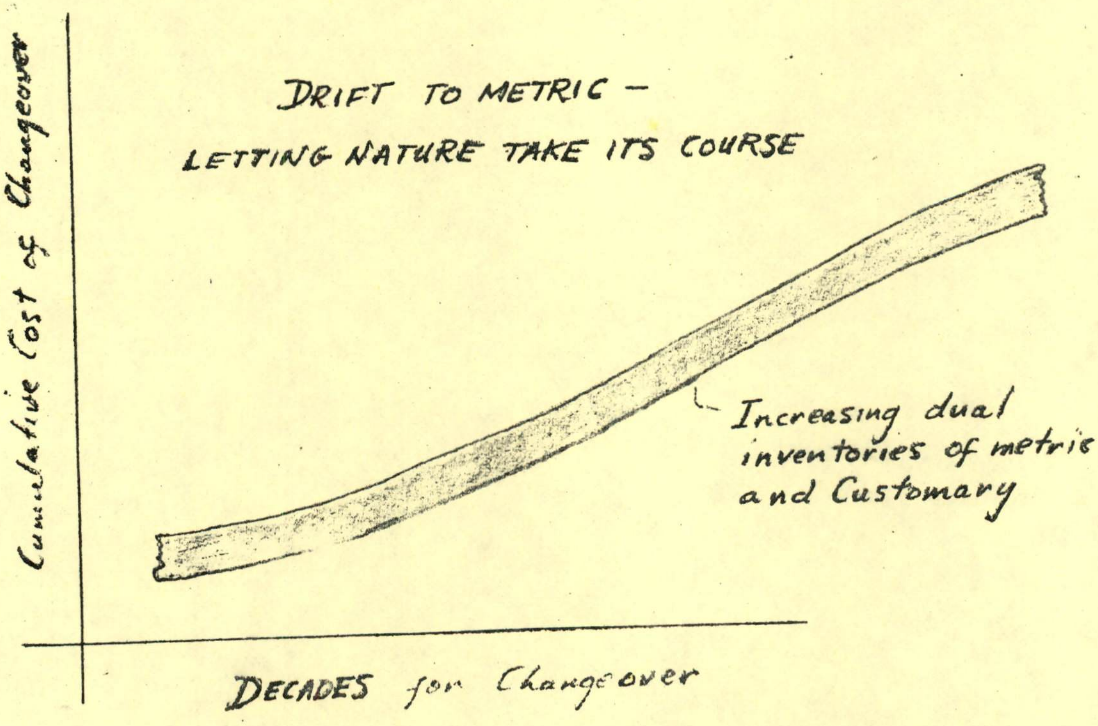

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COST OF GOING METRIC: HOW MUCH DEPENDS ON HOW AND HOW LONG

Precise cost estimates are elusive, if not impossible, but some relative comparisons can be made among the ways by which the U.S. might eventually become a primarily metric nation. The upper diagram appraises roughly how costs would pile up during three broad kinds of conversion. The lower diagram tries to depict the longer time span for a drift to metric.

A crash program at its very worst amounts to "instantaneous mandatory conversion," a scheme so objectionable that early in the U.S. Metric Study it was rejected as a possibility. More reasonably, a crash program might be interpreted as an attempt to convert to metric at a date that was inconveniently early for much of society, and without sufficient time for thorough planning. The lack of adequate planning would result in widespread waste, frequent delays, and the junking of many serviceable goods; hence the soaring costs. Nevertheless, the nation would become primarily metric at an early date.

A drift to metric ("letting nature take its course"), the few supporters of this approach emphasize, would add to normal costs much more gradually, depending on how rapidly businesses, industries, and other sectors of society switched, on their own, to greater use of the metric system. Nevertheless, although costs in the early years would be slight, they would rise and endure (lower diagram) -- owing to such factors as the

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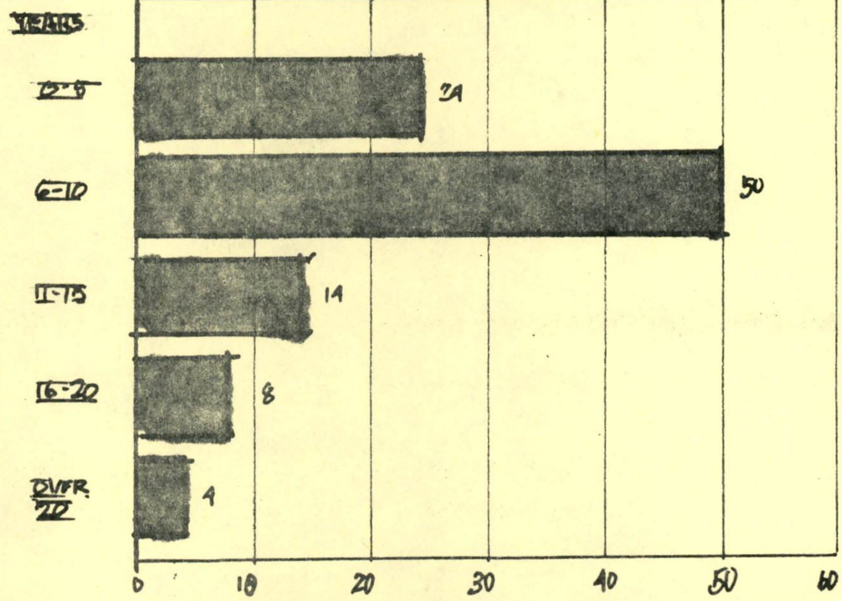
necessity of carrying dual inventories of metric and Customary parts for a prolonged time. Before the nation became primarily metric (at an indefinite date in the future), the total cost of drifting to metric could exceed that of a coordinated program and might even exceed that of a crash program.

A planned and carefully phased program, favored by the majority of the Study participants, would begin with a slow buildup of costs during the preliminary period. Then costs would increase as more and more hardware was being converted to metric measurements and standards at an "optimum" (about right) rate. A planned, carefully phased conversion would take longer than a crash program, but it would be much cheaper. The diagrams at left just show costs. What they do not show is that benefits would begin as the goal of becoming primarily metric was being reached and would continue indefinitely, thus reducing the real cost of the program.

For Chapter IX

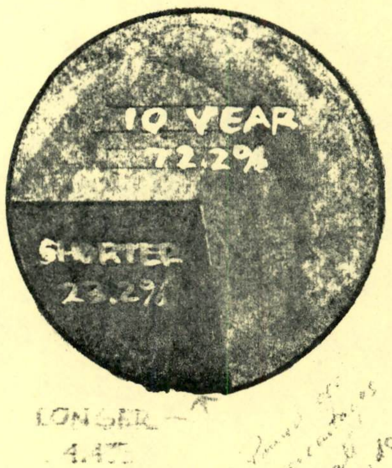
Manufacturing Industry Survey: Choice of optimum period for metric changeover

(Percent of responding manufacturers)



For Chapter IX

Attitudes of Federal Civilian Agencies Regarding Length of Transition Period



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IX -- TIMING AND PROBLEMS

Sooner or later the U.S. is going to be a primarily metric nation. The change may take place over a very long and indefinite period, coming about gradually in a drift toward more use of the metric system. Or it can be hastened by a coordinated national program with a definite target date, at which time metric will have become the primary measurement language in industry, in shops, in schools, and eventually in the home.

The Metric Study Act did not ask that specific plans and timetables for a metric conversion be developed -- and for a good reason. This would have to be done after a decision to go metric and after joint planning by all groups to be affected by the change. Nevertheless, Congress did ask for an evaluation of the courses of action that might be feasible. And so, the thousands of individuals and organizations participating in the U.S. Metric Study were asked, in broad terms, how a transition from a primarily Customary measurement system to a primarily metric one could best be accomplished.

There are many different ways in which nations have gone metric. The British decided on a ten-year program, which was initiated by industry and then supported by government.

The Australians, with the government taking the initiative, are also on a ten-year schedule. New Zealand decided on a transition period of seven years. Japan, after several starts and stops, finally reached its goal in 40 years. The Canadian government last year announced its intention of going metric but put off setting any target date.

There was no reason to presume, even tentatively, that any other nation's specific program would be appropriate for the U.S. There is an almost infinite number of conceivable programs and variations on them, because there is such a wide choice of target dates, sequences of transition among various sectors, and ways to handle special problems. In order that all the diverse groups in our society could prepare considered opinions on the metric question, the choice of ways of going metric had to be reduced to a reasonable number. The study thus focused attention on three modes of transition:

- The first said, in effect, that each entity in society -- firm, organization or individual -- would go metric as it pleased. Society would follow no overall plan.
- The second set a ten-year target date for the entire society, acting in concert, to become primarily metric.
- The third asked each company or other organization to figure out what would be its own "optimum" period

in a coordinated national program -- that is to say, to convert at a pace which would be most convenient and least costly for itself.

(IN MARGIN ALONGSIDE NEXT PARAGRAPH A "GAUSSIAN" BAR CHART SHOWING DISTRIBUTION OF MANUFACTURER'S PREFERENCES FOR LENGTH OF TRANSITION PERIOD).

As it turned out, most manufacturing firms judged that the ten-year period would be close to optimum. Weighting manufacturers according to size (i.e., value added), the Study found that only 18 per cent wanted more than 10 years to convert. The average optimum period was 9.6 years. On the other hand, the consensus was that costs would be about 10 per cent higher if all companies were required to follow a rigid ten-year schedule than if they adopted their own optimum periods, which were in some cases greater than 10 years and in other cases less.

Non-manufacturing businesses, with generally much less hardware needing conversion, were in favor of a shorter transition period. They thought that the nation as a whole might make the changeover in six to ten years. But speaking for themselves, most were willing to complete the task in five years or less. "Immediately" was the optimum period most often cited by spokesmen for eight non-manufacturing industries: finance, insurance, agriculture, services, real estate, forestry and fisheries, retailers, and transportation.

Time and again, especially at the public hearings, participants in the Study expressed concern that if they started to convert to metric, they might encounter serious difficulties if they moved faster than their customers, a critical supplier, or some other organization whose cooperation they needed. Metric parts must be available when needed. Metric products must be in demand when they are made. Metric scales must be ready before retailers can change over. And above all, adults as well as children must be taught what they need to know about the metric system at the right times.

It was to avoid these kinds of breakdowns in cooperation and communication that most participants in the study were in favor of a coordinated national program, whether voluntary or mandatory by law. Even if each organization were to convert at its own pace, the majority of the participants believed that some central planning mechanism would be needed to ensure a smooth transition.

The success of any kind of national program would hinge on the timely conversion of a relatively few products and activities that cut across many sectors of society -- e.g., education, weighing and measuring devices and regulations, and rethinking about engineering standards (see beginning of Chapter X). In these three fields the problems of going metric have already received critical study.

The National Education Association, which represents over a million school teachers and administrators, has urged that, starting this fall, all children be taught metric as the primary language of measurement. A survey conducted especially for the U.S. Metric Study suggests, however, that school systems are not ready to move that rapidly. The consensus was that for primary and secondary education a five-year transition period would be a bit tight, since two or three years would be needed for planning. But textbooks would probably present no obstacle; one major publisher of science texts assured the survey team that he could convert his entire line of books from Customary to metric units in successive printings over three years.

In a special survey of consumer attitudes, a few adults -- but only a few -- showed interest in enrolling in courses to learn everything there is to know about the metric system, even beyond their needs. British experience indicates that the general public does not really want this sort of comprehensive formal training.

Through newspapers, magazines, radio, television, and other media, the British Metrication Board has tried to tell people about kilograms, meters, degrees celsius, and a few other metric units they are likely to encounter in everyday life, trusting them to pick up on their own any further details they desire to know.

A U.S. national program could presumably rely on a similar low-key approach to adult education. The American Association of Museums has volunteered to display popular exhibits on the metric system. And the Advertising Council, which helped greatly to publicize the Peace Corps and the campaign against cancer, has offered its services in connection with going metric.

Weights and measures in commerce would play such an obviously pivotal role in a metric changeover that the U.S. Metric Study conducted a special survey of this field. Manufacturers of weighing and measuring devices foresaw no problems in changing their production rapidly and smoothly to metric devices. Because many scales in use are worth the cost of adapting and relatively few people are trained to work on them, adapting them would require several years.

The Post Office alone uses 240,000 scales. Most of them are the little sixteen-ounce beam scales used to weigh letters; it would probably be cheaper to replace these. But 35,000 larger and more expensive postal scales would be modified over the course of five years. Meanwhile, each post office would display a dual set of rates and would begin charging postage by the gram instead of the ounce as soon as its scales were changed.

The commercial weighing and measuring field strongly favored a coordinated program for their sector in order to minimize the side-by-side use of two measurement systems. The program would require goods to be labeled, at the start, in both Customary and metric units. After a while, the Customary units could be eliminated. This plan would not be practical, however, for marketing meat, cheese, and other commodities sold by the piece -- at least not with scales that automatically weigh the package and print out the price. State and local marketing codes would have to provide for a transition period during which such scales could continue to be calibrated in Customary units until the day they were converted.

One of the most important prerequisites of metric conversion is already being investigated: the redesign of fasteners (e.g., bolts, nuts, screws, and rivets). Early this year, quite independently of the U.S. Metric Study, the Industrial Fasteners Institute issued a report entitled: A Study to Develop an Optimum Metric Fastener System. It is intended to be the first step in the development of a complete range of threaded fasteners which, while eliminating many superfluous items, will satisfy stringent domestic engineering requirements.

So far, the Institute has been working on only screw thread sizes -- not on the many other requirements for a fastener (e.g., bolt length and head shape). Even on this limited basis, the proposed new system drastically reduces the variety of fasteners that would have to be manufactured and kept in stock. At the present time in the U.S. there are 59 Customary screw thread sizes, and 57 metric sizes are being added, making a total of 116. Under the new system there would be only 25 screw thread sizes. This new set of fasteners would not only simplify design, manufacturing, and repair, but also would be technologically superior.

Eventually, the Institute hopes, the new fastener system will be accepted as a superior international standard. (The role of the U.S. in helping to make engineering standards for a predominantly metric world will be discussed in more depth in the next chapter.)

Replace or Refit?

A few critics have maintained that metric conversion in the U.S. would be almost as drastic as tearing down society and rebuilding it from scratch. They support their arguments by pointing to all the resources invested in machinery and other equipment, trained manpower, and published documents. To be sure, a *mandatory* conversion conducted on a *crash* basis would be extremely costly and disruptive; it would also be unwise, and thus was rejected at the outset of the U.S. Metric Study as an alternative to be weighed.

Many participants in the Study, as well as those who have observed metric programs in other countries, suggest that almost all machinery, training, and documents could be continued in use -- or at least phased out only when they wore out or became obsolescent -- with careful planning and an adequate transition period.

A recent U.S. Air Force study indicated that many machine tools can produce metric parts with little more than the adjustment of a dial, while others require only minor modification. Engineering drawings, handbooks, and other costly paperwork are usually obsolete within a few years after publication; when updated in due course, it would be reasonably cheap to translate dimensions into metric units. The British have found that retraining workers is unexpectedly easy; it is most efficiently done if a man is taught on the job and told only what he needs to know to do his work.

Special Problems

In any coordinated national program a number of special problems would warrant special treatment. Not all of them could be anticipated in the early planning stages. But those that could be provided for in advance include the following:

- Small businesses and self-employed craftsmen might be at a temporary disadvantage, as some have been in Britain. Special programs of education and technical assistance could be provided for these people.

- The few laws and regulations that involve measurements would have to be reexamined and possibly amended.
- Consumers might be apprehensive about price increases linked to metric conversion. For instance, the price of a liter of milk would have to be greater than the price of a quart (.946 liter). But how much more? A consumer education program would be needed to allay fears. Unit pricing would help.
- Engineers would have to reassess many designs before agreeing on new metric standards (see next chapter). This would require expanded cooperative effort among businesses and standards making bodies.
- If competitors cooperated, anti-trust considerations would arise. Although Federal leadership in a coordinated national program would minimize this problem, some accommodations would have to be made to permit cost-saving coordination while avoiding illegal collusion. These problems would have to be resolved by business and industry, on the one hand, and the Department of Justice and the Federal Trade Commission on the other.

- Canada, our major trading partner, has not yet started metric conversion, although it has announced its intention to do so. As much as possible, the U.S. program would have to dovetail with Canada's plans.
- Costs of going metric would have to be apportioned and in such a way as to minimize the overall cost to society and to avoid bureaucratic waste. The British seek to attain this end by "letting the costs lie where they fall," although a few minor exceptions have been made where government has a clear responsibility -- e.g., citizen education. As a result, British metrication has been coordinated by a small group at insignificant cost to the taxpayer. The general rule is that everybody in the society, including government agencies, must share in the temporary costs, as they will in the continuing benefits.

The Consensus for Ten Years

The clear consensus for the length of the changeover period was ten years, at the end of which the society would be primarily, though not exclusively, metric. Some people wanted to change much sooner; a few later. Nevertheless, all could be accommodated by a ten-year transition. Those who could move faster would do so as soon as their customers and suppliers were ready. And those who needed more time could take it, since society's goal in a ten-year program would be to become mostly, but not entirely, metric.

If ten years is long enough for most of society, would fifteen or twenty years be preferable? "Definitely not," says one member of the British Metrication Board. "If you give people extra time, they will wait just that much longer before doing most of the work at the last minute."

Coordination

A coordinated national program would indeed be a monumental undertaking. Groups of industries would have to coordinate their efforts with the help of trade associations and regulatory agencies of federal, state and local governments. State weights and measures agencies would cooperate in making the changeover through their National Conference on Weights and Measures. Other groups, including educators, labor, standards-making bodies and consumers, would have to be brought in at the start. A hierarchy of definitive plans would have to be developed by all these participants for themselves. And each plan would have to provide for contingencies such as failures to meet deadlines.

All the detailed plans would fit into the framework of an overall national program. This overall program, too, would have to allow for contingencies. Some might be of major consequence. It is conceivable, for example, that parts of the program might be suspended or stretched out if the nation were involved in an international conflict.

Because of the scope of such a program, the Federal Government would, at the very least, have to stand behind it. There would have to be a central coordinating body. It would work with all groups in the society that were formulating their own plans so as to insure that the plans meshed. It would advise government agencies, at all levels (state, local and federal), of changes that would be needed in codes and regulations. It would help decide how the public could best be familiarized with the new measurement units. And it would anticipate other special problems such as those described earlier in this chapter.

Congress would decide when the program would begin and also the target date at which the society could expect to be mostly metric. At the target date, or possibly earlier, the coordinating body would have completed its work and would cease to function.

*   *   *   *   *

WHAT ARE ENGINEERING STANDARDS?

Their Importance

How they are developed

National Standards

International Standards

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WHAT ARE ENGINEERING STANDARDS?

Broadly speaking, engineering standards are agreements that specify characteristics of things or ways to do things -- almost anything that can be measured or described. They cover an enormous range: e.g., the diameter of wire; the length and width of typewriter paper; the purity of aspirin; the fire resistance of clothing; the meat content of frankfurters; the symbols on highway signs; the way to test for sulphur in fuel oil; local building codes; the strength of a safety belt; the wattage of light bulbs; the weight of a nickel.

Their Importance

Taken together, engineering standards serve as both a dictionary and a recipe book for a technical society. Without them we would have chaos, inconvenience, and higher costs for almost everything. Mass production would not be feasible, if there were no assurance that two parts, such as a nut and a bolt, would fit together. Automobile brakes would be untrustworthy, if all brake fluid did not meet standard performance requirements. Electric clocks would keep different time, if all household current did not alternate precisely 60 times a second.

Indeed, where standards have not been established, or when two different standards exist, life is much more complicated. In Europe, for example, standard household current is 220 volts, 50 hertz (cycles per second); in the U.S. it is 110 volts, 60 hertz. An American-made electric razor would not work on European current. For that matter, it could not even be plugged in because the receptacles are different.

How They Are Developed

Engineering standards are developed by many organizations or groups at different levels: a single organization, a national group, or an international group. A single company may develop standards for the products it makes. A local government issues codes and regulations for building construction, driving, highways. In either case, their standards may not be in agreement with those issued by other companies or other governments.

National Standards

For things generally used, such as television, national standards are essential if the system is to function. For example, a television set must be able to receive programs on all channels and television stations must broadcast in a prescribed way. The development of standards for such a complex system can be costly and time consuming; for instance, it took 10 million engineering man hours to develop national standards for color television. The Department of Defense and the General Services Administration have issued about 40,000 procurement standards encompassing most industrial products, food, clothing, and other consumer goods. These 40,000 procurement standards are twice the number of standards issued by private groups. In the absence of a standard issued by a private group, the government's procurement standard becomes, a *de facto*, national standard.

Private voluntary groups, numbering in the hundreds, have issued about 20,000 standards. About one-fifth of these standards are recognized by a voluntary national coordinating body called the American National Standards Institute, which represents the U.S. in international groups.

International Standards

The leading international groups are the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), in which all major nations are represented. IEC is concerned with the standardization of electrical and electronic equipment; ISO is responsible for all other fields. The work is done in technical committees, subcommittees and working groups. U.S. participation is voluntary and is not supported directly by the Government. The U.S. participates in all 70 IEC technical committees and 96 of the 139 ISO technical committees; participation in subcommittees and working groups is much less, amounting to about 50 percent. After member countries of IEC or ISO reach a consensus, a recommendation is published for adoption by any country as its national standard. Increasingly, countries are adopting IEC and ISO Recommendations instead of first developing their own national standards.

4th Draft
DVD/GAB
4/26/71

X - THE UNITED STATES IN THE FUTURE WORLD

Up till now this report has been concerned mainly with the past and the present. The question that remains to be explored is whether a change in our measurement system would put us in a better position to cope with the world of the future. Since we are not an isolated society, the U.S. Metric Study took a broad and long-range view in two special surveys, one of world trade, the other of international standards.

Many of the participants in these surveys believe that the Customary system is already becoming a burden in our international relations -- a burden that is easy to bear now but will become heavier with time.

The difficulty is not so much that we talk a measurement language different from that of other countries. Rather, it is that many of our engineering standards (see page facing the beginning of this chapter), based on Customary units, are incompatible with standards used elsewhere. And this hampers the export of some U.S. products.

A potential customer in another country may prefer a certain U.S. machine, but he may be less likely to import it if spare parts for repair and maintenance are not readily available in his country. And with the rest of the English-speaking world going metric, this may become even more of a handicap.

This problem is already with us and is becoming more and more troublesome. Imports of materials and equipment are increasing, and overseas subsidiaries of U.S. companies are having to develop standards programs that are independent of the parent company, because U.S. Customary standards do not meet their needs. Alluding to these complications, one participant in the U.S. Metric Study remarked that these are now "little clouds, no bigger than a man's hand," but they point up the urgency for the U.S. to strengthen its position in world standards-making before they grow much larger.

The mere existence of international standards that differ from ours is not the real problem. It is how they are applied to influence world commerce. For international standards can be a means of fostering or hindering trade. Between 1967 and 1970, for example, Britain, France, and West Germany agreed among themselves on comprehensive electronic standards based on metric units. The purpose was to facilitate trade among the three countries by setting up uniform schemes of quality assurance and product certification -- analogous to an underwriter's seal of approval.

It follows that nations not party to the scheme would find it harder to sell electronic products to the three countries.

It now appears that this agreement, initially limited to three nations and one class of products, will be extended to include all the rest of Western Europe and to embrace other products as well.

Going metric would not, in itself, enhance the U.S. position in the making of international standards, but it would help. Although international standards may be written in Customary units, they must be written in metric. Standard sizes tend to be expressed as small whole numbers or simple fractions, which are easy to remember and easy to do calculations with. A metrically minded standards group, when setting the diameter of a thin wire, for example, might make it exactly 1 millimeter (equal to .03937 inch). But if the standards makers were inch-minded, they would pick .04 inch as the standard, and let metric users worry about the cumbersome corresponding decimal fraction (1.016 millimeters).

This kind of thinking leads to the incompatibility of steel bars and rods produced in the U.S. and in metric countries. In the U.S. the range of sizes is covered in increments of 1/16 inch in the small sizes, 1/8 inch in the intermediate sizes, and 1/4 inch in larger sizes. In metric countries the increments are 1, 2, or 5 millimeters.

Conversely, if the U.S. plays a more effective role in making international standards, then the incompatibility between these standards and U.S. technology would be lessened. To that extent a U.S. metric changeover would be made easier. If international standards were already 100 percent compatible with U.S. technology, a U.S. metric conversion program would call for almost none of the very costly "hard" changes (discussed in Chapter VII) and, therefore, would be relatively inexpensive.

In the give and take of international standards making, compromises would tend to result in all parties giving a little ground and therefore sharing in the costs of changes. These costs are usually reflected in the price of products. Thus, the costs of making U.S. standards compatible with those of other nations would not be borne solely by the U.S. And our products would not be burdened by a competitive price disadvantage.

As a matter of fact, U.S. industry is already influential in setting international standards. This is particularly true where U.S. technology has taken the lead -- e.g., integrated electronic circuits, commercial aircraft, automobile wheels, computers, oil drilling machinery, and videotape.

Our opportunity to exert further influence is great. To date, relatively few international standards have been adopted.

But in the next decade the number on the books is expected to multiply roughly tenfold. The standards that exist today are but a few patches in a mosaic that an increasingly interdependent world will need to exchange products, materials, and ideas.

The urgency for the U.S. to participate more vigorously in world standards making was stressed in the first interim report of the U.S. Metric Study. Entitled International Standards, it was sent to the Congress in December 1970. The most important recommendations were:

- That Federal and non-government standards organizations develop together a firm U.S. policy about effective participation in international standards activities.
- That this action should be taken as soon as possible, regardless of any decision about the nation's going metric.

World Trade

In world trade, standards are important mainly in "measurement-sensitive" products. These are products in which dimensions are critical -- e.g., tractors, clinical thermometers, vacuum pumps, typewriters, and computers. In 1969 the U.S. exported about $14 billion worth of measurement-sensitive products and imported about $6 billion worth. The difference,

$8 billion, was considerably more than the nation's favorable balance of trade in 1969, which was only $1.3 billion. (It was $2.7 billion in 1970.)

Standards-based agreements, such as the quality assurance and product certification scheme mentioned above, could be a non-tariff barrier against our exports. And a relatively slight drop in our exports of measurement-sensitive products could wipe out our favorable trade balance.

(CHART OF BALANCE OF TRADE IN MSS)

So far the effect seems to be slight. The U.S. Metric Study asked exporters of measurement-sensitive products for their views about factors influencing trade . Differences in measurement systems and standards seemed relatively unimportant; they put more emphasis on reliability, reputation, superior technology, and high quality of product. They were also asked to estimate how much they would expect to export in 1975 if the U.S. had gone metric by 1970. The chart WHERE shows that, in their opinion, going metric would have increased 1975 exports by about $600 million. Importers, asked the same hypothetical question, estimated no difference in 1975 imports of measurement-sensitive products.

Apparently, the metric question has hardly affected the absolute amount of U.S. trade. But there are indications that we are losing our share of the world market, partly because Western European nations have been steadily lowering barriers of trade among themselves. These barriers are due to get lower still as national differences in engineering standards are ironed out. They regard these differences as one of the most troublesome obstacles to trade. Understandably, since Western Europe is exclusively committed to the metric system, the standards they agree upon will be metrically based. This effort will further strengthen Western Europe as a unified market and will tend to reduce the U.S. share in its trade.

(EEC AND EFTA TRADE CHART)

There are a few areas in which U.S. and European engineering standards are likely to remain in conflict. Paradoxically, these concern electricity, a field in which Customary and metric measurement units are identical. In view of the tremendous investments that have already been made in power generating and distributing equipment, appliances, and machinery, it is hard to imagine either the U.S. or Europe compromising on a common voltage and frequency for household electric current.

Another factor that is tending to integrate the world economy is the rise of giant multinational corporations, many of them either partly or entirely owned by U.S. companies. In hearings last year before the Joint Economic Committee of the U.S. Congress, it was brought out that their total annual output of goods and services is about $450 billion.

This exceeds the total output of all the less developed countries, and it rivals that of the Soviet Union, China, and Eastern Europe combined. In fact, $450 billion is almost half the gross national product of the U.S.

Through participation in these companies, the U.S. plays an even larger role in world commerce than U.S. export-import figures would indicate. U.S. businesses abroad account for roughly half of the $450 billion output of multinational corporations. Even in highly industrialized nations their impact is impressive. In the United Kingdom, for example, the output of U.S. subsidiaries is about 14 per cent of the total economy, and they account for almost 25 per cent of Britain's manufactured exports.

At the rate multinational corporations appear to be growing and proliferating, some day in the not-too-distant future they will control most of the industrial output of the world. They will help to bring about worldwide uniformity of engineering standards. For they are already assembling such complex products as automobiles, computers, and factory machinery from components made in different countries. In effect, this huge but almost invisible segment of American industry is already going metric. Small companies that supply them will have to go along.

The federal government must be concerned about self-employed workers and small companies that may have trouble keeping up with the change. When increased use of metric in large companies and government activities reaches a substantial level, then workers and small companies may find themselves at a competitive disadvantage. A national program of metric change designed to take account of their needs could ensure that the benefits of the change were shared by all Americans.

Customs and cultures around the world are coming to resemble one another. More and more, people are traveling to foreign countries. Satellite communication has, for some, become a form of instant travel. And the enormous outpouring of the multinational corporations is in its own way making the world more closely knit.

Thus, our culture and customs are being exported in many ways. But one thing the U.S. cannot expect to export is the Customary system of measurement. Most people in other countries are never going to use it; those that have used it are abandoning it.

Whatever machinery, engineering plans, and other measurement-sensitive goods and services we supply to developing countries would be more effective if these goods and services conformed to the measurement system and practices of the users. These countries are metric almost without exception. Moreover, we are increasingly tending toward multilateral aid programs, in which we cooperate with other industrial countries. These are all committed to the metric system.

Conflicts in measurement systems cause confusion and reduce the effectiveness of these programs, at least to some extent.

As the Department of Defense points out in its metric study report, the compatibility and interchangeability of equipment between the U.S. and its allies would expedite repairs, make possible support in areas where support is now nonexistent, simplify procurement across national boundaries, and increase communication of all data, including designs, operations, and training. It has been suggested, furthermore, that defense budgets on both sides of the Atlantic have been so seriously reduced that more selectivity, less duplication, and greater interdependence may be necessary in the future.

Even in outer space international standards may play a role. Nations with major programs have given thought to cooperating with one another in order to reduce duplication of missions and thus cut costs. In fact, the U.S. and the U.S.S.R. intend next year to open negotiations to standardize the escape hatches of space vehicles so that either nation can rescue an astronaut or cosmonaut.

It is often argued that the most favorable time for a metric changeover is now, before our society gets any bigger, more complex and, therefore, harder to change. On the other hand, there are reasons to believe that some difficult changes have become easier and may become easier still. Computers have already reduced drastically much of the drudgery that would be involved in translating one measurement language to another. Numerically controlled machine tools, which are increasingly used in manufacturing, are guided by a kind of computer program. Guidance to metric dimensions needs only a change in the program. The trend to prepackaged goods in the supermarket -- already above 90 per cent -- has eliminated at least some of the confusion that a metric changeover would impose on the consumer. As similar technologies emerge, other ways to facilitate change can be expected.

Planning for the Inevitable

The clear consensus of the participants in the U.S. Metric Study is that the U.S. will ultimately become a mostly metric country, along with the rest of the world. It is indeed an idea whose time has come. The question is how should the U.S. plan for this eventuality. The participants narrowed the options to three, each of which has substantial support.

Option 1:

Let nature take its course. The large multinational corporations are already going metric at their own pace. The rest of the society can follow on its own.

Option 2:

Go metric according to plan, everybody together. This would call for an overall national program with an overall target date. Within this framework, segments of the society would work out their own specific timetables and programs, dovetailing them with the programs of other segments. But concentrate initially on what needs to be done anyway: education and international standards. Then, when these aspects are well under way, move ahead on all other fronts until the nation is primarily metric.

Option 3:

A coordinated national program based on mandatory legislation. Although this would not be a crash program, participants would have less freedom to choose what steps to take and when to take them.

Which of these three options appears to be the most reasonable and the most acceptable to the participants in the Study? On both counts, Option 2 is the choice, by the process of elimination. There was vociferous opposition to Option 3 from people who felt that a forced change would impinge on their freedom of action and would be wasteful, although some favored it as the only way to keep everybody in step.

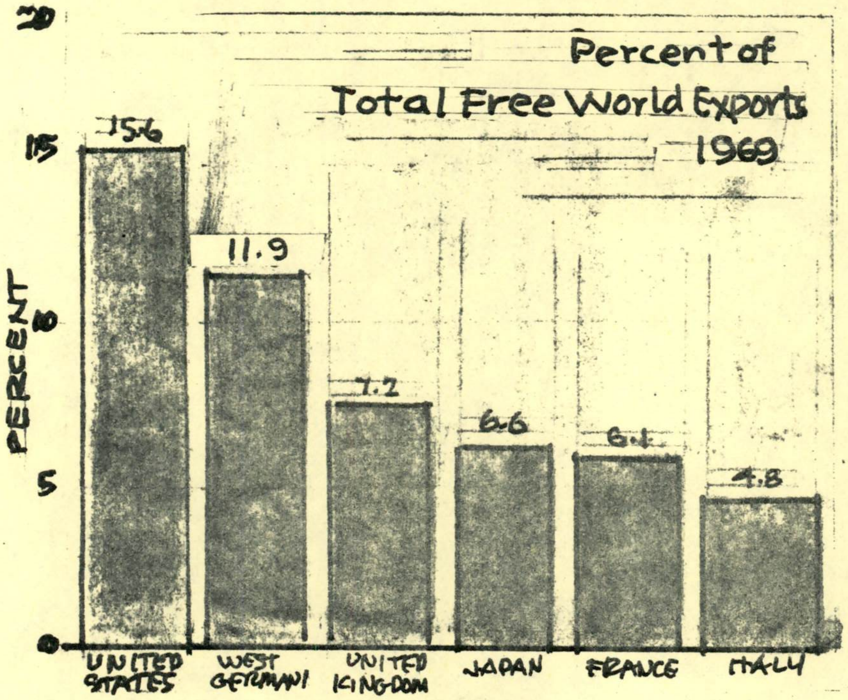
There was even more opposition to Option 1.

Some feared the cost of a prolonged period of metric and Customary duality in the U.S. Others were apprehensive about the attendant confusion in the absence of national coordination. Still others doubted that conversion could be accomplished this way and felt that it would be shirking a responsibility that this generation should assume for the sake of all future generations.

But there was very little opposition to Option 2. Time and again, participants in the U.S. Metric Study stressed the urgency of coming to grips with the problems of international standards and of preparing Americans, through education, to live in a metric world. There was a strong feeling that, with these problems under control, the inevitable change to metric could be accomplished with a minimum of cost and disruption.

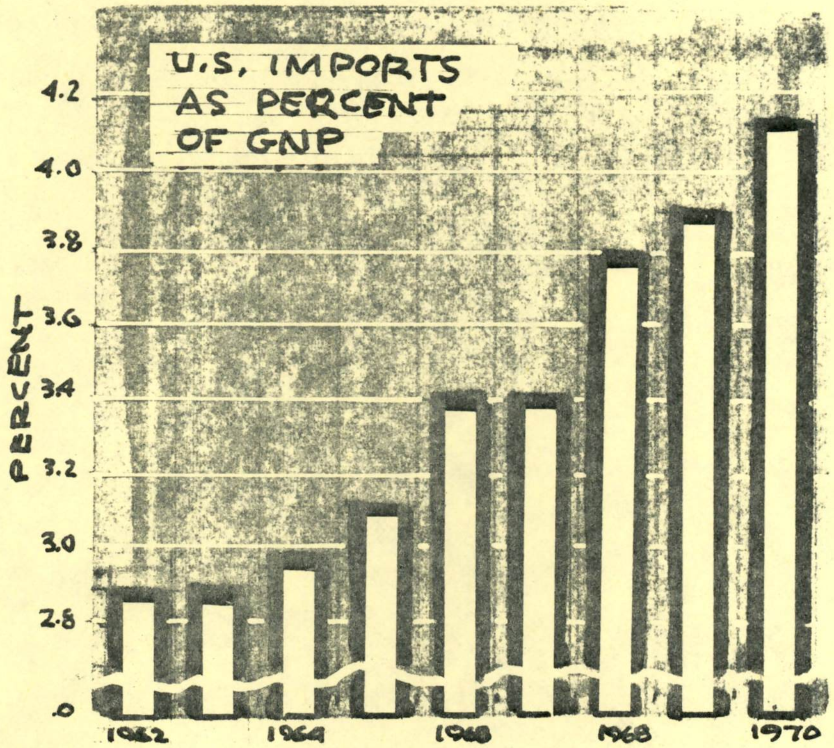
* * * * *

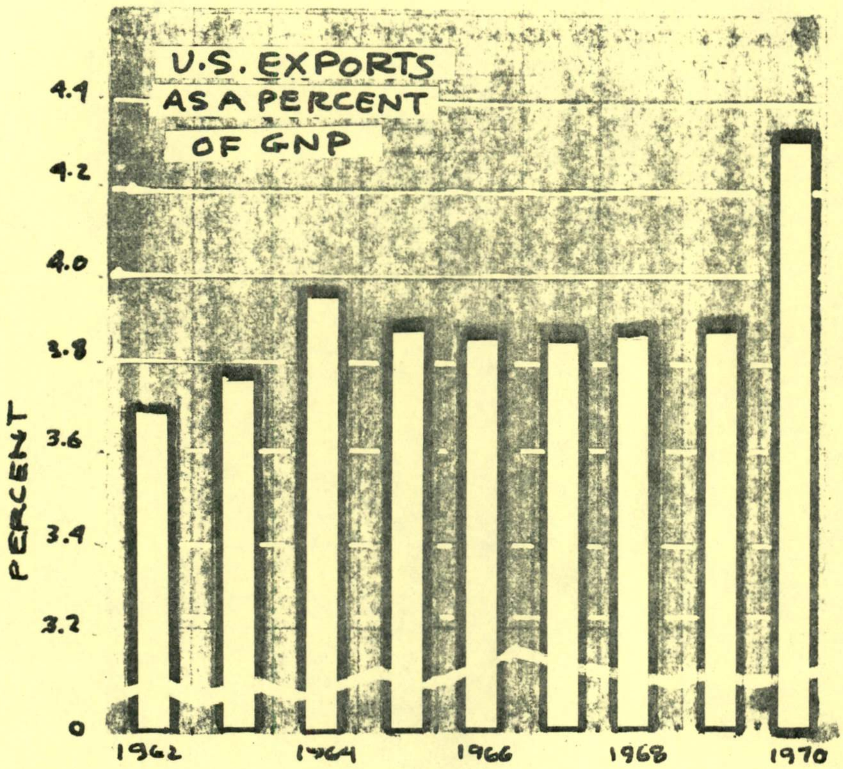
Inserts for Chapt. X



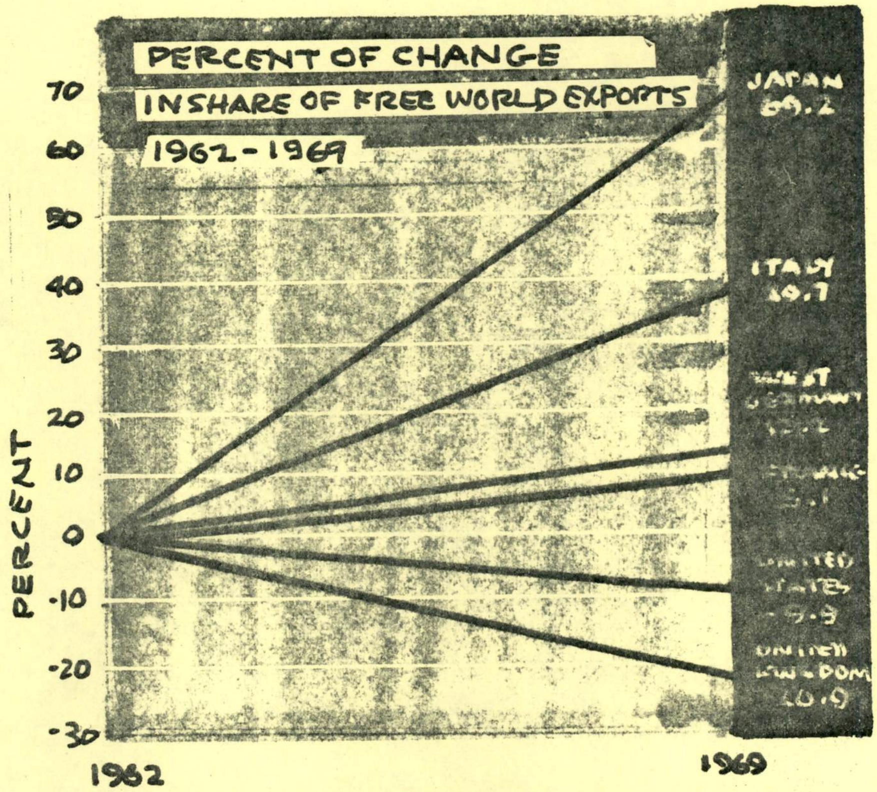
REMEMBER to ask Pete Peterson for his April White House presentation charts on Int'l Economics. Pages 197, 198, 202 (others?) don't come off as well as they might.

[redacted]

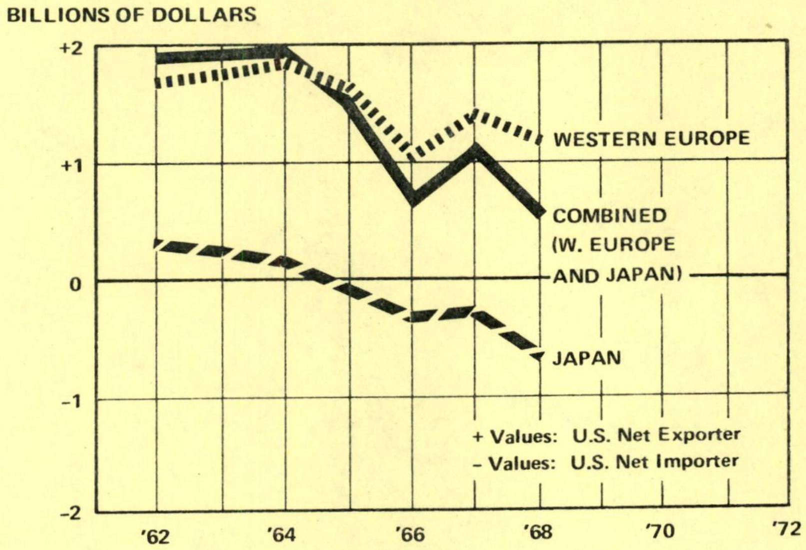

U.S. IMPORTS
AS PERCENT
OF GNP
PERCENT
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
.0
1962
1964
1966
1968
1970



U.S. EXPORTS
AS A PERCENT
OF GNP
4.4
4.2
4.0
3.8
3.6
3.4
3.2
0
PERCENT
1962
1964
1966
1968
1970

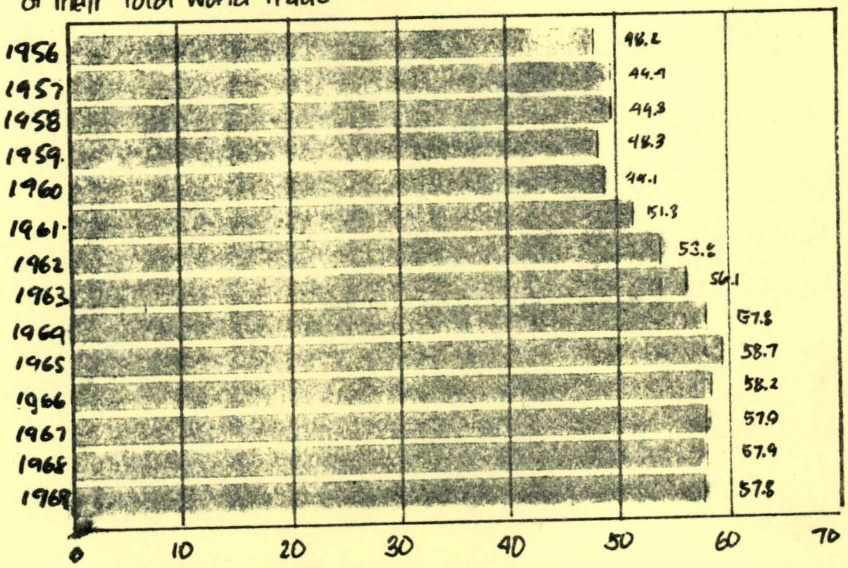

PERCENT OF CHANGE
IN SHARE OF FREE WORLD EXPORTS
1962-1969
PERCENT
70
60
50
40
30
20
10
0
-10
-20
-30
1962
1969
JAPAN
69.2

ANNUAL U.S. BALANCE OF TRADE TECHNOLOGY-INTENSIVE PRODUCTS

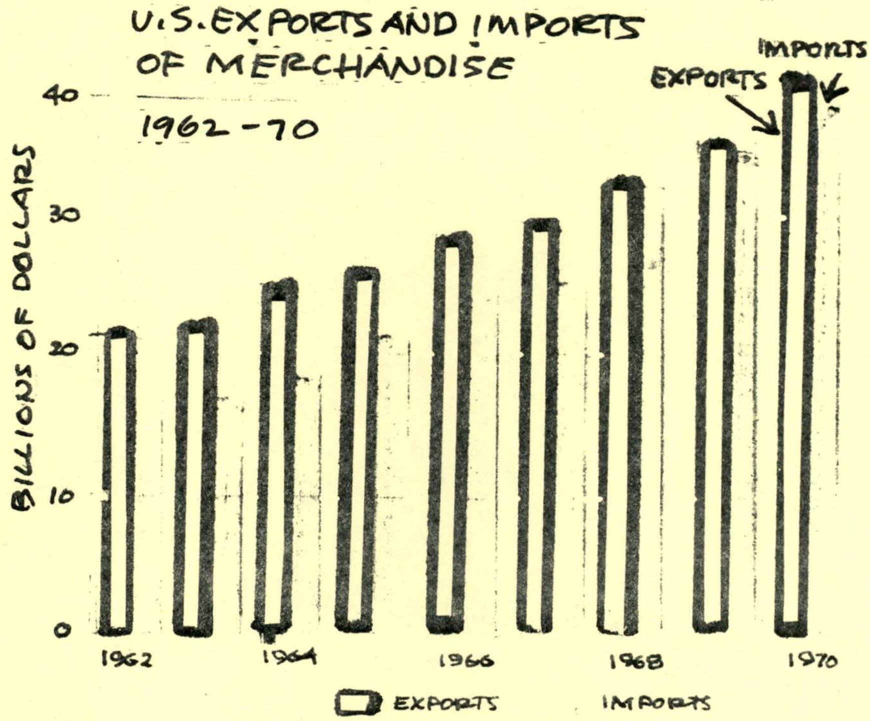


Western European countries are selling more to each other than to the rest of the world

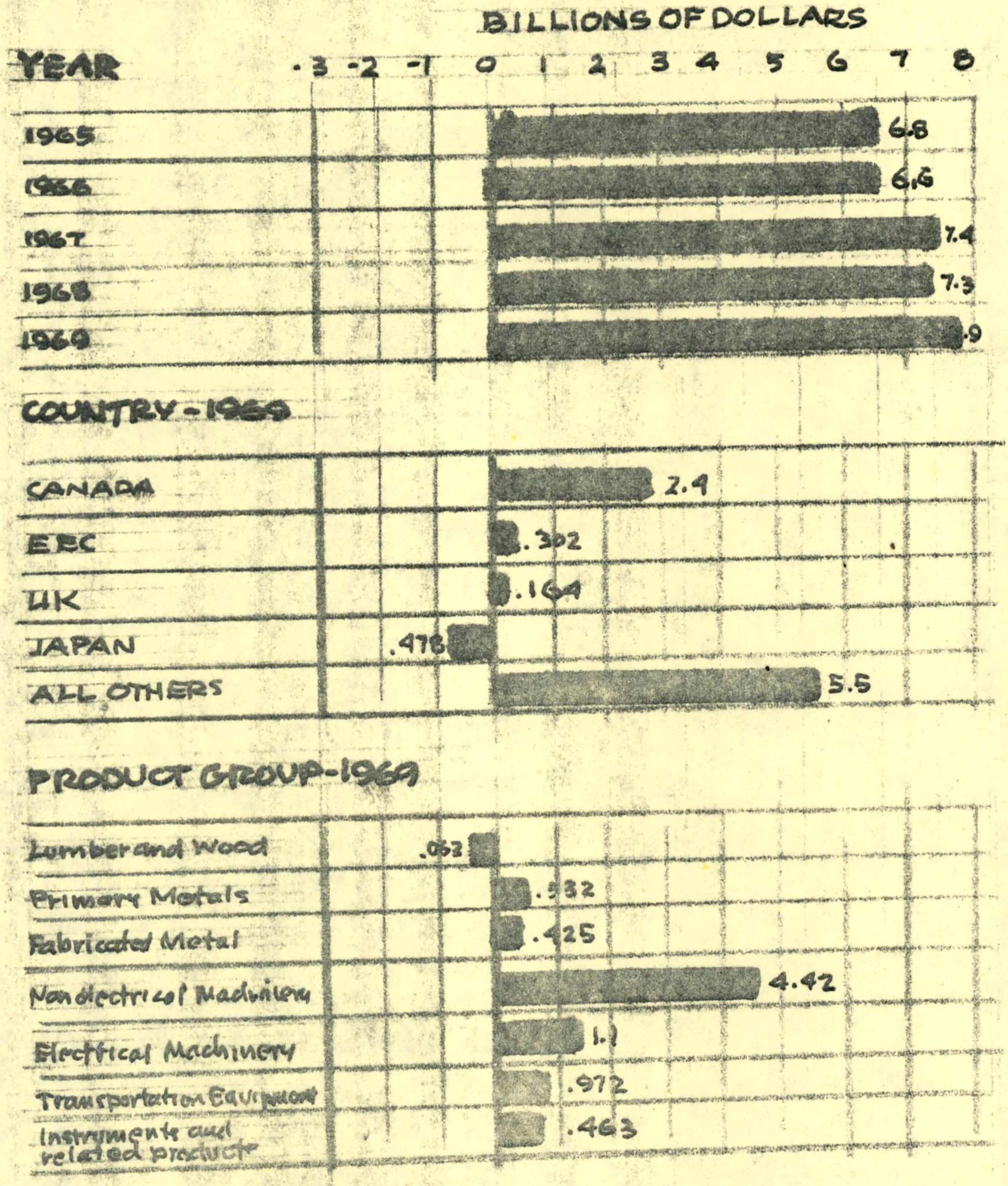
Trade among EEC and EFTA as a percent of their total world trade



Source:


U.S. EXPORTS AND IMPORTS OF MERCHANDISE
1962-70
BILLIONS OF DOLLARS
40
30
20
10
0
EXPORTS
IMPORTS
1962
1964
1966
1968
1970
EXPORTS
IMPORTS

TRADE BALANCE in Machinery, Instruments, and Other Measurement Sensitive Products.



TRADE BALANCE in Machinery, Instruments, and Other Measurement Sensitive Products.

BILLIONS OF DOLLARS

-3 -2 -1 0 1 2 3 4 5 6 7 8

YEAR	
1965	6.8
1966	6.6
1967	7.4
1968	7.3
1969	7.9

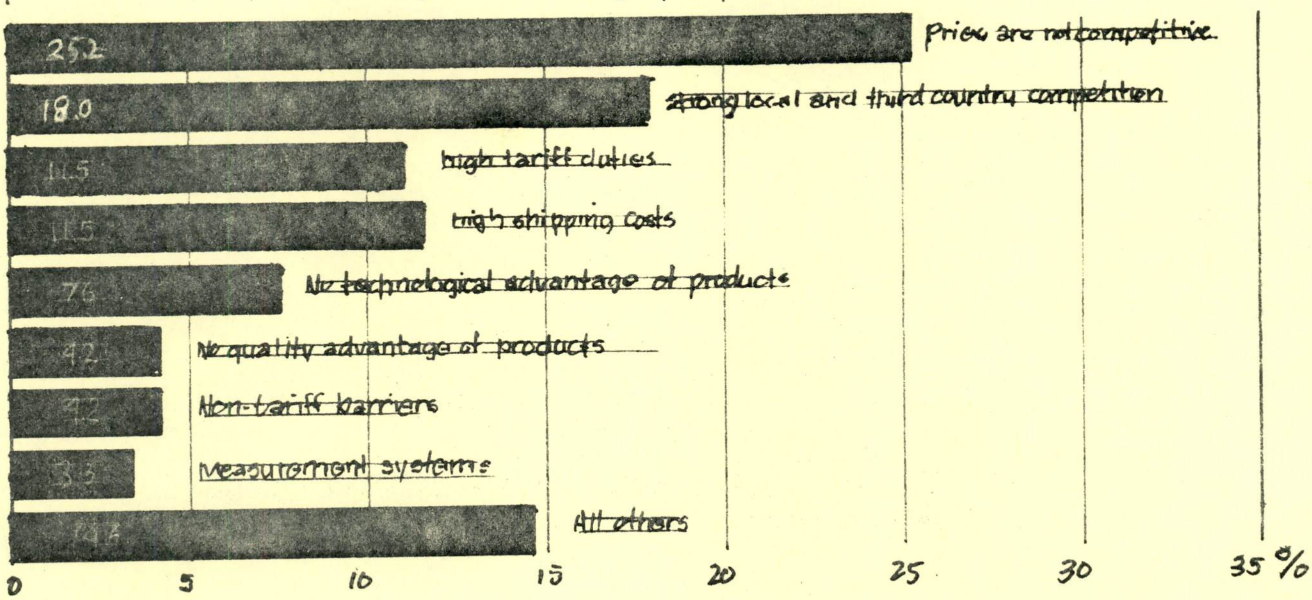
COUNTRY - 1969	
CANADA	2.4
EEC	.302
UK	.164
JAPAN	.478
ALL OTHERS	5.5

PRODUCT GROUP - 1969	
Lumber and Wood	.063
Primary Metals	.532
Fabricated Metal	.425
Nonelectrical Machinery	4.42
Electrical Machinery	1.1
Transportation Equipment	.972
Instruments and related products	.463

EXPORTS

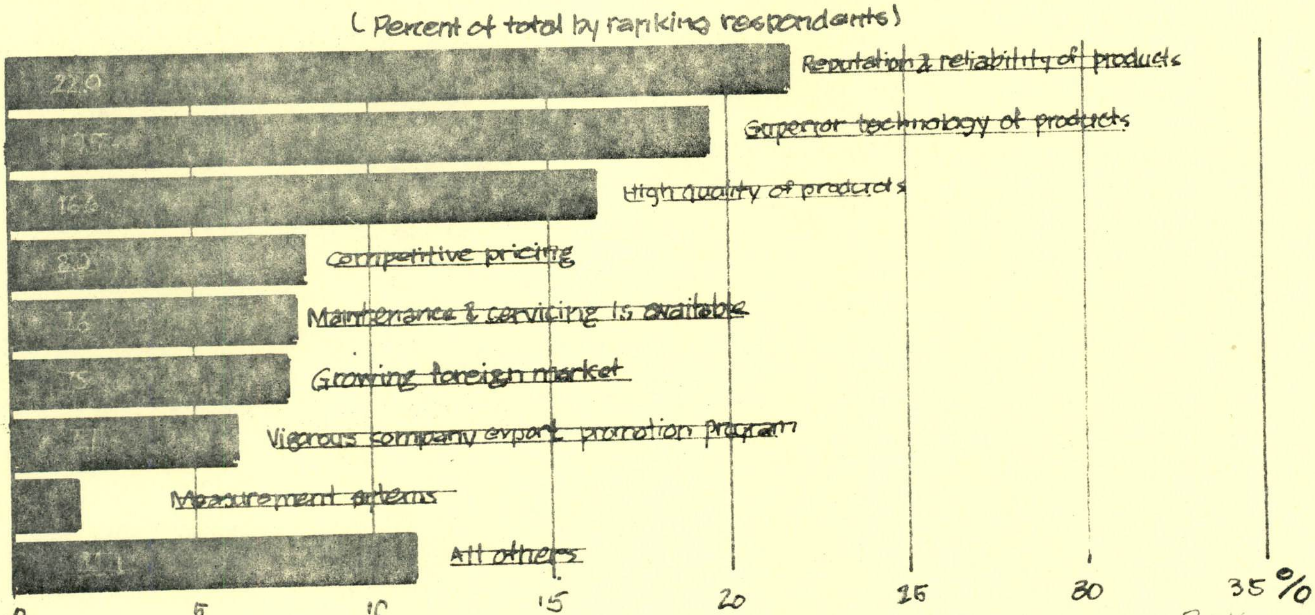
Factors Deterring U.S. Exports Of Machinery, Instruments, and Other Measurement Sensitive Products

(Percent of total rankings by respondents)



Factors Promoting U.S. Exports of Machinery, Instruments, and other Measurement Sensitive Products

(Percent of total by ranking respondents)



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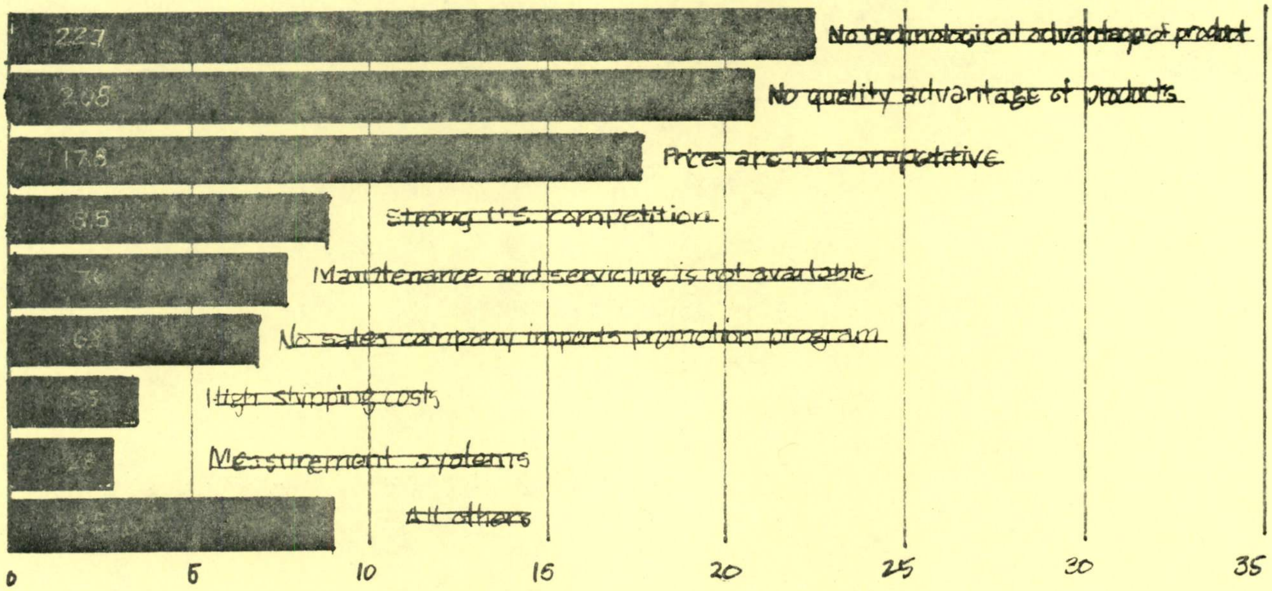
IMPORTS

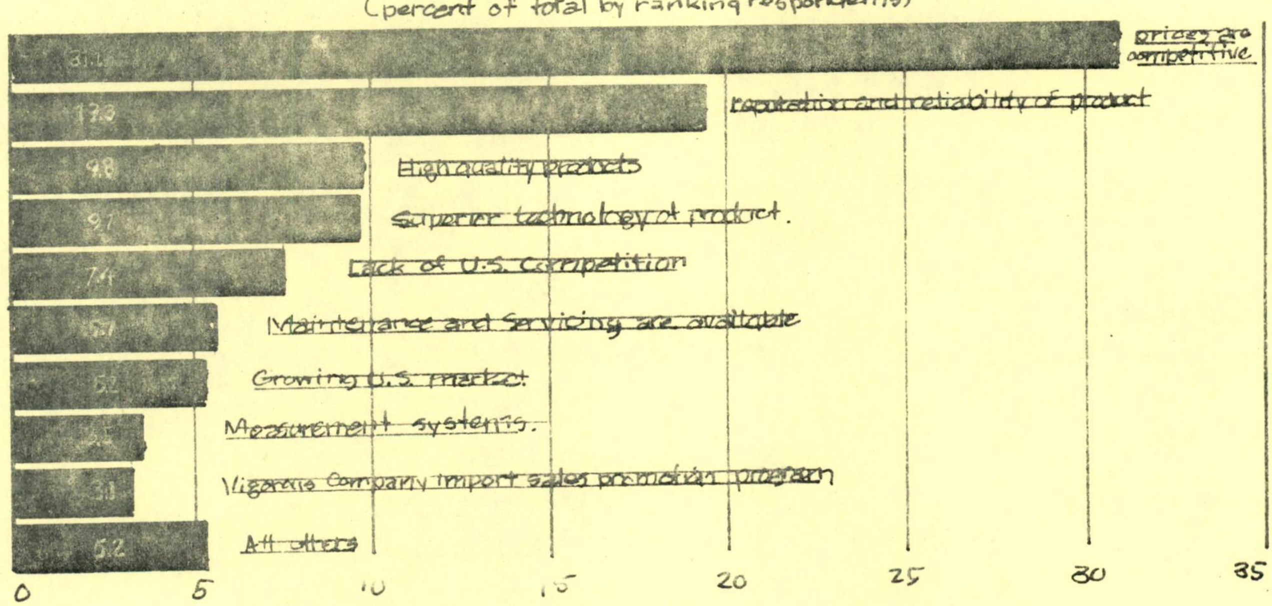
Factors Deterring U.S. Imports of Machinery, Instruments, and Other Measurement Sensitive Products

(percent of total rankings by respondent)

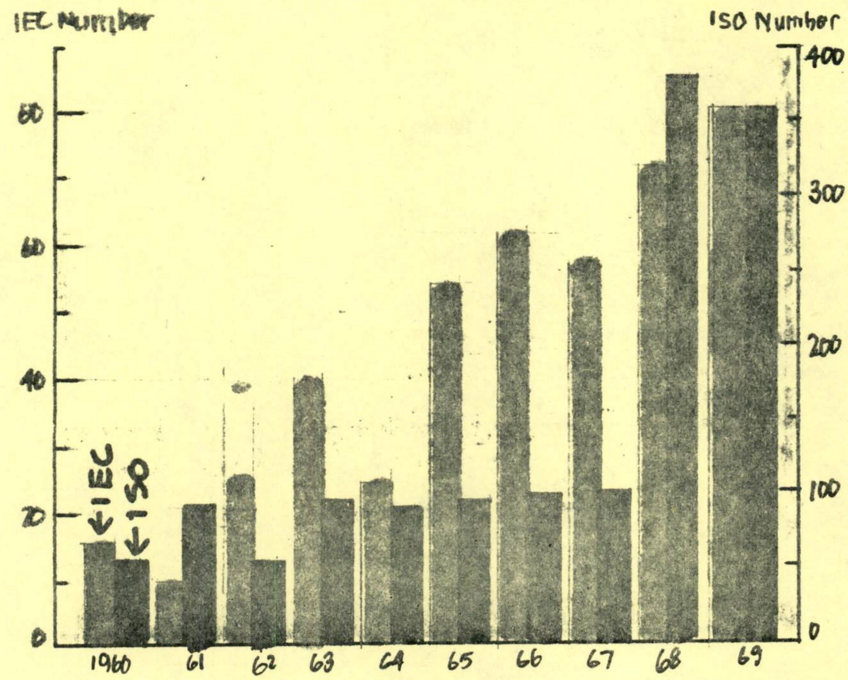


Factors Promoting U.S. Imports of Machinery, Instruments, and other Measurement Sensitive Products

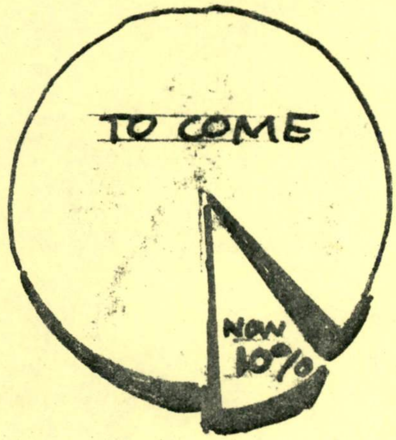
(percent of total by ranking respondents)



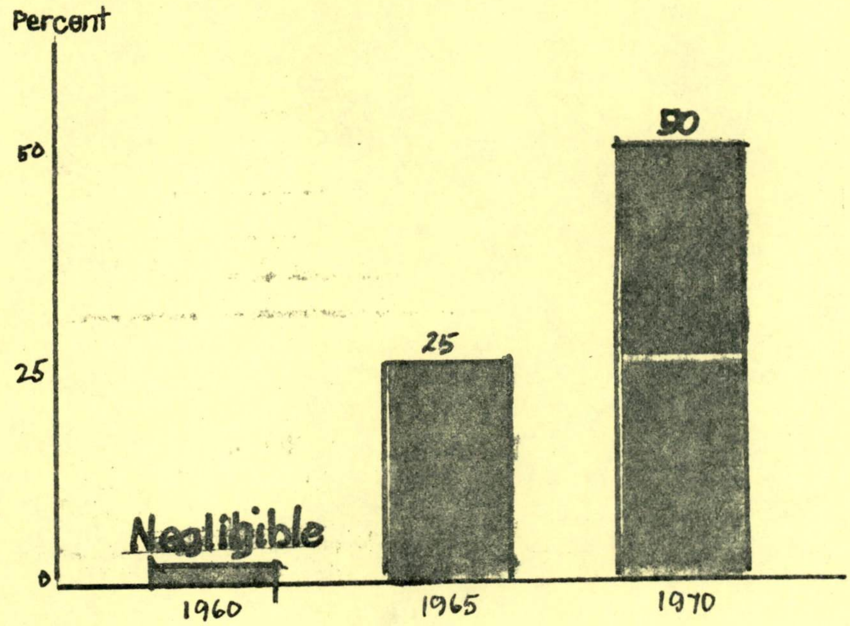
Trends in ISO and IEC standards — 1960-1970



International Recommendations now, contrasted with those expected to come.



Use of metric units on food packages



Note

Source

U.S. Grade School Books using at least some metric

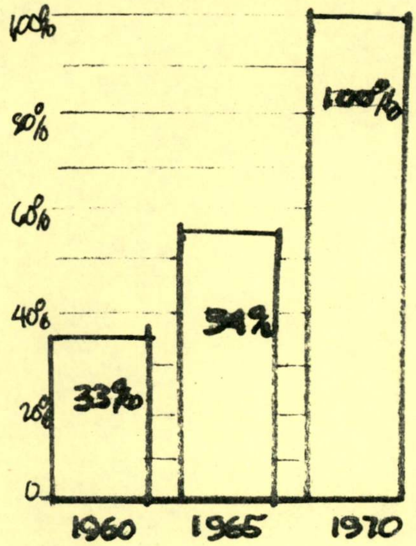
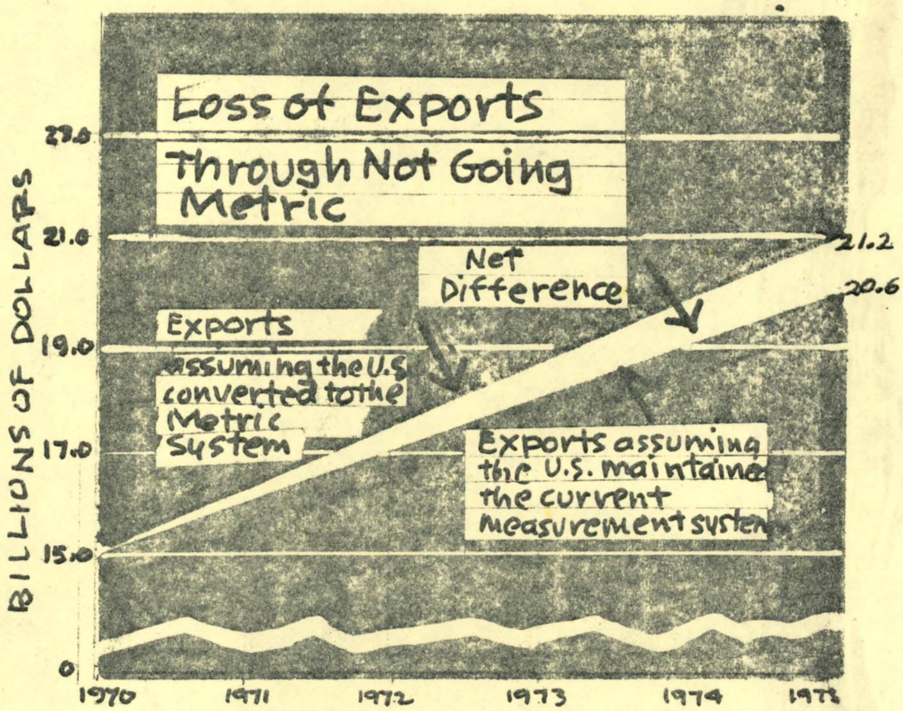
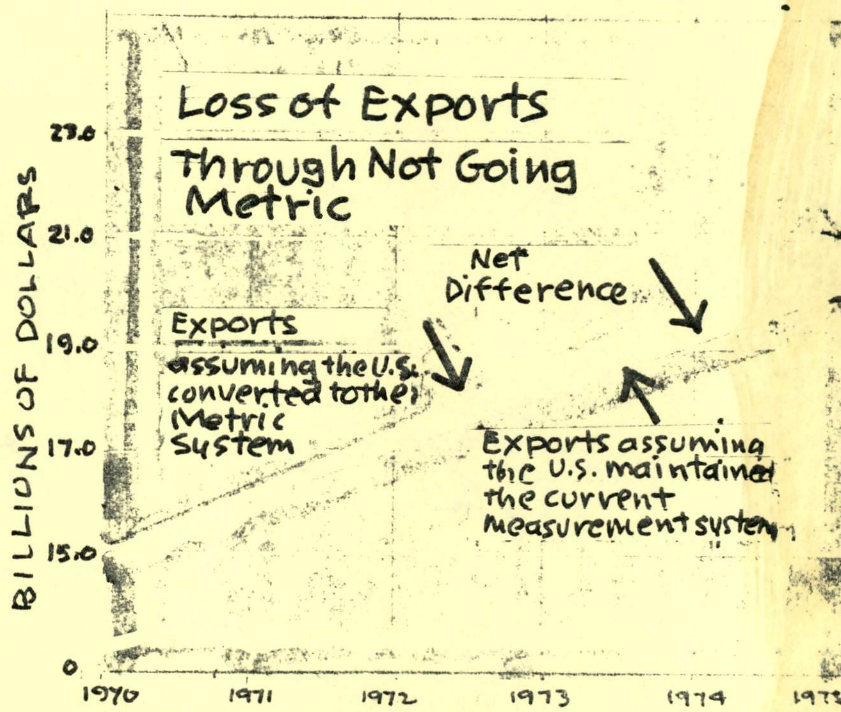


Chart to scale




Loss of Exports
Through Not Going Metric
BILLIONS OF DOLLARS
23.0
21.0
19.0
17.0
15.0
0
1970
1971
1972
1973
1974
1975
Net Difference
Exports assuming the U.S. converted to the Metric System
Exports assuming the U.S. maintained the current measurement system

*

SCHEDULE FOR SECRETARY'S REPORT ON THE U.S. METRIC STUDY

Secretary's Report to Congress	August 9, 1971
Printing Finished	August 1
O.K. to GPO to Print	July 19
Page Proofs from GPO	July 9
Galleys Proofread and Back to GPO	July 2
Galley Proofs from GPO	June 28
Magnetic Tape and Art to GPO	June 22
Final Draft Must be finished	June 15
Writing of Final Draft	
All Reviews and Comments must be in	June 1
Review by Secretary, Commerce Board of Directors, OMB [1], MSSAP [2], CTAB [3], PSAC [4], et al.	
Secretary's Draft Finished	May 1
Writing of Draft of Secretary's Report	

All 12 Interim Reports Finished (June 15)

Interim Reports Processed to Publication (up to June 15)

1. White House Office of Management & Budget
2. Metric System Study Advisory Panel
3. Commerce Technical Advisory Board
4. President's Science Advisory Committee