Objectives and Content of AASHTO *Guide to Metric Conversion*

DANIEL S. TURNER AND JAY K. LINDLY

In response to congressional action and an executive order AASHTO formed a task force to investigate metrication. In its report, the task force recommended development of the AASHTO *Guide to Metric Conversion*. The guide, a document prepared to help steer the American highway industry through metric conversion, was prepared by the University of Alabama, through a contract with NCHRP. Chapters in the guide introduce the reasons for conversion, give examples of conversions by other nations, outline the steps in forming an agency conversion plan, give hints and suggestions, and provide checklists of suggested activities. Appendexes provide tables of metric conversion factors, critical geometric design criteria expressed in metric units, and case studies that list conversion activities and estimated costs for two branches of highway agencies. Example materials taken from the guide are discussed to illustrate the content of the document, which was published by AASHTO in 1993.

The United States is converting to the metric system of weights and measures. Metrication was mandated by congressional legislation and by an executive order. This change reflects two significant factors: the move toward a global economy and the fact that the world's measurement system is now metric.

As of 1991, the United States was the only industrialized nation in the world that had not converted to metric (*1*). Congress, in adopting the Omnibus Trade and Competitiveness Act of 1988, amended the Metric Conversion Act of 1975 to require the federal government to convert to metric. Executive Order 12770 was issued on July 25, 1991. It required federal agencies to convert to metric under the leadership of the Secretary of Commerce within a fixed period of time.

In response to the congressional legislation and the executive order, FHWA formed a metric conversion plan that was approved on October 31, 1991. The plan called for an orderly series of conversion activities, terminating with a requirement that, after September 30, 1996, all direct federal and federal-aid construction contracts must be in metric.

PURPOSE OF PAPER

This paper was written to chronicle AASHTO's response to the federal metrication initiative and to introduce the AASHTO *Guide to Metric Conversion*. The objectives and content of the guide are covered in the remainder of this paper.

AASHTO ACTIONS

AASHTO's Standing Committee on Highways selected a metrication task force in 1991 that was chaired by Robert L. Clevenger, of the Colorado Department of Transportation. The task force was asked to work with FHWA to address the effects of converting to the metric system.

The task force identified three primary issues for early attention: (a) timing—meeting the conversion schedule adopted by FHWA; (b) cost—looking for cost-effective approaches; and (c) public relations—having a public awareness/information program. After assessing the overall situation, the task force obtained a budget from AASHTO that allowed it to take several decisive actions:

1. A resolution was prepared (and sent to the AASHTO policy committee) requesting the U.S. Department of Commerce to develop and implement a public awareness program.
2. A consultant was engaged to review the Canadian conversion experience and to prepare a summary report. The consultant also arranged a meeting between the task force and members of the Ontario Ministry of Transportation.
3. Requests were sent to all AASHTO subcommittees requesting that hard and soft conversions be reviewed and that conversion factors be developed in each subcommittee's area of expertise.
4. A second consultant was engaged to prepare a comprehensive metric conversion guide report.

The task force continued to function throughout 1992, periodically reviewing the work of its consultants and otherwise helping position AASHTO and the American highway industry to move smoothly forward with metrication. The metrication guide was approved by the task force in early November 1992 and forwarded to AASHTO for review and printing.

DEVELOPMENT OF AASHTO GUIDE

In March 1991 NCHRP issued a contract to the Civil Engineering Department of the University of Alabama to develop the AASHTO *Guide to Metric Conversion*.

The objective of the project was to develop a comprehensive guide document on metric conversion that could be considered for adoption by AASHTO. It would provide guidance to AASHTO and to national, state, and local transportation agencies on the planning, procedures, and actions necessary for conversion to metric. Materials were to be included to emphasize aspects of cost minimization—that is, methods by which unit costs and total costs could be reduced and possibly absorbed into the existing budgets of transportation agencies.

Under the guidance of the NCHRP Project Panel, the university developed a draft outline of the proposed guide. It included a main report text providing an overview of factors to be considered, the planning to be accomplished by the various departments within

Civil Engineering Department, University of Alabama, P.O. Box 870205, Tuscaloosa, Ala. 35487-0205.

agencies, and the sequential steps necessary for a smooth conversion. The planned report was also to summarize previous studies on metric conversion, to include several case studies on the conversion of branches of modern state highway agencies, to include flow charts or critical path method (CPM) charts, and to transmit any of AASHTO's new metric criteria that might be adopted by the time the guide was published.

Preparation of the guide was accomplished under the guidance of the NCHRP panel using the following work steps:

1. A literature review was conducted, using automated and traditional search procedures, telephone calls to knowledgeable experts, and interviews.
2. An outline was developed for the proposed report. It was annotated to show important topics and subtopics, and where possible it identified materials that could serve as source documents for preparation of each portion of the guide.
3. The NCHRP project panel reviewed the draft outline and offered suggestions and improvements.
4. The university prepared a list of key items for consideration for conversion. This list was organized by level of government, type of agency, highway functional area, and type of activity. The purpose was to begin developing categories of information for the guide.
5. The university developed the first draft of the guide using the list of key considerations, the annotated outline, and the literature review.
6. The NCHRP panel circulated the draft widely, gathered review comments, and offered constructive criticisms.
7. The university modified the draft document and provided a manuscript in a format suitable for publication by AASHTO.
8. The NCHRP panel balloted and approved the manuscript. Likewise, AASHTO balloted and approved the manuscript. Finally, the guide was published and assimilated by AASHTO in the spring of 1993.

The timetable for production of the guide was extremely compressed. The contract was issued in March 1992. The goal of the university was to have a first draft ready in time for review before the AASHTO annual meeting in October 1992. This meant that the majority of the project work had to be completed within 6 months. This somewhat constrained the number of activities that could be conducted and the amount of materials that could be placed within the guide. For example, the case studies were limited to states already deeply involved in metric conversion, and those within reasonable travel distance from the university. It also made it very difficult to collect and publish new metric criteria adopted by AASHTO. Most of the committees and task forces that were charged to develop metric criteria could not finish the experience and submit their results for balloting before publication of the guide.

CONTENT OF GUIDE

The guide is organized to make key pieces of information easy to find. The material is arranged topically, with each chapter devoted to a separate subject. The broad topic areas include reasons for making the change, procedures for forming a plan, hints and suggestions, and extensive checklists.

Chapter 1 contains an introduction to metrication and enough historical and background information so the user can understand why conversion is necessary. Important legislative and government activities are also introduced. Chapter 2 outlines the metric conversion experiences of other nations. The successful conversion of Canada in the mid-1970s provided a good example for the United States.

Chapter 3 lists the major steps in forming a metric conversion plan. Each step in the process is discussed sufficiently to guide agencies in forming their own plans. Practical hints and suggestions have been grouped into Chapter 4. These are useful in choosing strategies to enhance cost-effectiveness, improve timeliness, and avoid pitfalls. Chapter 5 contains extensive checklists of possible conversion activities. These are grouped by general process and by highway functional area.

The appendexes include a list of state highway agency metric coordinators; a review of metric units, terms, symbols, and conversion factors; example flow charts for conversion activities; interim AASHTO metric criteria for geometric design; two cases studies of conversion plans for branches of state highway agencies; and a bibliography of metric references.

Chapter 1: Introduction

Chapter 1 provides background information for metrication of the United States highway industry. It starts with an historical overview. The metric system started in France at about the time of the French Revolution (*2*). Over time it was improved and standardized, and in 1960 the General Conference on Weights and Measures adopted the International System of Units. This version of metric is known by its abbreviation SI and is now the most-used measurement system in the world.

Chapter 1 goes on to explain the necessity for conversion. With all of the world's other nations working in metric, U.S. businesses are at a distinct competitive disadvantage. This disadvantage will grow larger over time if the United States does not convert.

Several benefits of metric conversion are discussed in this chapter. These include international acceptance of metric, conversions already under way in the private sector, simplicity of use and calculations, and the opportunity to "rationalize" or redesign operations during the conversion process.

The majority of this chapter is spent outlining the legal basis for highway conversion. The Metric Conversion Act of 1975, the Omnibus Trade and Competitiveness Act of 1988, and Executive Order 12770 are explained. Department of Transportation (DOT) metric conversion planning guidelines and FHWA conversion activities are also reviewed.

Chapter 2: Conversion Experiences of Other Nations

Chapter 2 draws from the conversion experiences of other nations to illustrate some of the aspects of metrication. A large number of nations made the conversion in the 1960s and 1970s. America's neighbor Canada had a conversion experience that was almost uniformly positive. The Roads and Transportation Association of Canada (the equivalent of AASHTO) let this change. The Canadian experience provided many positive examples for America, including the following:

- Architectural and engineering firms found that it took less than 1 week for staff members to learn to think and produce in metric. Most tradespeople were able to adapt within hours.

- The changeover of highway signs turned out to be the biggest "non-event" in the entire conversion experience (*3*), thanks to a thorough public awareness program.
- The highest cost area was conversion of signs, followed by conversion of computer programs, then staff training, and public information.
- Thorough planning and a good public awareness campaign improved the success of the metrication program.

This chapter of the guide concludes by emphasizing three primary lessons found in the metrication of other nations: (a) metrication was not difficult once the decision was made to proceed, (b) the process should begin early because there is never too much time, and (c) strong leadership must be established at the top.

Chapter 3: Forming a Metric Conversion Plan

Chapter 3 establishes the broad general steps that are used to form metric conversion plans for individual agencies. Whether an agency is large or small, the same general steps are used, including the following:

- The agency leadership demonstrates metric support.
- A metric coordinator is named.
- A metric committee or work group is formed.
- A study is undertaken to identify activities and programs subject to conversion.
- An agency conversion plan and timetable are formulated.
- Conversion responsibilities are assigned to individuals and sections of the agency.
- Metric standards are established.
- A public awareness program is planned and conducted.
- Laws and statutes are revised to reflect metric units and to encourage the conversion process.
- Coordination efforts are conducted with other government agencies, units of local government, industry, contractors, materials and equipment suppliers, professional organizations, utility firms, and others.
- Metric training activities are conducted.
- The plan is monitored and modified as necessary to ensure implementation.

The chapter goes on to explain each of these basic steps. For example, qualifications and responsibilities of the metric coordinator are discussed. This job probably will be a full-time responsibility for at least the first portion of the conversion program. This individual should have the authority to make most metric decisions and may need a separate budget and staff members. This person should have a sound knowledge of the overall operation of the agency, a good working relationship with people, and a personal interest in the metric system (*4*). The primary job of the metric coordinator will be organizing and leading the conversion. However, training and dispensing metric information will occupy large portions of this person's time.

The remainder of this chapter amplifies the other steps in forming and implementing the plan. For example, metric standards and criteria must be adopted during the early portion of the process. Otherwise, it is impossible to revise agency publications, specifications, and other documents to conduct the conversion. Likewise, changes to laws and regulations must begin early because these are normally time-consuming, lengthy experiences.

An important part of the overall conversion is continuous and close coordination and liaison activities within each agency. The metric coordinator must be kept informed of each step during plan development and implementation by each section of the agency. The coordinator must ensure that every work unit is aware of the conversion plans and current status of every other unit, and of the agency as a whole.

It is very important for each agency to develop information networks to provide coordination with affected groups. Other units of government (environmental organizations, policy organizations, permitting organizations, etc.) must be kept informed. Likewise, contractors' organizations, utility firms, consulting engineers, and many others must be aware of the conversion timetable so that they can plan their own conversions. It would not be realistic to expect contractors to suddenly begin building roads in metric without prior knowledge of the desired timetable. Other topics discussed in the chapter include methods for educating and training employees on metric issues and monitoring the conversion implementation program.

Chapter 4: Hints and Suggestion

Chapter 3 outlined the major steps in a typical metric conversion plan. Application of any step to a particular highway agency is a matter of preference and degree of emphasis necessary to fit the needs of that agency. Chapter 4 was written to provide helpful hints and suggestions to help agencies tailor and fine tune the contents of their conversion plans.

This chapter contains a sampling of ideas from countries that already have converted and suggestions taken from current publications. A total of 15 major topics are discussed:

- Computer programs and data bases,
- Costs,
- Conversion of historical data,
- Discouraging use of dual units,
- Equipment modifications and purchases,
- Granting exceptions,
- Flexibility of the plan,
- Hard and soft criteria,
- Materials,
- Metric pilot projects,
- Conversion of publications,
- Rationalization,
- Screening for errors,
- Metric highway signs, and
- Timing.

For each of these topics, enough discussion is included to provide a rationale for forming a strategy. Reasons are often given why one type of conversion activity might be preferred over another type.

An example is the discussion on discouraging the use of dual units. The natural tendency for people is to prefer that dual (both U.S. and metric) units be used whenever possible. Unfortunately, as long as U.S. units are used (even in dual listings) people read only the numbers given in U.S. units. They will not convert. It is best to discourage dual listings. The FHWA plan indicates that

dual measurements are to be avoided after fiscal year 1993 unless it is determined to be beneficial in specific instances. (*5*).

Chapter 5: Checklists

Chapters contains a series of checklists that are provided as convenient reminders to those agencies preparing conversion plans. Two broad categories of checklists are presented: (a) general processes and (b) highway agency functional areas. Highway agencies of any size or any level of government may use the checklists to identify appropriate activities for their conversion plans.

This chapter is the largest in the guide. This allows agencies ample opportunities to pick and choose from the suggested activities. The following general processes are covered:

- Awareness and training;
- Contracts;
- Equipment;
- Formats and forms;
- Legislation and regulations;
- Machinery;
- Manuals and references;
- Materials and supplies;
- Output, communications, and publications;
- Conversion management;
- Standard specifications and policies;
- Storage; and
- Tools, jigs, and templates.

In addition to the general topics, additional checklists are provided for the following highway functional areas:

- Computer services;
- Construction;
- Environmental concerns;
- Location, surveys, and photogrammetry;
- Maintenance;
- Materials;
- Management systems;
- Planning and coordination;
- Preconstruction or design;
- Research;
- Right of way; and
- Traffic engineering.

These lists are not exhaustive, but they do include most of the functions and activities performed in a normal highway agency. These checklists should be considered only as starting points or reminders for the agency during preparation of its own unique plan.

Appendix A: State Highway Agency Metric Coordinators

Appendix A contains a list of the persons appointed as metric coordinators for the various state highway agencies. It also includes as resource persons three Canadian managers familiar with that country's conversion experience. The authors recognize that this list will rapidly become out of date. However, it provides names, addresses, and telephone numbers that will be of great use during the early stages of conversion. It allows the state-level coordinators to telephone each other. It also provides local governments and others possessing copies of the guide access to the appropriate state highway agency coordinators. This should provide timely access to information about ongoing conversion activities.

Appendix B: Metric Units, Term, Symbols, and Conversion Factors

FHWA has adopted the SI version of metric and has adopted the provisions of ASTM E380 Standards of Metric Practice as the authoritative reference to proper use of SI. This appendix contains extremely useful references to types of units, symbols, prefixes, pronunciations, and rules for writing metric symbols and names. It also contains useful tables of conversion factors from U.S. units to metric units.

Appendix C: Example Flow Charts

To assist in preparing conversion plans, Appendix C contains several typical flow charts. Examples include two flow charts from the FHWA metrication plan. Several flow charts developed during the Canadian conversion are also displayed. These range from very simple overviews to complex CPM charts showing the earliest and latest possible start dates for each conversion activity to complete all activities within the allotted time frame.

Appendix D: AASHTO Metric Criteria and Controls

Each AASHTO committee and task force was asked to recommend metric criteria for its appropriate area. This appendix contains the interim recommendations of the Subcommittee on Design. These criteria have been approved by AASHTO and are tentatively scheduled for inclusion in the next version of the Green Book.

Over time, virtually all AASHTO controls and criteria will be converted to metric. This will be a lengthy process requiring balloting of the states. Some interim criteria might change as the states gain experience in using them. Although some of the new criteria are contained within the guide, readers are reminded to check with AASHTO for the most up-to-date criteria before initiating a design.

Appendexes E and F: Case Studies

Two cases studies are included in the guide. The first study documents the preparation of a metrication plan by the Maintenance Bureau of the Alabama Highway Department. The second case study involves development of a metrication plan for the Design Section of the North Carolina Department of Transportation. Each case study is presented in abbreviated form.

For both states, a general description is included of the highway agency and the roadway system. Information is presented on the size and function of the bureau or section under study. This allows the reader to make comparisons with his or her own highway

agency. The steps undertaken during the studies and the resulting plans are summarized in these appendexes, and both include conversion cost estimates. Of particular interest is the Alabama presentation of typical sign conversion costs.

Appendix G: Partial Bibliography of Metric References

The authors developed a limited bibliography of metric references. It is organized into categories on professional and technical societies, government publications, training information, general publications, and international publications. Overall, there are more than 100 references in this appendix.

SUMMARY

The metrication of the American highway industry will not be simple. It will require substantial commitments of time, resources, and management efforts. This paper introduces the AASHTO *Guide to Metric Conversion*, which has been prepared to facilitate the conversion. The guide is intended for highway agencies at all levels of government, for the private sector, and for affiliated organizations. Its publication will provide an excellent starting place for conversion activities.

ACKNOWLEDGMENTS

This work was sponsored by AASHTO, in cooperation with FHWA, and was conducted in NCHRP, which is administered by TRB.

REFERENCES

1. *Metric Reporter*, Vol. 21, No. 4. American National Metric Council, Arlington, Va., April 1992.
2. *Metrication Report*. AASHTO, Washington, D.C., June 1974.
3. Gleeson, J. E. Conversion of Metric Traffic Control Devices in Ontario. *ITE Journal*, pp. 35–38, Aug. 1979.
4. *Guide to Metric Conversion of Highway Engineering*. Roads and Transportation Association of Canada, Ottawa, Ontario, 1976.
5. *Federal Register*, Vol. 57, No. 113, Washington, D.C., June 11, 1992.

Publication of this paper sponsored by Committee on Section B—Pavement Management.