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Study to Identify Industries Positioned for Significant Impact on U.S. Metrication

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Technology Administration
National Institute of Standards
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Gaithersburg, MD 20899

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Mary L. Good, Under Secretary for Technology

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FINAL REPORT - R2

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EXECUTIVE OVERVIEW

An initial look at metrication in twelve industries led to the selection and preliminary study of ten industries which were the subject of the Interim Report (Appendix B), dated 21 December 1994. Principal findings were presented as was the rationale for selection of the two industries, *i.e.*, Construction and Electronics. These industries were then the focus of further study, culminating in the development of metrication strategies, and the subject of this Final Report. Construction and electronics are large industrial sectors, have excellent export potential, and represent huge food chain opportunities for a host of related products and components as well as involving engineering, design, technical and trade skills. The food chain participants of each selected industry are identified later in Figures 1 and 2 and are further defined and examined in the text.

Each of the two selected industries has a well developed *infrastructure* for promoting desired changes. They have trade and professional or other, organizations that are knowledgeable of the industry and actively pursuing metrication by defining goals, mustering industry support, identifying obstacles, and seeking solutions.

This report includes information gathered during telephone interviews with many of these organizations as well as with various companies within the identified food chain industries, *e.g.*, wall board, ceiling tile, raised floor tile, brick and block manufacturers, as well as integrated circuit, electronic component and printed wiring board designers and manufacturers. Problem areas in each food chain (*e.g.*, general contractors/tradespeople in the construction industry and printed wiring board designers in the electronic industry) and potential solutions as well as strategies for accelerating metrication within the entire food chain are discussed. Industry conversion progress and potential are also addressed.

The research conducted under this contract is intended to provide insight into the metric conversion problems of two industries and may be used as a pilot program to assist the federal government in focusing its commitment and leadership role to support national metric conversion in other industries.

INTRODUCTION

The Interim Report, dated 21 December 1994, is included as Appendix B because it provides background on this study and details the findings of the initial study of ten industries which lead to the two industries selected for further study *(i.e.*, Construction and Electronics). As research progressed, the two selected industries were investigated in terms of current status and degree of metrication, near term and long term prospects, export potential, and food chain participants including related opportunities and conversion obstacles. These issues, as well as the development of the recommended strategies to accelerate metrication, are discussed in the two major chapters of this final report.

The first chapter covers the Construction industry and proposes several strategies to accelerate metrication within this industry. This industry is positioned for significant growth in federally-financed metric construction largely as a result of the efforts of the Construction Metrication Council, discussed in detail later. However, many other construction food chain members require additional encouragement in order to respond positively to metrication and to participate more fully in the prospects for this huge industry. The potential payoff in terms of increased efficiency, improved quality control, expanded export opportunities for U. S. building products and architectural, engineering and construction services is enormous.

Chapter two is devoted to the rapidly growing and highly complex industry historically seated in the U. S.--the Electronics industry. The organization of the chapter on electronics mirrors construction covered in chapter one. While the investigative process and the metrication developmental strategies sections evolved in similar fashion, the electronics industry metrication problems are quite different. In construction, architects/engineers readily adapt to metric, but are somewhat concerned about availability of metric materials/products. Conversely, in the electronics area, virtually all new components are designed in metric, but printed wiring board designers integrate them onto an inch based grid, despite the fact that it would be easier to place them on the metric grid for which they were designed. As in the construction industry, many resources exist within the electronics industry to facilitate metrication, including leadership such as provided by the Electronics Industry Association.

The design change to metrication is subtle in that inch/pound and metric dimensions of standard components are so close that the impetus to change from inch/pound is retarded since many applications can be accommodated without the conversion to metric. Thus, the metrication program in this industry must include educating U. S. electronics participants from the standpoint of taking a longer term view of the demands of future global markets. They can still

INTRODUCTION (Continued)

survive with inch/pound designs in many markets but all indications are that the acceptability of inch/pound designs is rapidly diminishing in world outlets. Metrication would represent a competitive advantage to those who convert now, and most likely could be an essential requirement to do business in the near future.

> **NOTE:** *As a general rule the first time an organization is mentioned the complete name is spelled out, and the appropriate acronym is given parenthetically. The acronym is used in subsequent references to that organization. Spelling out the complete name each time (e.g., Institute for Interconnecting and Packaging Electronic Circuits, rather than IPC) would detract from the readability of the report. The names and acronyms are listed on pages 21 and 22 for the Construction Industry and pages 39 and 40 for the Electronics Industry.*

CONSTRUCTION

BACKGROUND

The construction industry is huge in size, scope and potential for metrication. With estimated expenditures of $470 billion in 1994 for new construction, it directly accounts for approximately 6 million jobs and 8 percent of the gross domestic product. The percentage of domestic construction designed and built in metric is currently small, but the potential is enormous. Both metric design expertise and metric building products are enjoying growing domestic demand and excellent export prospects. The likelihood of further metrication is significantly enhanced by the government's adherence to PL 100-418 which requires metric design and construction of the billions of dollars of federally financed new building and highway programs. Another positive factor is the Construction Metrication Council (CMC) which through its education and solicitation efforts has gained the support of many industry participants, professional organizations, the Department of Defense (the Army, Navy, Air Force, *etc.*) and many other federal agencies.

Surprisingly, the construction business has become increasingly international during the last two decades. Many large foreign construction contractors have entered the U. S. construction market, without much success. On the other hand, large U. S. construction contractors have become internationally active, winning about one half of all international construction dollars in 1992. Substantial housing needs in Mexico, Poland, South Africa and Russia bode well for the future. Rapid economic growth in Asia and the resultant need for infrastructure will present additional opportunities for U. S. architectural/engineering/construction companies, as well as for U. S. construction materials exporters. Structural metal products, plumbing and lighting equipment, gypsum products and glass are some of the materials experiencing export demand.

The exporting of U. S. construction skills and construction materials not only helps reduce the trade deficit, but it is an important factor in developing metric skills within the U. S. industry. These same skills and materials can be effectively employed in federally-financed (metric) construction programs.

CONSTRUCTION

CONSTRUCTION INDUSTRY FOOD CHAIN

Architectural/engineering (SIC 8712) companies (A/Es) prepare a sequence of documents (*i.e.*, concept drawings, schematic design, design development and construction documents) that are used for customer evaluation, cost estimating and construction. These companies employ architects, engineers and designers, and use Computer Aided Design (CAD) systems for preparing drawings. The CAD systems are capable of functioning in both metric and inch/pound. Historically, A/Es earned about 80 percent of their income from engineering services, 17 percent from architectural services and 3 percent from surveying. It is common for some of the engineering design work, especially in specialized disciplines, to be subcontracted. Some architectural firms do not employ engineers directly but have arrangements with engineering companies with which they work.

Many, if not most A/Es have some metric experience. Architects and engineers learn the metric system in college. Those who have worked on overseas programs or on recent federally funded projects have on-the-job metric experience. Thus, there is little concern relative to preparing metric drawings and construction documents. There is concern, however, about the availability of metric materials and construction costs. The architects must learn what metric materials are available and where they can be procured. They must also build a library of metric product data sheets. (See Figure 1 for a depiction of food chain relationships within the construction industry.)

Concerns about availability of metric building materials are often overstated. Ninety-five percent of construction products will not change, they will just be relabeled. The remaining 5 percent are modular products such as brick, block, wall board and ceiling tiles. Metric modular products are currently available from several suppliers, and availability is improving. Information on metric building materials is available through the CMC and the U. S. Metric Association. Information on metric training is also available through the U. S. Metric Association. Some A/Es have embarked on their first metric program without any additional training, while others decided upon a full day of training. Four hours of training for architects, engineers and designers prior to embarking on a metric project is usually very beneficial.

General Contractors (GCs) **(SICs 154, 161, 162)** are called in by the A/E and/or the client to bid on the cost of constructing the building as described by the design development drawings. Initially, some GCs said that they would not bid jobs that are specified in metric. The results of a survey of GCs in the Kansas City area indicated that 25 percent said that they would not bid a metric

THE CONSTRUCTION INDUSTRY FOOD CHAIN

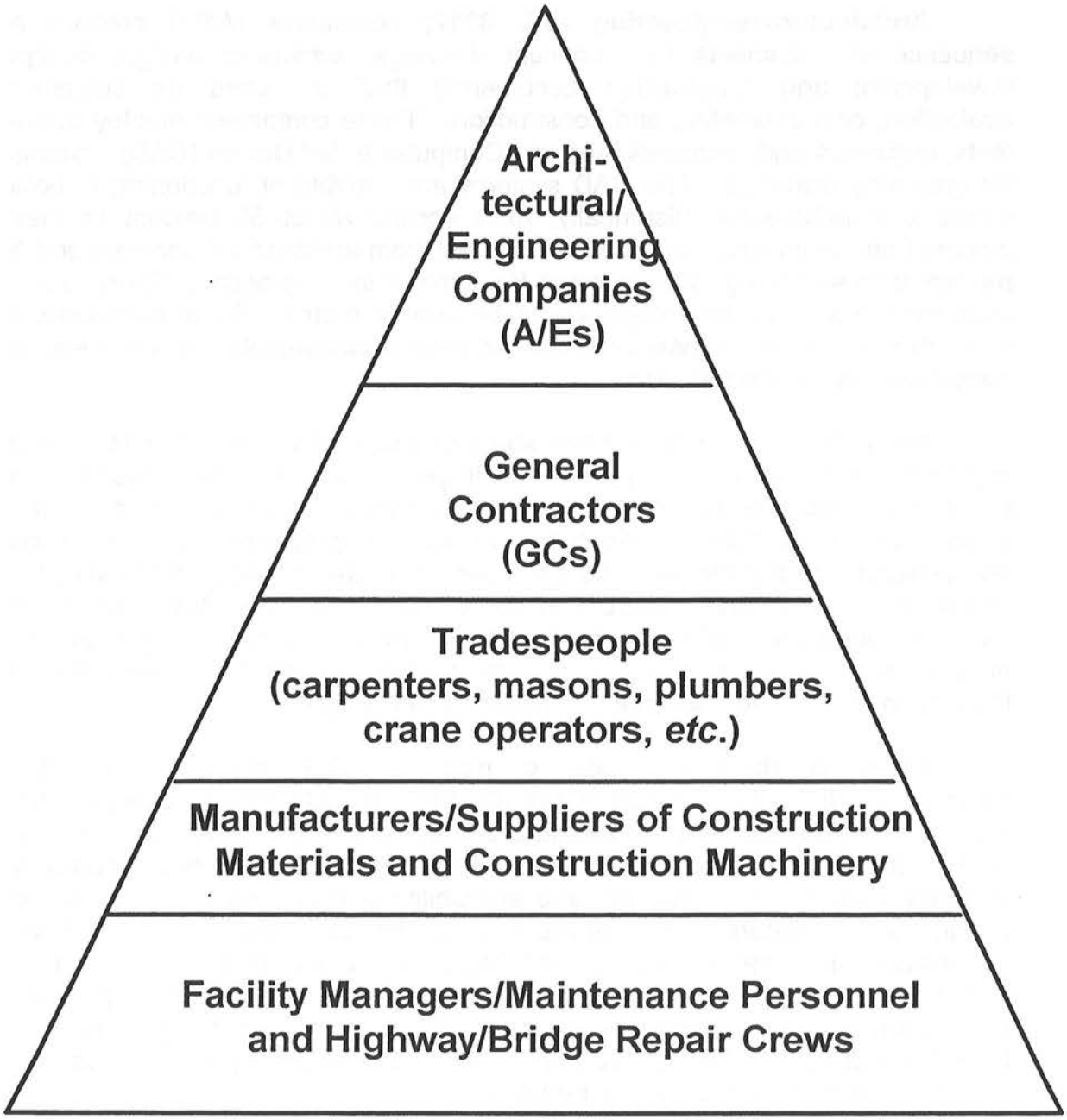

Figure 1

CONSTRUCTION INDUSTRY FOOD CHAIN (Continued)

job because of the fear of financial loss resulting from their own mistakes and lack of efficiency working in an unfamiliar measurement system, *e.g.*, lack of experience in estimating costs of metric materials, a concern that errors in procurement and/or construction will occur when working in metric, and finally, that tradespeople, instead of working in metric, would convert dimensions to inch/pound. This reverse converting has several negative effects: it wastes time; it introduces another possible source of error; it prevents the tradespeople from gaining experience with working in metric; and, it precludes the savings that invariably occur when tradespeople learn and work in the metric system.

More than 80 percent of those GCs (in Kansas City area survey) who stated initially that they would not bid a metric job, said that they *would* bid metric jobs after a number of metric projects had been successfully completed by other contractors in the area. Actual experience on Federal programs (in several other areas) indicates that most metric jobs have the usual number of bidders. It is likely that some GCs who indicated that they would not bid metric jobs will in fact bid when given the opportunity. Two likely reasons for this are (1) some GCs may state that they will not bid metric jobs in the hope that this would stop or at least delay the construction metrication effort, and (2) as more metric construction success stories circulate within the industry, through the efforts of the CMC and its *Metric In Construction* newsletter, through industry organizations and trade journals as well as USMA and ANMC publications, fear of bidding is being replaced by a desire to join the metrication movement and enjoy the benefits. Larger GCs look upon bidding a metric project as an opportunity. This is based on the knowledge that the industry is transitioning to metric, and companies with metric experience will be in the best competitive position.

Tradespeople (SICs 171, 172, 173, 174, 175, 176, 177 & 178), *e.g.*, carpenters, electricians, masons, plumbers, highway construction workers, steel assemblers, *etc.*, are generally hired by the GC on an as required basis. At this point in time, the great majority of tradespeople do not have metric experience. Exceptions are those that learned their craft in a foreign country, those that worked on a project in a foreign country, and those that worked on a federally funded (metric) program. If tradespeople are not given training and a metric ruler or metric measuring tape, they will generally convert the metric dimensions to inch/pound and work in the inch/pound system.

CONSTRUCTION INDUSTRY FOOD CHAIN (Continued)

Most tradespeople with the benefit of a couple of hours of instruction, learn all they need to know about metric construction. Typically this involves learning the basic metric units of length (the meter and millimeter), volume (the cubic meter and liter) and mass, or weight, (the kilogram) as well as basic knowledge of metric drawing practice. It is also important to include in the training the background information on why the U. S. is moving to metric, and the experience of other countries that have gone through the transition. Knowing that experience has shown that most tradespeople become comfortable working in metric after a few days and often prefer metric once they get used to it does much to allay the fears of learning a new measurement system. Experience in the GSA Philadelphia Region construction indicated that five months into construction, metric use had become a virtual non-issue.

Manufacturers/suppliers of construction materials and machinery will experience little change. As previously noted 95 percent of construction products will not change due to metrication. Plumbing, heating, air conditioning, steel beams, and concrete, for example, will be described in metric terms, but will be otherwise unchanged. Pipe length and diameter will be expressed in millimeters instead of inches. Heating and air conditioning loads will be in watts instead of BTU/hour. The mass (weight) of steel beams will be in kilograms per meter instead of pounds/foot. Forms for concrete foundations will be made to metric dimensions, but filled with the same concrete mix as before.

More and more manufacturers of non-modular products are making metric dimension data sheets available for their products. This simple step is a great aid to engineers and designers working on metric construction programs, and it enhances the marketability of the products, making them more attractive for use on both Federal (metric) and overseas construction.

Modular products such as brick **(SIC 3251)**, block **(SIC 5032)**, wall board **(SIC 3275)**, raised floor tile **(SIC 3251)**, ceiling tile **(SIC 3296)** and lighting (troffer) fixtures **(SIC 3646)** that fit into the ceiling tile grid, must be hard metric designs. Other hard metric products are rebar (**SIC 3316**; for reinforcing poured concrete) and structural bolts (**SIC 3452**; for bolting steel beams). All of these metric products are currently available from a limited number of suppliers.

As domestic demand increases, more manufacturers will produce metric modular products, and some of these manufacturers will take advantage of the export opportunities that exist for metric products. Also, additional metric construction products are starting to appear, *e.g.,* glass in metric thickness and

CONSTRUCTION INDUSTRY FOOD CHAIN (Continued)

roofing materials in metric sizes. Increasingly, U. S. construction product manufacturers are looking overseas for market expansion. An example is Owens-Corning which recently announced that it is aggressively going to market its pink trademarked fiberglass insulation in Europe.

Highways and related structures (*e.g.*, bridges, overpasses, tunnels, culverts, *etc.*) are generally designed by engineering companies. If aesthetics are involved; the engineering company may use staff architects or subcontract this portion of the design to an architectural firm. Virtually all of the materials used in metric highway construction are identical to those used in inch/pound construction because there is seldom a need for modular products. Since engineers readily adjust to metric designs, and the tradespeople use the same materials they are used to, adjusting to metric highway design and construction is generally easier than adjusting to metric building construction. Additionally, the Federal Highway Administration (FHWA) started their metric planning early. In 1992 they awarded a contract for the development of metric training for highway construction people. Currently, there is a one-day course for highway engineers. There was so much interest in this class that the first forty sessions were completed on an accelerated basis. A contract for eighty additional sessions will be awarded soon, with classes scheduled to start in April of this year. For non-technical personnel at FHWA headquarters, there is a two-hour course that focuses on commonly used metric units and the correct use of metric symbols in purchase orders, correspondence, *etc.*

To date, 43 states are designing highway projects in metric and 45 states have completed or are in the process of completing the metrication of their standard highway specifications. All 50 states say that they will meet the FHWA deadline of October 1996 for constructing new highway projects in metric.

Construction machinery (SIC 3531), *i.e.*, backhoes, bulldozers, cranes, loaders, paving equipment, power shovels, *etc.*, is not measurement sensitive and need not be designed in metric in order to accommodate construction of metric roads and structures. Nevertheless, it should be noted that several construction equipment manufacturers (*e.g.*, John Deere and Caterpillar) converted to metric many years ago are enjoying excellent overseas sales, exporting about 35 percent of production. The use of metric printed wiring boards in construction equipment, as discussed in the Electronics Industry section of this report, would help accelerate metrication of both construction machinery and electronic equipment.

CONSTRUCTION INDUSTRY FOOD CHAIN (Continued)

Facility managers/maintenance personnel are responsible for the day-to-day operation and maintenance of the office buildings, warehouses, theaters, roads, bridges, *etc.* In many cases they may be unaware of whether the building or structure for which they are responsible was designed in metric or inch/pound units. One concern is the availability of metric modular products for repair of a wall, raised floor, or dropped ceiling that is damaged. These products are available in construction quantities at competitive prices, but they are not yet readily available in small quantities or from retail outlets. One solution, which the GSA intends to employ, is to include extra metric modular materials for maintenance in the construction purchase order. Another approach would be to buy the equivalent inch/pound product and cut it down. This is relatively easy to accomplish since the metric sizes are smaller, *e.g.*, common inch/pound ceiling tiles are 24" x 24" or 24" x 48". The metric sizes are 600 mm x 600 mm ($23\frac{5}{8}$" x $23\frac{5}{8}$") and 600 mm x 1200 mm ($23\frac{5}{8}$" x $47\frac{1}{4}$"). Common inch/pound wallboard is 48" x 96". The metric size is 1200 mm x 2400 mm ($47\frac{1}{4}$" x $94\frac{1}{2}$"). Materials required for metric road/highway/bridge maintenance and repair are generally inch/pound and do not present a procurement problem. One or two hours of metric training for facility managers are desirable but not essential.

CONSTRUCTION

CURRENT STATUS AND POTENTIAL FOR METRICATION

Currently, metric modular products can be procured with little difficulty, and availability is improving. Interest in bidding on metric programs is increasing, and current estimates for 1997 indicate that $50 billion (including about $20 billion of highway projects) of federally-funded projects representing about 10 percent all new construction, will be designed and built in metric. This level of metrication is expected to double by the year 2000 to 20 percent (*i.e.*, $100 billion metric of $500 billion of new construction). Experience has shown that engineers, designers and architects can start working effectively in metric after 4-5 hours of training. While this training is recommended, it is not essential for all engineers/architects. Tradespeople need only 1 or 2 hours of training. After a learning curve of a few months for white collar workers and a few days for tradespeople, the benefits of increased efficiency, and improved quality control take effect. Government funded construction (state and federal combined) which is mostly non-residential, accounts for approximately 25 percent of all new construction. Private non-residential (office buildings, theaters, supermarkets, *etc.*) make-up another 25 percent of new construction. The same kind of large companies that do the government construction also do most of private non-residential work.

It should not take these companies long to realize:

- It would be more efficient to work in one, rather than two different systems of measurement.

- That working in the world's standard system, *i.e.*, metric, has benefits that quickly compensate for training and learning curve expenses. These benefits continue to accrue forever.

If and when these large architectural/construction firms design and build the private sector non-residential structures in metric, then 50 percent of the U. S. construction industry would be metric! The purchaser of an office building, theater, or supermarket is interested in getting the job done at the lowest cost, and companies that design in metric are in the best position to offer that by working in the most efficient measurement system, *i.e.*, metric. It is not uncommon or difficult to provide the customer with drawings that show room sizes and other important parameters in dual dimensions (*i.e.*, metric and inch/pound). Dual dimensioning is done in the manuals for automobiles, television sets, VCRs and is mandated by law (Fair Packaging and Labeling Act)

CONSTRUCTION

CURRENT STATUS AND POTENTIAL FOR METRICATION (Continued)

on most consumer products. (Note that dual dimensioning of architectural/engineering drawings is limited to those required for customer use. Other construction drawings should not be dual dimensioned.)

Converting the remaining 50 percent of U. S. construction, that of residential housing, mainly 1 and 2 family homes will require some public awareness and customer buy-in. The small builders, many of whom have never worked on government contracts or large commercial buildings, are not knowledgeable of the advantages of designing and building in metric. Consequently, the lack of knowledge of metric among these builders is likely to perpetuate "metriphobia" (author's term) among home buyers and small builders. This phase of metrication is five or more years away and the magnitude of the problem will depend on the extent to which the public, including small builders and tradespeople, have become familiar with the simplicity and benefits of the metric system.

There is a world wide market for international architectural and engineering services in which companies with metric expertise can participate. Few U. S. construction companies are internationally active, but those with metric construction skills are extremely successful. The *Engineering News-Record* reported that in 1992, U. S. contractors won 51 percent of all international construction billings. Private sector company members of the Architectural Task Group of the government's Metrication Operating Committee (MOC) Construction Subcommittee report that working in metric has been taken in stride by their personnel. These architectural and engineering firms work in inch/pound units on private sector projects in the U. S., and in metric units for federally financed and overseas projects. Companies that gain metric experience on government-sponsored construction in the U. S. can use this experience in overseas markets. There are also export opportunities for U. S. manufacturers of metric modular materials and many other construction products, some of which were first produced to meet the needs of federally financed metric projects in the U. S.

The U. S. exports a range of materials from cement **(SIC 3241)**, glass **(SIC 3211)**, gypsum products **(SIC 3275)** which includes gypsum boards, ceramic tile **(SIC 3253)**, plumbing fixtures **(SIC 3261, SIC 3431, SIC 3088)**, plumbing fittings **(SIC 3432)**, lighting fixtures **(SIC 3645, 3646 and 3648)**, structural bolts and nuts **(SIC 3452)**, lumber **(SIC 5031)**, concrete block **(SIC 5032)**, roofing, siding and insulation materials **(SIC 5033)**, *etc.*

CONSTRUCTION

CURRENT STATUS AND POTENTIAL FOR METRICATION (Continued)

Certain materials are not measurement sensitive such as bags of cement (which only require metric labels). Other items require only metric dimensional data sheets, *e.g.*, plumbing fixtures, and some must be hard metric products, such as wall board, suspended ceiling tiles, raised access flooring, drop-in lighting fixtures, concrete block, lumber, *etc.*

Some companies do not produce metric size product because there is insufficient domestic demand at this time. As metric construction becomes more common place and those companies produce metric product to meet domestic demand, they will open the door to export potential. In many cases the same production machinery that produces inch/pound can produce metric sized product. The only requirement is that the production equipment must be adjusted or "setup" to produce metric product. Examples of metric products that can be produced with current equipment include brick (when made by the extrusion process), dry wall, glass, lumber and mill products.

U. S. exports of non-lumber products increased for eight consecutive years, and almost doubled in 1994 relative to 1993, to about $4 billion. The value of lumber **(SIC 5031)** exports (not including logs and pulpwood) was $2.6 billion in 1993. Continued growth is expected in both these areas.

CONSTRUCTION

STRATEGIES

This section contains an overview of metric-motivating forces within the construction industry, as well as impediments to metrication and related strategies aimed at overcoming those impediments.

Architects and engineers readily adapt to metric construction projects. This is due to several factors. They learn the metric system as part of their formal education, and they are generally aware of the fact that that working in metric is easier and less prone to error than working in the inch/pound system. These facts are reinforced by the ever growing number of A/Es that have worked on a metric construction project; and these metric-experienced architects and engineers often look forward to subsequent metric programs. One challenge for the A/Es is locating sources of metric building materials and building a metric catalog library. Another, perhaps greater concern, is locating general contractors who will provide competitive bids on metric designed projects. Most GCs, at this early stage of the metric transition, are not familiar with the simplicity of the metric system, and may be reluctant to bid or may bid higher on metric projects. GCs may also be concerned about the availability of metric building materials and of tradespeople that are able/willing to work in metric. The following strategies address these concerns.

The construction industry has the benefit of an active organization that has focused effectively on promoting and aiding metrication industry-wide. Both the metrication progress and the plans and commitments to future metrication in the U. S. construction industry are to a very large extent due to: (1) the efforts of the Construction Metrication Council (CMC), within the National Institute of Building Sciences (NIBS), and (2) those federal agencies and industry organizations that have actively participated in CMC initiatives.

Architectural/engineering firms and General Contractors should request a subscription to the *Metric in Construction* newsletter which is a publication of the CMC. This publication provides facts about metric construction including U. S. laws and Executive Order 12770, the experience of other countries that have converted, metric case studies in the U. S., availability of metric building materials, *etc.* This newsletter is available, at no charge, by simply sending a FAX transmittal with name, concise address and only the words "Metric Newsletter" to NIBS at 202-289-1092. (Note that phone orders are <u>not</u> accepted.)

CONSTRUCTION

STRATEGIES (Continued)

As A/Es and GCs become more aware of the successes of other companies that have embarked on a metric program, they will become more inclined to participate in metric construction. The strategy here is, therefore, to prepare a flier (1 or 2 sheets) that documents a number of success stories. This should include at least one case study that documents the successful completion of a GC's *first* metric program. The GCs initial fears and concerns, how they were addressed and the successful end result should be noted. Data for this one or two page flier could be obtained through the CMC which has data on actual case studies. Copies should be included in each request for quotation (RFQ) package and should be made available to all GCs.

Locating sources of metric building materials and building a metric catalog library is a concern for both A/Es and GCs. Availability of metric materials is improving rapidly. The strategy therefore is to use references that are updated periodically. The U. S. Metric Association's *Metric Vendor List* was updated in 1994 and will be updated and republished again in 1995. The *Thomas Register*, updated yearly, has a growing list of companies that provide metric materials. The Construction Metrication Council (202-289-7800) and the U. S. Metric Association (818-368-7443) can be contacted for additional procurement information.

Although some A/Es commence their first metric project without the benefit of additional training, most A/Es find that a brief metric construction course is very beneficial. Training for GCs is even more important, since very often metric was not part of their formal education. The strategy here is to make the A/Es and GCs aware of the availability of metric training aids (books, videos, *etc.*) and metric instruction for the construction industry. Construction-specific metric publications, *e.g.*, the GSA *Metric Design Guide* and the *Metric Guide for Federal Construction* are available from the National Institute of Building Sciences (NIBS) at 202-289-7800. Metric training aids including instructional books and video tapes are available through the U. S. Metric Association (818-368-7443) and the American National Metric Council (410-727-0882). These organizations can also provide information on experienced metric instructors who offer metric-in-construction training.

Another strategy for GCs is to offer a free introductory (perhaps just one hour long) metric course, initially in the Washington, DC area. The agenda might include brief segments on...

(a) Basics of the metric system

STRATEGIES (Continued)

(b) Working in metric versus working in inch/pound

(c) What will change and what will remain the same

(d) Metric resources

The goals of the seminar would be to allay fears and to start the metric education process by demonstrating the simplicity of the metric system. Fees should be low to encourage participation. A public facility could provide the space required and the instructor's fee might be paid by the government. Alternatively, each contractor could be charged a nominal fee, or perhaps some instructors would teach the introductory class free, in return for the opportunity to offer subsequent, more intensive metric training (for a fee) to a roomful of GCs.

Educating the tradespeople and providing them with the required tools (often just a metric tape measure) are essential. This is the responsibility of the GC. Those GCs that attend the proposed introductory seminar will have learned (a) what training is required, (b) where to find it at nominal cost, (c) pitfalls and how to avoid them. An alternative strategy, in lieu of the seminar, is for the GCs to educate themselves and their tradespeople "in-house" using video tapes, metric training materials, and/or a metric instructor. The *Freeman Training-Education Metric Materials List*, available from the U. S. Metric Association, is an excellent resource for locating sources of training materials. The U. S. Metric Association (818-368-7443) can provide information on experienced metric instructors who offer metric-in-construction training.

Sources of metric modular products are limited but will expand to meet market demand. Metric drywall, ceiling systems and raised access flooring are made by U. S. companies for export and are also marketed domestically. A couple of block manufacturers have metric sized molds. At least one of these companies sells metric block both in the U. S. and Canada. More companies will buy metric molds as block demand increases. Brick can be cast in molds (an older dated process) or it can be extruded. Most brick companies use the newer extrusion process. Metric bricks can be produced easily using the correct extrusion die and adjusting the wires that cut the unbaked brick. Some inch-sized brick is virtually the same size as metric modular brick and can be used without difficulty. For more information read *What Metrication Means to the Brick Industry* in the *Brick Institute of America (BIA) News--January 1993*, or contact Tina Subasic at BIA (703-620-0010).

CONSTRUCTION

STRATEGIES (Continued)

Large lighting fixture companies, which are highly automated, say that they do not want to modify or invest in equipment to produce metric-sized drop-in (troffer) fixtures. Smaller companies that are less automated can and do make metric-sized fixtures. This is a welcomed competitive advantage for the smaller companies. Increased demand may attract the larger, more automated, companies at a later date.

One strategy suggested in the building materials area is to keep the suppliers aware of current and anticipated demand, and of the associated export potential for metric-sized products. Publications such as *Metric in Construction* (NIBS) and *The Construction Specifier* (published by the Construction Specification Institute) are ideal for this purpose. Those companies that want to do business will respond. Building material suppliers have responded to the need for metric modular products in the areas of troffer lighting fixtures, brick and block, construction bolts, wall board, ceiling tiles, *etc.*

Companies that offer or that are considering offering metric construction services and/or products should obtain free export information by FAX from an export hotline setup by AT&T in cooperation with several multinational companies and trade associations and the Department of Commerce. Registration for the Export Hotline is free. The database contains over 5,000 market research reports. It is updated twice weekly and is available 24 hours per day, 7 days a week. When you register for Export Hotline you are automatically registered to use "Tradebank", an electronic listing of more than 10,000 companies. This service is also free. Companies can be listed in the electronic yellow pages for a nominal fee of $100/year. Dial 1-800-USA-XPORT, key in your FAX number, and information will be faxed to you within five minutes!

Construction machinery is a non-issue since inch/pound machinery can be used to build metric structures and roads, and *vice versa*. Most construction equipment is of metric design, adding value to foreign customers by improving its maintainability in a metric world.

At the largest rung of the construction food chain are the facility managers, maintenance personnel and highway repair crews. Some metric training for those that work on metric buildings is very desirable, but not essential. The strategy is simply to encourage metric training, at least for facility managers and road crew supervisors. The Building Owners & Managers Association (BOMA) has focused, for the last several years, on the changing industry and the impact that emerging technologies are having on it. The presi-

STRATEGIES (Continued)

dent of BOMA (Thomas B. McChesney) stated that "Things are happening fast, it's hard to predict the outcomes, and our future successes depend on understanding what's coming." Taking advantage of readily available metric training video tapes or a 1 to 2 hour class would be ideal for this purpose. Both the USMA and the ANMC have training information available.

If the United States' construction industry reaches the 50 percent metric point as outlined on page 14, a new plan of action will be required to complete the transition. This plan will involve the much larger number of small GCs that build residential housing, mostly 1 and 2 family homes. Small GCs do not bid on government contracts or overseas projects. They usually have no metric construction experience. If the public is metrically literate at that point in time, and if metric building materials are readily available at no cost penalty, or perhaps even at a discount relative to inch/pound products, then the transition can be completed with a little education of small GCs about the advantages of designing/building in metric. If, on the other hand, the public has the same anti-metric bias that it has today, then a more comprehensive education program, perhaps through public television, must be undertaken. The objective of the program would be to demonstrate the simplicity of the metric system, teach the basic units (*i.e.*, meter, liter and kilogram) and inform the public of the relationships among designing in metric, export opportunities, and job creation (*i.e.*, 20,000 jobs per $1 billion of exports).

> **NOTE:** *In addition to the specific construction strategies listed above, the general strategies contained in the Electronics section and in the summary tables in Appendix A are also applicable.*

CONSTRUCTION

RESOURCES

American Institute of Architects (AIA)

American Society of Heating Refrigeration and Air-conditioning Engineers (ASHRAE)

Associated General Contractors of America (AGC)

Bohlin, Cywinski, Jackson (Architects)

Breaking into the Trade Game (Small Business Administration and AT&T)

Brick Institute of America (BIA)

Brier, Neidle, Patrone (Engineering Consultants)

Building Owners & Managers Association (BOMA)

Business Almanac--Louis Rukeyser

Business America--11 January 1993

Business Journal Serving Greater Sacramento--18 January 1993

Business Week--16 May 1994

Caterpillar, Inc.

Coal--July 1993

Construction Metrication Council (CMC), part of the National Institute of Building Sciences (NIBS)

Construction Specification Institute (CSI)

Federal Highway Administration (FHWA)

General Services Administration and Public Building Service (GSA/PBS)

Hillier Group (Architects/Engineers)

Industrial Finishing--September 1993

CONSTRUCTION

RESOURCES (Continued)

International Fastener Institute (IFI)

John Deere & Company

Metric for the Construction Trades (Training Program developed by J. J. DeBartolo, 1994)

Metric in Construction (CMC Publication)

Metrication in the Commercial Construction Industry by Elizabeth V. Suerth

Metric Reporter (Newsletter of the American National Metric Council)

Metric Today (Newsletter of the U. S. Metric Association)

National Aeronautics and Space Administration (NASA)

National Institute of Standards and Technology (NIST)

Nucor Steel Company

N. Y. Times--12 November 1994

Ontario Concrete Block Association

Orlando Sentinel Tribune--29 July 1994

Siska & Hennesy (Engineers)

Smithsonian Office of Design and Construction

Sunday--Three Star Edition--26 September 1993

U. S. Industrial Outlook--1994 (U. S. Department of Commerce)

U. S. Metric Association (USMA)

ELECTRONICS

BACKGROUND

The electronics industry, born in the U. S., was naturally based on inch/pound standards, and these standards were generally accepted around the world. The U. S. electronics industry has grown by a factor of over 1 million, from a $200 million industry in 1927 to over $300 billion now. By 1988 it became the nation's largest manufacturing employer. The industry is vast in diversity and complexity of products and enterprises which comprise it. It is also extremely dynamic, in an early stage of its life cycle and has an ever increasing number of participants. Given the magnitude of this food chain, substantive changes within this industry would have large and long-lasting effects on the U. S. economy. Despite long-term robust growth (*e.g.*, in 1994 electronic components was the second fastest-growing manufacturing industry, after machine tools, in the U. S.), several factors have hurt the industry. First, the strong dollar and the appeal of cheaper foreign goods made the U. S. a net importer by the mid 1980's. Second, more innovative applications to consumer products, by the Japanese and others, of U. S. developed technology undercut industry growth in this country.

Increasingly electronics has become an industry that is international in scope. Companies that do not conform to the growing body of international standards which are transitioning to the metric system, will be at a competitive disadvantage. Additionally, some countries have local content regulations that require a specified percentage of certain products to be manufactured locally. If the U. S. manufacturer and exporter of these products has designed and documented its components in the inch/pound system, it will be very costly to change the drawings to metric so that the required "local content" can be manufactured and/or procured in the local (metric) area.

The electronics food chain described in the following section starts with the design of electronic components, and includes fabrication of those components as well as the engineering, design and fabrication of printed wiring boards (PWBs) and the card cages that support and connect these PWBs within the OEM (original equipment manufacturers) equipment into which they are integrated.

ELECTRONICS

ELECTRONICS INDUSTRY FOOD CHAIN

Electronic components (SIC 367) are the building blocks of the electronics industry (see food chain representation in Figure 2). Electronic component engineers design a range of components including diodes **(SIC 3674),** capacitors **(SIC 3675),** resistors **(SIC 3676),** connectors **(SIC 3678),** coils and transformers **(SIC 3677),** semiconductors and related devices **(SIC 3674),** *etc.* They vary in size and complexity from simple tiny diodes to sophisticated microprocessors as large as the palm of the hand. Semiconductors are the largest, most dynamic and complex segment of the components market. Eighty-five percent of semiconductors are integrated circuits (ICs) ranging from complex memory ICs, microcomponent ICs (including microprocessors and digital signal processors) to analog and discrete semiconductors.

Factors that affect the marketability of electronic components are size (smaller is better), cost, reliability, functionality, and measurement system. In those component areas where a device is available in both metric and inch/pound, such as film capacitors, the export market for U. S. produced inch/pound product slowly disappears. Complex microprocessors contain millions of circuits and are the backbone of modern personal computers. As small as modern-day components are, research sponsored by the National Science Foundation (NSF) under the direction of Dr. Rao Tummala at the (Low-cost Electronics) Packaging Research Center, Georgia Institute of Technology, may produce a new generation of components that are ten times smaller and much less expensive than present designs.

Many electronic components are so delicate that they can be damaged merely by touching them. Some components are very small and cannot easily be handled without mechanical and/or optical aids. The great majority of electronic components are employed on printed wiring boards (discussed in greater detail later) that provide the connections between components as well as the physical structure for mounting, and to some degree, protecting these components.

Virtually all new components are designed in a metric package with terminations that match a metric PWB grid (see second paragraph on page 27 for additional information on grids). The impetus for this metrication was provided by the Electronics Industry Association's (EIA's) Joint Electron Device Council (JEDEC) decision in January 1992 that new semiconductor packages would not be registered unless they were designed in metric. A similar decision effective on the same date, was made for all other electronic components by the EIA's P-4 Committee.

THE ELECTRONICS INDUSTRY FOOD CHAIN

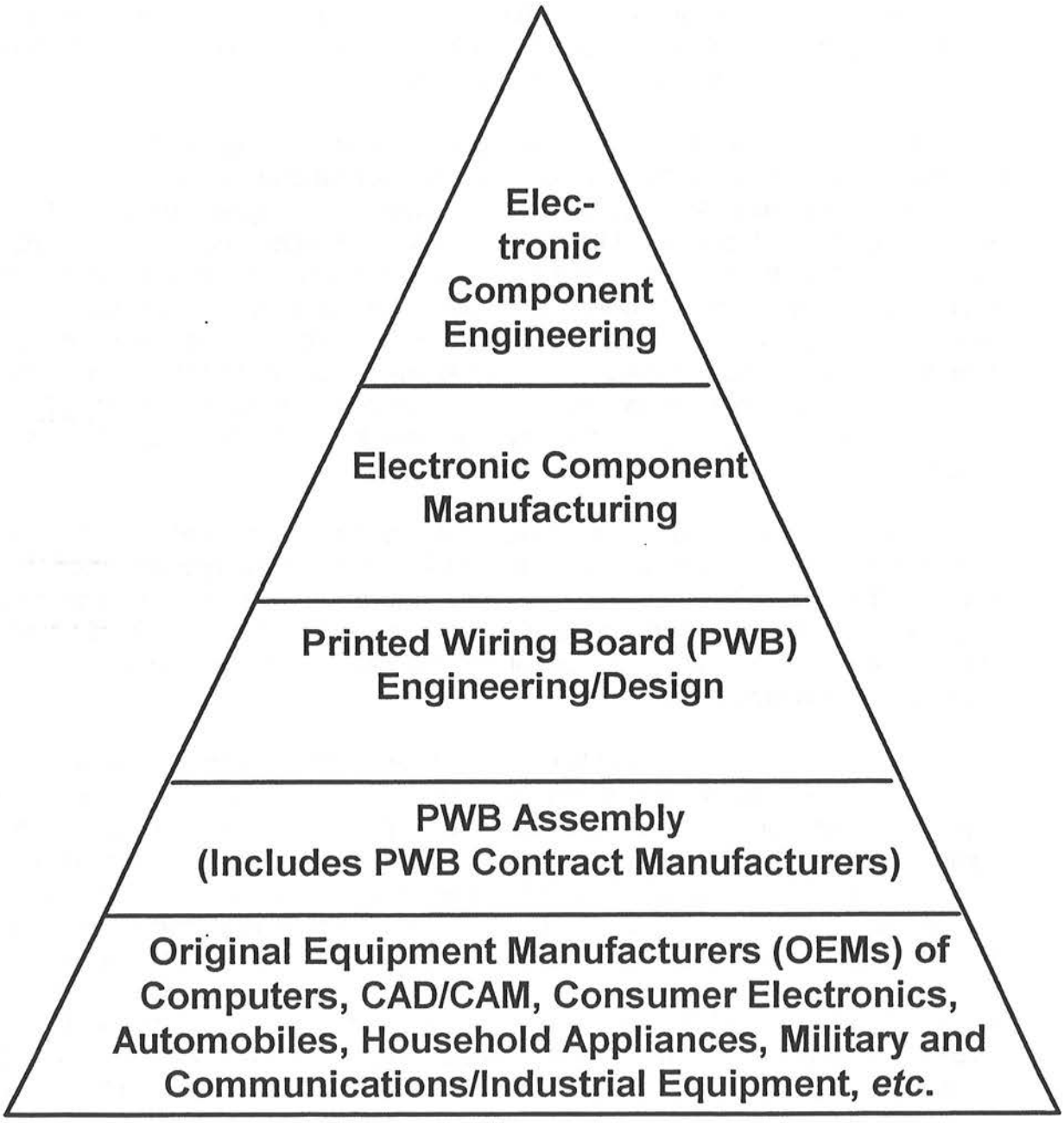

Figure 2

ELECTRONICS

ELECTRONICS INDUSTRY FOOD CHAIN (Continued)

Electronic component manufacturers (SIC 367) use **semiconductor manufacturing equipment** (SME) **(SIC 3559)** to produce integrated circuits and discrete devices. The three segments of SME are:

One, the wafer processing equipment--approximately 100 to several hundred "dies" (a "die" in this context is an unprocessed component) are made from a single silicon wafer, depending on the size of the chip and the size of the wafer. There is a decades old trend toward larger diameter wafers. Originally, wafers were 1 inch diameter, then 2 inch and 3 inch which remained popular to 1975 after which 5 inch and 6 inch took over. An 8 inch wafer was developed about a year ago and has gained approximately 20 percent of the market in that short time. Metric oriented manufacturers call the 6 inch wafer 150 mm, and the 8 inch 200 mm, but they are in fact identical. There is now talk of a 12 inch (300 mm) wafer. Larger, complex microprocessors like Intel's Pentium require larger wafers.

Two, are test, handling and process diagnostics equipment. Each of the dies is tested before it is cut from the wafer, and the acceptable ones are marked. This procedure saves the expense of further processing of those dies that will not produce good semiconductors. Cleanliness and process parameters are critical. Robots do virtually all of the handling in order to minimize the possibility of contamination.

Three, consists of assembly equipment (bonding leads to the silicon chip, *etc.*). Other less sophisticated manufacturing equipment is used to produce capacitors, resistors, *etc.* Modern SME can produce both inch and metric components, therefore, manufacturing concerns are related to the rapidly changing technology rather than the measurement system. Semiconductor manufacturing equipment must be frequently updated or replaced in order to accommodate advances in manufacturing (*e.g.*, larger wafers, improved technology, *etc.*) and to keep pace as state-of-the-art component designs advance from through-hole components to surface mount technology (SMT), flip chips and ball pin arrays (these are alternative design approaches for mounting components in PWBs). Thus, U. S. companies spend an average of 14 percent of annual revenues on capital equipment and facilities, well above the industry average.

Circumstances that encourage the machine tool industry's move toward metrication of SME are (1) more than 40 percent of SME is exported, and overseas markets prefer metric, (2) virtually all new electronic components are

ELECTRONICS INDUSTRY FOOD CHAIN (Continued)

metric designs, and (3) support for metrication by industry organizations such as the Manufacturers Alliance for Productivity and Innovation and the Association for Manufacturing Technology (formerly the National Machine Tool Builders Association). For more information on metrication in the machine tools industry, of which SME is a part, see Appendix B.

Printed wiring board engineers (SIC 8711) and **PWB designers (SIC 7389)** utilize a variety of components (newer ones are metric, older ones are inch/pound) in circuits designed to do everything from selecting the optimum air/fuel mixture for an automobile engine to a VCR (which was demonstrated in January 1995 at the Electronics Industry Association (EIA) show in Las Vegas) that will *automatically*, as you record various programs, create a menu that displays the name of the program, the time and date of the recording, its length, and the location on the tape. Upon selecting any item on this menu, the VCR will automatically go to that portion of the tape where that program is stored. The VCR obtains all the required information from a subcarrier transmitted by the television station. No user input is required.

Printed wiring board (PWB) designers utilize the schematics of the circuit prepared by the electronic engineers to design an assembly of the selected electronic components mounted on a PWB. The first edition (1957) of the International Electrotechnical Commission (IEC) Publication 97 described a grid system for printed wiring boards with nominal grid spacings of 0.10 inch (2.54 mm). Component manufacturers and PWB designers throughout the world used that recommended grid. As overseas countries metricated they adopted a 2.50 mm grid and, as components become smaller, have utilized smaller grids based on multiples of 0.5 mm.

Computer aided design (CAD) systems can easily handle metric, inch, and designs combining both systems. Printed wiring boards usually contain a mixture of both, since most older components are still inch based. Most U. S. PWB designers continue to employ the inch based grid despite the fact that virtually all new component designs are metric and they are most easily accommodated on a metric sized (global standard) grid.

Printed wiring board manufacturing (SIC 3672) involves "stuffing boards"--placing the components in the proper location on the PWB and soldering the components to the board. Businesses that manufacture PWBs can generally handle metric, inch and combination designs. These businesses have grown dramatically during the past five years. Many original equipment manu-

ELECTRONICS INDUSTRY FOOD CHAIN (Continued)

facturers (OEMs) that used to produce their own PWBs now purchase or subcontract them. A major factor in this shift are the high costs associated with modernizing production equipment, especially the expense of incorporating surface mount technology (described later) equipment. Some companies that assemble PWBs also provide electronic design services. These contract manufacturers can take a circuit design (prepared by PWB engineers) and make decisions related to: location of components on PWB, conductor spacings, metric or inch grid, edge connector selection, overall size of board, *etc.*, within the constraints that the engineer and/or OEM specifies.

Both PWB technology and the associated manufacturing processes are rapidly changing. In the traditional through-hole technique the terminations of components are inserted into holes and soldered on a wave solder machine. This approach is being rapidly replaced by surface mount technology (SMT). With SMT, holes are not required and soldering is accomplished by infrared or vapor phase techniques. Some PWBs are designed with both through-hole and the newer SMT components. These PWBs usually undergo dual processing, *i.e.*, infrared or vapor phase followed by wave soldering.

Even more advanced component mounting techniques, *i.e.,* ball-grid arrays and flip-chips are already being developed. Surface mount technology and these newer variations are virtually all metric based but, as noted earlier, a PWB designer can incorporate metric components into an inch based PWB grid, and *vice versa*, with little difficulty.

Original Equipment Manufacturers are at the base of the electronics industry food chain and use PWBs in their products. It is virtually impossible to list all of the OEM equipment that utilize PWBs because traditional mechanical devices are, to an ever growing degree, being replaced by advanced technology electronic devices performing the required functions more accurately and more reliably. They control wrist watches, thermometers, automobile engines, anti-lock brakes on airplanes and cars, computers and computer-controlled machine tools, industrial process equipment, navigation systems, new and better telephone systems, *etc.* The four largest OEM customers for PWBs with the related percentage of the end markets are computers **(SIC 3571, 72, 75, 77)** 46 percent, communications **(SIC 366)** 18 percent, military 11 percent and automobiles **(SIC 371)** 9 percent. These four areas account for approximately 84 percent of PWB end markets. The remainder is split between instruments **(SIC**

ELECTRONICS INDUSTRY FOOD CHAIN (Continued)

381, SIC 382, SIC 384) 6 percent, industrial **(SIC 3629)** 6 percent and consumer products **(SIC 363** and **SIC 365)** 4 percent. The automobile industry is virtually all metric, many computer companies have metricated, and by law and Department of Defense (DOD) directives, the military must go metric. Despite this metric "environment", in the U. S., the great majority (perhaps 70 percent) of PWBs are still being designed in the inch/pound system.

Use of metric PWBs, PWB connectors and card cages in OEM products will have two beneficial effects: (1) it will make these products more attractive in global markets, and (2) it will give OEM engineers/designers some experience in working with metric, and will encourage further metrication of these products.

ELECTRONICS

CURRENT STATUS AND POTENTIAL FOR METRICATION

Growth in worldwide markets was a major factor in the recovery of the U. S. semiconductor industry. The implementation of NAFTA and GATT and good demand overseas, especially Asia, bode well for exports. Nevertheless, the U. S. imports more than it exports, and will likely continue to be a net importer for at least the near term. Additionally, the recent devaluation of the peso will hurt exports and encourage imports from Mexico, a major U. S. trading partner.

Components engineers and manufacturers are well aware of the universal move toward a metric grid system. Consequently, virtually all new components are metric sized packages designed to fit onto metric grids. Updating of relevant documents, *e.g.*, International Electrotechnical Commission (IEC) Publication 97 (PWB grid systems), the Institute for Interconnecting and Packaging Electronic Circuits (IPC), Policy on Metrication (IPC-MP-83) and the Joint Electron Device Engineering Council (JEDEC) decision that as of 1 January 1992, all new semiconductor packages must be designed in hard metric, gave important support to metrication. The JEDEC will not "register" a new non-metric design (with few exceptions) and that means that the component outline will not be listed in JEDEC Publication 95, which is an important reference document for PWB engineers and designers.

It must be noted that adherence to the policy that all new components be designed in metric does not, in itself, guarantee competitiveness in global markets. If, for example, a company introduces a new metric design to replace an old inch/pound component it would have a competitive edge in overseas markets, over those companies that offer the old inch/pound design. This has already occurred in some limited areas, *e.g.*, film capacitors. European companies now offer metric designs and the export market for U. S. film capacitors (still an old inch/pound design) has virtually disappeared. It is, therefore, important that when economically feasible, taking into account engineering/design and retooling costs, components be redesigned in metric.

Since (1) most new component designs are metric, (2) the metric grid is an international standard, (3) during PWB design, metric components are most easily placed on a metric grid, and (4) older (not yet *re*designed) inch-based components can be easily accommodated on a metric grid, it is logical that virtually all PWBs would be designed on a *metric* grid. Nevertheless, most PWBs continue to be designed in inch/pound. This is a phenomenon of concern.

ELECTRONICS

CURRENT STATUS AND POTENTIAL FOR METRICATION (Continued)

If PWBs are not designed on metric grids with metric connectors to fit into metric card cages, U. S. designed/manufactured PWBs will lose marketability as the global market transitions to metric.

The most common metric grid (2.5 mm) and the most popular inch grid (.100 inch = 2.54 mm) are so close that metric components can be easily mounted on an inch grid with only minor difficulty. This may be a factor in explaining why many U. S. designers are unwillingly to make the change to metric. Some of the designers consider metric as a temporary inconvenience that will eventually go away as it did the in the 1970s. Most PWBs in the U. S. are incorporated into inch/pound designed products and designers think that it does not make sense to design a metric PWB for an inch/pound product. This is incorrect and destructive because it forces the electronics industry to support two different design philosophies *(i.e.*, metric and inch/pound). Both sides lose and concomitantly put the U. S. in a less competitive position. This occurs because the industry is forced to continue to design and manufacture both metric and inch/pound parts in several important areas (*e.g.*, PWB connectors and PWB cages) thus denying the economies of scale that occur when only one type is designed, manufactured and inventoried. Even the customer suffers, because both types become more expensive and they are not interchangeable. The situation is somewhat akin to the early video cassette recorder days in which both Beta and VHS formats were marketed.

ELECTRONICS

STRATEGIES

The first strategy for the U. S. electronics industry is for industry trade, manufacturing and professional organizations to play an active role in establishing global standards. Metric grids for printed wiring boards, metric pitch connectors, metric racks and panels and metric sized electronic components are rapidly replacing inch/pound equivalents in world markets. Participating in the formulation of the standards that establish requirements for these components will help U. S. manufacturers remain competitive in export markets. The second strategy is to revise U. S. standards so that they conform to the new global standards. If this is not done, U. S. manufacturers will become less competitive due to the increased costs associated with design/developments and inventory of two series of components/assemblies, one for export and one for domestic use.

The Electronics Industry Association metrication committee has prepared a schedule for the industry's transition to metric. It has also formulated a strategy entitled "*What NIST Can Do*". This strategy was presented at the Interagency Council on Metric Policy (ICMP) meeting on 30 November 1994 and was subsequently published in the U. S. Metric Association newsletter *Metric Today* in the January-February 1995 edition. Robert W. Checkaneck, the EIA Metrication Chairman, believes that the published schedule could be accelerated. This would help the U. S. in protecting/expanding its electronics exports. A copy of "*What NIST Can Do*" is contained in Appendix C.

A third strategy is to take advantage of the fact that:

- The Secretary of Defense, in his June 1994 directive *Specifications and Standards* asked the Under Secretary of Defense (Acquisition and Technology) "to form partnerships with industry associations to develop non-government standards for replacement of military standards where practical."

- Department of Defense Directive No. 4120.18 states that "It is DOD policy to use the metric system in all of its activities..."

This presents an obvious opportunity to have industry standards adopted by one of the largest consumers in the U. S. (*i.e.*, DOD) and at the same time, bring U. S. standards into conformance with the global measurement system, thus enhancing export opportunities.

ELECTRONICS

STRATEGIES (Continued)

Designing PWBs on a metric grid, initially with the current inch/pound edge connectors, but gradually transitioning to metric connectors, is an essential step in the U. S. electronic industry conversion. The IPC is committed to metrication and has taken many positive steps to encourage conversion. The following strategies could accelerate the process.

- In communications with its members, the IPC should stress the benefits of metrication (as it is now doing) and also point out the problems association with not keeping pace with the global transition to metric (*e.g.*, loss of overseas markets, lack of compatibility with equipment manufactured overseas, *etc.*).

- Since more than half of the PWBs were produced by 35 companies in 1992, and 80 percent of the total independent market was produced by 125 companies (IPC estimates) it should be relatively easy to contact those comparatively few companies responsible for the major portion of the U. S. PWB production.

- The IPC should accelerate the transition from dual dimensioned standards to metric only standards in order to discourage the use of inch/pound parameters in PWB designs.

- The IPC should encourage CAD and software companies to include standard metric (JEDEC) component outlines in the "tools" that are normally provided for PWB designers. When these metric tools are not readily available, PWB designers are more likely to design in the inch/pound system.

The export market is extremely important to the U. S. electronics industry. American chip makers, for example, ship over $43 billion per year to foreign markets, and the U. S. now controls a greater share (43%) of that global market than does Japan (40%). A strategy for increasing business and accelerating metrication is for industry trade, manufacturing and professional organizations to encourage their members to investigate export opportunities for their products.

When metric sized film capacitors became available, the export market for U. S. inch/pound designed film capacitors disappeared. The strategy, therefore, is for U. S. component manufacturers to transition from inch/pound based discrete components to metric packages as quickly as economically feasible. Starting metric production early will not only provide continued access to foreign markets, but may provide a competitive edge at home, *e.g.*, metric

STRATEGIES (Continued)

connectors are rapidly gaining favor overseas, and they are also selling very briskly in the domestic market. Manufacturers that produce metric connectors can participate in both markets.

There is a wide range of products that are produced by the electronic/electrical industry and utilized by the construction industry. Examples are electronic instruments for surveying, controls for heating and air conditioning, industrial control circuits, motor controls, fire and smoke detection and protection systems, *etc.* The recommended strategy is for the National Electrical Manufacturers Association (NEMA) and related manufacturer and trade associations to ensure that members provide metric (or dual dimensioned) data sheets for their products. This will encourage the use of these products in metric construction, both domestic and overseas, and it is an important step in the transition to metric. A couple of hours of basic metric training including an explanation of the economic advantages of metrication would also be very beneficial for association members.

NOTE: *The strategies detailed below are applicable to both the Electronics and Construction Industries.*

Several industry associations, *e. g.*, the Manufacturers Alliance for Productivity Innovation (MAPI), periodically conduct surveys in order to determine their members' progress in metrication. Such surveys have several beneficial effects.

- They create an awareness that industry is transitioning to metric.
- They create an awareness of markets (U. S. government and foreign, *etc.*) that demand metric products/services.
- They help uncover problems/concerns in metrication. Identifying problems is the first step in seeking a solution.
- They often publicize metrication success stories, *e. g.,* new markets, increased sales, reduced design time, ease of transition.

The strategy here is for industry and trade associations to conduct periodic (perhaps every 3 to 5 years) surveys and to publish the results for the benefit of their members.

ELECTRONICS

STRATEGIES (Continued)

Since large international manufacturing companies are already aware of the need for exports and metrication, the following strategy is most appropriate for those smaller companies that may not be aware of foreign market opportunities. These opportunities have been further enhanced by the weakness of the dollar which makes U. S. produced goods relatively less expensive in global markets. In implementing this strategy, industry and trade organizations should encourage their members to obtain publications and assistance from the Small Business Administration (SBA) and Manufacturing Technology Centers (MTCs). The SBA's publication, *Breaking into the Trade Game*, is an excellent guide to exporting for the small business. This 300 page book is available, without charge, from any of over one hundred SBA offices across the country. The SBA also publishes *Converting to Metric--A Guide for Small Business*, which describes a simple planning process to help small business decide when and how fast to phase in metric capability.

Additional help for small companies that wish to consider export opportunities is available from any of the Manufacturing Technology Centers (MTCs). There is a nationwide network of 44 Manufacturing Technology Centers (MTC) which are supported by NIST under the provisions of the Omnibus Trade and Competitiveness Act of 1988 (PL 100-418). "Exports" is one area for which support is offered, and there is an MTC brochure entitled *Giving Manufacturers the Edge in Exports.* Some MTCs have cooperative arrangements with export/metric consultants that can provide invaluable assistance to companies that wish to pursue export opportunities.

Companies that offer or are considering offering metric services and/or products should obtain free export information by FAX from the export hotline setup by AT&T in cooperation with several multinational companies and trade associations and the Department of Commerce. Registration for the Export Hotline is free. The database contains over 5,000 market research reports. It is updated twice weekly and is available 24 hours per day, 7 days a week. When you register for Export Hotline you are automatically registered to use "Tradebank", an electronic listing of more than 10,000 companies. This service is also free. Companies can be listed in these electronic yellow pages for a nominal fee of $100/year. Dial 1-800-USA-XPORT, key in your FAX number, and information will be faxed to you within five minutes!

The Department of Commerce's Advanced Technology Program (ATP) began in 1990 with only $10 million of funding. Currently it is funded with a budget of $431 million (this budget is currently in jeopardy as a result of the administration's new cost cutting efforts). One of ATP's five program areas is

ELECTRONICS

STRATEGIES (Continued)

computer integrated manufacturing (CIM) for electronics. The strategy, here, is for industry associations to help ensure that the machine tools and related software being developed under the program are metric based. In 1993 over 40 percent of U. S. produced semiconductor manufacturing equipment was sold outside the country. Metric designed machine tools are more competitive in global markets and they can produce inch/pound parts as well as metric parts. (See *Machine Tools* section of Appendix B.)

There is an inaccurate, but widely-held perception that the metric system is difficult to learn. Most Americans have been exposed to the inch/pound system for most of their lives. Yet many do not know how many pints to a quart, how many grains to an ounce or how many yards in a mile. Faced with the prospect of having to learn a new measurement system when they do yet fully understand the inch/pound system, therefore, seems a daunting task. This perception, carried to the workplace as well as the market place is a serious impediment to the U. S. metrication effort. Industry alone cannot overcome this obstacle. The strategy here is for the government to take an active role in educating the public in both the simplicity of the metric system and the economic necessity of metrication. Public television and public radio would be excellent forums for these educational messages.

Other government strategies are:

- Accelerate the awareness of the public and government employees of the need for metrication by encouraging national leaders to incorporate metric references and positive remarks whenever the subjects of global markets or the creation of American jobs arise. The lack of such statements by the very leaders who espouse the need for global trade make both the public and government employees doubtful that the provisions of PL 100-418 will be enforced, or that they are of any value.
  - For example, after President Bush signed Executive Order 12770 and mentioned "kilometers" in a talk, all scheduled GSA Interagency Training Center metric classes were well attended and many extra classes were scheduled. During the last year virtually all the classes were canceled because so few people signed up.

ELECTRONICS

STRATEGIES (Continued)

- The General Services Administration (GSA) Interagency Training Center has developed a metric orientation course (Course #950) that offers two important advantages. First, it clarifies the requirements of PL 100-418 so that government employees can accelerate industry metrication through metric procurement in accordance with the law and Executive Order 12770. Second, it is non-technical and designed for general audiences and thus provides an opportunity for thousands of government employees to learn the basics of the metric system and the economic rationale for the transition to metric. The Metric Program should work with the GSA Interagency Training Center to develop ways to encourage greater participation in these classes.

- The Metric Program should encourage strict conformance with the provisions of PL 100-418 and Executive Order 12770 in all procurement activities to benefit companies that have metricated.

- The *U. S. Industrial Outlook--1994* is an excellent almanac of current industry data and forecasts, published by the Department of Commerce. There are over a dozen sections entitled "International competitiveness" and a number of references to the need for metrication, as well as a conversion table provided by the Metric Program. *The U. S. Industrial Outlook* will not be published in 1995, but it will be replaced by a new publication with an international viewpoint called the "U. S. Global Trade Outlook". The Metric Program should work with the director of the International Trade Administration (ITA) to ensure that the new publication adequately addresses the need for metrication as a requirement for U. S. competitiveness in global markets.

- The Metric Program Office should supply the 44 MTCs with basic metric publications relating to manufacturing and exports, *e.g., A Metric for Success* and *The Metric Path to Global Markets and New Jobs*. The Metric Program should also provide the MTCs addresses and telephone numbers of organizations that can provide additional information relating to metrication, (*e.g.*, the U. S. Metric Association and the American National Metric Council).

ELECTRONICS

STRATEGIES (Continued)

- The Metric Program should also supply metric brochures and lists of metric resources to the Small Business Administration, for use by the SBA in assisting businesses in developing export opportunities.

ELECTRONICS

RESOURCES

AMP, Inc.

Avex

Breaking into the Trade Game (Small Business Administration and AT&T)

Center for Global Competitiveness (at Fairfield University)

Connection Technology--November 1990

Dictaphone Corporation

Digital Equipment Corporation (DEC)

EIA presentation to the ICMP--30 November 1994 (Washington, DC)

Electronic Business Buyer--December 1994

Electronics Industry Association (EIA)

General Electric (GE)

General Motors (GM)

Hewlett-Packard (HP)

International Business Machines (IBM)

Institute for Interconnecting & Packaging Electronic Circuits (IPC)

Institute of Electrical and Electronic Engineers (IEEE)

International Electronic Packaging Society

International Trade Administration (ITA) (U. S. Department of Commerce)

Joint Electron Device Council (JEDEC--part of EIA)

(Low Cost Electronics) Packaging Research Center (Georgia Institute of Technology)

ELECTRONICS

RESOURCES (Continued)

Manufacturing Technology Center (MTC) (Fort Collins, Colorado)

Manufacturing Technology Center (Kansas City, Missouri)

Manufacturing Technology Center (Storrs, Connecticut)

Matsushita

Metric Reporter (Newsletter of the American National Metric Council)

Metric Today (Newsletter of the U. S. Metric Association)

Micro Board Processing

National Electrical Manufacturers Association (NEMA)

New York Times--17 April 1995

Perkin-Elmer

Pitney Bowes, Inc.

R. Howard Strasbaugh, Inc.

Semiconductor Equipment and Materials International

Tech Circuits

Texas Instruments

The Kiplinger Washington Letter

Thomas & Betts Corporation

U. S. Industrial Outlook--1994 (U. S. Department of Commerce)

U. S. Metric Association (USMA)

Vero Electronics

Xerox Corporation

APPENDIX A: STRATEGY SUMMARY TABLES

INTRODUCTION TO APPENDIX A

Specific strategies aimed at accelerating metrication in the Construction and Electronics Industries are discussed in the appropriate sections of this report (see Table of Contents).

The following tables have been prepared to assist the reader in locating sections of the report wherein factors impacting metrication (either negative or positive) are discussed. The tables give the location (page number), the industry element affected, a brief description, and a general strategy for consideration, *e.g.*, training to alleviate an impediment or publication of information to take advantage of positive developments. These tables should be utilized by organizations and agencies as an aid in developing their own strategies for eliminating impediments and for leveraging positive developments in metrication.

CONSTRUCTION INDUSTRY METRICATION

OVERVIEW TABLE

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
Entire industry (p. 6)	Government's adherence to PL 100-418 results in metrication of 25% domestic non-residential construction.	Does not address residential construction.	Use these projects to demonstrate/educate construction firms and workers on ease of metric and increasing business opportunities.
Entire industry (p. 6)	Construction Metrication Council (CMC) provides effective leadership and education--receives widespread industry and government agency support.	Funding is from various government agencies on a voluntary basis.	CMC should expand education and information dissemination activities to be more inclusive of industry food chain elements.
Entire industry (p. 6)	Construction business has become increasingly international; markets and exports of both construction materials and expertise have expanded rapidly.	Foreign companies have more metric construction experience than do U. S. companies.	Large U. S. firms have successfully competed metric projects; DOC should promote this fact to encourage other firms and suppliers to metricate.
Entire industry (p. 13)	Metrication offers benefits that quickly compensate for training and learning curve expenses.	Industry support of two measurement system in terms of design, product/materials procurement, construction and maintenance perpetuates inefficiencies and higher costs.	Lobby industry associations to publicize the many benefits of metric as a single measurement system.
Entire industry (p. 13)	Dual dimensioning is normally employed for the customer.	Dual dimensioning on construction and shop drawings is costly and confusing and should not be permitted.	This basic concept can be properly explained in the recommended brief metric training courses.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
Entire industry (p. 16)	Construction industry has the benefit of active organizations that have promoted and aided metrication industry-wide.	Initiatives are dependent upon the continued effort and voluntary support of the CMC and affiliated agencies.	Continue to support the "Metric 2000" plan of the CMC and maintain industry initiatives by supporting industry organizations and federal agencies that are active in metrication.
A/E companies (p. 7)	Many architects and engineers have metric experience.	A/Es learn metric in college but many lose their facility with it due to not using metric on-the-job.	Professional societies should encourage single measurement system by recommending metric and testing metrication expertise during state P.E. licensing exams.
A/E companies (p. 7)	A/Es use CAD systems capable of functioning in both metric and inch/pound.	The versatility of CAD systems enables continued use of both measurement systems which retards the move towards metric and perpetuates the costs and difficulties of maintaining two design philosophies.	Professional societies should encourage single measurement system--metric.
A/E companies (p. 7)	Most architects and engineers know the ease of working in the metric system and would readily adapt to working in that system if given the opportunity and management support.	Some A/E companies have operated in two measurement systems for many years; they have lived with the additional costs and may believe metric is only for international business.	Industry associations should emphasize the cost savings aspects of a single measurement system to their membership and promote the public's knowledge of metric products and the efficiency of metric design.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
A/E companies (p. 7)	Most architects and engineers are concerned about the availability of metric products and materials.	Knowledge of metric products and sources of supply is not yet widespread and there is only modest private sector resources available to collect and disseminate this information.	DOC should initiate clearinghouse activities to become a focal point for metric information to U. S. businesses; coordination with private sector agencies (*i.e.*, USMA and the ANMC) will expedite this mission; use of existing network of SBA offices is appropriate and will enable immediate dissemination of information.
A/E companies (p. 7)	Many manufacturers are making metric or dual dimensioned product data sheets available.	A/Es have libraries of product data sheets in the inch/pound system and need to develop similar libraries of metric product data sheets.	A/Es should contact the CMC and the USMA to obtain current lists of metric suppliers to begin building their metric design libraries.
A/E companies (p. 7)	Many A/Es have begun building a library of metric product data sheets.	A/Es sometimes have difficulty in identifying and obtaining product data sheets in metric measurement.	Private companies would be encouraged to produce metric products and data sheets by an offer to be listed, free of charge, as a metric supplier.
A/E companies (p. 7)	95% of construction products will not change, just re-labeled.	The 5%, known as modular products, that will change are sometimes difficult to source.	SBA should advertise the fact that this represents an unique opportunity for small firms.
A/E companies (p. 7)	Some A/E firms have embarked on their first metric construction project without additional training.	Studies have shown that metric construction efficiencies have more than offset associated learning costs.	The learning curve can be shortened with four to eight hours of metric refresher training and practical exercises prior to one's first metric construction project.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
A/E companies (p. 7)	Preparing metric drawings and construction documents is not a significant problem for U. S. A/E firms.	Use of dual dimensioning of metric construction documents can lead to costly errors and confusion on-the-job.	Professional societies, industry associations and construction customers should discourage the use of dual dimensioned documents and educate as to the difficulties they cause.
A/E companies (p. 16)	A/E firms have little concern about bidding metric programs since metric knowledge was part of their original technical education.	Difficulties arise from the necessity of working in two measurement systems and in maintaining documentation control with both systems.	Promote the use of metric only design in building construction much like the conversion that is occurring in highway construction.
General Contractors (p. 7)	GCs will bid metric jobs once they know about successfully completed metric jobs in their geographic area.	GCs fear financial loss from working in an unfamiliar measurement system--metric.	Industry groups should publicize the success of metric construction and make metric use familiar to GCs through industry sponsored training.
General Contractors (p. 7)	GCs who know that most construction projects involve 95% of the materials and products with which they are familiar will bid metric jobs.	GCs have not bid metric jobs because they fear they will not accurately estimate construction costs involving metric materials and products.	Industry associations should advise GCs that they are more familiar with metric construction than they realize and that training exist that can increase their confidence level and convince them to bid metric projects.
General Contractors (p. 7)	GCs who know that metric procurement will involve only about 5% of the building materials and that metric suppliers are available are less fearful that procurement errors will occur.	Knowledge of local suppliers of metric materials and products is information that is gathered through job experience and is currently difficult to acquire through secondary sources and local suppliers may not exist.	Information dissemination through professional and industry associations regarding metric products and vendors is recommended using existing compilations by various private sector organizations.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
General Contractors (p. 7)	GCs who know that construction workers make fewer errors when making measurements and calculations in the metric system are more inclined to bid metric jobs.	Construction workers who have not previously worked in metric or who have not had any metric training are likely to convert metric dimensions to inches and will increase the risk of error and preclude the benefits of working in metric.	GCs should show the ease of working in metric to their workers by offering training currently available from several sources at modest cost, including courses developed by the USMA and ANMC and by private consultants .
General Contractors (p. 7)	Many larger GCs are increasingly looking upon metric construction projects as an opportunity to hone their competitive advantage.	Much of the construction in the U. S. is done by smaller GC firms and individual contractors who have fewer opportunities to learn about the metric potential and to gain working experience in the metric system.	Trade schools and local and state licensing authorities should be urged to employ metric in their training and licensing requirements.
General Contractors (p. 16)	Ample evidence exists regarding successful metric construction projects even among first time contractors.	Many GCs are not aware of this fact.	The CMC or other industry organization should prepare a flier outlining metric construction successes and include this information in RFQ packages.
General Contractors (p. 17)	GCs would attend metric training that was inexpensive and available, and that would address their fears and concerns.	GCs may not be aware of the availability of metric training.	Government agencies should offer free introductory metric training (possibly given by instructors who would teach free in order to teach roomful of GCs) to demonstrate the simplicity of the metric system and to aid the GC in recognizing the need and the means to train tradespeople.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
Tradespeople (p. 9)	Tradespeople born in other countries have had metric training and quickly readapt to metric construction in the U. S.	Most tradespeople in the U. S. have had no exposure to the metric system and have a natural fear of the unknown.	GCs should offer metric training and metric measuring tapes to tradespeople working on metric projects for the first time.
Tradespeople (p. 9)	Tradespeople given a few hours of metric training and a metric tape will soon be able to work with metric measurements.	Tradespeople not given metric measurement tools and metric training will revert to working in inch/pound by converting the metric dimensions back into inches/feet, etc., and greatly increase the chance of error.	GCs should provide metric training and metric measuring tapes to tradespeople working on metric projects for the first time.
Tradespeople (p. 9)	Most tradespeople become comfortable working in the metric system in a few days after having the benefit of training including orientation on why the U. S. is moving to metric.	Tradespeople have an understandable fear of working in an unfamiliar measurement system.	Developing an understanding on why the U. S. benefits from using the metric system and gaining first-hand experience actually using the metric system will overcome this fear.
Tradespeople (p. 9)	Experience has shown that after tradespeople become familiar with the metric system many prefer it and metric becomes a non-issue.	Training opportunities are not widespread and some GCs that desire metric training for their tradespeople do not know how and where to procure it .	The CMC and other metric advocacy groups should publicize metric training that is available.
Manufacturers/suppliers of construction materials (p. 10)	Most manufacturers/suppliers will experience little change due to metrication.	Non-modular products will remain the same but the labels and dimensional units may change causing possible confusion with specifications.	An easy to publicize fact that can be disseminated through many different trade publications throughout the food chain on all levels of participation including periodicals for individual trades.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
Manufacturers/suppliers of construction materials (p. 10)	A growing number of manufacturers of non-modular building products are making metric dimension data sheets available for their products.	Many companies do not realize how valuable these metric data sheets are in enabling A/Es to select their products for use in metric construction projects.	An easy to publicize fact that can be disseminated through many different trade publications throughout the food chain on all levels of participation including periodicals for individual trades.
Manufacturers/suppliers of construction materials (p. 10)	As metric data sheets become more available for U. S. construction products both domestic metric construction and exports are encouraged.	Many construction product suppliers are not well aware of the vast export market that is possible when metric specification is available.	Trade publications and government publications should explain the metric relationship to opening global markets for U. S. suppliers.
Manufacturers/suppliers of construction materials (p. 10)	Modular products that must be hard metric designs in order to conform to metric design grids are generally available from a limited number of suppliers.	Modular products are not equally available in all parts of the country and may cost a premium if not bought in construction quantities.	A/E firms should promulgate a policy to procure quantities of modular products beyond those needed for initial construction so that the client will have a reserve supply for replacement purposes until supplies become more uniform and economical in small replacement quantities.
Manufacturers/suppliers of construction materials (p. 10)	More manufacturers are producing metric modular products as domestic metric construction is increasing.	Domestic demand is currently limited to the commercial construction market, in particular to public sector construction.	Residential construction would add tremendous demand for metric products and introductory metric awareness training of the general public should be promoted and sponsored by industry groups and the U. S. government, *i.e.*, DOC.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
Manufacturers/suppliers of construction materials (p. 11)	Highway construction is even simpler than building construction in that virtually all materials remain the same whether the metric system or inch/pound is used.	Overcoming the fear of working in an unfamiliar measurement system must be accomplished.	Training and experience will quickly dispel the fear of an unfamiliar measurement system and are readily available through FHWA early planning efforts.
Manufacturers/suppliers of construction materials (p. 11)	The FHWA early planning effort yielded metric training in 1992 and many highway construction people have already been trained.	Early training programs need to be offered again for new personnel at FHWA.	Implement existing FHWA plans for training remaining highway construction personnel and non-technical people at FHWA headquarters.
Manufacturers/suppliers of construction materials (p. 11)	All 50 states say that they will meet the FHWA October 1996 metrication deadline.	All states have not completed the metrication of their highway specifications.	Sustain the FHWA commitment to implement metric despite the recent political backlash.
Manufacturers/suppliers of construction materials (p. 18)	Metric modular products are a small percentage of the overall materials list for a construction project and non-modular products are readily available.	Metric modular products (*e.g.*, brick, block, ceiling lighting fixtures, *etc.)* are in relatively limited supply.	Metric modular products will become in greater availability as demand increases and all metric projects requiring them should be advertised.
Construction machinery (p. 11)	Construction machinery is not measurement sensitive and need not be metric to be used in any construction project.	The domestic market for construction machinery provides no incentive for conversion of construction machinery to metric design.	Industry associations should educate construction machinery manufacturers about expanding export markets and their preference for metric.
Construction machinery (p. 11)	Several major construction machinery manufacturers made the transition to metric some time ago and have been enjoying booming growth due mainly to international sales.	Smaller construction machinery manufacturers may have overlooked the export market and have lacked the motivation to change traditional designs.	Printed wiring boards based on a metric grid should be used in construction machinery which would increase its acceptability overseas.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
Facility managers/maintenance personnel (p. 12)	Much of what the facility managers and maintenance personnel are responsible for is unrelated to the measurement system used in the buildings, so the metric impact is small.	This fact tends to reduce the metric awareness of facilities people and continues to retard the impetus to develop metric knowledge within this element.	Publicize the modest challenge to indoctrinate facilities personnel in the characteristics of metric construction and employing metric measurement.
Facility managers/maintenance personnel (p. 12)	Modular metric products are available in construction quantities at competitive prices.	Modular metric products are not readily available in local retail outlets.	Stocking extra modular products purchased at the time of construction for replacement and repairs reduces difficulties encountered by facilities personnel.
Facility managers/maintenance personnel (p. 12)	Many metric modular sizes are close to the inch dimensions of the products.	Knowledge of metric and inch conversions and a "feel" for metric dimensions is generally lacking among facilities personnel.	One or two hours of metric training would be helpful though not essential in developing effective management of metric buildings.

ELECTRONICS INDUSTRY METRICATION

OVERVIEW TABLE

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
Entire Industry (p. 23)	Electronics industry was born in the U. S. so our products and standards were accepted world wide and the U. S. was the pre-eminent supplier in this rapidly growing global market.	The pre-eminent U. S. position was diminished as suppliers grew to match burgeoning global markets and alternative sources of supply emerged offering electronic products on metric grids and in conformance with metric standards.	U. S. industry must produce products acceptable to world markets and in conformance with international standards.
Entire Industry (p. 23)	The electronics industry is vast in terms of both diversity and complexity providing the opportunity to have a major positive economic effect from metrication of products for export.	With so many participants in the food chain the interrelationships and associated need for coordination of interfaces is very great.	Industry diversity and complexity demand an industry wide effort to coordinate and help steer individual efforts to metricate.
Entire Industry (p. 23)	The electronics industry is in an early stage of its life cycle which offers a tremendous payoff in terms of long-lasting effects from positive economic change such as metrication of products to increase sales to world markets.	As an industry in an early stage of development there are many participants in a growing and dynamic environment which makes industry wide efforts more difficult to initiate, focus and coordinate.	In a dynamic industrial environment the potential benefit of government efforts to guide standards and facilitate change is very large; the DOC can respond in this industry to demands for information and guidance within the existing organizational framework.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
Entire Industry (p. 23)	The electronics industry remains one of the fastest growing industries in the U. S.	The historically strong dollar and appeal of foreign goods has increased demand for imports.	Encourage U. S. innovation and exploit the recently weakened dollar as a boost to U. S. exports.
Entire Industry (p. 23)	The electronics industry is increasingly international in scope with a corresponding large number of diverse buyers and sellers, virtually all of whom are transitioning to metric.	Competition is increasingly from foreign manufacturers both domestically and abroad.	Educate U. S. industry to compete on the most favorable terms with foreign competition by producing goods in the world's preferred measurement system--metric.
Entire Industry (p. 23)	Metric drawings lend themselves to use around the world permitting ready accommodation of "local content" regulations where they exist.	Most U. S. electronics product drawings are in inch/pound and the first time metric drawings are contemplated in an organization can be upsetting initially.	Educate U. S. companies to the competitive advantage of metric designs and drawings to meet any "local content" or other metric related requirements that will appear in global markets as they metricate.
Entire Industry (p. 32)	The EIA has prepared a metric transition schedule and educated its members as to the necessity of implementing metric for global markets.	DOD is one of the nation's largest consumers of electronic components and has not yet adopted U. S. industry metric standards which are in conformance with the global measurement system.	Industry must initiate dialogues with military electronics purveyors and encourage DOD to implement Directive No. 4120.18 which calls for the use of the metric system.
Entire Industry (p. 34)	The SBA publishes several guides that are useful in developing export opportunities for U. S. businesses.	Some of these guides do not mention the pervasiveness and importance of the metric system in global markets.	The Metric Program should communicate to other federal agencies the need to explain the role of metric in developing world markets for U. S. goods and services.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
Entire Industry (p. 36)	The government should encourage strict conformance with PL 100-418 to benefit companies which have metricated.	Short term accommodations which appear to be in the interest of efficiency can undermine long term objectives.	The metric awareness of government employees as well as that of the general public must be cultivated as it will not happen casually.
Electronic Components (p. 24)	Many U. S. companies produce electronic components that are the building blocks of the electronics industry.	As more of these components become available in metric, the export market for U. S. produced inch/pound components shrinks and many of the U. S. manufacturers do not have metric product to offer.	The changes in supply and demand which have occurred and are continuing must be an important topic of concern for company five year plans and metric designs must be accelerated.
Electronic Components (p. 24)	Metric is an important factor affecting the marketability of electronic components.	The U. S. electronics industry has embraced a metric-only policy for new component designs but continues to tolerate non-metric grids for PWBs.	Educate the industry as to the importance of transition to metric components and metric grids for PWBs.
Semi-conductor Manufacturing Equipment (SME) (p. 26)	Modern SME can produce both inch and metric components.	Manufacturing concern focuses on meeting rapidly changing technology rather than on the measurement system.	The necessary short term focus of the industry must be augmented by an understanding of the long term significance of metric equipment and components.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
Semi-conductor Manufacturing Equipment (SME) (p. 26)	SME must be frequently updated or replaced in order to accommodate advances in technology and, thus, a conversion to metric could be accomplished in a relatively short time.	The commitment within the industry to convert to metric is not universal despite strong industry metric policy and leadership.	The position of the EIA must be promulgated and the necessary education to fully appreciate the position should be begun immediately through private sector and public agency support.
Semi-conductor Manufacturing Equipment (SME) (p. 26)	More than 40% of SME is exported.	Conversely, the larger share (60%) of domestic production is taken by U. S. firms typically operating in inch/pound.	Publicize the fact the rapid growth in the foreseeable future will be in exports to global markets.
Semi-conductor Manufacturing Equipment (SME) (p. 26)	Virtually all newly designed electronic components are being produced to metric dimensions.	SME will be increasingly responsive to the universality of the metric measurement system if it continues to see the strong domestic commitment to metric electronic components.	This trend will occur naturally as buyers demand is articulated and informed sources continue to educate all segments of the industry.
Semi-conductor Manufacturing Equipment (SME) (p. 34)	DOC has an Advanced Technology Program which could promote metrication in the area of the computer integrated manufacturing (CIM) for electronics.	Budgetary uncertainty will have a negative influence on broadening the role and influence of the ATP program.	Communications between the ATP and the Metric Program could be very helpful to expanding the role of the ATP in fostering metric electronics.
Printed Wiring Board Engineers and Designers (p. 27)	PWB designers use a variety of components including metric and inch/pound.	Newer components are generally metric while older ones are inch dimensioned.	Promote the use of single dimensioned components which naturally would be metric designed.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
Printed Wiring Board Engineers and Designers (p. 27)	The United States PWB designers in the 1950s established the original grid system on a 0.10 inch (2.54 mm) grid spacing which evolved easily to a 2.50 mm grid with 0.5 mm multiples.	Rather than ease into the compatible metric grid most U. S. PWB designers have chosen to continue with the "close" inch based grid system.	Few interface problems with metric components on inch-based grids should be downplayed and the fundamental lack of compatibility should be stressed when discussing U. S. inch-based PWBs.
Printed Wiring Board Engineers and Designers (p. 28)	CAD systems can easily handle metric, inch, and designs handling both.	Instead of regarding the versatility of the CAD software as an asset toward metrication many PWB designers are using its features to perpetuate designing in inches and simply switching to metric in a "soft" conversion when necessary.	Encourage schools and major employers to actively promote metric-only CAD designs.
Printed Wiring Board Manufacturers (p. 27)	PWB manufacturers can generally handle metric, inch and combination designs.	Some manufacturers view metrication as a "temporary inconvenience" and are therefore reluctant to change.	Educate the industry food chain participants on the economies resulting from using a single measurement system throughout the vast and diverse electronics industry.
Printed Wiring Board Manufacturers (p. 27)	The majority of OEM now contract out the production of PWBs so they can avoid the high costs of rapidly changing technology and equipment.	U. S. OEM continues to call out inch-based PWB designs and the PWB manufacturers supply what they want.	U. S. OEM is increasingly recognizing the greater acceptability of metric designed products and this awareness must be reinforced through industry leadership and public information dissemination.

Food Chain Element	Metrication Assets	Metrication Obstacles	Strategies
Printed Wiring Board Manufacturers (p. 28)	While PWB manufacturers and designers are responding to continued domestic demand for inch design, the newest PWB component mounting techniques are metric based.	The adaptability of inch components on metric grids and metric components on inch grids is a detriment to further metrication because it permits the continuation of the inherent inefficiencies of working in two measurement systems.	Promote use of a single measurement system as part of the cost savings movement in the U. S. to regain the nation's previous competitive advantage.
Printed Wiring Board Manufacturers (p. 31)	Utilizing a metric grid on PWBs would accelerate the transition to the new technology of surface mounted components.	Existing inventories and conversion costs are slowing the transition to metric connectors and metric grids.	The pace of the transition just needs to keep up with the overseas connector transition.
Original Equipment Manufacturers (p.28)	Several large industry users of electronic components (*e.g.*, autos and consumer electronics) have created a "metric environment" in the U. S.	Despite this "metric environment" as much as 70% of the PWBs are still being designed in the inch/pound system in the U. S.	Strict adherence to the JEDEC metric policy is imperative to offset the virtual disappearance of the export market for many inch/pound electronic components.
Original Equipment Manufacturers (p.32)	Manufacturing and professional organizations have been playing an increasing role in establishing global standards.	U. S. standards need to be rewritten to conform with international standards.	Industry organizations must continue to monitor and promulgate metric standards development throughout the transition to metric, both domestically and internationally.

APPENDIX B: INTERIM REPORT

Reference Order No. 43NANB422225
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Study to Identify Industries Positioned for Significant Impact on U. S. Metrication

INTERIM REPORT--R1 (Updated 2/13/95)

TASK ONE: Initial Screening of Industries for Focus of Metrication Development Efforts

21 December 1994

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EXECUTIVE OVERVIEW

An initial look at metrication in twelve industries led to the selection and preliminary study of ten industries which are the subject of this report. This is an interim report of an investigation into ten of the more promising industries relative to their *food chain* characteristics and the degree to which they represent opportunities for joint efforts (including inter-industry and government) in metric conversion. Principal findings are presented and the rationale for selection of the two industries for continuing investigation are contained herein.

The two industries identified for further study and development of strategies for expanding metrication are **Construction** (page 9) and **Electronics** (page 15). They are large industrial sectors, have excellent export potential, and represent huge food chain opportunities for a host of related products and components as well as involving engineering, design, technical and trade skills. The food chain participants of each selected industry are identified in their respective sections of this report and will be further defined and examined in the final report.

An additional advantage that each of the two selected industries has is a well developed *infrastructure* for promoting desired changes. They have trade and professional, or other, organizations that are knowledgeable of the industry and actively pursuing metrication by defining goals, mustering industry support, identifying obstacles, and seeking solutions.

The research conducted under this contract is intended to provide insight into the metric conversion problems of American industry to assist the federal government in focusing its commitment and leadership role to support national metric conversion.

The final report will include information gathered during telephone interviews with various companies within the identified food chain industries, *e.g.*, wall board, ceiling tile, raised floor tile, brick and block manufacturers, as well as integrated circuit, electronic component and printed wiring board designers and manufacturers. Problems and potential solutions in various segments as well as strategies for accelerating metrication within the entire food chain will be discussed. Industry conversion progress and potential will also be addressed.

INTRODUCTION

Eight industries selected from Louis Rukeyser's *Business Almanac* and two other industries (*i.e.*, beverage packaging, industrial fasteners) were selected for review relative to position for significant impact on metrication development. Industry metric specialists and other knowledgeable individuals from various disciplines were contacted for discussion of each candidate industry's metric progress, plans and problems and *food chain* potential.

The ten selected industries are:

Automobiles	Household Appliances
Beverage Packaging	Industrial Fasteners
Construction	Machine Tools
Defense and Aerospace	Packaging and Containers
Electronics	Steel and Mill Products

The initial research for industries and contacts consisted of review of personal files, library search of numerous secondary business sources, and computerized literature searches of business and professional periodicals. The initial effort was fruitful and, in a systematic manner, extensive reference libraries of industrial information, listings of cooperative, knowledgeable people on relevant topics, and identification of industry-wide resources such as associations, alliances, *etc.*, were developed during the conduct of Task One of this study. Many of these people and organizations have been contacted.

Each of the industries was reviewed relative to:

- Degree of metrication
- Potential for further metrication
- Potential benefits (*e.g.*, food chain effects) of further metrication

The results of these industry reviews follow.

AUTOMOBILES

The automotive industry started metrication over 20 years ago. This is a well-documented success story. The industry viewed metrication as necessary to preserve and expand foreign markets and the SAE (Society of Automotive Engineers) shared that vision and provided leadership and coordination in metrication activities including rewriting standards. The SAE policy of the Board of Directors states that operating boards, committees and subcommittees shall not *"use any weights or measures system other than metric (SI) except when conversion is not practical or where a conflicting world industry practice exists."* The transition cost far less than originally estimated, the savings due to concurrent standardization are still accruing, as are reduced design and quality control costs and increased economies of scale (*i.e.*, savings due to producing larger quantities of fewer items). Every American automobile is a hard metric design except for a few inch/pound or hybrid components. Tires are metric, but the wheels are typically rational inch diameters. Spark plugs have metric threads but an inch sized hex body. The pop-rivets used in air-bag assemblies are inch/pound designs soft converted to metric dimensions. These minor inch/pound exceptions are *not* peculiar to American designed automobiles. The wheels, spark plug hex body and soft converted pop-rivets are used throughout the world.

Metrication in the automobile industry has created significant food chain effects, including demand for metric training, metric CAD/CAM programs, metric sized sheet metal, fasteners, components, machine tools, and small, portable tools used by service people and do-it-yourselfers. These demands play a continuing role in ensuring production of those metric materials, components and tools and this can be a factor in the planning of other industries that are contemplating conversion. As the automotive industry expands into other technologies (*e.g.*, electric cars, very high mpg vehicles, *etc.*) with support from the Partnership for a New Generation of Vehicles (PNGV), demands and thus supplies of other metric services and items will develop. Nevertheless the opportunity for significant *additional* food chain effects is judged to be marginal at this time because:

- There is little potential for *additional* metrication in automobile design until new technologies are further developed.

AUTOMOBILES (Continued)

- The long-term trend for new car sales in the U. S. has been almost flat, and the situation is expected to continue for the next five years, although sales will oscillate above and below that slow growth trend line.

Resources:

Bossard International

Business Almanac - Louis Rukeyser

Chemical Engineering - April 1993

General Motors

Manufacturers Alliance for Productivity and Innovation (MAPI) Reports dated August 1989 and October 1994.

Metric and Multistandards Components, Inc.

New Steel, September 1994

Pop Rivet, Inc.

Society of Automotive Engineers (SAE)

Technology News - April 1993

U. S. Industrial Outlook - 1994

U. S. Metric Association

BEVERAGE PACKAGING

There are three sectors of the beverage industry that have metricated to some degree: wine and liquor, soda and aseptic packaging.

The wine and liquor industry went metric many years ago, replacing 53 different bottle sizes with 7 metric sizes. This gave the U. S. industry commonality with the world, an important factor for an industry so dependent upon both imports and exports. Substantial savings were realized because of economies of scale (*i.e.*, producing larger quantities of fewer sizes) and reduced inventories. Labels are typically hard metric, and the capacity of the container is also molded into the glass base. Both the wine and liquor trade associations asked the government to mandate the change under the regulations of the U. S. Treasury's Bureau of Alcohol, Tobacco, and Firearms. This had two important advantages: it set a time frame for conversion (three years) permitting an orderly transition, and it removed the possibility of competitive barriers to change. No company could attempt to profit by staying with inch/pound sizes while the others made the change.

The soda industry replaced the one quart bottle with a one liter bottle and introduced two and three liter bottles. Unfortunately, the industry has chosen not to change the size of the smaller bottles and cans to hard metric. Retooling costs are a factor, although in many cases, the present container could be filled and labeled a rational metric size.

A relatively new segment of the beverage industry, aseptic packaging, manufactures plastic coated paper boxes in hard metric sizes (*e.g.*, 250 mL, 1 L and 1.5 L) because the industry is a European transplant. These containers are used mainly for fruit juices and fruit-based drinks. Demand from non-metric U. S. drink processors forced the industry to introduce some non-metric sizes including a 64 ounce size.

Recently, milk and other perishable liquids have been packaged in aseptic boxes and, like all aseptic packages, they can be stored indefinitely without refrigeration. Although milk in aseptic packaging is marketed in inch/pound units, consistent with the rest of the dairy industry, the boxes are often standard metric sizes. For example, the one quart size is actually the one liter size container labeled "1 quart" and filled with that quantity of milk.

BEVERAGE PACKAGING (Continued)

While there is potential for further metrication, little potential for significant food chain effects remain in the beverage industry. Nonetheless, the hard metric container sizes (*i.e.,* 250 mL, 500 mL, 1, 2 and 3 L) perform an important function by exposing the American public to the simplicity and advantages of the metric system. It takes an astute buyer to know whether the large "economy" size is a better buy when its content is expressed in quarts while the smaller size is labeled in pints and fluid ounces. This problem is virtually eliminated by metric measures where only liter and milliliter units are used for all fluid volume, permitting easily performed consumer comparisons to be made at the point of sale.

With a little education Americans would learn that it is much easier to compare package sizes and determine relative value with metric packaging rather than the traditional inch/pound packaging. Once that occurs, the entire packaging industry (a much larger segment discussed later) would respond and Americans would express a preference for metric packaging.

Resources:

Aseptic Packaging Council

Can Manufacturers Institute

Combibloc

General Conference on Weights and Measures

Metric Usage Study: A Look at Six Case Histories, U. S. Metric Board

Plastic Shipping Container Institute

Tetra Pack

CONSTRUCTION

The construction industry is huge in size, scope and potential for metrication, with an estimated value of $470 billion for new construction alone in 1994, it directly accounts for approximately 6 million jobs and 8 percent of the gross domestic product. Upstream and downstream food chain participants include architects, engineers, designers, CAD/CAM manufacturers, construction managers, trade craftsmen of every discipline and construction products (brick, block, wall board, ceiling and floor tiles, *etc.*) involving many industries (steel, concrete, asphalt, glass, *etc.*).

Excellent conversion progress has been made because of the efforts of the Construction Metrication Council (CMC) which through its education and solicitation efforts has gained the support of many industry participants, professional organizations, the Department of Defense (the Army, Navy, Air Force, *etc.*) and federal agencies. Open meetings of the CMC give private industry and government participants the opportunity to discuss issues, raise concerns and work together on agreed-upon courses of action. Publication of meeting reports helps to keep interested parties informed. Another communication vehicle is *Metric in Construction*, a free bi-monthly technical newsletter that keeps abreast of all aspects of construction metrication from contract awards, availability of building materials, metric resources and educational programs, *etc.* The circulation of this publication is growing rapidly along with interest in metric construction. Communication forums such as these provide a promising foundation for effective expansion of interaction and accomplishment within this uniquely vital industry.

Both metric design expertise and metric building products enjoy growing domestic demand and significant overseas potential. The percentage of construction designed and built in metric is currently small, but the possibilities are enormous. The likelihood of further metrication is very high due to government funding of many building and highway projects and the benefits of metrication, as noted by the CMC, *i.e.*:

- Increased U. S. construction efficiency and quality, thereby making it more cost effective at home and a tougher competitor abroad.

CONSTRUCTION (Continued)

- Expanded export opportunities for U. S. building products and architectural/engineering/construction services.

- Moving a large and important part of the U. S. economy into the world standard of measurement for the eventual benefit of all Americans.

The construction industry is the #1 choice for further study and development of metrication expansion strategies.

Resources:

American Institute of Architects

American Society of Heating Refrigeration and Air-conditioning Engineers

Business America - 11 January 1993

Business Week - 16 May 1994

Coal - July 1993

Federal Highway Administration

General Services Administration and Public Building Service

Industrial Finishing - September 1993

Metric in Construction (CMC publication)

National Institute of Building Sciences (NIBS) and its Construction Metrication Council

National Aeronautics and Space Administration (NASA)

National Institute of Standards and Technology (NIST)

Orlando Sentinel Tribune, 29 July 1994

Smithsonian Office of Design and Construction

Sunday - Three Star Edition - 26 September 1993

Metric for the Construction Trades (four-hour training program developed for AlliedSignal and NASA by J. DeBartolo, 1994).

U. S. Metric Association

DEFENSE AND AEROSPACE

Aerospace is one of United States' most important industries, accounting for more than 25 percent of the Nation's research and development expenditures. It utilizes a number of technologies identified as critical by the White House Office of Science and Technology Policy, the Department of Defense and the Department of Commerce. It is large, *i.e.*, $121 billion in shipments in 1993, and it produces the largest trade surplus of any U. S. manufacturing industry.

The aerospace industry throughout the world mainly uses U. S. standards in the design, manufacture, certification and operation of aircraft and aerospace equipment. This wide acceptance of U. S. standards, mainly due to the fact that the industry was born and developed in the United States, led to their becoming *de facto* international standards. Consequently, the U. S. airframe manufacturers, led by Boeing, have enjoyed a pre-eminent position in the industry. Airbus (a consortium of British Aerospace PLC, Aerospatiale SA of France, Deutsche of Germany and Constructiones Aeronautics of Spain) and virtually all the other foreign airframe companies use fasteners, hydraulic hoses, fittings, and other reparable components and assemblies that are inch/pound based and, to a great extent, manufactured in the U. S. Even the Boeing space station module will employ inch/pound designs and fasteners despite the fact that the European and Japanese laboratory sections and the Canadian robot arm will be built to metric measurements.

The SAE Aerospace Council membership consists of executives of airframe manufacturers, airlines and DOD representatives. The SAE policy (see first paragraph of Automobiles, page 4) permits the use of inch/pound units in its aerospace activities because those units are the world standard for airframes. The Aerospace Industries Association (AIA) is a trade association representing the Nation's manufacturers of commercial, military and business aircraft, helicopters, aircraft engines, missiles, spacecraft and related components and equipment. The American Institute of Aeronautics and Astronautics (AIAA) is the leading professional, technical society for aeronautical research, design, development, manufacture, operation and maintenance. In general the industry position on metrication is that its members would design and build *metric* aircraft if their customers asked for such products. They report that, to date, only a few small U. S. military contracts have specified metric designs. In 1992, the AIA recognized that the approximately 3,000 National Aerospace Standards developed in the U. S. and accepted around the world would be slowly replaced by ISO standards, specifying metric units. Thus, the association has decided to

play a more active role in international standards and certification. Currently, the Director of Standards of the AIA serves as the Secretariat of the ISO T-20 "Aircraft and Space Systems" committee.

Also contributing to aerospace metrication is a contract issued by the Defense Industrial Supply Center, under which the SAE developed and issued several hundred metric standards for small parts including fasteners, fittings, couplings and hoses. Unfortunately, components made to these standards are *not* generally available, due to a lack of demand.

Approximately one year ago the AIAA prepared and circulated a position paper recommending that the AIAA promote the use of metric in aerospace technical and business activities. Nonetheless, this "Metric Conversion" position paper, approved in August 1994, states that *"The aircraft industry believes that there is an insufficient supply of metric standard parts and materials available in the United States for it to consider metric conversion at this time".*

The food chain potential of aerospace metrication would be enormous, because of its size and many components, *i.e.*, aircraft, aircraft engines, engine parts, ground support equipment, guided missiles and space vehicles, and guided missile and space vehicle parts. These segments would in turn create demand for metric sized aluminum, steel, fasteners, hydraulic pumps, hose and fittings, electronic systems, navigation systems, and all the related engineering, design and support activities.

The *likelihood* of metrication in the aerospace industry at this time is very limited for the following reasons:

- There is a concern within the industry that metrication would cause the U. S. to lose its competitive edge because it would be much easier for foreign competitors to metricate since they are located in metric countries.

DEFENSE AND AEROSPACE (Continued)

- There are some costs associated with metrication (converting standards, finding sources of metric materials, training, loss of productivity during conversion, *etc.*) These costs are normally recovered quickly due to longer term increased productivity in engineering, design and quality control. With the prospects of increased competition as noted above, and steadily declining sales for three consecutive years, the industry is not willing to make the required investment at this time.

- Some defense programs (*e.g.*, THAAD and Comanche helicopter programs) are metric, but they have been scaled back significantly, most recently this month, deviations have been granted to enable the use of many non-metric components as a cost saving measure.

Longer term potential for airframe metrication could come from the airlines' desire for a very large (perhaps 600 to 800 seat) passenger aircraft. There is already some demand for this plane, and both Airbus and Boeing have done some preliminary work (Airbus has constructed a full scale wood model). Since no single manufacturer has the resources to handle this enormous development program, there is a possibility of a joint venture. Such a joint venture, with participation by the British, French, German, Spanish and Italian airframe industries with Boeing, could lead to the first major metric commercial plane development, *if* the airlines express an interest in going metric. This is not considered likely at the present time.

Resources:

Aerospace Industries Association

American Institute of Aeronautics & Astronautics

Boeing Aircraft

Boeing Defense & Space Group

Department of Aeronautical Engineering, University of Texas (Austin)

DEFENSE AND AEROSPACE (Continued)

Dunlap & Associates, Inc.

Lockheed Missiles & Space

Plant Engineering

Society of Automotive Engineers/Aerospace Council

U. S. Metric Association

ELECTRONICS

The electronics industry, like the aerospace industry, arose in the U. S. and thus, was based on inch/pound standards. Also like the aerospace industry, it is huge and a very important contributor to the U. S. economy. Despite robust sales, however, the U. S. imports billions more than it exports, due to imports of TVs, VCRs, microwave ovens and many electronic components. From a metrication standpoint it has two advantages over the aerospace industry: 1) shipments of electronic components and sales of semiconductor manufacturing equipment expanded in 1993 and 1994; and 2) there is industry support for metrication, with some provisos. Additionally, the Electronic Industry Association's (EIA's) Joint Electron Device Council (JEDC) provided significant impetus to metrication when, about two years ago, it decided that all new integrated circuits (ICs) and discrete components (resistors, capacitors, diodes, *etc.*) shall be designed in metric.

The EIA has stated that it will actively support a planned transition to the SI-based metric practice in the design and manufacture of electronic equipment with the *caveat* that "it must be clearly understood that the transition to the SI system of measurement is intended to improve industrial competitiveness without imposing unnecessary costs."

The transition to metric may be a slow process for a number of reasons. The electronic industry started and evolved in the United States, and all the standards for racks, panels, connectors, printed wiring board (PWB) grids and integrated circuits (ICs) were in the inch/pound system. Other countries adopted the same standards but, over time, made significant progress in developing international standards that are metric based. Although many new components and PWBs are being designed in metric in the U. S., the large majority of these items are still being manufactured in the inch/pound system and much of the production equipment is inch/pound based. This equipment will likely be phased out slowly to minimize costs. It will also be some time before the enormous base of inch/pound components is replaced by newer metric designs.

Fortunately, modern computer-aided design (CAD) systems can accommodate a mixture of both inch/pound and metric-based components on a PWB. Over time the PWBs will go from inch/pound to hybrid (a mixture) and finally to metric. A similar transition will occur in the cages that support and hold mating connectors for PWBs, in the rack and panels that hold electronic subassemblies, and the bus system, or cables and connectors that join them together. Newly developed international standards for these components are metric and the U. S. must follow to maintain competitiveness in world markets.

ELECTRONICS (Continued)

According to the EIA all new and reissued standards will employ metric or dual dimensions this year. By 1996, all new standards will use metric only, and in 1999 all new and reissued standards will use the metric system only. At this point in time the majority of printed circuit boards in the U. S. are designed and built on a conventional inch grid with inch designed integrated circuits (ICs).

The food chain effects of metrication in the Electronics Industry would be substantial. Component, PWB board and electronic assembly engineers and designers would work in metric. Greater production of metric based ICs, discrete components and semiconductor manufacturing equipment would follow and all of these would be more attractive in the export market. This, combined with the fact that the Chairman of the EIA Metrication Committee stated, at the 30 November 1994 Interagency Council on Metric Policy meeting, that the EIA metrication plan was based on conservative time estimates and might be accelerated by several years, makes the Electronic Industry the #2 choice for further study and development of metrication expansion strategies.

Resources:

AMP, INC.

Avex

Dictaphone Corporation

Digital Equipment Corporation

EIA presentation to the ICMP (30 November 1994)

Electronics Industry Association (EIA)

General Electric

Hewlett-Packard

National Electrical Manufacturers Association (NEMA)

Pitney Bowes, Inc.

Tech Circuits

Texas Instruments

U. S. Industrial Outlook - 1994

U. S. Metric Association

HOUSEHOLD APPLIANCES

Appliance industry shipments were a record $17.7 billion in 1993. It is a very competitive, high volume, capital intensive industry. High labor content makes the U. S. vulnerable to imports, which are greater than exports and constitute more than 50 percent of the domestic market.

Major appliances (refrigerators, ranges, washers, dryers and dishwashers) or "white goods" as they are called in industry vernacular are generally not exported or imported mainly due to the fact that their size and weight make shipping costs prohibitive. Additionally, overseas markets prefer smaller, relatively featureless appliances. International appliance manufacturers respond to these market forces by setting up overseas manufacturing facilities.

If all domestic white goods plus kitchen (portable) appliances (which enjoy worldwide distribution) were converted to metric design and manufacture these would be significant food chain effects. This industry is a large consumer of sheet steel, electric motors, switches, sensors, solenoids, printed wiring boards, fasteners and other mechanical components. Potential food chain participants include engineers, designers, CAD/CAM software providers and the sheet metal, fastener and electronic industries. There would be a greater demand for metric machine tools (for production) and hand tools (for service).

Very few appliance manufacturers are currently designing in metric, and at least one of them continues to use inch/pound sheet metal, fasteners and other components even though its drawings are metric.

There is no industry association support for metric, nor was any anti-metric sentiment uncovered. Each manufacturer makes its own decision and does not know or apparently even care, what the others are doing. One manufacturer of small appliances has been designing all its products in hard metric for about ten years, but buys only inch-sized sheet metal and fasteners, thus limiting the food chain effects. An Association of Home Appliance Manufacturers (AHAM) spokesman expressed the opinion that many small companies would consider metrication if they were given financial support to help defray the cost of converting standards from inch/pound to metric.

Without organized support for metrication, the transition is likely to be slow and without significant food chain effects.

HOUSEHOLD APPLIANCES (Continued)

Resources:

A. D. Little
Appliance Manufacturer - November 1994
Association of Home Appliance Manufacturers
Black & Decker
Caloric
Electric Power Research Institute (EPRI)
Gas Research Institute
General Electric
Heat Craft
Matsushita
Maytag
Whirlpool
Viking

INDUSTRIAL FASTENERS

Fasteners represent a 5.9 billion dollar industry . It is one industry that touches every other manufacturing industry, *albeit* in seemingly minor ways. Exports account for almost $700 million with Canada the number one customer and Mexico the number two. Unfortunately, imports are expanding faster than exports.

There are a number of advantages to using metric fasteners in the design of a wide range of products. Products are more serviceable because metric fasteners are readily available both in the United States and in virtually every other country of the world. Conversely, since the world is predominantly metric it is quite difficult to buy an inch/pound screw or nut in many foreign countries.

Metric fasteners are close to the ideal design, *i.e.*, when they are tensioned to their tensile strength, stripping of the threads occurs at about the same time the screw breaks. With an inch/pound Unified Coarse Thread the screw breaks first, and with an inch/pound Unified Fine Thread the threads strip first. Thus, both inch/pound designs require more material and are heavier than the optimal design.

Inventory costs and inventory control are better with metric fasteners because a smaller variety accommodates all design requirements.

United States manufacturers can produce metric fasteners rather easily. The same cold heading machines that produce the inch/pound screws can be used, only the relatively inexpensive punches and dies have to be replaced.

Unfortunately, most of the metric fasteners currently used in the United States are imported. Few American manufacturers are willing to tool-up for metric screw production, despite the relatively small additional tooling investment, citing low demand and severe competition from overseas. This situation is likely to change as more American manufacturers start or expand production of metric products and thereby increase the demand for metric fasteners in automobiles, business machines, machine tools, appliances, *etc.* Demand will also increase because exports to Canada, Mexico and other metric countries are increasing. This is due in part to some companies becoming more competitive due to new technologies to improve efficiency and quality. This industry should be revisited in a year or two.

INDUSTRIAL FASTENERS (Continued)

Resources:

Bossard International, Inc.
Metric and MultiStandards Components Corporation
Metric Bolts & Nuts, Inc.
Metric Fasteners Corporation
Industrial Fasteners Institute
Society of Automotive Engineers

MACHINE TOOLS

Machine tools, for the purpose of this study, are non-portable, power driven and designed and built to cut and form man-made materials. These are the tools that make everything else. Thus, for example, mining, oil drilling and petroleum and farm equipment are not included but the machine tools used to *manufacture* mining, oil drilling and petroleum and farm equipment *are* included. It is a $5 billion industry that is a bellwether for productivity. When machine tool sales are up, productivity and sales of the products these tools make (*e.g.,* automobiles, appliances, hardware, etc.) will follow. Orders for U. S. tool makers were up 24% in the first seven months of 1994. Exports of U. S. tools climbed about the same as domestic demand, up 24.2% in the first half. Unfortunately, imports grew faster than exports, and claimed 50% of the U. S. market, up from 46% in recent years.

As noted above, U. S. industry buys about half of its machine tools from overseas. The majority of these tools are used to manufacture inch/pound products. Likewise, overseas manufacturers buy a substantial quantity of U. S. made machine tools, most of them designed in the inch/pound system, and use these tools to produce metric parts. Thus designing in metric does not ensure a machine tool manufacturer a greater share of the overseas market. Nonetheless, when quality and cost are about equal, an overseas buyer would probably prefer a metric machine tool because it would be easier to maintain and repair using metric tools and metric spare parts (bolts, gears, drives, belts, *etc.*), utilizing employees who are already schooled in the metric system.

U. S. machine tool manufacturers, some of whom are overseas *transplants*, have made progress in metrication. About 10% are fully metric, another 10% have undergone little or no metrication, and the remaining 80% have experienced some metrication. The 80% which have achieved some metrication have converted less than half of their products.

The Association for Manufacturing Technology is supportive of metrication, and provided the information on degree of metrication given above. The food chain participants are steel plate, drive components (gears, sprockets, transmissions, drive belts, drive chains, etc.) and other component manufacturers as well as all the related engineering, design and support activities.

MACHINE TOOLS (Continued)

The likelihood of substantial metrication and food chain effects is limited for the following reasons:

- Inch/pound machine tools can produce metric parts, and are frequently used for that purpose, so overseas customers do not have a *strong* preference for metric machine tools.

- Many U. S. machine tool industry participants have little incentive to convert at this time because of the lack of a strong customer preference overseas, and the slow pace of metrication domestically.

Resources:

American Supply and Machinery Manufacturer's Association

Association for Manufacturing Technology

Business Week - 26 September 1994

Machine Design - 25 June 1993

National Tool, Die and Precision Machining Association

PACKAGING AND CONTAINERS

The U. S. packaging industry is an $80 billion business. Each year Americans buy approximately 110 billion metal cans, including 42 billion soft drink cans, 38 billion beer cans and 28 billion food cans. Additionally, they use 42 billion glass containers, 19 billion plastic bottles and over 2 billion plastic food containers. Packaging machines make the packages and are covered by the discussion of machine tools on page 25. There is little food chain potential in the packaging industry because:

- As noted in the Machine Tools section, inch/pound machine tools can make metric parts. Conversion of U. S. packages to rational metric sizes would not, therefore, have substantial food chain effects.

- The packaging industry, with the exception of beverage packaging, seems to have an anti-metric leaning. It used its considerable lobbying power to change and weaken the February 1994 modification to the Fair Labeling and Packaging Act.

- There would be, however, three noteworthy benefits of rational metric package sizes with hard metric labels: 1) metric sized packaged products would enjoy a more global market since over 90% of the world population prefer metric; 2) rational sized metric packages would perform an important function by exposing the American public to the simplicity and advantages of the metric system, as further discussed in the section of Beverage Packaging; and 3) industries/companies that have made the transition to metric sized packaging have enjoyed the benefits of concurrent standardization and economies of scale. The liquor industry went from 53 different sizes to 7, thus reducing the cost of the bottles as well as costs relating to storage space, money tied-up in inventory, inventory insurance costs, shipping, *etc.* Du Pont saved more than $200,000 a year by changing its packages of neoprene (a Du Pont plastics product) to metric sizes.

PACKAGING AND CONTAINERS (Continued)

Resources:

Atlanta Journal and Construction - 16 August 1993

Business Almanac - Louis Rukeyser

Can Manufacturers Institute

FDA Consumer - September 1994

Food Labeling News - 21 April 1994

General Conference on Weights and Measures

Hardware Age - May 1994

Orlando Sentinel Tribune - 29 July 1994

Plastic Shipping Container Institute

U. S. Industrial Outlook - 1994

U. S. Metric Association

STEEL AND MILL PRODUCTS

Steel and mill products are a $60 billion industry currently (1993 and 1994) enjoying a modest turnaround after several years of declines. Reduction in personnel, closing of inefficient plants and investment in new technologies have made this U. S. industry more competitive.

The steel industry is currently producing metric sizes for automobile, machine tool, and heavy construction equipment. A survey conducted for *New Steel* (a trade magazine) indicated nine major corporations and dozens of smaller companies with metric requirements. Add to this the demand from overseas and one might wonder about the industry's reluctance to produce metric steel except on special order. The problem is related to composition rather than inch *versus* metric. Each of the three automobile producers (Chrysler, Ford, General Motors) demands a different formulation. The problem is exacerbated by a lack of standardization among overseas customers, with no uniformity of grades of steel internationally.

The inch *versus* metric problem is thought to be relatively simple compared to the metallurgical composition dilemma. The International Organization for Standardization (ISO), the European Committee for Iron and Steel (ECISS) and the American Society for Testing and Materials (ASTM) have worked together and produced a harmonized ISO standard. Unfortunately, approval by the participating countries is thought to be unlikely.

The food chain effect of metrication in the steel industry could be substantial, with demand growing in both quantity and variety of metric steel and mill products. For the near future at least, it appears that the industry will respond only to large special orders for metric sized materials.

Resources:

Business Almanac - Louis Rukeyser

Industrial Finishing - September 1993

New Steel - September 1994

Society of Automotive Engineers

U. S. Industrial Outlook - 1994

U. S. Metric Association

APPENDIX C: ELECTRONICS INDUSTRY ASSOCIATION REPORT *"WHAT NIST CAN DO"*

Metrication Program
What NIST Can Do

- Make all metrication programs Customer Focused

- Define the Metrication Process regardless of Industry utilizing IDEF.
  (Integration DEFinition)

- Be the resource for common needs:
  20 most frequently asked metric questions
  Conversion Standards
  Training
  Software
  Success Stories
  Consultation

- Become the role model, best in class benchmark, on managing the transition
  IDEF Model
  Life Cycle Manage Programs & Projects
  Reduce new project implementation intervals

- Make metrication the tool for standardization enhancing US competitiveness
  Select a pilot program and create a success!!!