National Aeronautics and
Space Administration

Office of Inspector General
Headquarters
Washington, D.C. 20546-0001

Reply to Attn of: W

February 20, 2001

TO: A/Administrator

FROM: W/Inspector General

SUBJECT: Assessment of NASA's Use of the Metric System, G-00-021

Following the loss of the Mars Climate Observer, the NASA Office of Inspector General initiated a review of the Agency's use of the metric system. By law and policy, the metric system is the preferred system of measurement within NASA. However, our review found that use of the metric system is inconsistent across the Agency. A waiver system, which was required by law and put into effect to track metric usage and encourage conversion, is no longer in use. In addition, NASA employees are given little guidance on the Agency's policy and procedures regarding use of the metric system.

Based on our review, we made eight recommendations intended to improve the use of the metric system within NASA in accordance with national policy and NASA guidance. We recommended NASA:

- reexamine the Agency's effort to convert to the metric system and develop a new approach for converting to the metric system,
- closely monitor technical interfaces between metric and English units,
- reinvigorate the metric waiver system, and
- use the metric system as the preferred system for interactions with the public.

Management concurred with all of the report's recommendations, except the recommendation that NASA use the metric system for interactions with the public. In responding to this recommendation, management agreed to use metric units in all education programs and when communicating with the public about programs that use metric or hybrid metric/English units. However, the Public Affairs Office plans to use English units of measurement when communicating about programs that use English units exclusively. We continue to hold that since public law requires NASA to use metric units where economically feasible, the Agency should use metric units in all communications with the public.

As the United States continues its slow transition to the metric system, NASA must decide whether it wants to be a leader or a follower in the transition process. Both roles come with a cost. If NASA chooses to push forward with the Agency's use of the metric system, near-term costs may increase and short-term risk (both to schedule and mission success) may rise

to some degree. However, if the Agency follows the aerospace industry's slow transition to SI, the protracted period during which NASA uses mixed metric and English systems may further increase costs and risks for NASA programs.

NASA is the nation's most visible science and technology agency, and is involved in highly publicized cooperative projects with a world that almost exclusively uses the metric system. Certainly an argument could be made that as the nation's symbol of technological prowess, NASA has a role in promoting acceptance and use of the metric system. We believe the Agency should reassess its conversion to the metric system and determine the most appropriate approach for the Agency to successfully transition to the metric system.

[original signed by]

Roberta L. Gross

Enclosure
Assessment of NASA's Use of the Metric System, G-00-02

National Aeronautics and
Space Administration

Office of Inspector General
Headquarters
Washington, D.C. 20546-0001

Reply to Attn of: W

February 20, 2001

TO: AE/Chief Engineer

FROM: W/Assistant Inspector General for Inspections, Administrative Investigations, and Assessments

SUBJECT: Assessment of NASA's Use of the Metric System, G-00-021

In September 1999, the Mars Climate Orbiter spacecraft failed to enter orbit around Mars. Review teams found that a contractor had used English, rather than metric, units of measurement in a navigation software program. Outputs from this program were used to compute the spacecraft's trajectory, causing a navigation error.[1] Inadequate software testing, poor communications between engineering groups, inadequate independent review, insufficient systems engineering oversight of the navigation function, and inadequate training of the navigation team compounded the navigation error, resulting in the loss of the spacecraft.[2] Following this incident, the NASA Office of Inspector General initiated a review of the Agency's use of the metric system.

We found that NASA's use of the metric system varies from program to program and from Center to Center. Federal regulations and NASA policy require "an effective process for a policy-level and program-level review of proposed exceptions to metric usage."[3] However, the Agency has not used its metric system waiver process for several years. Also, we found that NASA provides program and project managers with minimal guidance for using the metric system. NASA management concurred with seven of our eight recommendations (See Appendix B).

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[1] The Mars Climate Orbiter Mishap Investigation Board reported that "the root cause for the loss of the MCO spacecraft was the failure to use metric units in the coding of a ground software file, "Small Forces," used in trajectory models. Specifically, thruster performance data in English units instead of metric units was used in the software application code titled SM_FORCES (small forces). A file called Angular Momentum Desaturation (AMD) contained the output data from the SM_FORCES software. The data in the AMD file was required to be in metric units per existing software interface documentation, and the trajectory modelers assumed the data was provided in metric units per the requirements."

[2] *Mars Climate Orbiter Mishap Investigation Board Phase I Report* dated November 10, 1999 and *Report on the Loss of the Mars Climate Orbiter Mission* dated November 11, 1999.

[3] Executive Order 12770. Metric Usage in Federal Government Programs. 1991.

I. BACKGROUND

A. The Metric System in the United States

The International System of Units (*SI),* commonly known as the metric system, was developed in the late 1700's. Since 1875, when the United States and 17 other nations first signed the *Treaty of the Meter, SI* has gained worldwide acceptance. Because *SI* values are based on a standardized decimal system, calculations using *SI* units are often simpler than calculations using English units.[4] The principal attraction of *SI*, however, is that its universal adoption will eliminate the need to convert between systems of measurement, thereby simplifying commerce and communication.

The United States is currently the only industrialized nation that has not designated *SI* as its official system of measurement.[5] Although the metric system has been the "preferred system of weights and measures for United States trade and commerce" since 1988,[6] use of the metric system is voluntary and Congress has created no deadline for conversion.

The American public has slowly accepted certain metric measurements (e.g., grams of fat, liters of soda, 10-kilometer races, 35-millimeter film, 500-milligram tablets), but most measurements in the United States are still designated in English units. The U.S. aerospace industry, for example, mainly uses English units.[7] However, many areas of the U.S. private sector, especially those involved in exports, are slowly increasing their output of metric products.[8] In addition, the United States scientific community works and communicates almost exclusively in metric units.

B. Metric Laws, Regulations, and Policies

1. Federal laws and regulations

The Metric Conversion Act of 1975 (Public Law 94-168) declared a national policy of converting to *SI* and established the United States Metric Board to coordinate the voluntary

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[4] English units are also known as inch-pound units and include the inch, foot, pound, horsepower, and degree Fahrenheit.

[5] The other nations that have not designated *SI* as the official system of measurement are Liberia and Myanmar.

[6] Public Law 100-418, the Omnibus Trade and Competitiveness Act of 1988.

[7] A 1994 paper by the American Institute for Aeronautics and Astronautics (AIAA) reported that virtually all parts of aircraft made in the United States, as well as their entire airframes were designed and produced on an inch-pound basis. In addition, some aircraft components made to inch-pound standards were used worldwide by nearly all aircraft manufacturers. The paper also noted that (in 1994) the U.S. aircraft industry experienced no trade impact due to its continued use of English units. (Source: *Metric Conversion*: an AIAA Position Paper prepared by the AIAA Standards Executive Council and approved by the Board of Directors, August 1994.)

[8] In 1998, approximately 20 percent of U.S. companies offered products conforming to metric standards, up from approximately 16 percent in 1996. (Source: Thomas Register of American Manufacturers.)

transition. The Act did not include any target dates for *SI* conversion. In 1982, President Reagan dissolved the Metric Board, cancelled its funding, and transferred its responsibilities to the Department of Commerce, which is currently responsible for overseeing *SI* conversion in the United States.

The Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418) amended the 1975 Act and declared *SI* the preferred system of weights and measures for trade and commerce. The 1988 Act charged Federal agencies with converting to the metric system to the degree economically feasible by the end of Fiscal Year (FY) 1992, and required each agency to submit plans to convert to *SI* as part of agency budget justifications. In 1995, the Federal Reports Elimination and Sunset Act (Public Law 104-66) repealed the reporting requirement.

In 1991, President Bush issued Executive Order 12770, *Metric Usage in Federal Government Programs*, which directs all executive departments and Federal agencies to use *SI* by the end of FY 1992 or by another date determined in consultation with the Secretary of Commerce. Executive Order 12770, which remains in effect, highlights the importance of *SI* in procurements, grants, and other business-related activities, including all measurement in agency programs and functions related to trade, industry, and commerce. The Executive Order states:

> Heads of departments and agencies shall establish an effective process for a policy-level and program-level review of proposed exceptions to metric usage. Appropriate information about exceptions granted shall be included in the agency annual report along with recommendations for actions to enable future metric usage.

2. NASA policy directives and guidance

NASA's Policy Directive (NPD) 8010.2, *Use of the Metric System of Measurement in NASA Programs,* is the primary Agency policy regarding *SI* usage (see Appendix A). The most recent revision of NPD 8010.2, effective July 20, 2000, continues NASA's policy of adopting *SI* as the preferred system of measurement. The policy also requires consideration of *SI* usage in all new programs, projects, New Capability Construction of Facilities Projects, procurements, grants, and business activities. Also, NPD 8010.2 generally describes the process by which programs or projects can waive the use of the metric system. Waiver justifications must demonstrate that use of the metric system is impractical or likely to cause significant inefficiencies or loss of markets by U.S. firms. However, the NPD does not provide details about the process under which an *SI* waiver should be granted.

NASA Procedures and Guidelines (NPG) 7120.5, *Program and Project Management Processes and Requirements,* requires NASA managers to address *SI* usage in all project plans.[9] However, NPG 7120.5 does not state that *SI* is the preferred system of measurement, and does not provide any guidance on the waiver process. NASA officials stated that they plan to add guidance on metric system usage to NPG 7120.5.

[9] NPG 7120.5, Appendix E, Section E.4 *Project Plan*.

II. NASA'S USE OF THE METRIC SYSTEM

A. Past Use of the Metric System at NASA

In 1980, NASA issued its first Agencywide metric policy, NASA Management Instruction (NMI) 8010.2, *Use of the Metric System of Measurement in NASA Programs*. NMI 8010.2 designated the Chief Engineer as the key executive responsible for NASA's metric usage policy and required each new project or program to thoroughly consider *SI* usage.

After passage of the Omnibus Trade and Competitiveness Act of 1988, NASA engaged in widespread efforts to convert to *SI* usage. In the early 1990's, NASA Centers developed metric transition plans, purchased *SI* measurement equipment and machine tools, and trained employees on *SI* usage. NASA also began to assess requirements for space-quality piece parts fabricated to metric standards and developed qualifications for commonly used parts, such as threaded fasteners and fluid fittings. In 1991, NASA published NMI 8010.2A, which adopted *SI* as the preferred system of weights and measurements for the Agency. NMI 8010.2A required new projects and programs to use *SI* unless a waiver was granted and further stated that the Agency would use *SI* to the extent economically feasible in procurements, grants and business-related activities by the end of FY 1992.

However, during the same time period, some of NASA's major programs made long-term decisions to work in English units. In 1989, the Space Station Program decided to continue to use English measurements and to require a waiver to permit *SI* usage. In 1992, the Aeronautics and Research Technology Program[10] obtained a multi-project *SI* waiver with no sunset date. Today these two programs receive annual funding totaling approximately $3.5 billion, more than 25 percent of NASA's budget.

In 1992, NASA's Metric Transition Plan stated that the Agency would use *SI* (to the greatest practical extent) for program development and functional support activities by the end of 1995, and in all new programs (except those directly related to past English programs) by 1998. Despite the existence of conversion timelines, momentum for metric conversion slowed when the Federal Reports Elimination and Sunset Act of 1995 repealed the requirement for NASA to report annually on its metric transition progress.

B. Current Use of the Metric System at NASA

Projects at NASA today employ measurement systems that vary from fully *SI* to completely English. Fully *SI* programs may be "hard metric" (where the original design uses *SI* units) or "soft metric" (where the original design uses English units, which are then mathematically converted to equivalent *SI* units). NASA also operates hybrid programs, which use both *SI* and English components. The Mars Climate Orbiter is one example of a hybrid program.

[10] Now the Aerospace Technology Enterprise

In the summer of 2000, NASA's Office of the Chief Engineer polled NASA's Centers to survey their experience with use of the metric system. The survey asked the Centers to:

- Provide information on programs/projects that implemented full or hybrid use of metrics and the lessons learned.
- Identify real and perceived barriers.
- Assess present metric implementation capability.
- Identify areas where there is the possibility for advancement to metric implementation in the near future.
- Identify areas with significant continuing challenges/obstacles to metric implementation.

The following section draws primarily upon the responses to that survey to describe NASA's current approach to use of the metric system.

1. Who is Using the Metric System and Who is Not?

Today, use of the metric system at NASA varies between and within programs, disciplines, and Centers. For example, NASA's aeronautics programs almost exclusively use English units, while scientific research funded by the Agency almost exclusively uses *SI* units. Some educational material distributed by NASA uses English units while other educational material uses *SI* units. Facility construction at NASA is conducted exclusively using *SI* measurements.

The Jet Propulsion Laboratory (JPL) has taken the most proactive stance regarding the use of *SI* units. Of 52 JPL projects in varying stages of development, 32 percent are classified as all metric, 66 percent use a hybrid system, and 2 percent use only English units. In 1994, JPL initiated *SI* training courses, paid initial contractor tooling costs for metric fasteners, set up a metric structural fastener inventory, designed hardware in hard metric units, bought metric lathes and inspection equipment, and began using metric units in mission status reports. However, since 1996, JPL's efforts to use *SI* have slowed. Other NASA Centers report that *SI* usage occurs primarily in hybrid projects. Many projects use English units exclusively.

The International Space Station (ISS) is a hybrid program. While most of the hardware, including research payload hardware and extravehicular activity tools and equipment, are built to English units, *SI* is used in interfaces with components supplied by the ISS international partners. The ISS Program generally uses *SI* for mission operations, both in onboard and ground support systems. Exceptions to *SI* usage in mission operations generally occur in areas where the ISS interfaces with the Space Shuttle, which uses the English system of units.

The scientific community at NASA uses the metric system. However, because non-scientific collaborators and commercial partners involved in NASA's programs and projects may not use SI, scientific results are sometimes converted to English units. Several Centers reported that although their scientific researchers, instruments, and collected data use *SI* units, results are often converted to English units for local users.

2. What are the Barriers to Increased Use of the Metric System?

Barriers to NASA's use of *SI* are both real and perceived. Respondents cited increased cost, risk, and time, in addition to the lack of industrial standards, as reasons for limited use of *SI*. For example, metric hardware often is not readily available and must be specially ordered from a manufacturer, resulting in an increase in the manufacturing cost, and in the time required to deliver that order. Further, the use of hybrid methodologies, as exemplified by combining inherited parts and *SI* components, often requires engineers to develop two sets of calculations, thereby increasing the time spent on a particular activity. These factors tend to reinforce the institutional resistance to *SI*.

Many engineers perceive increased risk in using SI because they are familiar with English units and lack experience with *SI* data and hardware. Some have developed an intuitive sense regarding the outcome of calculations using English units, or the use of particular English-measured parts (e.g., 3/8" drill bits). When working with *SI* units, these engineers believe they will no longer benefit from this experience and confidence. The problem arises when senior engineers comfortable with the English system encourage or require young (often metric-trained) engineers to use English rather than *SI* units, indefinitely delaying the transition to *SI* usage.

Even when engineers use the metric system in the design process, the lack of aerospace-quality standard parts and components (such as fasteners and valves) makes implementation of fully metric designs difficult. The lack of metric hardware results from the realities of the market economy—until a demand exists for qualified metric parts, technical standards, and reference data, these items will not be generated. A metric NASA project, by itself, is typically too small to influence the manufacturing community to increase the availability of metric parts.

The economic costs and benefits of using SI in NASA projects are not well understood. In the past, NASA employees and contractors attempting to waive use of the metric system have claimed that SI usage was "economically infeasible," but they generally have not provided evidence to support their claims. Using the metric system may result in a cost increase; however, some evidence indicates that conversion estimates may be overstated.[11]

Recommendation 1: The Office of the Chief Engineer should reexamine NASA's effort to convert to the metric system and develop a new approach for the Agency's conversion to *SI*. The NASA Chief Engineer should, among other steps, include additional guidance on *SI* usage in *Program and Project Management Processes and Requirements* (NPG 7120.5). At a minimum, NPG 7120.5 should (1) state that *SI* is the preferred system of measurement, (2) define and describe the process for requesting and receiving a metric system usage waiver, and (3) state the conditions under which such a waiver should be granted.

[11] For example, a 1999 Construction Metrication Council study of 25 *SI* highway projects around the country found that although contractor personnel, especially workers over the age of 50, were initially resistant to *SI*, those contractors that began and carried the project through in *SI* had few difficulties. The study also found that costs of *SI* projects were similar to the costs of projects using English units.

Recommendation 2: The status of *SI* use for each project should be made a performance metric reported to the Chief Engineer and the Engineering Management Council. If NASA management determines that the transition to the metric system is a high priority, the Agency should consider making the status of *SI* conversion a Government Performance and Results Act metric.

Recommendation 3: Each design review of a project using hybrid units of measurement should address the issue of interfaces between the two systems of measurement and ensure that steps are being taken to ensure consistency and compatibility across such interfaces.

C. The Metric Waiver System

Executive Order 12770 requires "an effective process for a policy-level and program-level review of proposed exceptions to metric usage." Although the Executive Order also requires NASA to report annually on waivers granted, the Agency does not do so. NASA Policy Directive 8010.2 allows new projects or programs to waive use of the *SI* system where justified, or, in the case of hybrid systems, where full implementation of *SI* is not feasible. However, NPD 8010.2 does not describe the waiver process by which a *SI* waiver should be granted.

Appendix B of the NASA Metric Transition Plan, dated February 20, 1992, offers a detailed description of the waiver process.[12] The plan states that waiver requests must be supported with "an assessment of the entire program that demonstrates that *SI* system use has significant adverse impact." The plan also states that waivers would be considered only when at least one of the following conditions applied:

- Hardware would be built to an existing English design.
- Recognized international standards for the intended application use English units.
- Commercial practice beyond NASA's control dictates English use.
- Metric usage would be impractical or have significant adverse effect on program costs, schedule or performance.

From 1992-1994, several programs and projects obtained *SI* waivers. The Space Station Program and the Aerospace Technology Enterprise both received long-term multi-project *SI* waivers, although both of these programs are comprised of individual projects that may be completed using *SI*. Although NASA initiated many new programs that use hybrid or English units since 1994, no *SI* waivers were granted. Officials in NASA's Chief Engineer's office confirmed that the waiver process has fallen into disuse.

Recommendation 4: The Chief Engineer should update, publish, and widely disseminate its *SI* system waiver process and requirements.

[12] Although the NASA Metric Transition Plan is still in effect, the plan has not been updated since 1992.

Recommendation 5: The Chief Engineer should immediately take steps to ensure that new projects or programs that do not plan to use *SI* go through the waiver/review process established in NPD 8010.2C. Waivers granted should be reported to the Department of Commerce for their annual report to the President, as required in Executive Order 12770.

Recommendation 6: NASA should be cautious in granting *SI* waivers to entire programs Some programs which, viewed as a whole, could legitimately waive use of *SI* may contain projects that might best be conducted using *SI*. If a program is granted an *SI* waiver, use of *SI* within the program should be permitted where appropriate. Any program waivers granted should not be open-ended, but should be reviewed after approximately 5 years.

D. Where Can Use of *SI* be Increased?

1. NASA-wide SI Central Supply Program

A resounding theme that emerged from the survey of *SI* usage was a lack of available *SI* parts and components. Metal fasteners were cited most often. Increased costs for projects were associated with *SI* usage because of small order size and required lead-time for manufacturing for those parts. To avoid increased costs for projects, NASA's Goddard Space Flight Center developed a central supply of common sizes of *SI* fasteners. Greater awareness and use of this supply, and the creation of additional supplies of common *SI* parts and materials such as valves, regulators, actuators, and tubing, could alleviate some of the initial cost and time constraints of using the metric system.

2. Communications with the External Community

Interaction with the public through press releases, educational materials, and Web sites provide NASA with a low cost mechanism to support *SI* usage. Currently, the NASA Office of Public Affairs issues press releases in English units with *SI* values in parentheses. Materials from the Education Division at NASA Headquarters also use *SI*. Most Center-prepared material also uses *SI*; however, there are no controls to ensure that Center-prepared materials use SI, even when the programs. Each NASA enterprise and functional office[13] develops its own Web site content. No policy exists regarding *SI* usage on those sites.

Recommendation 7: NASA should inform engineers at other NASA Centers about Goddard's supply of common sizes of *SI* fasteners. The Agency should also consider creating additional Agencywide supplies of common *SI* parts and materials such as valves, regulators, actuators, and tubing.

[13] Functional offices establish and disseminate policy and leadership strategies within their assigned areas of responsibility. Functional offices are defined at NASA Headquarters to include the offices of the Senior Advisor to the Administrator, the Chief Engineer, the Chief Information Officer, the Chief Technologist, the Chief Financial Officer, Headquarters Operations, Equal Opportunity Programs, Human Resources and Education, the General Counsel, Procurement, External Relations, Management Systems, Small and Disadvantaged Business, Legislative Affairs, Public Affairs, Safety and Mission Assurance, and Policy and Plans.

Recommendation 8: NASA's program and functional offices should use *SI* as the preferred system for interactions with the external community in public events, educational materials, and Web site viewing. English units can be presented parenthetically.

III. SUMMARY AND EVALUATION OF NASA MANAGEMENT RESPONSE

NASA management concurred with recommendations 1 through 7. We consider these recommendations resolved pending verification of Agency compliance.

Management did not concur with recommendation 8. Management's response to recommendation 8 stated that NASA's education programs (all of which use *SI*) fulfill the Agency's responsibility to promote the use of and familiarity with *SI* units. In communications with the public that are not strictly educational, NASA will use metric units when discussing programs that use *SI* or hybrid units, but will not use metric units to describe programs that employ only English units.

We recognize that management's planned use of *SI* in public communications about programs that use *SI* or hybrid units is a significant positive step. However, Public Law 100-418 charges Federal agencies with converting to the metric system to the degree economically feasible. Since it is certainly economically feasible for NASA to use *SI* as the preferred system for interactions with the external community in public events, educational materials, and Web site viewing, we believe the Agency should do so, regardless of whether the program being described uses metric or English units.

IV. CONCLUSION

By law and policy, *SI* is the preferred system of measurement within NASA. However, we found that the use of *SI* varies across the Agency. NASA employees are given little guidance on the Agency's policy and procedures regarding use of the metric system. The waiver system, which was put into effect to track *SI* usage and encourage conversion, is no longer in use. We believe the recommendations we make in this report will improve the use of the metric system within NASA in accordance with national policy and NASA guidance.

As the United States continues its slow transition to the metric system, NASA must decide whether it wants to be a leader or a follower in the transition process. Both roles come with a cost. If NASA chooses to push forward with the Agency's use of the metric system, near-term costs may increase and short-term risk (both to schedule and mission success) may rise to some degree. However, if the Agency follows the aerospace industry's slow transition to *SI*, the protracted period during which NASA uses mixed metric and English systems may further increase costs and risks for NASA programs.

NASA is the nation's most visible science and technology agency, and is involved in highly publicized cooperative projects with a world that almost exclusively uses the metric system. Certainly an argument could be made that as the nation's symbol of technological prowess,

NASA has a role in promoting acceptance and use of the metric system. We believe the Agency should reassess its conversion to the metric system and determine the most appropriate approach for the Agency to successfully transition to *SI*.

[original signed by]

David M. Cushing

3 Enclosures:
Appendix A: NPD 8010.2C, *Use of the Metric System of Measurement in NASA Programs*, dated July 20, 2000
Appendix B: NASA Management Response
Appendix C: Report Distribution
NASA Office of Inspector General Reader Survey

MAJOR CONTRIBUTORS TO THIS REPORT

Dr. Holly K. Patton, Aerospace Technologist/Life Scientist
Andrea Pawley, Presidential Management Intern
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Appendix A

NPD 8010.2C, *Use of the Metric System of Measurement in NASA Programs*, dated July 20, 2000

NASA POLICY DIRECTIVE

Directive: NPD 8010.2C
Effective Date: July 20, 2000
Expiration Date: July 20, 2005

Responsible Office: AE / Chief Engineer

Subject: Use of the Metric System of Measurement in NASA Programs

1. POLICY

NASA policy for systems of measurement to be used on NASA programs/projects is as follows:

a. Adopt the International System of Units (also known as the SI - Systeme Internationale or "metric") system of measurement, defined by Section 4.a below, as the preferred system of weights and measurements for NASA.

b. Require consideration of the metric system of measurement for all new programs and projects and New Capability Construction of Facilities (COF) Projects, and use the metric system of measurement in related NASA procurements, grants, and business activities, unless such use can be demonstrated to be impractical or likely to cause significant inefficiencies or loss of markets to U.S. firms.

c. Evaluate and approve the basis for exceptions or waivers to use of the metric system of measurement, where justified, during new Program/Project Formulation.

d. Permit controlled use of hybrid units (mixed inch-pound/metric) measurement where full implementation of the metric system is not feasible.

e. Permit continued use of the inch-pound system of measurement for existing inch-pound-based systems.

f. Cooperate with the private and public sectors and the international community to overcome barriers to use of the metric system and increase understanding of the metric system.

2. APPLICABILITY

This NPD is applicable to NASA Headquarters and NASA Centers, including Component Facilities, and to the Jet Propulsion Laboratory to the extent specified in the contract.

3. AUTHORITY

a. 15 U.S.C. § 205b, Subsection 5164(b) of the Omnibus Trade and Competitiveness Act of 1988, Public Law 100-418, as amended.

b. Executive Order 12770, Metric Use in Federal Government Programs, July 25, 1991.

4. REFERENCES

a. ANSI/ASTM/IEEE SI-10, 1997 Standard for Use of the International System of Units (SI), the Modern Metric System.

b. NPG 7120.5 NASA Program and Project Management Processes and Requirements.

5. RESPONSIBILITY

a. The Chief Engineer is responsible for the following:

(1) Establishing guidelines and coordinating implementation of this policy.

(2) Advising Enterprise Associate Administrators regarding their approval of exceptions to use of the metric system of measurement.

(3) Serving as the NASA Metric Executive on the Interagency Council on Metric Policy.

(4) Evaluating measurement system decisions for consistency with policy during Formulation phase Program/Project reviews conducted under the authority of NPG 7120.5.

b. Enterprise Associate Administrators or, in the case of New Capability COF Projects, the Associate Administrator for the Office of Management Systems are responsible for the following:

(1) Approving selection of measurement systems for Programs/Projects during the Formulation process specified in Section 4b above.

(2) Reporting to and consulting with the Chief Engineer regarding all decisions to waive use of the metric system on new Programs/Projects and New Capability COF Projects.

c. Directors of NASA Centers are responsible for the following:

(1) Ensuring timely analysis, evaluation, documentation, and review, during the Program/Project Formulation Phase, of opportunities and requirements for use of the metric system on those Programs/Projects or elements and for New Capability COF Projects for which they have lead responsibility.

(2) Planning for and implementing use of the metric system of measurement wherever practical.

(3) Requesting waiver of the metric system on Programs/Projects to the Enterprise Associate Administrator(s) only where such use can be demonstrated to be impractical or likely to cause significant inefficiencies or loss of markets to U.S. firms.

(4) Developing and maintaining capability for effective and consistent support of the metric system of measurement where used on NASA Programs/Projects, including interfaces between metric and nonmetric elements.

6. DELEGATION OF AUTHORITY

None.

7. MEASUREMENTS

None.

8. CANCELLATION

NPD 8010.2B, Use of the Metric System of Measurement in NASA Programs, dated January 19, 1996.

/s/ Daniel S. Goldin
Administrator

ATTACHMENT A: (TEXT)

None.

(URL for Graphic)

None.

DISTRIBUTION:
NODIS

Appendix B

NASA Management Response

National Aeronautics and
Space Administration
Office of the Administrator
Washington, DC 20546-0001

FEB 8 2001

TO: W/Assistant Inspector General for Inspections, Administrative Investigations, and Investigations

FROM: AE/Chief Engineer

SUBJECT: Revised Reply to Inspector General Report G-00-021, Assessment of NASA's Use of the Metric System

After discussions with your staff that further clarified the intent and terminology of your report, we believe it is appropriate to recharacterize our response for recommendations 1 through 5 from "Partially Concur" to "Concur" and for recommendation 8 from "Partially Concur" to "Non-Concur". As in our initial response of January 8, 2001, we "Concur" with recommendations 6 and 7. The nature of the intended action in response to all recommendations, remains essentially the same as in our initial response.

IG Recommendation 1: The Office of the Chief Engineer should reexamine NASA's effort to convert to the metric system and develop a new approach for the Agency's conversion to the International System of Units (*SI*). The NASA Chief Engineer should, among other steps, include additional guidance on *SI* usage in Program and Project Management Processes and Requirements (NPG 7120.5). At a minimum, NPG 7120.5 should (1) state that *SI* is the preferred system of measurement, (2) define and describe the process for requesting and receiving a metric system usage waiver, and (3) state the conditions under which such a waiver should be granted.

Code AE Response: Concur. The report correctly describes the evolution of the NASA Metric Transition Program including the issues that have and still complicate further implementation. Primary among these issues is lack of acceptance of *SI* by the aerospace community, an issue over which we have very little control. Fortunately, the Federal requirements for use of *SI* Public Law 100-418 (Omnibus Trade and Competitiveness Act) and Executive Order 12770 (Metric Usage in Federal Government Programs) recognize potential limits to metric transition by mandating it "except where impractical." We believe NASA can meet the requirements of the law through the following: 1) determining an appropriate level of implementation for NASA by continuing our current reexamination of available *SI* capability; 2) incorporating SI requirements into the current program/project development process; 3) encouraging acquisition of and sharing of *SI* resources (such as standard parts inventories, fabrication and metrology capabilities) across NASA; and 4) encouraging use and acceptance of *SI* through information dissemination through engineering training programs, and through education materials and appropriate use of *SI* in publicly distributed information. We would characterize this activity as "reactivating" elements of the 1992 NASA Metric Transition Plan rather than a "new approach", but

believe it will respond to the need. Supplementary guidance is needed to require verification of measurement unit consistency in programs/projects, particularly at interfaces (which was a root cause of the Mars Climate Orbiter failure), and Agencywide sharing of *SI* capabilities.

We agree with the specific recommendation that formal requirements on use of SI should be inserted in active management documents. We have recommended additions to NPG 7120.5, Program and Project Management Processes and Requirements, and will develop an appendix to NPD 8010.2C (in lieu of a separate NPG) to meet that need. These additions will provide criteria for allowable exceptions to the use of SI, address use of hybrid systems, define a point in the formulation process where *SI* use must be identified and waiver requests submitted for exceptions, and identify the information requirements for waivers. Currently, NPD 8010.2C assigns responsibility for evaluating and approving waivers to the NASA Enterprises. We believe these additions will be adequate for Enterprises and Functional Offices to establish internal procedures, tailored to their own needs, for approving waivers. Approval of waivers would still require consulting with the Chief Engineer, as per NPD 8010.2C (Section 5.b(2)).

IG Recommendation 2: The status of *SI* use for each project should be made a performance metric reported to the Chief Engineer and the Engineering Management Council. If NASA management determines that the transition to the metric system is a high priority, the Agency should consider making the status of *SI* conversion a Government Performance and Results Act (GPRA) metric.

Code AE Response: Concur. We agree that the extent of planned and actual use of *SI* should be reported for programs and projects, and that doing this at defined points in the Program/Project review cycle established by NPG 7120.5 will meet external reporting requirements. Once these points are defined, reporting through the NASA Program Management Council (PMC) reviews should provide the information needed by the Chief Engineer and the Engineering Management Council. For several years, use of SI has not being advanced actively by either the Administration or the Congress, and reporting requirements have been eliminated from PL 100-418. We believe it is appropriate to wait for direction from the new Administration before considering *SI* use as a GPRA metric.

IG Recommendation 3: Each design review of a project using hybrid units of measurement should address the issue of interfaces between the two systems of measurement and ensure that steps are being taken to ensure consistency and compatibility across such interfaces.

Code AE Response: Concur. We agree with adding requirements to verify consistency and compatibility of measurement units at interfaces as part of the design review process, and will take steps to do so. How this is addressed in design reviews should be left to the Enterprises.

IG Recommendation 4: The Chief Engineer should update, publish, and widely disseminate its *SI* system waiver process and requirements.

Code AE Response: Concur. We agree that requirements and guidelines for *SI* implementation and criteria for approving waivers to *SI* should be updated and published in current guidance documentation as addressed in the reply to recommendation 1. These requirements and guidelines will provide an Agency-wide basis for Enterprises and functional offices to establish internal procedures tailored to their needs.

IG Recommendation 5: The Chief Engineer should immediately take steps to ensure that new projects or programs that do not plan to use *SI* go through the waiver/review process established in NPD 8010.2C. Waivers granted should be reported to the Department of Commerce (DoC) for their annual report to the President, as required in Executive Order 12770.

Code AE Response: Concur The proposed additions to NPG 7120.5 and NPD 8010.2 discussed above will clarify the requirement and make reporting part of the Agency Program/Project Management process. The Chief Engineer will monitor implementation of the requirements through reviews of programs and projects conducted by/for the NASA Program Management Council and through the consultations with Enterprise Associate Administrators already required by NPD 8010.2. Implementation of *SI* for programs/projects under the control of Center Governing Program Management Councils can be monitored by the Center Systems Management Offices.

Executive Order 12770 requires reporting "appropriate information" on waivers, which is generally recognized as "statistical" reporting rather than detailed waiver reporting. We believe the amended guidance will allow us to meet that requirement.

IG Recommendation 6: NASA should be cautious in granting *SI* waivers to entire programs. Some programs which, viewed as a whole, could legitimately waive use of *SI* may contain projects that might best be conducted using *SI*. If a program is granted an *SI* waiver, use of *SI* within the program should be permitted where appropriate. Any program waivers granted should not be open-ended, but should be reviewed after approximately 5 years.

Code AE Response: Concur. We agree with the recommendation. NPD 8010.2C will be modified to note that program-wide waivers should not prohibit use of *SI* in specific areas where appropriate, and to require reassessment of opportunities and rejustification of program-wide waivers where still required, at least once every 5 years.

IG Recommendation 7: NASA should inform engineers at other NASA Centers about Goddard's supply of common sizes of *SI* fasteners. The Agency should also consider creating additional Agencywide supplies of common *SI* parts and materials such as valves, regulators, actuators, and tubing.

Code AE Response: Concur. We agree that better means are required to notify programs and projects of the availability of space quality *SI* parts and will take steps to do so. We have conducted preliminary surveys of parts availability in other areas without much success, but agree that efforts should continue to identify opportunities.

IG Recommendation 8: NASA's program and functional offices should use *SI* as the preferred system for interactions with the external community in public events, educational materials, and Web site viewing. English units can be presented parenthetically.

Code AE Response: Non-Concur. *SI* units should be used in communications with the external community where the programs being described are baselined in *SI* or use hybrid units, but we believe it is inappropriate and potentially confusing to convert real inch-pound information to *SI* units solely for public consumption. NASA has a responsibility under the law to promote the use of and familiarity with *SI* units, and we do that effectively through our education programs. Hopefully, these education programs are laying the foundation for increasing use of *SI* in the future, which is the intent of the law. Conversion should not be required, however, just for dissemination of information in areas where use of *SI* has been determined to be impractical; we believe this position is consistent with PL 100-418.

General Comments:
The Office of the Chief Engineer agrees fully with the statement in the report, that NASA must "determine the most appropriate approach for the Agency," even if the answer is that full transition is not possible in the near term. Considering the NASA limited ability to affect aerospace industry practice, we believe that we should implement *SI* where we can, and support improvements, but attempting to be a leader in the aerospace sector – without industry support – would be unacceptably costly. What we must do without fail, is to ensure that, wherever *SI* units are used in NASA programs in conjunction with inch-pound units, that interfaces are consistent so that the problem experienced with the Mars Climate orbiter is not repeated.

W. Brian Keegan

Appendix C

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Report: Assessment of NASA's Use of the Metric System, G-00-021

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