U.S. METRIC STUDY MISSION

to the

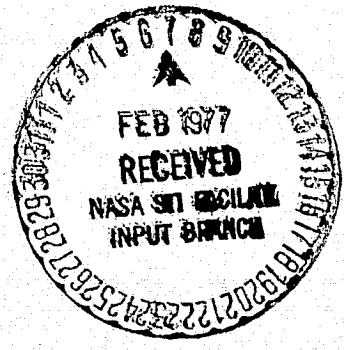
UNITED KINGDOM AND THE FEDERAL REPUBLIC OF GERMANY

OCTOBER 1976

Report of the NASA Representative

P. N. Vlannes

FULL REPORT



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16. Abstract

This document is the full trip report of the NASA representative of the U.S. metric study mission to the United Kingdom and the Federal Republic of Germany. The mission was organized and conducted under the aegis of the American National Metric Council to learn at first hand the progress of metrication in the United Kingdom and the progress of metrication in the aerospace industry in both the United Kingdom and the Federal Republic of Germany. Representatives of the mission included a cross section of government, industry, labor, and other segments of the private sector. After general and special meetings in the United Kingdom, U.S. members with aerospace-related interests met with aerospace representatives in the Federal Republic of Germany.

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ABBREVIATIONS/INITIALISMS
(Selected)

AECMA	Association Européenne des Constructeurs de Matériel Aérospatial
AIA	Aircraft Industry Association
ANMC	American National Metric Council
ANSI	American National Standards Institute
ASC	Aerospace Sector Committee
BAC	British Aircraft Corporation
BCAR	British Civil Airworthiness Requirement
BSI	British Standards Institution
CAA	Civil Aviation Authority
CAB	Civil Aeronautics Board
CBI	Confederation of British Industry
DIN	Deutsches Institut für Normung
DOD	Department of Defense
EEC	European Economic Community
FAA	Federal Aviation Administration
FRG	Federal Republic of Germany
ICAO	International Civil Aviation Organization
ISO	International Standards Organization
ITB	Industrial Training Board
M DAY	Metrication Day
MOD	Ministry of Defense
NASA	National Aeronautics and Space Administration
NL	Normung Luftwaffe
SBAC	Society of British Aerospace Companies
SAE	Society of Automotive Engineers
Si	Système International d'Unités (International System of Units)
TC	Technical Committee
UK	United Kingdom

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REPORT OF THE NASA REPRESENTATIVE

I. INTRODUCTION

The purpose of the U.S. Metric Study Mission to the United Kingdom and the Federal Republic of Germany was to permit those responsible for metrication programs in the United States to learn at first hand the metrication programs of the two countries, how they were initiated, conducted, and assessed, the problems encountered, and how the United States might benefit from their experiences.

The study mission was organized and conducted under the auspices and direction of the American National Metric Council (ANMC). Representatives included a cross section of government, industry, labor, and the public and private sectors. A list of the delegates may be found at Attachment 1. The meetings were divided into two parts: (a) three days of general discussions involving the total U.S. delegation, and (b) three days of special discussions in given areas of interest to the individual delegates. In the aerospace area, the special discussions were arranged by the Aerospace Sector Committee of the ANMC. Members of the delegation, who also were members of the Aerospace Sector Committee, attended the meetings with aerospace representatives of the United Kingdom (U.K.) and the Federal Republic of Germany (F.R.G.). The present report consists of the highlights of information presented at the Metric Study Mission meetings and is divided into two parts: (a) the general meetings in the U.K., and (b) the aerospace meetings in the U.K. and the F.R.G.

II. GENERAL MEETINGS IN THE UNITED KINGDOM

The general meetings covered the period October 4 through October 6, 1976. (A copy of the summary of presentations prepared by the U.K. Metrication Board may be found at Attachment 2.) The following discussion does not follow the meeting sequence. It is organized to provide a chronological sequence of the events that occurred in the U.K.

A. MEETINGS WITH THE BRITISH STANDARDS INSTITUTION

1. BACKGROUND ON THE BRITISH METRICATION PROGRAM

The initiative for the U.K. to consider metrication began during the period 1960-1961, prior to the time the U.K. joined the European Economic Community (EEC). At that time, the British Standards Institution (BSI) became concerned about the

U.K.'s declining position in international trade. A survey by the BSI determined that it was appropriate for the U.K. to change to the International System of Weights and Measures and that the changeover period would be approximately 20 years, from 1965 to 1985.

In 1963, BSI posed the metrication question to the Confederation of British Industry (CBI). CBI's subsequent survey showed that British industry was ready to make the change. In 1965, the British Parliament enacted a bill giving initial responsibility for the U.K. conversion to BSI, which determined that there were five phases inherent in the conversion: (1) a rational review and metrication of all specifications, standards, and procedures, (2) metrication by the raw materials industry, (3) metrication of the engineering industry, (4) metrication of the consumer materials production industry, and (5) metrication of the retail industry. The five phases were to be conducted concurrently with a program for keeping the public informed and involved.

During 1965-1969, all basic standards were converted. BSI used the opportunity to adopt "rational" standards and international standards. Examples of metrication were given for the construction industries, the engineering industries, and the retail industry.

2. THE BRITISH CONSTRUCTION INDUSTRY

Metrication of the construction industry began in 1965 with the establishment of a panel representative of all sectors of the construction industry. This panel began the preparation of a program which involved consultation all over England. The program consisted of a series of interrelated actions covering a span of six years. In its deliberations and consultations, the panel found it was necessary to revise British standards. By 1973 the panel had completed its full program including the entire spectrum from metrication of standards to preparation of implementing regulations.

The panel also found that metrication offered an opportunity to change to "Dimensional Coordination," which calls for adoption of sizes that are multiples of a basic standard. The panel initially considered the merits of both the 300-mm and 100-mm standards and decided to settle for the 100-mm. The British program accordingly became a dual program of metrication plus dimensional coordination. Problems encountered were on the dimensional coordination side because designs can be accomplished using the SI system without dimensional coordination. The documentation for dimensional coordination has been completed.

3. ENGINEERING-RELATED INDUSTRIES

The British program was divided into three parts: raw materials, tools and equipment, and components. The program involved the materials supply industries, the engineering equipment manufacturers, and the process industries that use engineering products. The British immediately acknowledged that there is no clear distinction among the three groupings. A summary of the status of conversions was presented by the British through the following examples:

(a) STEEL INDUSTRY

(1) ANGLES - All are metric. There is a price penalty for nonmetric angles.

(2) BARS - No Imperial sizes remain.

(3) FLAT ROLL - Completely metricated.

(4) BEAMS AND COLUMNS - Not metricated yet. Working with the International Standards Organization to come up with new international standards.

(5) RAILS - Completely metricated.

(6) REINFORCING BARS - All metric.

(7) PIPE SIZE - Converted from Imperial sizes.

(8) WIRE - Specifications developed on use basis. All standards are metric.

(b) NONFERROUS METALS INDUSTRY

Standards and products metrication were completed between 1968 and 1970.

(c) MACHINE TOOLS INDUSTRY

Since 1969, only metric standards are being published. Metric standards used by the British are 90% ISO. The United States has been involved in the metrication of the ISO standards. Standards for modular units for tools are completely metric, and all machine T-slots are now metric. The changes were made by industry investment in new equipment.

In the small tools area, the following examples were given:

(1) REAMERS - Although metricated, Imperial dimension reamers are still available.

(2) CENTER DRILLS - All metric.

(3) CARBIDE TIP TOOLS - All conform with ISO metric standards.

(4) TAPPING DRILLS - All metric.

(5) JIGS and FIXTURES - Now completely metric.

(6) MEASURING INSTRUMENTS - All metric.

(d) FASTENERS, PIPE AND FLANGES INDUSTRIES

For fasteners, the Imperial units were declared obsolete in 1974 and 1975. Pipe threads follow ISO standards. Flanges conform to European standards, promulgated by Deutsches Institut für Normung (DIN). All others are declared obsolete. According to the British, only two standards remain for flanges - European and American.

4. ENGINEERING INDUSTRIES, INCLUDING AEROSPACE

Principles used by British industry for production of engineering drawings are independent of units. New procedures do not change the various practices, but examples are given in SI. The British use BSI Publication PD 5686:72, The Use of SI Units, as their SI standard. This publication conforms to the EEC directive on units of measurement.

Within the engineering-related industries, almost everything has been metricated, but there are a few areas yet to be complete, for example: (1) for pressure vessels and boilers, pressure is expressed in BARS rather than PASCALS; (2) the shipbuilding industry had very few standards; and (3) in the automotive area, most metric standards are concerned with safety, this being an area requiring more work.

For the aerospace industries, a considerable number of standards have been metricated. Changes are being made via the International Standards Organization (ISO). A lot of work remains to be done.

In response to a query as to aerospace metrication leadership, the British responded that in the aviation production industry everything has been metricated. Flight and commercial air transport have not been metricated, even though a great deal of work is under way via the International Civil Aviation Organization (ICAO). However, all ground support operations have been converted. On the space side, the British say they are looking to the United States and in particular to NASA for leadership. The British advised that because they have metricated their aircraft production industry, they also have developed metric fasteners for use by the industry.

5. RETAIL INDUSTRY AND CONSUMERS

On the retail side, all prepackaged products (such as corn flakes, sugar, and flour) have been converted. However, for the "weighed-out" goods and the "greengrocer" there has been practically no progress toward conversion. In many instances the consumer has the feeling that he is "being taken" because metrication is just another opportunity to increase prices. There also exists a problem in that the conversion of retail scales apparently would require 2 or more years to accomplish. Currently, British law requires that preference be given to the use of the Imperial System of Weights and Measures. This has mitigated against the "small shop" conversion. Legislation is before the British Parliament to correct the law and to establish a series of "Metrication" or "M" days. Even though a single "M" day may have been feasible, there were no proponents, and the idea was discarded.

B. MEETINGS WITH THE U.K. METRICATION BOARD

1. BACKGROUND

In 1969 the U.K. Metrication Board assumed the responsibility for coordination of metrication within Britain. Voluntary change has worked in some sectors, but legislation should establish cutoff dates after which the use of the old system should be stopped. A prolonged change is both costly and irritating. The British hoped to have the new legislation establishing "M" days through the Parliament by Christmas 1976. The legislation for the cutoff is overdue because a minority of backsliders retarded the change. The British point out two great mistakes: (1) failure to establish a terminal date or dates by which metrication is completed, and (2) starting the changeover with education and industry instead of moving forward on all fronts including areas of high visibility like road signs, recreation, sports, and entertainment.

In this regard, the British point out that the United States has an advantage in that new legislation exists that causes movement on all fronts and involves every sector of American endeavor. If anything raises a specter of horror to the British, it is the fact that even though the United States has the disadvantage of a late start, the Americans just might beat the British to completion of the metrication changeover.

2. ORGANIZATION, MISSION, AND OPERATION OF THE BOARD

The next discussion concerned the organization of the U.K. Metrication Board. An organizational chart may be found at Attachment 3. The Board is a governmental agency staffed by

civil servants. It has no enforcement authority. Everything to date has been accomplished on a voluntary basis. Because of the impediments to completion of metrication, and hence the increasing costs and disruption, the British feel that voluntariness must come to an end.

The mission of the Board is to facilitate transition. Because metrication permeates every facet of human endeavors and because the fields are so wide and diverse, it is virtually impossible to do all things for all people. Currently the Board's major workload involves encouraging participation by all affected groups, advising the governmental departments, and answering inquiries and complaints.

At the national or any other level, a metrication program involves the following ingredients:

(a) A decision to change

(b) Consultation with all affected elements as to methods and timing

(c) Preparation, in concert with the affected sectors, of a program

(d) Legislation, regulations, etc., where needed

(e) Keeping the public and all segments informed

(f) Dedication and hard work to implement the program

The decision to change to the metric system in the U.K. was made in 1965 and announced by the Parliament. The British Government then established a joint steering committee to advise on the changeover. This joint committee recommended the establishment of the U.K. Metrication Board, which was set up in 1969. From 1965 to 1969, metrication had been under the British Standards Institution.

The Board established a series of programs covering the various national sectors such as agriculture, fuel and power, and fabrics and carpets. Only one sector has encountered any obstacles. This is the retail trade and weighed goods. Here the problems arise from the fear on the part of the shop owners that, if they convert to the metric system and the competition does not, there will be a loss of business. This attitude is also reflected in the attitude of the British consumer that metrication offered business an opportunity to increase prices and the result would be a "rip-off." These latter factors pointed to the need for additional legislation on metrication and the introduction of a second metric bill in the Parliament. The feeling is that if metrication is to be completed, a series of "M" days will have to be established. The new legislation is intended to achieve

this.

The advantages of the U.K. Metrication Board are: (1) It was set up and continues to be financed as a government entity; (2) it is an independent body; (3) it acts as a buffer between the public, industrial, and academic sectors and the government; and (4) it can work out and establish programs that are coordinated and conducted with and between all of the various segments of the nation.

The Board currently has a full-time staff of 57, down from a 1971 high of 71. It will continue to phase down as metrication is moved toward completion. Most of the staff functions are administrative, with the largest part of the workload in responses to inquiries. The composition of the staff is entirely civil service with a diversity of backgrounds, e.g., industrial, engineering, information, etc. The staff of the Board is a rather infinitesimal part of the people working on metrication within the U.K. The British view is that "Metrication is a process in which participation is essential." The Board initially met once a month. Currently the Board meets once a quarter. Board members do not have their own staff but are supported by the Board staff. The various divisions of the Board provide the support to the Board members.

From the legislative point of view, a U.K. act in 1897 made the use of the metric system lawful. The 1963 act does the same, but also recognizes two systems - Imperial and metric. Clause 1010 of the 1963 act says that the Government cannot do anything to prevent the use of Imperial units. This clause is one of the factors inhibiting final conversion. In 1970, the Government reviewed the decision to convert and affirmed the policy to metricate, and in 1972, issued a white paper reaffirming the policy. The current debate in Parliament is on establishment of the cutoff dates for discontinuance of the Imperial system.

The Board is financed by appropriations voted by Parliament. Like every other government agency, it goes through the budget cycle. Its publications (and there is quite a variety) are free. A few special reports are sold. It has no other funds. It does contract out some of its studies. It prepares annual and semi-annual reports covering such representative areas as public awareness and impact on the aged.

The Board has received no objections from labor. Labor's position is that they do not want their members working in both the Imperial and the metric system and that the U.K. should "get on with metrication." The individual worker is faced with the dilemma of working all day in the metric system and going home to the use of the Imperial system in the retail trade weighed goods. This brings up the only point of opposition which is emanating from the small business retail trade. The small shop

owners have been most unwilling to convert unless the Government establishes authority for cutoff dates. The unwillingness to change stems from a fear that their competitor down the block will have an unfair trade advantage.

3. INFORMING THE PUBLIC

The British did establish a program of informing the public. They concentrated at the beginning on industry, the trades, and the technical communities, which were made aware of what was occurring in metrication. An effort was undertaken to get the information program out of London and into the outlying parts of the country. The program was conducted via local organizations, and displays, brochures, pamphlets, etc., were locally oriented. The approach was thought to be more effective and less costly.

Current policy on information is to provide that information which is responsive to inquiries and based on what is needed. They use a low key approach and try to be timely. Information programs are now aimed mostly at the consumer. They have found that displays are very effective. One message that is coming through is that consumers resent usage of dual systems because of the confusion. The consumer position is "just go ahead with metrication." The main problem that is voiced is "value for money." There is no "unit pricing" in the U.K. comparable to that existing in the United States. This tends to accentuate confusion. A counter to this problem is the use of "Aids." These help, but there is no substitute for learning by using the metric system.

The lesson that has come through is: (1) Don't make assumptions about people, particularly consumers; (2) test, measure, evaluate, and repeat; (3) keep a low profile (referred to by the British as the crocodile approach) with a worthwhile message; (4) keep those people informed who need to know and want to know.

Currently, the Metrication Board receives about 2,000 letters per week. About two of these come from "nuts", a small number (10 or so) are carefully reasoned objections, and a fair number come from the press.

4. EDUCATION AND INDUSTRIAL TRAINING

According to the British, metrication in education is a success story. This part of the program got under way, even before the U.K. Metrication Board came into existence, with the greatest impetus occurring between 1969 and 1970. Children have learned the SI as their first and primary system. Experience has shown that SI was devised for the unsophisticated as well as the highly technical and skilled. One thing the British cautioned was, "DO NOT TRY TO TEACH THE WHOLE SYSTEM TO THOSE

WHO DO NOT NEED IT."

In the educational approach, they begin with the metre, millimetre, and centimetre. The basic approach is to start with decimetre and go up and down by 10's. Then they go to the square metre, the square hectometre, and so forth. Once they have covered the two-dimensional block of training, they go to three-dimensional by introducing the cubic metre, etc., followed by the litre, decilitre, centilitre, millilitre, and then up the scale to the hectolitre. Weights are covered next in the curriculum sequence beginning with the gram. They go up the scale to kilograms and megagrams, which is the "tonne" or metric ton, and then down the decimal scale to milligrams. This process is repeated with the other parts of the metric system.

The British claim that the teaching of SI in the schools has resulted in an increase in the extent to which children can learn and grasp ideas at the university level, and, equally important, it has enhanced the ability to communicate. There are two very important steps to be observed: (1) Develop an early awareness in practice "in the marketplace", and (2) make sure everyone knows how to use and spell the SI units correctly.

They advised that style guides were excellent teaching tools and cautioned that a single style guide is not enough. A style guide should be prepared for each community of users, complete with examples of usage for the community.

Training programs in industry also are conducted via the Industrial Training Board (ITB), which was established by an act of Parliament in 1963. The ITB is financed by a levy on industry.

5. METRICATION IN THE ENGINEERING INDUSTRIES

After much research and discussion, the British found that metrication is a broad area that permeates standards and standardization. The motivation to change at the national level stems from advantages that accrue in world trade. Metrication is a current motivator that: (1) initiates a reexamination of standards and specifications, (2) permits a rational evaluation of what is being done, and (3) asks why it is being done that way. This is perhaps the area of greatest payoff through discarding of the obsolete and updating to new technologies and methods. It is in the area of standards and standardization that the greatest work load lies, which calls upon the talents and input of the engineering community. In Britain, all national and international standards are the responsibility of BSI.

The British established a basic program for the engineering industries. Again, they stressed the importance of getting everyone involved. The Confederation of British Industry made representation to the Government for financial support. The Government position was that no public funds would be used to subsidize the changeover. Coordination was effected at the national level, initially by the BSI. In 1968 a broad time scale was set in the individual industries. Targets were 25% metrication by 1971 and 75% by 1975, but a residual capability would be kept in industry for spare parts.

The engineering industries were divided into three broad groupings: (1) basic engineering commodities, (2) equipment manufacturers, and (3) process industries. There was a constant exchange of information among the groupings. A phased program was established. It began with the BSI's scheduling the preparation of new standards that were mandatory to initiate engineering design. As these new metric standards became available, engineering design procedures were metricated for all new starts. With new engineering designs becoming available, production planning phased in, and once this had progressed to a point of implementation, production was initiated. During the entire process all concerned were involved, even though there were schedules for the various actions involved. This permitted each successor group to anticipate, participate in, prepare for, and get their part of the program into operation.

Progress to date shows that over 1300 basic engineering standards have been metricated by the BSI. A recent survey of the British engineering industry showed that in 1972 about 38% of industrial production was metric, in 1973, about 43%, and in 1974, about 58%. Of the industries surveyed, 52% had converted more than 50% of their production to metric units. The shortfall in reaching 75% by 1975 was attributed to the recession. However, there continues to be an increase in the number of firms using SI for new components, and an increase in purchase of metric products to 75% of industry. The Government has aided the process by prescribing the use of SI in government procurements such as the Jaguar Aircraft and the Type 22 Frigate.

Small firms have not changed over at the same rate as medium or larger firms. This is attributable to a variety of reasons, including availability of resources, nature of the work the small firm is engaged in, interaction with other industries, and type of product produced by the firm. The British define a small firm as one employing fewer than 50 persons.

As a footnote to the metrication of the engineering industries, they point out that some real economics can be achieved. In the cable industry, metrication has effected a

5% decrease in costs, and in the fastener industry, 1250 nonmetric items have been reduced to 91 metric items.

6. METRICATION IN AGRICULTURE AND HORTICULTURE

In this area, the British planned the conversion only to the wholesale level. Retail trade was handled separately. The program was set up under the National Farmers Union Groups. Representation came from agriculture workers' groups, land owners' groups, and wholesalers' groups. They found they had to move in concert with the national metrication effort. The timing was 1974-1975. They picked a "price review" as a point of change in 1976. They foresaw no problems in the changeover, including no impact on food prices.

With the decision to change by 1976, the work got under way. All suppliers achieved their target years. (For example, beer, milk, wool, sugar beet, and sugar were all metricated by 1976.) The Potato Board amended its schedule to convert potato sales to 25 kilograms instead of 65 pounds. Corn is now sold by the metric ton and the kilogram. On January 1, 1977, all livestock sales will be in metric units. From the starting date in 1972, to date, there have been no major problems.

Training was accomplished via pamphlets, books, films, courses, seminars, and meetings. Much of the training was carried out through the local farmers', growers', and workers' organizations. Farmers were among the first to recognize the advantages of the use of the metric system.

Land measurement will utilize hectares. All maps are being changed. It is estimated that conversions of all the records will take a total of 14 years. The change for official deeds and registration is awaiting legislation.

Costs for metrication were permitted to lie where they fell. There were no government subsidies and no attempts to keep track of the costs, which were handled as costs-of-doing-business.

Except for the records conversion, metrication in agriculture and horticulture will be achieved by the end of 1976, and the completion will be handled as a "nonevent."

7. METRICATION OF CONSUMER PRODUCTS

The British consider consumer goods to be included under retailing, which has been and continues to be the greatest problem area. Most things are bought by number and not by weight or volume. There are four main areas of consumer interest --- textiles, clothing, food, and drink. The food industry is the largest industry. Prepackaging of consumer

products to metric units is increasing. Not only does prepackaging facilitate the handling and sale of items, but it also assists in metrication. However, there is still an exceedingly large traffic in the bulk sales of consumer products such as meat, green and root vegetables, and confections. These latter are the areas of greatest resistance to the phase-out of the Imperial system.

In prepackaged goods, the first thing to be accomplished was the standardization of "pack" sizes. Examples given were for corn flakes, flour, sugar, etc. It is interesting to note that the European Economic Community (EEC) is standardizing package sizes that will become incumbent upon the member countries of the EEC.

Another problem in Britain in conversions at the "weighed" bulk goods level is in the use of an "order" that is a statutory instrument. Orders are permissive in nature, but do not prohibit the use of Imperial measures. Consequently, there is no compulsion on the industry for change to the metric system. This problem can be alleviated only by legislation, containing the establishment of a series of metrication or "M" days. The British consistently brought up the need for cutoff dates for use of the Imperial system and noted that metrication is dependent upon the Government's setting these dates by law.

Another problem in Britain stems from the fact that there are no "unit pricing" requirements. This creates the anomaly that although Imperial packages look smaller and appear to be cheaper, the actual unit cost would not be different. This is augmented by the fact that consumers actually purchase by the can, bottle, or package and not by weight or quantity. The current schedule requires that all containers bear dual markings by 1978. Other interesting aspects that surfaced are:

1. Over 6000 scales in the retail industry itself will have to be converted after new legislation is passed. This will probably require at least 2 years.

2. Although petrol (gasoline) pumps were designed and manufactured to metric standards, they had to be retrofitted to dispense gasoline by the Imperial gallon and not by the litre. The switch back to litres would not be difficult.

3. Sale of natural gas and coal by metric units is scheduled to start in April 1978.

4. Clothing sizes are to become the same as continental sizes. However, these still have to be coordinated with Canada, Australia, and Italy. Britain has

metricated all clothing sizes, and the EEC standards are what are being proposed as international standards via ISO.

5. Can sizes are being standardized. The bulk weight of the can contents will be permitted to "fall-where-it-may".

6. Weights listed on packages will be the minimum permissible weight. The containers could contain more than the specified minimum weight.

7. New standards for marking packages and containers will come into effect in January 1978.

8. Draft beer and milk will be permitted to be sold by the pint. This is a concession to British tradition.

9. Ninety percent of breakfast foods are metric. Fruit juices are sold by the litre.

10. Manufacturers who export will probably speed up their metrication.

11. The U.K. Metrication Board has not been involved in any kind of litigation.

8. METRICATION AND CONSUMER INTERESTS

The salient points of the discussion are:

1) The pharmaceutical industry was the first to be metricated. This was accompanied by a variety of public education activities, the most notable being the give-away of 5 millilitre spoons.

2) The paint industry went next. This caused the elimination of many of the smaller size containers. Although this was caused by standardization of sizes of containers, this happenstance was blamed on metrication.

3) Although Britain had a "D" day for decimalization of its currency, there is no statutory requirement for "M" days. This is badly needed. To date, the conversion has been voluntary. The change is by persuasion and by involvement of people in the metrication program. This approach has now run its course, and legislation should be effected.

4) The voluntary system in the retail trade has reached its limits. Competition is the bugaboo. In the weighed

goods areas, merchants refused to convert because of competition indicating a lower per-unit cost for the Imperial system. This, of course, is not true. There is no legislative requirement for a conversions date; and, indeed there is existing legislation that gives preference to the use of the Imperial system.

5) Consumers have been apprehensive about metrication. This fear is in knowing that one is receiving value for the money spent. Confusion is further augmented by refusal of the retail industry to convert over. This forces the consumer into having to deal in two systems.

6) From a consumer point of view, they need to know only the kilogram, metre, and litre.

7) To assist the consumer, the British are providing charts and aids. These are consumer-tested before being made available generally.

8) The elderly do not need any information different from the rest of the community. Elderly people do not think of themselves as being elderly and can cope with metrication the same as everyone else.

9) Transition periods are unavoidable but should be as short as possible.

10) Of all the consumer groups, as might be expected, the women are the most exasperated with the delay in changeover. They are the ones who come into direct contact with the problems of use of the dual systems. They encounter local opposition; butchers, fishmongers, and greengrocers declare they will be the last to convert without a government decree. As yet, there are no recipes in metric appearing in women's magazines. However, work behind the scenes has been going on. The British are using 25 grams as the base unit for setting recipes. At present, metric recipes are being tied to the milk pint measure, yet the British are still trying to establish the metric volume of the pint and are hoping to settle on the 600-ml bottle. This causes problems not only internally to the country but also to the EEC member countries.

11) Although Britain does not have unit pricing in their stores, they do have existing powers to require it.

12) The Post Office went metric about a year ago. Postal rates went from a 2-oz. to a 60-gram base.

13) The telephone industry also has converted. Long distance rates are based on metric distances.

14) There are no tax incentives for merchants for metrication. They have the same write-off provision for depreciation, etc., as any other business or industrial groups.

9. METRICATION IN THE CONSUMER FIELD--A MANUFACTURER/RETAILER VIEWPOINT

When examined from the perspective of the manufacturer/retailer, the real crunch in metrication occurs at the retail level. They are the front-line forces with the consumer. When this crunch is minimized by all concerned, the transition is smoother.

The U.K. has 450,000 retail outlets. Co-op sales are 20% of the total of prepackaged foodstuffs. The Co-operative Wholesale Society (CWS) is the central trading body of co-ops that deals directly with the public. The turnover is about 2 billion pounds. The co-ops own over 100 manufacturing units.

In the U.K., most of the conversion in manufacturing is completed. In most areas this was accomplished without trauma or unusual attention. The approach that resulted was one of getting on with the job. There were four essential elements in the transition: (1) consultation, (2) coordination, (3) communication, and (4) common sense. These apply, not only in organizations and groups, but among them. It is very difficult to achieve. The big problem is to keep people informed. The conversion program was decentralized with a designated metrication officer responsible for the program and was set into operation via a pyramidal reporting and control organization. Metrication was not isolated but made a part-time function of all operations, with liaison groups for coordination.

There were very few problems in the clothing and textile trades; however, there is pressure to retain dual markings because of the resistance at the retail trade level. Changes in the retail shops are very slow. The current feeling, owing to this situation, is to retain dual measurement systems and dual pricing.

Cosmetics, toiletries and related industries have been metricated. There have been no problems in these areas.

From the manufacturer's viewpoint, 90% of production is in foodstuffs. There are three types of foods:

1. Prescribed quantity foods - the quantity is prescribed by law.

2. Prepackaged or unprescribed - the quantity is set by the producer.

3. Catch weight - the quantity is weighed in front of the customer.

In the food area there are advantages to be gained if packages are done to prescribed units. This sets nationwide standards and permits an easier unit price comparison by the consumer.

In Britain, there are over 600,000 scales in 250,000 shops that need to be converted at the weighed goods level. This is a job that will not occur overnight even if an "M" day is prescribed by legislation. It is interesting to note that dual marking has little impact on conversion in the weighed goods industry.

One fact that was emphasized during this discussion was the need for a strong commitment on the part of Government as being an essential requirement.

10. THE TECHNICAL ASPECTS OF METRICATION

The technical aspects of metrication have many facets. They can be as comprehensive as the bibliographies on metrication, which are most important tools, or as confusing as the colloquialisms that creep into conversations. Examples of the latter are the terminology for the decimal parts of a millimetre. 0.005 millimetres is spoken of as "five, ten-thousands" and also as "five thou", whereas 0.0005 millimetres is referred to as: (1) "five ten thousands", (2) "five tenths", and (3) "five ten thou."

On the clerical side, it became necessary to consider modification of typewriters. BSI was asked to develop a new standard, which has been done and is available from BSI.

A problem currently plaguing the British is the international standard for computer printouts. Currently the Europeans are advocating the use of the comma as the decimal marker with a space between the groupings of digits, for example 574,321.123 would appear as 574 321,123. The British point out that this could lead to errors through insertion of digits in the blank spaces. The British are advocating the way the United States currently formats its digits, example 574,321.123 with the period as the decimal marker and the comma as the divider between the digits. The British solicited the support of the United States for their proposal.

The British point out that there are technical differences between SI and the ISO that need to be resolved. These cover a gamut of items from pressure measurement to the "vulgar fraction"

which has to do with rounding off of numbers during conversion between SI and non-SI units. There also are differences between SI and ISO in metric fasteners and screw threads that need to be resolved.

One area that is of constant concern is insuring that all technical documents and literature are not only scientifically and technically sound, but correct, down to the usage of proper symbols and abbreviations. This, of course, produces a great workload on the U.K. Metrication Board.

Conversion tables are not produced by the Metrication Board, but "comparison shoppers" have been made available to the public. The Board has kept copies of the conversion tables that have been produced elsewhere and makes available lists of sources of tables. As one example, the National Engineering Laboratory and Electrical Research Association produced the new metric steam tables.

11. METRICATION IN THE CONSTRUCTION INDUSTRY

To the British, metrication in the construction industry is "old hat." The Board still gets inquiries in this area, but conversion is now history. The real change took place in 1972, when the British converted their building regulations. A summary of conversion in the construction and related industries may be found at 11.A.2 and 3 of this report. This part of the discussion by the U.K. Metrication Board is presented in chart form (see Attachment 3). The chart is self-explanatory.

12. SUMMARY PRESENTATION BY THE U.K. METRICATION BOARD

Metrication is not only a technological problem but involves everyone from many points of view and at all levels. It is an across-the-board problem. Metrication has in no way contributed to inflation. No evidence exists to substantiate the allegation. Decimalization of currency also did not contribute to inflation; but, like metrication, it caused a lot of speculation.

There are certain key words that have been associated with or evolved from metrication. These are:

1. Government Department -- or who carries the ball.

2. Dedication -- the requisite and most desired quality needed to get the job done.

3. Financial Help from Government -- a proposition that is to be avoided for metrication.

4. Legalization -- the statuatory laws that remove barriers to metrication.

5. Devolution -- who does the job?

6. Voluntary Bodies -- organizations, groups, and persons ensnared in the metrication program. (Women's organizations and groups play a key role in getting the job done.)

7. Unit Prices -- the cost per unit measurement of an item or something covered by legislation, but not effected at the consumer/retailer interface.

8. Prescribed Quantities - the net contents of a packaged item prescribed by the Government, or how many millilitres will there be in a pint, when and if the Government ever decides.

9. Promotional Confusion -- that which appears in the mind of the consumer when he is given conflicting, erroneous, incomplete, or incorrect information about metrication in any given area.

The British also summarized their rationale or "arguments" for metrication given to small business. These are:

1. Efficiency Advantage -- It is more efficient to deal in metric units than in Imperial units. It is easier, quicker, and causes less confusion.

2. All supplies are either metric or will be converted to metric units from the producer, processor, and wholesaler.

3. Reverse conversion costs money, not only for the reconversion of equipment, e.g., scales, measurement devices, etc., but personnel have to be reverse trained.

4. Easier to "tote up" accounts. Everything is decimalized.

Retailers are part of the industrial whole. There also is a negative side to metrication presented by the retailers. Three things emerged: (1) the problem of so-called "pre-fab packaging"; supposedly this limits the choice to the customer; (2) the nonavailability of metric scales and retail measurement tools, and (3) the cost of conversion to the retailer versus the manufacturer--the retailer has to deal directly with the customer.

There are many payoffs in metrication. Among the payoffs is the opportunity for everyone to rationally approach what they are doing and assess that which is obsolete or too costly

and to get a fresh start. This opportunity does not come in a national context at very many points in history. Because of the opportunity, many benefits can be enumerated, such as (1) a reduction in the number of items needed for national commerce and well-being. Many examples could be cited, from reduction in numbers of fasteners to standardization of containers; (2) an ability to participate in worldwide commerce without the encumbrances of a multiplicity of measurement systems; (3) a simplification of the measurement system for better understanding by all concerned and an ability to discard a more error-prone measurement system. Perhaps the greatest benefit that ensues from a national point of view is not having to pay the penalty of not converting.

III. AEROSPACE SECTOR MEETINGS WITH REPRESENTATIVES OF THE UNITED KINGDOM AND THE FEDERAL REPUBLIC OF GERMANY

A. AEROSPACE MEETINGS IN THE UNITED KINGDOM

The meetings with the aerospace representatives were arranged by the Aerospace Sector Committee of the American National Metric Council (ANMC) through the Aerospace Industries Association (AIA) and the Society of British Aerospace Companies (SBAC). The meetings in London were held at the American Embassy and at the British Air Traffic Control Authority. Persons in attendance may be found at Attachment 4.

The meetings were opened by the chairman, who expressed appreciation for the attendance and participation. He stated the purpose of the meeting and asked all present to identify themselves and their organizational affiliation. He pointed out the voluntary nature of the U.S. program, with industry providing the leadership except in regulatory areas, and referred to the list of questions previously submitted by the ANMC (copy appended as Attachment 5.)

The discussions began with the representative of the Ministry of Defense pointing out that there were two problems in semantics that needed to be clarified:

(1) "Conventional Units" as used by the United States is sometimes accepted as being synonomous in Britain with the Imperial system. For the purposes of the discussions, the phraseology "nonmetric" will be used.

(2) There is a difference between conversion and metrication. To the European, metrication is equivalent to the U.S. hard conversion, and conversion is equivalent to the U.S. soft conversion.

He went on to say that SI is a system that is so pure that in many practicable respects it is unworkable without

international agreement on derived units. The Europeans are going to use the International Standards Publication 1000 (ISO-1000), which is acceptable worldwide. There are a few exceptions to the units in ISO-1000 which the British have not accepted. These are GRADE, STOKES, ANGSTROMS, POISE, and STILB. To the British, a "mil" means mil and not milliradian. The British are asking NATO to adopt ISO-1000.

The voluntary mode of national conversion to the metric system has been followed in the aerospace sector. In the Ministry of Defense (MOD), terminal dates are firm dates for changeover. It is the policy of the MOD not just to change the system of weights and measures but to accomplish as much international standardization as possible. The British are utilizing ISO standards, and all new or revised ones will be in accordance with ISO recommended standards. They are using "rationalization" in their approach, challenging the way things have been done and assessing the need for continuing in the old way. This has led to some unexpected benefits such as a streamlining of their operations and a reduction in the great number of parts and components such as fasteners. They hope to recoup costs by reduction of their inventories, which contain over 3 million items. The estimated cost saving is 20 pounds per item per year.

In the MOD, metrication began in concert with the national program in 1965. By 1975, all drawings were in metric, but very few items now in service are metric. This is attributable to production lead time and to the use of commercially acceptable specifications for military procurement. The MOD pointed out that there is in existence a white paper that says that one objective is to remove the difference between civilian and military specifications for civilian items that can meet military requirements.

The British military service will not be metric by 1985 and will not be completely metric before 2010. This is due to the long lifespan of many items and facilities. The biggest cost will be in the maintenance of nonmetric items. As an example, there is already in existence a premium price on nonmetric fasteners. As industry goes more and more metric, it will become increasingly difficult and more costly to obtain Imperial parts. Although the objective is pure metric, the progress will be prescribed by industry and not the military.

The British are aware of and sensitive to the metrication and standardization of international standards, particularly in concert with their EEC partners. In the EEC agreement, there is a provision against restraint of trade. When a member EEC country acts to restrain the trade of its partners, the offended countries have a right to indemnity

from the offending country or countries. The failure of the British to remove such constraint, which is embodied in legislation prohibiting discrimination against use of the Imperial system, could open them to a charge of trade restraint. This means that the legislation currently before the British Parliament to change the existing statutes cannot be ignored and must be given serious consideration.

The discussions with the U.K. Civil Aviation Authority (CAA) dealt mainly on metrication of the British Civil Airworthiness Requirements (BCAR's). Emphasis is on the operational side of the CAA. The problem is in moving in concert with the air carriers and with international requirements. The British have established no timetable for the actual changeover, although the groundwork has been laid. The British will be influenced by what the United States does, and they extend an invitation to the United States to participate more actively with them. As a regulatory authority, they have used only the consultative approach and have not encountered any problems.

Metrication from the CAA management point of view is dependent upon what the aviation industry does itself in conversion. The CAA waited until industry got started and got all interested factions involved, including the Air Worthiness Board. The economics of metrication stem from the entire nation's going metric.The adverse effect of not going metric was the motivator. The CAA made no conscious effort to track the costs of metrication.

As yet, there has been no CAA metrication training. They assumed the engineering and professional staff was competent and could cope with the change as had occurred in the nation as a whole. The training problem, from an engineering and professional point of view, appeared to be in industry. As yet, there is no direct experience on the air traffic side, and no unusual problems are expected.

In air-ground communications, the British, like the Americans, use the measurement units set forth in the Blue Table of Annex 5 of the International Civil Aviation Organization (ICAO). There is much discussion on what the measurement units should be, particularly for speed, height, and pressure. The British will use whatever comes out of the current activities of ICAO.

Among the metrication achievements to date are:

(1) Air navigation rules have been metricated.

(2) Airport lighting and marking standards have been metricated.

(3) Documentation covering standard operations have been converted.

(4) Approach procedures have been changed to SI.

Although the work on the documentation side appears to be well under way, the CAA has not moved to metricate the actual flight operations but will continue to wait on the international changes.

In response to a request for advice from the U.S. aerospace industry, both the CAA and the MOD representatives gave almost identical responses. The advice, which was reiterated at subsequent meetings in both the U.K. and F.R.G., is summarized below:

1. Minimize hybrids.

2. Do not confuse the start of metrication with the cessation of nonmetric.

3. Carefully watch your cataloging systems. They not only tell what has been metricated but also give the rate at which metrication is occurring.

4. Have a coherent program and stick to a schedule.

5. Do not let the public relations program be neglected.

6. Too long a time schedule can be overly costly.

The meetings with representatives from the British aerospace industry were held at the American Embassy. The participants were provided a list of questions by the U.S. Aerospace Industries Association via the Society of British Aerospace Companies (SBAC). A copy of the response from the SBAC may be found at Attachment 5.

There are two main influences in aviation, namely military and civil. The military department as a government entity has to follow governmental policy. As a result, military contracts are in metric. Civil aviation has no such requirement. The British Aircraft Corporation has made no decisions with regard to metrication and decided it may be politic not to change at this time.

Rolls Royce made a commitment to use the continental metric system for military aircraft. In 1966, when the British Government announced the decision to go metric, Rolls Royce also made the decision to begin metrication in

conformance with the SI. They progressed very rapidly in their program. All production equipment is now metric equipment. All drawings are to metric standards. For 2 to 3 years, they used dual dimensions on drawings. However, they have used some nonmetric wire and screw threads. In the final analysis, it depends upon what the customer does. Their customers are mainly in the United States. The original "M" day for Britain was 1975, but Rolls Royce calculated it would take 18 years. They have replaced all test-bed instruments with SI instruments. Everything up to performance testing is in metric. As things stand now, the British are waiting for the United States to make the change.

British equipment manufacturers began submitting all of their documents in SI in 1970, unless the customer requested otherwise. They had to look at what was happening in education. Students were coming out of schools completely versed in SI but not trained for the Imperial system, which is still hanging around. The United States should make a closer study of SI education in Britain. It may be possible for the United States to avoid many of the British mistakes. In any event, the aircraft equipment manufacturers were faced with a task of retraining to the Imperial system during the transition period.

Since the life of an aircraft is about 25 to 30 years, while that of an aircraft engine is somewhat less, the challenge is to provide replacement parts in nonmetric units and to minimize the number that are being produced to that required to go through the phase-out cycle. The commitment to spare-part organizations will be to carry units in both measurement systems. This means that there must be a strict in-house control on production of components.

The most important aspect from the manufacturer's point of view is in the preparation and coordination of standards. Scrutinize all existing metric standards and utilize all of those that you possibly can. It not only saves time and effort, but makes for a smoother and less costly changeover.

A serious changeover in the aerospace materials area began in 1967. At that time, for example, the British Aluminum Company went metric. The problem was in the availability of SI standards for materials, not only as to sizes but as to performance characteristics and properties. The industry underestimated the time required for customers to place orders in metric. Initially, less than 10% came in metric units, and there was a great deal of confusion in the interface between production and consumer specifications. The change has now been made, and it has not been difficult, but only time-consuming.

All military aircraft being produced today are not in metric. Some are hybrids, because of the availability of components. The Jaguar was a hybrid, but as metric components became available, the change is progressively to metric. The Tornado's initial design was hard metric, and there was no problem in the shops to produce metric components. Where metric-dimensioned components were not available in industry, the metric requirement was reduced to one of attachment. This solved the problem of component availability but produced a hybrid problem.

The motivating force in civil aviation usually springs from the consumer requirements, which in turn are derived from government regulation and international agreement. The policy of the aircraft industry is to make the transition to SI. This is based on the experience with the Jaguar and the Tornado. The industry has been doing the planning and is moving toward total conversion, with tooling and equipment being converted for dual production of both metric and nonmetric. Eighty percent of the capacity of the aircraft industry can now produce items in either measurement system. The metrication of equipment has been approached on a replacement basis.

Industry worked out details with the unions on provision of metric measuring instruments and tools. The unions were not only kept informed but were kept involved. Industry helped by providing the metric tools needed to accomplish the in-house work in industry. This has been achieved at minimal cost. Almost all shops are now on the metric system with a move toward the industry's not condoning two systems.

For the Concorde, the requirement was based on millimetres and not on the SI per se. The fuselage is based on Imperial measurements. Essential features such as Category I requirements (skin) called for metric. Every thread fastener is "Unified" (American UNF thread form). Specifications are in metric units for procurement. Hopefully, the next civil aircraft project will use metric fasteners, and hopefully these will be available. In future projects the British expect the United States to respond to requests for metric components.

The U.K. has accepted SI for all its endeavors and will follow ISO-1000. All future activities will be in SI. The aircraft industry is using the six base units and six derived units. There are no perceived shortfalls. People trained in SI evidence no problem in use of SI units. There are some specific problem areas for derived units that are going to be adopted. These include fuel consumption, thrust, stress, speed, and pressure. The British are working

with the ISO Technical Committee (TC) and the aerospace manufacturers' community to produce ISO standards.

The cost impact is difficult to quantify. Even cost guidelines for metrication of production are not only nonexistent, but also nondefinable within existing policy of rationalization of metrication and letting the costs remain as a cost of doing business. Upgrading existing equipment or purchasing of new equipment are handled as capital improvement or capital acquisition costs and are considered not as a metrication cost but as a business investment as well as an investment in the future. There are only two other recognized areas of metrication costs: (1) the costs of maintaining a dual production capability for replacement parts, and (2) the cost of maintaining dual inventories.

The British Aircraft Corporation (BAC) embarked upon a dual capability. Their rationale was to maintain a level of manpower for the dual capability. The BAC looked upon their approach not as a problem in economics but strictly as a way to meet customer needs. Rolls Royce decided not to go dual. They found that the dual capability increased operating costs by 20%. They used the "replacement" approach and "rationalization" on tools, parts, etc. (Here an observation is in order. No matter which rationalization or approach is used, as metrication proceeds and nonmetric items become scarcer, the customer will be the one who pays the bill.)

Materials manufacturers do not face the need to carry a dual production. One approach used was to metricate Imperial tools, dies, etc., and replace with metric parts, components, etc., as these became available. This may have "begged the issue," but it permitted the materials industry to phase over without incident. "M" day for the materials industry was July 1, 1970. Customers had been advised of the upcoming change and were simultaneously advised of any cost increases of Imperial dimensioned materials. Anticipated problems did not materialize, but the industry found that on "M" day, only 10% of the orders were fully metricated. Almost all new metric sizes overlapped tolerances of the nonmetric sizes. However, all new shops for the materials industry are invariably metric.

For metric training, all of the British representatives were pretty much in agreement. For example, the BAC made an analysis of the training requirements for all divisions of their company. They then established training rules. The program encompassed the following:

1. Orientation briefings for the department officials.

2. Training that was oriented to job-related work.

3. Accomplished on company time.

4. Established a feedback mechanism and retrained or elaborated on previous training.

5. Used posters, charts, cards, and aids as reinforcing mechanisms and tools.

6. Programs were both comprehensive and intensive.

7. After training sessions, used the reminder approach.

8. Training covered a span of about 6 months.

9. Policy announced in 1965 and training started in 1968.

10. People were trained on a need-to-know basis.

11. Selected personnel were trained first. They, in turn, did the local training.

12. Training dealt only with metric units.

The British representatives also were pretty much in agreement on the sequence of events that transpired at the initiation of the metrication in-house. The steps are:

1. Announcement of policy.

2. Appointment of metricating coordinators or directors beginning at top level of management.

3. Establishment of a steering or advisory committee and subcommittee.

4. Development of rules and procedures for metrication.

5. Issuance of directives covering each aspect of metrication.

6. Metrication of sales procedures and conversion of documents.

7. Training program initiated on a need-to-know basis.

8. Assuring that all affected and interested parties are kept informed.

In response to questions on organizational placement of metrication responsibility, the British advised that the bulk

of the work and the effecting of conversion fall into engineering areas. Metrication cannot be achieved without the fundamental documentation changes, the follow-on engineering, and finally the actual production of the tools and equipment that are necessary for metrication to proceed. Because of this, the metrication responsibility was placed on the engineering side of the house (e.g., under a VP for engineering) usually in an organizational element responsible for standards and standardization, quality assurance, or production engineering. This organizational placement may also be found in U.S. industry such as the automotive industry, which is the most advanced. The U.S. aerospace industry has reached the same conclusion, and metrication responsibility is assigned to similar organizational elements. Once the metrication program is completed through the engineering production stage, the remainder of the program is considered to be a "nonevent."

The British have been working and collaborating with their EEC partners. They are all working with the International Standards Organization (ISO), the Association Européenne des Constructeurs de Matériel Aérospatial (AECMA), and the International Civil Aviation Organization (ICAO). The EEC group is charged with furthering European standardization for aerospace, and their concern is across the board. The U.K., as well as their EEC partners, particularly F.R.G. and France, are anxious to develop European metric standards. They will use ISO-1000 as the base document. AECMA has been and is concerned with keeping an eye on U.S. metrication activities. AECMA needs a U.S. involvement to prevent a divergence in the engineering and operational approach. It is critical that the United States get involved. It is possible to work via the ISO, but the lead time is too long. AECMA has been talking to the U.S. Aerospace Industries Association (AIA) as to how AECMA can get the United States involved. THE AIA provides the executive secretariat for aerospace for the ISO and serves as the U.S. coordinator. AECMA has a very large workload, particularly in the development of standards, and United States involvement at an early date would preclude the necessity of retracing much of the effort. Arrangements have been made by AECMA with AIA for distribution of AECMA documents. Arrangements also have been made for U.S. experts to visit with U.K. firms. Current AECMA specifications are very advanced and very detailed. The question that is extant is "How can the U.K. get the United States involved in AECMA activities?"

The final discussion was in response to a question on metrication of space activities. It was noted that the aviation side of aerospace was covered in detail. Engineering design documents were metricated, engineering practices were converted, specifications and standards have been rationalized

and metricated, production engineering has gone through the metrication process, metric components and parts are being produced, a premium price is being asked for non-metric items, and everything had been metricated except existing operational aircraft and flight operations. What is being done about space activities? The response was that the U.K. is looking to the United States and specifically to NASA to provide the leadership.

A listing of the documents furnished by the U.K. representatives may be found at Attachment 6 .

In the concluding remarks, the British emphasized the following:

1. All existing metric specifications and standards should be scrutinized and used rather than creating new standards.

2. Metrication must be recognized and accepted by top management or success will be doubtful. The first step is announcement of policy with intent to convert to the metric system.

3. Keep all affected and interested parties involved and informed.

4. Engineering will be the key and will have the greatest workload and should provide the leadership.

5. The Europeans are intent on developing European standards that will be submitted for consideration as international standards. The United States should get involved now.

6. Training should be on a need-to-know basis, with practical application enhancing and amplifying the training through use.

B. AEROSPACE MEETINGS IN THE FEDERAL REPUBLIC OF GERMANY

The meetings in the Federal Republic of Germany were held in Munich and were for the purpose of receiving first-hand information about: (1) the approaches, techniques, solutions, and problems faced by a "metric" country's converting to SI in the aerospace area, and (2) the role the United States plays in foreign aerospace metrication. The problem in this "metric" country is illustrative of the current problem in all other foreign countries. Since World War II, the United States has played the dominant role in aviation, being the supplier of most of the world's aviation hardware. Even though most

foreign countries were metric countries, they use the U.S. system of weights and measures for aviation.

The F.R.G. has accepted the SI and has enacted legislation which requires its usage and prohibits the use of some former metric units. There are some specific differences such as bar (for pressure), atmosphere, miles, and knots which will continue to be used until such time as these differences are settled via the ISO. The law establishes a very short span for metrication (2 to 4 years), but document conversion in many areas will continue for a long time, particularly where there is a need for international agreement. Some of the SI units are strange, but F.R.G. will accept and adapt to the new units. The law already requires the use of new SI units, e.g., the kilogram. The Germans have set the German pound at 500 grams, or one-half of a kilogram. It was suggested that the United States should also consider making the U.S. pound equal to 500 grams. Among the general population, e.g., at the greengrocer level, the change is expected to proceed more slowly.

There is a problem of education in F.R.G., brought about by the usage of the nonmetric system in aviation. This means that two systems have to be taught.

For temperature, the Germans now use Celsius. It is also permissible to use the Kelvin scale for technical work. However, for everything else, only Celsius will be used.

The Germans, like the British, are using ISO-1000 as the standard. They will revise the national usage as the ISO-1000 changes. SI is close to being final; however, there are still some problems, stemming from nationalism, that inhibit or delay reaching agreement on something as objective as units for weights and measures.

In Germany, there is a government agency, the Deutsches Institut für Normung (German Institute for Standards) also referred to as the "DIN." This agency is the government agency responsible for metrication nationwide. Within the DIN is an organization, the Normung Luftwaffe (NL) which is responsible for aerospace standards. Like the British, the Germans establish their standards via governmental approval. This is at variance with the establishment of standards in the United States, where it is accomplished via professional and private organizations, largely supported by industry. The Germans also have a national program on certification. In addition, the Germans have a decentralized regulatory authority which functions similarly to the authority of the various states in the United States. As an example, Bavaria has a special ministry for environment which includes noise pollution.

Metrication in Germany is being accomplished via existing standards organizations. In pre-World-War-II days, the old classical CGS metric system was used exclusively. After World War II, they converted to the U.S. system for aviation. They are now converting to the SI. All military aircraft now are about 80% metric. Currently they are dependent on the United States for components. As metric replacements become available, it is their intent, depending on the nature of the item, to phase out the nonmetric item. They still need a few nonmetric tools for use with nonmetric fasteners.

The Germans have developed some nonmetric fasteners. If available, and if the price was right, they used the metric fasteners. If the price was not right, they used the nonmetric fasteners. They advised that more and more metric fasteners are becoming available at competitive prices and that they intend to use the metric fasteners. Within the EEC, France has been a producer of nonmetric fasteners, and continues to fill this role. This may be a retardant to the accelerated use of metric fasteners; however, the upward trend in the use of metric items is expected to continue.

In Germany, technical drawings for aerospace and shipbuilding use millimetres or fractions of millimetres. Architects use centimetres, and geologists use metres and kilometres.

The EEC accepts the SI, so consequently the Germans also accept it. In SI, the units are all defined; dimensions are established and rules for derived dimensions are set forth. Although the EEC accepts ISO-1000 as the international standard, not all of the ISO-1000 units are defined. Examples of some of the problems to be resolved are:

1) Use of "l" as the symbol for litre (now resolved as "L")

2) Tonne = 1000 kilograms

3) Use of "mega pascal" for hydraulic systems

4) Use of "Bars" for atmospheric pressure

5) Use of Newton/mm^2 for stress

Europe cannot wait for ISO to develop standards owing to long lead time. Consequently, they are developing European standards which they will use and will forward them to ISO as candidate international standards. The United States is invited to participate in the joint development of what could be considered as American-European Standards. Because of the slowness of ISO, the Europeans propose to use agreement on standards by direct approach to the aerospace companies and to

present the resultant agreement to ISO.

During the period 1977-1980, the Europeans plan to establish standards for both military and civilian aviation applications. The AECMA is taking the lead and providing the motivation. Again the Germans pointed out the desirability of the United States' participating in the development of the international approach. Their position is that the United States must be a partner in the development of standards.

AECMA is comprised of representatives of 11 European countries. There are 111 aerospace technical and engineering specialists and 87 specialists from aerospace suppliers. These are the best available in Europe. For an agreement on a standard, the vote is split with 20% each to Germany, Britain, and France, with the remaining 40% divided among the other nations. Proposed standards are forwarded by each country's representatives to the various aerospace industries or companies for review and recommendations. If a proposed standard is accepted, it becomes a European Standard for the member countries.

Aviation projects now under way, e.g., the airbus project, will use SI except for a very few areas such as designation of pressure. If ISO-1000 changes, the SI units in the projects will change. The Germans feel that engineering design can proceed irrespective of which system of units is being used, and they are flexible enough to adapt to the changes. In the Jaguar project, the design engineers refused to use nonmetric fasteners and won.

The Germans pointed out that the metrication problems relative to the aircraft life span also pertain to other areas such as ships, trains, and power plants. They are similar, if not identical, with military metrication problems, to include the concept to disposal cycle and including the tooling, production, and dual inventory problems. They stated that total metric airplanes, irrespective of whether they are military or commercial, will become a reality, even though the present market with operational nonmetric aircraft does not have a stated demand. The airlines themselves do not want dual units because of the need for dual tooling but the changeover is inevitable. This stems from the fact that other areas of the national production, such as automotive, machine and hand tools, etc., that do not make items exclusively for aviation, will force the change since the production of common items to metric units will be less costly than catering to nonmetric production which could be accomplished only at a higher cost.

In the aerospace industry, no special training was provided. For engineers, conversion handbooks, charts, and pocket guides are provided and reissued as updating is required. This is also true where aids or tools are needed for shop use.

The Germans reiterated the fact that the EEC would be looking forward to 1978 when all trade is to be in metric units and to metric standards and pointed out that restraint-of-trade could become a real factor.

Their real question is not whether the U.S. aerospace industry can convert to the metric system, but when. They are inquisitive as to how the United States looks upon cooperation in the development of international and/or American/European aerospace standards. They know that all NATO Governments are saying that military aircraft will use the SI and that Europe itself will have all metric aircraft. They are aware that the AIA has advised (and they have received copies of) some 276 metric standards that are metric aerospace standards. Examination has shown that some of these are soft conversions.

When questioned about metrication in the space area, per se, the German position is identical with that of the British, and they make the same statements about looking to the United States and particularly to NASA for leadership.

C. SUMMARY

The facets, results, and status of European aerospace metrication are summarized below:

1. The U.S. aerospace industry can expect to face increasing international competition in worldwide aerospace sales. The Europeans are intent on converting to the metric system, have completed the basic transition, and have created the mechanisms for metric production. (A premium price for nonmetric requirements is levied for materials, engineering, and production.)

2. Long-life equipment, such as that for aviation, ships, railways, and stationary power plants are expected to be operational for 25 to 35 years. This means a long-term phase-out of dual inventories and indicates the need for a supplementary production capability for production of nonmetric replacement parts and components.

3. The EEC will use the International Standards Organization publication 1000 (ISO-1000) as the basis for SI for aerospace, even though there are still some technical

differences in measurement units that have to be resolved. The Europeans feel they are flexible enough to accommodate to any changes to ISO-1000. (Note: Since the United States also is committed to the SI and has adopted the ISO-1000 as the base documentation for SI units, the Department of Commerce, under its statutory authority for U.S. weights and measures, should move forward to vigorously resolve the questions pertaining to those SI units that are now in controversy or remain unresolved.)

4. The greatest workload, particularly in aerospace, and the key to metrication are in the engineering areas. Metrication in the engineering areas begins with the changeover of documentation required to permit engineering design and from there proceeds through the various engineering phases needed to effect production of the equipment and tools that enable all other phases of metrication to move forward.

5. All aerospace drawings, specifications, standard parts, documentation, etc., have been metricated or converted. Design of new components and new aircraft or systems is in SI.

6. Unspoken, but implied, is that the Europeans have used metrication as a device and motivator for streamlining and updating their systems, procedures, methods, etc., and as a motivator for replacing and updating their production equipment. This should make them more competitive in the marketplace. Both Britain and the F.R.G. are anticipating the need to comply with EEC requirements to conduct trade in metric units by 1978.

7. The need for U.S. participation in the establishment of aerospace standards, whether for American/European standards or as international standards, is evident. U.S. participation is both desired and requested by the Europeans. (Note: The NASA representative recommends that the U.S. aerospace community should become more actively involved in AECMA and ISO, as well as with other organizations such as AIA, the ANSI, and the Society of Automotive Engineers (SAE), which are involved in the establishment of international standards. Federal agencies such as the DOD, NASA, FAA, and the Civil Aeronautics Board (CAB) should provide active participation in these endeavors.)

8. Where international standards do not exist, and in the event that the international collaboration is not forthcoming, the Europeans are prepared to go forward with the establishment and use of European standards.

9. As evidenced by the above, the U.S. aerospace industry will need to set the pace for the U.S. changeover to the metric system. Federal agencies with regulatory authority or legislative mandate should assume leadership in a collaborative endeavor with industry and the public and private sectors in aerospace metrication.

10. Air carriers are waiting on the International Civil Aviation Organization (ICAO) for metrication of flight operations. Here, U.S. participation is mandatory.

11. Most training for metrication has been accomplished in the schools. In all other sectors, only that training needed to accomplish a specific job is given. Training by practical use of SI has been the most expeditious, least costly, and most effective route.

12. No costs write-offs and no government subsidies were provided for metrication. Costs were permitted to lie where they fell, and were handled by industry within normal cost accounting and amortization procedures. The only government funding was that inherent in education and for funding of government agencies such as the U.K. Metrication Board. Because of the costing approach, no cost guidelines were prepared and no metrication cost studies were undertaken. The aerospace sector, like all other sectors, received no government subsidies for metrication. None were sought by the industry, and none were allowed by the government.

13. Costs for metric tools provided by workers in industry were not allowed. Industry provided the metric tools needed to get the job done in-house. This cost was stated to average about $75-$78 per worker.

14. The Europeans believe the least costly route is the shortest phase-over period.

15. The Europeans state that early U.S. metrication for aerospace, particularly in aviation, could be mutually beneficial, particularly in those areas that would minimize nonmetric components and reduce the size of dual inventories.

16. The Europeans are looking to the United States to provide leadership for "space metrication." (Note: This is stated after emphasizing that metrication of all other aspects of aerospace is complete.)

The advice the British and West Germans had for the U.S. aerospace industry may be summed up as follows:

1. Eliminate or minimize hybrids.

2. Do not confuse start of metrication with cessation of use of nonmetric.

3. Carefully watch all cataloging systems; they give what is converted and the rate of conversion.

4. Have a coherent program, and stick to the schedule.

5. Keep all interested parties informed and involved.

6. Do not neglect public relations.

7. Keep abreast of metrication education in school because it impacts industry operations.

8. Too long a time schedule can be overly costly.

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Summaries of talks given to American National Metric Council Delegates during their visit to the Metrication Board, London 4 - 6 October 1976

Attachment 2

THE WORK AND ORGANISATION OF THE UK METRICATION BOARD.

by A B Clarke, Secretary to the Metrication Board

Weights and measures concern many aspects of life. The work of a national body (or Board) concerned with the change from the imperial or customary system of weights and measures to metric has, therefore, to cover a wide field. The Board can only play a limited part. It has to rely on help from other organisations and individuals.

The British Metrication Board's main work comprises -

(a) encouraging all parts of the economy to carry out the change - by publicity and practical help in preparing programmes;

(b) informing the public about the metric system and metric changes;

(c) advising Government Ministers on action needed to bring about the change;

(d) answering enquiries from the public.

Preparing and implementing metrication programmes (including the national programme) involves the following main stages -

Decision to change;
Consultation about methods and timing;
Preparation of programme;
Carrying through legislation when needed;
Informing all parties concerned;
Putting the programme into effect.

The British decision to change to metric was made in 1965. The Metrication Board was set up in 1969. Between 1965 and 1969 the British Standards Institution prepared metrication programmes for engineering and construction. Since 1969 the Metrication Board has, in consultation with those concerned, prepared programmes - for example, for agriculture and horticulture, for fuel and power, for metric sales of fabrics and carpets. But in the case of weighed out foods, the retail trade has been unwilling to commit itself to the change until the Government has powers to fix cut-off dates for the use of imperial measures in trade. The Weights and Measures Etc (No 2) Bill now before Parliament seeks to provide these powers. Otherwise the transitional stage of trading partly in customary units and partly in metric could be long drawn out. This would be costly and confusing.

The British Metrication Board has committees to advise on the change in major sectors. But when programmes are being prepared, *ad hoc* working groups representing the sector concerned have to be organised. Wide consultation is necessary.

The Board's staff are engaged on informing the public, preparing programmes and answering enquiries. But the work of bringing about the change has to be done by people throughout the economy.

INFORMING THE PUBLIC

by Norman Stone, Chief Information Officer, Metrication Board.

The change to metric depends for its success on effective communication with those making and carrying out the metrication programmes and with those affected by them. Informing these publics, who together make up the general public, has always been one of our chief tasks in the Metrication Board and our main executive responsibility. At first we were concerned mostly with the public in the materials industries, in construction, in engineering and in education. More recently we have moved into agriculture and its supplying and marketing industries. Now the main concentration of information is directed towards the consumer goods industries, distribution and retail trades and increasingly towards shoppers. We use the full range of media, paid and unpaid, to make the most of our own resources and we support and reinforce the metric information efforts of industry and consumer organisations.

From now on our information objectives are to help consumers become familiar with the commoi common metric weights and measures they will be meeting increasingly; to give them advance notice of specific metric changes affecting them: to help them retain their sense of value for money during the changeover period: to give special attention to the information needs of the elderly and of handicapped people: in short, to provide reassurance, help and practical working knowledge to all who need it. All our information programmes are backed by research into awareness and knowledge of the metric changes and attitudes towards them.

One of our continuing and growing activities is to provide a general-information service for press, radio and television organisations, for industry and trade associations and for the general public. This is a non-stop dialogue in which we encourage public discussion of the real issues, and try to counter misunderstandings and misrepresentations. We attach great importance to answering questions from the public quickly and accurately. Our publications are designed to increase awareness and impart factual information through leaflets, posters, comparison cards, regular Bulletins and Memos. Some are short-lived, others have a much longer life. Our exhibitions and displays are an effective way for people to gain experience of metric weights and measures through demonstration and audience participation. They also act as a focus for local activities and promotions. Our films show what is actually happening, in industry, on the farm and in the shops. Audiences all over the country identify themselves with the situations on the screen. We give talks and take part in conferences and meetings of all kinds.

To alert very large audiences to the changes taking place, and to familiarise them with the everyday metric weights and measures, we use advertising. So far we have had campaigns in national and regional newspapers, in trade and industry journals, and in women's and consumers' magazines. The metric changes have not yet reached the stage where we will make use of television advertising or of direct mail to all households. The timing of this very intensive stage is crucial and has yet to be determined.

THE USE OF SI IN EDUCATION AND INDUSTRIAL TRAINING

by Professor M L McGlashan, Member of the Metrication Board: Chairman of the Steering Committees for the Fuel and Power Sector and for the Education and Industrial Training Sector: Member of the Steering Committee for the Engineering Industries.

The International System of Units (SI) was devised within the Metre Convention as a simple universal system sufficient for all needs, from those of the scientist and engineer to those of everyday life, and in all countries of the world. And so it is proving in practice. For most people only a small part of the SI is needed, and only that part should be taught (or only a little more than is actually needed). For everyday life, and for many technical jobs too, one needs at most: metre (m) with millimetre (mm), centimetre (cm) [the correction of a stupid misunderstanding that led to the centimetre being regarded by some as not properly belonging to the SI cost us a great deal of time and effort], decimetre (dm), and kilometre (km); square metre (m^2) with square centimetre (cm^2) and square hectometre (hm^2) [or hectare (ha)]; cubic metre (m^3) with cubic centimetre (cm^3) and cubic decimetre (dm^3) [or litre (1, but probably L in the future if CGPM agrees) with millilitre (ml), centilitre (cl), decilitre (dl), and hectolitre (hl)]; kilogram (kg) with gram (g) and megagram (Mg) [or tonne (t)]; second (s) [with the non-SI units min, h, d, and a; but not, or not too much, in compound units]; metre per second (m/s) with kilometre per hour (km/h); pascal (Pa) with kilopascal (kPa); watt (W) with kilowatt (kW); joule (J) with megajoule (MJ); volt (V); ampere (A); ohm (Ω); hertz (Hz); and degree Celsius (^{0}C).

In our schools and technical colleges and universities the teaching of SI units can already be seen to be opening the way to a striking advance in the numeracy of our people, especially of those mathematically less gifted. Even for the most gifted, time previously devoted to elementary arithmetic is now being most profitably used for more interesting things. The introduction of the SI into schools has also been accompanied by a most welcome increase in the attention given to the early introduction of the ideas and practice of measurement; elementary physics, though not under that name, is now being most successfully taught to infants. At the other extreme the use of SI units is already improving communication among scientists and engineers coming from different disciplines and from different countries.

It is hoped that the USA will learn from one of our mistakes; it is highly desirable that as the SI is introduced into schools and colleges it is seen to be being introduced in the market place, on the roads, and in weather reports. However effectively SI units are being introduced into industry and wholesale trade, the child at school (and the teacher) can believe fully in their relevance to everyone only when they are widely seen in use in everyday life.

We regard it as very important that the correct grammar and spelling of numbers and units be taught early and thoroughly (eg 96453 or 96 453 not 96,453; 96.453 not 96.453; kg not Kg or KG or kgm or kgms. or ...). In spite of our efforts the metric markings on our packs and cans are already a horrible mixture of the correct and incorrect. Even at this stage we are finding it necessary to produce a comprehensive but elementary *Style Guide.* Instruction is needed not only for school children but, especially at first, for technicians and engineers, for secretaries and managers, and indeed for all who use units and so help to spread good or bad practice.

METRICATION IN ENGINEERING

by J M Ferguson, C Eng, Member of the Metrication Board:
Member of Steering Committee for the Engineering Industries.

The change to the metric system in the United Kingdom was recognised as a unique opportunity to rationalise product ranges and reduce excessive variety. Metrication and standardisation are closely connected and the growth of international standarisation was as important factor in favour of metrication. Adherence to international standards is the declared policy of the UK: metric is internationally accepted.

The broad time scale for the metric change in the engineering industries was set in 1968 when the British Standards Institution published the basic programme which set an interim target of 25 per cent metric production by 1972 and a main target of 75 per cent metric production by end-1975. The timetable included preparing essential British Standards in metric: making metric materials and components available: design and development: production planning: an overall change to metric production starting in 1970. The BSI achieved the priority task of preparing essential basic Standards in metric and the 1972 target of 25 per cent production in metric was achieved.

Progress in engineering was monitored by sample surveys. The 1973 survey showed signs of slackening momentum and only 44 per cent of production was in metric. This had improved to 58 per cent by the end of 1975 and progress would have been faster if there had not been a general economic recession. There was a significant increase in metric design, with 57 per cent of firms in 1975 doing all their designs in metric, which is important in relation to future production. By 1975 there was an improvement in the availability of metric supplies.

It is important that government should be seen to be taking a lead in metrication. Government purchasing policy (and that of the public sector generally, including nationalised industries) has been to support the change by introducing metric specifications for public puchases where practicable.

There is some evidence that not enough firms have taken full advantage of metrication to maximise the benefits and offset costs by rationalising design and product ranges.

The non-metric North American market and the influence of non-metric American designs have been factors tending to hold back metrication in the UK. Now that it is clear to the engineering industries that the USA and Canada are committed to going metric, the position is rapidly improving.

METRICATION IN AGRICULTURE AND HORTICULTURE

by D H Darbishire, Member of the Metrication Board and Chairman of the Steering Committee for the Agriculture, Forestry, Fisheries and Land Sector.

In 1969 the Metrication Board established a Steering Committee for Agriculture, Forestry, Fisheries and Land to stimulate interest in metrication throughout these sectors and act as a co-ordinating body. In the same year a Joint Metrication Group of the National Farmers' Union was set up as the main metric planning body in farming, to align their metrication programme with those of related industries and sectors and to enlist the support of Government Agriculture Departments which are responsible for legislation affecting the sector. It was clear that a farming metrication programme could only be carried out as part of a general national change.

Following the publication of the Government's 1972 White Paper on Metrication, extensive consultation took place throughout the sector and views were invited on whether the change should be on a gradual basis in step with other industries and trades or whether a co-ordinated timetable should be drawn up. There was overwhelming support for a co-ordinated programme of change centred on the farming year 1974/75. In October 1972 the Government endorsed the principle of a co-ordinated timetable but suggested it should be delayed to the farming year 1975/76. This was broadly agreed. The general aim was substantial completion by the end of 1[illegible]; with planned timetables for industries and trades, supplies and marketing, and conversion to metric of all official activities affecting farming.

The Metrication Board has kept farmers and growers informed and guided by publications, films and exhibitions at agricultural shows. Farming organisations and related associations, trades and industries have organised courses and seminars. Agricultural Training Boards and Colleges provide training facilities for all sectors.

The metric changeover in agriculture is largely completed. The 1976 Annual Farm Review and Agricultural Census were in metric. Most supplies are now marketed in metric; the wool trade is metric; Scottish farm and wholesale milk sales are now in metric and the change in England and Wales is scheduled for October 1976. In 1976 the whole of the home grown sugar operation has been in metric; so has the marketing of cereal crops. Potato producers are using 25 kg as the normal wholesale pack. The fruit and vegetable wholesale trades have agreed in principle to work in metric by January 1977. Sales of livestock from farmers to wholesalers will be in metric from then on.

From the preparation of the timetable in 1972 to date no major problems have been encountered. Farmers have proved adaptable to this change as to others.

METRICATION OF CONSUMER PRODUCTS

by W A Methven, Head of Consumer Goods and Distribution Division, Metrication Board.

The range of consumer goods available in metric has increased substantially over the past decade. However, it is only in the last two years or so that metrication has had a significant effect on everyday shopping.

Textiles, clothing, food and drink, and fuel are the four main classes of goods for which units of measurement are of particular interest to shoppers.

February 3, 1975, was a notable date in the retailing of textiles and carpets. Many retailers then changed to selling textile lengths by the metre and began pricing carpets by the square metre.

Most clothing is now marked in centimetres and inches - for women's outerwear the traditional size codes, 10, 12, 14 etc, remain.

Basic shopping basket foods, such as butter, tea, sugar etc, can be sold prepacked only in quantities prescribed in the Weights and Measures Act 1963. The Act is being amended to permit ranges of metric sizes. Pasta, salt, dried vegetables, breakfast cereals and sugar may be, and are being, sold in metric now: edible fats (butter etc), flour, dried fruit, bread and tea may be sold in metric at various dates from 1 January 1977 to 1 April 1978. Legislation is awaited for the six remaining groups of prescribed quantity foods.

Other prepacked foods may be sold in any quantity. Some products (eg cooking oils, ice cream and soft drinks) are increasingly being packed in round metric quantities.

Foods weighed out by retailers in front of customers (eg wet fish, unwrapped meat and loose greengroceries) may be sold in metric now. Few retailers sell in metric and no timetable for the changeover has been agreed.

Metrication does not affect the unit used for retail sales of electricity. Provided the necessary legislation is forthcoming in good time, coal merchants plan to begin the change to metric trading on 1 April 1978: there are no firm programmes for gas or forecourt sales of fuel to motorists.

Further progress in the metrication of consumer goods is heavily dependent on the Weights and Measures Etc (No 2) Bill being enacted by Parliament. This would give the Government powers to set cut-off dates after which retail sales in imperial would no longer be permitted.

METRICATION AND CONSUMER INTERESTS

by Mrs Ailsa Stanley, Member of the Metrication Board:
Chairman of the Steering Committee for Distribution and Consumer Interests.

In Britain, manufacturing industry led the way in metrication. It is only in the last two years or so that metrication has begun to be manifest in the consumer sector.

It has been suggested that the use of imperial measures should continue in the consumer sector although industry uses metric measures. This is impracticable and uneconomic.

It is not possible to have one M-day on which all consumer goods should change. So we have aimed for sector by sector changeover on a voluntary basis.

In most sectors of retail trade, however, the voluntary system has about reached the limit of its effectiveness. Retail, consumer and industrial organisations have drawn attention to the need to complete the changeover in an orderly manner. The only way to achieve this is the establish cut-off dates after which the use of imperial units for purposes of trade would not be permitted.

The Government has introduced the Weights and Measures Etc (no 2) Bill which would empower it to establish such cut-off dates after consultation with the consumer and trade interests affected.

Consumers are naturally apprehensive about metrication. The Board and the Government are taking steps to reassure them by providing information at the right time and by some degree of price surveillance.

The Board's Steering Committee for Distribution and Consumer Interests set up a Working Group to assess the need for, and to evolve, consumer aids. As a result several aids have been issued and more are under consideration. Draft aids are subject to pilot trials with consumers and retailers, both directly by the Board and through professional market research organisations.

The Board has been concerned lest its information effort for the general public was not sufficient for, or did not reach, elderly people. Our publication *Metrication and Elderly People* sets out the main findings of commissioned research into this question together with the action which the Board recommends should be taken.

We encourage retailers to ensure, in their own interest, that their staff are knowledgeable about metric changes in their shops so that they can answer shoppers' questions. The Distributive Industry Training Board, with which we have collaborated, can help retailers to train their staff in metrication.

Experience so far indicates that informed consumers adjust to short-period changeovers to metric without great difficulty. But prolonged changeovers are liable to confuse them and to make it more difficult for them to judge value for money.

METRICATION IN THE CONSUMER FIELD-A MANUFACTURER/RETAILER VIEWPOINT

by D M Landau, Deputy Chief Executive, Co-operative Wholesale Limited: Member of the Metrication Board.

Metrication in the retail sector is a most important factor in the whole metrication process in the United Kingdom. Success in this sector depends on all parties, not only retailers, playing their role effectively. If anyone fails, retailers will have to bear the brunt.

The co-operative organisation, particularly the Co-operative Wholesale Society, is in a unique position because it is (a) involved in all stages, from primary producer to retailer, and (b) primarily a consumers' organisation. The scope and market penetration of the co-operative organisation in the United Kingdom is unique.

The main factors in the Co-operative Wholesale Society's preparation for metrication are -

(a) acceptance of metrication;
(b) overall objectives: to achieve maximum benefit at least cost and to ensure no detriment to consumer service;
(c) internal planning, organisation and implementation of metrication;
(d) liaison with retailers;
(e) liaison with Government, trade bodies and the Metrication Board.

Retailers want a smooth orderly change to metric but they cannot do the job alone. They look for support and co-operation from manufacturers and Government and statutory bodies. They want the changeover to be made as easy as possible for consumers.

Retailers with weighing equipment which registers only in imperial will at some point in time have to have these converted or replaced by equipment which registers in metric.

Retailers were thought by many members of the general public to have taken unfair advantage of the change to decimal currency. Retailers are anxious to avoid any similar deterioration in retailer/customer relations during the change to metric. The United Kingdom is part of a world commercial structure which is almost wholly committed to the metric system, neither this country nor its retailers can opt out.

THE TECHNICAL ASPECTS OF METRICATION

by J G H Deacon, Technical Services, Metrication Board.

The Metrication Board's Technical Services Section is staffed by engineers. Some of the matters which have arisen in the course of the Section's work are -

(a) giving advice on the availability of technical information and on technical problems.

For example, during the metric change there is an important need for training aids, learning texts and technical literature. The Section has advised both on the production of such publications and on the availability of bibliographies. Other matters on which advice has been provided are -

metric measuring instruments, eg
micrometers, verniers, sine bars;
names for parts of a millimetre;
the availability of appropriate metric design data;
the use of SI symbols in typewriters and computers;
metric screw threads and wrenches.

(b) checking that the Board's publications are correct with particular regard to technical aspects and the accepted rules of metric style and the presentation of numerals.

(c) giving advice to industry on practical aspects of the change - for example the costs of converting machinery and equipment and the use of indexing dials in machine tool conversion.

(d) dealing with enquiries from industry and the public on the approved metric units of measurement and on conversions - metric to imperial and imperial to metric. The Section keeps lists of published conversion tables, wall charts, slide converters, ready reckoners etc. It also provides advice on price conversions, the use of the decimal marker and the use of the centimetre.

METRICATION IN THE CONSTRUCTION INDUSTRIES

**by A B Clarke, Head of Industries Division,
Metrication Board.**

Construction was one of the first major industries in Britain to commit itself to the metric change. Its metrication programme was published in February 1967. To begin with, metrication was linked with the process of co-ordinating the dimensions of components and assemblies to achieve economies and more accurate fits. In the event metrication went ahead faster than dimensional co-ordination and the two concepts became separated.

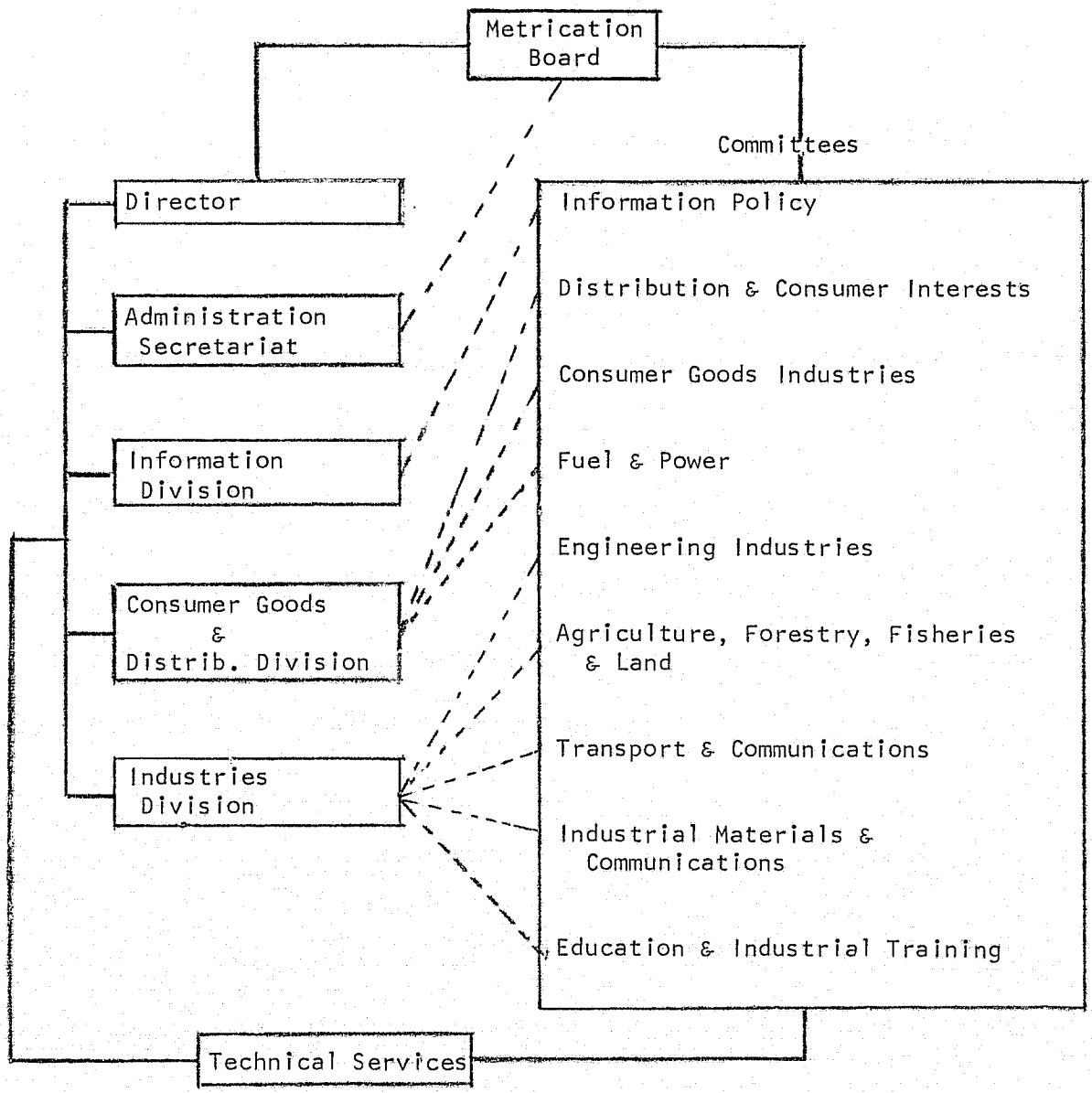
The British Standards Institution played a central role in planning the change in construction - the Metrication Board had not been set up by then. The planning and preparation also involved all the organisations within and associated with the industry - professional institutions, trade associations, supplies industries, education and training organisations and Government departments. Arrangements were made to monitor the changes, identify existing and potential difficulties and to co-ordinate the whole programme. Government departments and other public authorities supported the industry by specifying their requirements in metric. Manufacturers of the construction industry's supplies announced programmes to make metric sized supplies available by 1972. The Building Regulations were changed to metric in 1972; this was a watershed in the history of the change.

Some studies of early metric projects showed that the industry had been able to adjust rapidly. The professionals - architects, surveyors etc - were conscious of the need for reform and innovation and found a ready response in the large construction firms. The change stimulated the general examination by management of procedures and practices. The most important general conclusion was that metric measures could be used from the start throughout and working in both measurement systems should be avoided. Apart from some slowing down in estimating in the early stages and some training costs, the only cost definitely attributable to the change was the purchase of measuring instruments.

By the end of 1973 over 80 per cent of new construction work was being designed in metric. The metric change in construction is now largely completed, but part of the industry, especially the sector concerned with maintenance work and extensions, is likely to continue working in imperial for some years, even when all new construction is in metric.

The construction industry's requirements for metric supplies and components helped to influence related industries to change to metric but if more changes had been happening in other industries and in the consumer sector, the construction programme would have been achieved more easily.

ORGANIZATION CHART OF THE U.K. METRICATION BOARD



Attachment 3

Persons in Attendance

at the

Aerospace Meetings

in the

United Kingdom and Federal Republic of Germany

United Kingdom

Ken Callis
U.K. Assistant Director
Metrication, Ministry of Defense

Brian Black
Civil Aviation Authority
Air Worthiness Division

R. A. Jones
Head of Standards, BAC Ltd.

H. R. A. Delleroche
U.K. Civil Aviation Authority

John Bancroft
Assistant Chief Standard
Engineer for Rolls Royce, Derby

Henry S. Bottoms
Chief Design Engineer
Lucas Aerospace Ltd.

J. E. Tomlinson
British Aluminum Co., Ltd.

Federal Republic of Germany

Werner Goetell
Coordinator of Special Assign.
Messerschmitt-Bölkow-Blohm

F. G. Flamm
Central Mgt for Mfg Production
Messerschmitt-Bölkow-Blohm

H. Amthur
Aircraft Division
Messerschmitt-Bölkow-Blohm

United States

Lt. Col. Robert A. Mangum
U.S. Army, Mat. & Readiness Com.
for Department of Defense, Wash., DC

J. Stuart Jamison
Office of Aviation Systems Plan
FAA - Washington, DC

M. M. Casey
FAA - London

P. Vlannes
Dep. Dir. Sci & Tech Info Office
NASA Headquarters, Washington, DC

J. G. Davis (Chairman)
Boeing Commercial Airplane Co.
Seattle, Washington

QUESTIONS AND ANSWERS RELATING TO METRIC CONVERSION IN THE AEROSPACE INDUSTRY
(F.R.G.)

1. What is the status of the amendments proposed to the European Economic Community (EEC) Directive on Units? A decision was to be reached by August 31, 1976. What is the status of implementation? Are the units of nautical mile, feet, and knot prohibited after December 31, 1977? If so, has the International Civil Aviation Organization (ICAO) accepted the change?

   Answer The directive remained unchanged. The BDR adheres to "The Lawful Units in Technology" with rules and production regulations. We cannot make any statements for the International Civil Aviation Organization. You have to contact ICAO, resp., Boeing in this matter.

2. Will only SI units as defined in International Standard (ISO)-1000 be used? If not, what are the exceptions?

   Answer Units according to ISO 1000 are being used. (Modifications in the LN original copy -February '75).

3. Will "Conventional Units" sometimes be converted to Metric (1/4 inch= 6.35mm; referred to as "Soft Metric" conversion)? If so, when and why is this done? When this is done how do you determine the Metric tolerances?

   Answer American drawings used in production (tooling machines produce metric) are being converted. Tolerances are established according to the "Handbook on Conversion Keys for Production Drawings in Inches".

4. What conversion process is being implemented toward producing a totally Metric designed vehicle? Standard Parts, Specifications, Allowables, etc?

   Answer Our developments are based on the metric system.

5. Will all drawings, specifications, standard parts, documents, analyses, etc., use the same Metric units? Or are units such as millimeters, centimeters, and meters used interchangeably?

   Answer The metric unit for scaling aircraft construction drawings is mm.

6. Do you expect to use dual dimensions in drawings, documents, specifications, etc.?

   Answer For our drawings no (American drawings yes?)

7. Will the vehicle performance be expressed solely in metric? How about the engine? Vehicle systems (hydraulic, electrical, environmental control, flight controls, etc.)?

   Answer For aircraft based on the British system of units in inches; for aircraft based on the metric system in mm; for military developments in metric units

8. Will all standard parts be designed using only Metric units? If not, which parts and why?

   Answer Yes (otherwise it depends on cooperation)

9. Do you use a comma or a point for the decimal indicator?

   Answer Comma

10. We would like to have a list of the units to be used, both Metric and "Conventional" should some be retained.

    Answer ISO 1000, LN-Design, MBBN 158

11. What impact do you expect the U.S. Metric conversion rate of implementation in its Aerospace Industry will have on your Aerospace Industry; Military and Commercial?

    Answer Currently both systems are used (British and metric); would appreciate metric only.

12. What problems do you expect the vehicle user will encounter with a mix of Metric, partial Metric, and "Conventional" unit vehicles? How will they be solved?

    Answer Double spare part pool. Technical solution so that nothing happens

13. To what extent is Air Traffic Control converting to Metrics? Is it expected they will totally convert to SI or will some conventional units be retained? Which units will be retained?

    Answer Has to be answered by Air Traffic Control

14. What training of employees was used and how much?

    Answer Handbook on conversion keys

15. What cost impacts do you visualize?

    Answer Cheaper with metric only; currently both systems are used (British and metric)

16. What advice do you have at this time for the U.S. Aerospace Industry?

Answer To metricate together with the U.S.A and not to introduce a new system. The U.S.A. established after the war measurements for the aircraft production. It is regrettable that the U.S.A. did not metricate earlier.
The standardization Agency Aviation and the aviation industry (MBB), Dornier, VFW-Fokker, MTU) are interested in a joint hearing and wish to help, especially since the BDR has experience in conversion (British and metric units).

It is recommended that the U.S.A. take part in AECMA.

QUESTIONS AND ANSWERS RELATING TO METRIC CONVERSION IN THE AEROSPACE INDUSTRY
(U.K.)

1. What is the status of the amendments proposed to the European Economic Community (EEC) Directive on Units? A decision was to be reached by August 31, 1976. What is the status of implementation? Are the units of nautical mile, feet, and knot prohibited after December 31, 1977? If so, has the International Civil Aviation Organization, ICAO, accepted the change?

   Answer This is a question for B.S.I. or the Metrication Board.

2. Will only SI units as defined in International Standard ISO-1000 be used? If not, what are the exceptions?

   Answer For aero engines a selected list of units has been produced from ISO-1000. This is Rolls Royce document JDS 1800.01.

   AECMA are producing a similar document.

   Rolls Royce have also produced a document to provide representation for units, in place of their international symbols, for use in systems with limited graphic character sets viz: JDS 1800.02. This agrees with ISO 2955-1974.

3. Will "Conventional Units" sometimes be converted to Metric (1/4 inch = 6.35mm; referred to as "Soft Metric" conversion)? If so, when and why is this done? When this is done how do you determine the Metric tolerances?

   Answer For new design work there will be no soft conversion. However, retrospective conversion of existing engines, for example, for license agreements will involve soft conversion. In the latter case a precise conversion of tolerances related to the fineness of the inch tolerance is specified.

4. What conversion process is being implemented toward producing a totally Metric designed vehicle? Standard Parts, Specifications, Allowables, etc?

   Answer The conversion so far has centered around providing a complete manufacturing facility to handle metricated drawings and specifications. Manufacturing are using Engineering Drawings and Specifications which are only specifying the selected metric units in answer 2 above. Standards for cutting tools have been 'hard' converted, e.g., drills, cutters, tool radii, etc.

   Raw Materials

   Sheet sizes - Purchase are allowed to use acceptable listed inch or metric equivalent depending on commercial price advantages.

Tube sizes - Inch sizes still selected for engines for U.S.A. market. Metric sizes selected for European military applications.

Wire sizes - Inch sizes still used in view of large stocks held but position is under review for change to metric as and when commercial considerations demand it.

5. Will all drawings, specifications, standard parts, documents, analyses, etc., use the same Metric units? Or are units such as millimetres, centimetres, and metres used interchangeably?

Answer Units on drawings, specification standards parts, etc., will only use the Metric units selected in JDS 1800.01, as stated in answer 2 above. Exceptions are permitted with numerical values less than 0, 1 or above 1,000.

6. Do you expect to use dual dimensions in drawings, documents, specifications, etc.?

Answer Dual dimensioning was adopted initially but is now dropped except where demanded by contract.

Mainly SBAC standards are dual dimensioned and this is for the benefit of users outside of Rolls Royce, e.g., customers in U.S.A. for instance. New "hard" metric standards are in metric units only but these would not be used on orders from the U.S.A. market at the present time.

7. Will the vehicle performance be expressed solely in metric? How about the engine? Vehicle systems (hydraulic, electrical, environmental control, flight controls, etc.)?

Answer Performance figures for engines other than for engines designed in conjunction with European partners and for military uses are still specified in Imperial units mainly for the requirements of the U.S.A. market.

8. Will all standard parts be designed using only Metric units? If not, which parts and why?

Answer All standard parts with the exception of threaded parts will be designed in Metric units. For commercial reasons threaded parts for engines will not be converted to metric until U.S.A aero engine companies make this change.

9. Do you use a comma or a point for the decimal indicator?

Answer Rolls Royce use the comma to agree with Continental practice. This practice is also adopted by SBAC for standard drawings, See SBAC spec. TS 66 para. 6.2. The decimal point is permitted for computer work.

10. We would like to have a list of the units to be used, both Metric and "Conventional" should some be retained.

    Answer List of units to be used is as for answer 2.

11. What impact do you expect the U.S. Metric conversion rate of implementation in its Aerospace Industry will have on your Aerospace Industry; Military and Commercial?

    Answer U.S.A. Metric conversion rate of implementation will decide the completion date of the Rolls Royce conversion, e.g., adoption of metric threads, performance figures.

12. What problems do you expect the vehicle user will encounter with a mix of of Metric, partial Metric, and "conventional" unit vehicles? How will they be solved?

    Answer The biggest problem for the airline operator will be the need to double his inventory of spares to maintain both existing "inch" aero engines and new "metric" aero engines. The full impact of this will be felt when metric threaded fasteners are universally adopted for U.S.A. and U.K. aero engines. It is our opinion that standards such as rivets which have been established on the Continent as metric standards but are nevertheless "soft" conversions should be maintained in order to reduce the costs of conversion. After all the main benefits of going metric is that all countries are able to compromise. If acceptable metric standards exist these should be used. We should at all times be concerned about cost, maintainability and safety.

13. To what extent is Air Traffic Control converting to Metrics? Is it expected they will totally convert to SI or will some conventional units be retained? Which units will be retained?

    Answer This is a question for Air Traffic Control.

14. What training of employees was used and how much?

    Answer Selected personnel from each department were put through a course at our training centre and these people subsequently desseminated their knowledge throughout their respective departments. Training courses were tailored according to the requirements of disciplines, e.g., typists, technicians, draughtsman.

15. What cost impacts do you visualize?

    Answer There is a cost involved and whilst the incentive to change are fairly logical and acceptable for military projects it is not clear looking at the problem from the UK/USA view point what incentive would trigger off the requirement for change in the commercial aircraft business. Such a change can only mean an increase in the first cost of the product and for at least 20 to 30 years, there will be the added doubling of inventory costs referred to in answer 12 above.

16. What advice do you have at this time for the U.S. Aerospace Industry?

Answer One step that must be avoided at all costs is a conversion to metric on a standard that is not ISO approved. This step will never be cost effective.

List of Items in Folders

Issued to

Members of the U.S. Metrication Study Mission

to the

United Kingdom

Item No.	No. of Pgs.	Title/Remarks
1	92	Advantages of the Metric System by A. J. Ede. Copyright 1972. SBN 11700183X 55p net
2	2	Flyer (MG3) - Going Metric-The Metric World. August 1975
3	2	Flyer (MG5) - Going Metric-Engineering Industry Manuals. Jan. 1976
4	2	Flyer (MG9) - Going Metric-Films. Nov. 1975
5	2	Flyer (MG10) - Going Metric-Metrication in Britain. June 1975
6	2	Flyer (UM1) - Going Metric-The International Metric System. Feb. 1976
7	2	Flyer (IM1) - Going Metric-Steel Sheet and Plate. Mar. 1972
8	2	Flyer (IM2) - Going Metric-Steel Conduit and Fittings.
9	2	Flyer (IM3)- Going Metric-Aluminum Sheet.
10	2	Flyer (MG15) - Going Metric-Fabrics and Clothing.
11	2	Flyer (MG18) - Going Metric in the Petroleum Industry
12	2	Flyer - Going Metric-Using a Metric Micrometer.
13	4	Flyer - Going Metric in the Kitchen.
14	4	Flyer - Going Metric-Four Filmed Reports from Industry.
15	12	Pamphlet - Going Metric in the Small Firm - A Practical Guide for Management.

Attachment 6

Item No.	No. of Pgs.	Title/Remarks
16	22	Booklet - Going Metric-Farming and Horticulture
17	32	Booklet - Report on Metrication in the Construction Industry. Copyright 1974 - ISBN 0 11 706 1996
18	4	Flyer - Metric Memo (M1-revised) Metric Identification
19	4	Flyer - Metric Memo (M15-revised) Metrication of Land Measurement and Maps
20	4	Flyer - Metric Memos (M31) Metrication and Cookery Recipes
21	4	Flyer - Metric Memo (M33) Metrication of Prepacked Foods - A Background Note for the Food Trade
22	4	Flyer - Metric Memo (M34) Metric Progress in the Engineering Industries, 1975
23	2	Flyer - Metric Memo (M35) Metric Price Comparisons for Farmers
24	2	Flyer - Metric in Shops, May 1975
25	4	Flyer - Going Metric-Quarterly Issue No. 17, Oct. 1975
26	4	Flyer - Going Metric-Quarterly Issue No. 18, Jan. 1976
27	4	Flyer - Going Metric-Quarterly Issue No. 19, May 1976
28	20	Document - Metrication in Retail Trade
29	18	Assorted Flyers - Information for the Handyman on Metric Materials, Tools, and Components Now Available
30	30	Document - Value for Your Money in Metric - Report of the Consumer Safeguards Group - 1973
31	68	Document - Metrication and Elderly People, 1976
32	40	Document - Going Metric: Progress in 1975. Copyright ISBN 0 11 700310 7. £1.49 by post.
33	2	Pocket Table for Engineers - SI Einheiten- (Developed by Messerschmitt-Bölkow-Blohm (MBB))
34	2	Pocket Table for Engineers - SI Units-Developed by Derby Engine Division, Rolls-Royce Ltd)

Selected items from this listing are available (photo-copies) upon request. Items 1 and 32 should be purchased through your normal procurement channels.