NASA ENVIRONMENTAL MANAGEMENT SYSTEMS (EMS)

COSTS AND BENEFITS

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EXECUTIVE SUMMARY

Executive Order (EO) 13148, *Greening of the Government through Leadership in Environmental Management*, requires that all Federal agencies conduct pilot tests of an Environmental Management System (EMS) at selected facilities by 2002, and that all Agency facilities implement an EMS by December 31, 2005. An EMS incorporates people, procedures, and work practices in a formal structure to ensure that both adverse and beneficial environmental impacts of the organization are identified and managed.

Glenn Research Center (Cleveland, Ohio), Johnson Space Flight Center (Houston, Texas), and John C. Stennis Space Center (Bay St. Louis, Mississippi) volunteered to be test sites. An EMS Core Team, which included representatives from NASA Headquarters, Ames Research Center (Moffett Field, California), Goddard Space Flight Center (Greenbelt, Maryland), and the three test centers, was established to develop an EMS Procedures Manual and to support the implementation of the EMS at the 3 test sites. This Costs and Benefits Report is based on data obtained from the 3 test sites and the input of the EMS core team.

The cost and benefit report is organized into the following sections:

(1) Executive Summary

(2) Costs

- ~ Implementation costs
- ~ Maintenance costs

(3) Benefits

Implementation Costs

The study performed the following:

- Collected and evaluated costs at test-bed centers
- Identified factors that can affect costs
- Projected NASA-wide costs based on test bed experience

Estimated implementation costs at test-bed centers include civil servant (environmental and non-environmental) and contractor time and other direct expenses:

Test Bed Center	Implementation Costs	Implementation Hours	Center Population	$ per Capita	Hours per Capita
GRC	$445K	5,243 hours	4,000	$111	1.3
JSC	$1,450K*	17,692* hours	10,500	$138	1.7
SSC	$550K	10,521 hours	4,500	$122	2.3

* JSC costs estimated through 9/30/01.

The test-bed centers' cost and hours data were compiled in a spreadsheet that distinguished among a variety of activities oriented either toward compliance with Executive Order 13148 or toward compliance with ISO 14001 requirements. Most of the EMS requirements are driven by the Executive Order, with only a few requirements otherwise driven by ISO 14001. The Executive Order required implementation planning, identification and assessment of aspects and impacts, development of management plans, training, communication, documentation, and environmental functional reviews, among other activities. Most of the implementation costs were directed toward (1) identifying impacts and developing management plans and (2) training and awareness. Among the ISO requirements, Center preparation for and support of the registration process represented most of the cost. The costs per

employee shown above range from an average of $111 to an average of $138 for EMS implementation at the test bed centers. The corresponding average hours range from 1.3 to 2.3; these averages overstate the median time commitment as some environmental civil servants spent significantly more time on EMS implementation and some EMS contractor hours were provided by personnel not counted in the Centers' populations (i.e., off-site contractors). For most employees, the hours associated with EMS implementation will be minimal.

As shown below, 80% of the costs were incurred for Executive Order activities while 20% were incurred due to ISO-specific activities:

EMS IMPLEMENTATION COSTS BY ACTIVITY

• Executive Order EMS	• 80%
~ Implementation planning	~ 12%
~ Identify impacts and develop management plans	~ 22%
~ Training and awareness	~ 18%
~ Communication	~ 9%
~ Documentation and document control	~ 13%
~ Environmental functional reviews	~ 2%
~ Miscellaneous	~ 5%
• ISO 14001 unique activities	• 20%
~ Center-wide communication	~ 4%
~ Registration process	~ 10%
~ Other	~ 6%

The percentages shown above represent averages of the test bed experiences. While the Centers had different approaches and different needs, costs for implementing the Executive Order EMS varied between 79% and 83%.

Factors that affect implementation costs. The Core Team discussed the following factors:

1. Center size
2. Center environmental issues
3. Gap between existing EMS and compliant EMS

In addition, different approaches to EMS implementation can affect costs. Likewise, civil servant and contractor labor rates can affect costs. Test-bed centers reported various, typically composite, labor rates for civil servant time. Contractor rates varied considerably and were higher than reported civil servant rates; contractors did much of the work at all three test beds.

Extrapolating implementation costs. The cost and benefit report was charged with developing estimates of EMS implementation costs for the other NASA Centers. The report developed these estimates by extrapolating from the test beds' experience. Three potential approaches to extrapolation were identified:

(1) By size -- the Core Group preferred population over acreage or budget as the measure of size

(2) By environmental issues -- the Core Group suggested using staffing levels from the NASA staffing algorithm as proxies

(3) By size of "gap" between existing EMS and compliant EMS -- because data were not available, this option was not implemented

The table below shows the results of extrapolating the test-bed centers experience to other NASA Centers. The first column extrapolates implementation costs based on the population of each facility (e.g., $ per capita). The second and third columns extrapolate implementation costs based on the environmental issues at each facility, using the NASA environmental staffing algorithm as a proxy.[1] Two values are reported because of differences in test bed experiences, as evaluated by this variable. The fourth column represents the average of the three prior columns.

SUMMARY OF EXTRAPOLATED IMPLEMENTATION COSTS
(EXCLUDING HEADQUARTERS COST)

Facility	Based on Population	Based on Suggested Environmental Staff	Based on Suggested Environmental Staff (alternate)*	Average
Ames	$710K	$982K	$645K	$779K
Dryden	155K	669K	439K	421K
Goddard	1,531K	678K	445K	885K
Kennedy	1,987K	2,099K	1,378K	1,821K
Langley	645K	608K	399K	551K
Marshall	903K	864K	567K	778K
Plum Brook	19K	653K	428K	367K
Wallops	183K	771K	506K	487K
	$6,133K	$7,324K	$4,807K	$6,089K

* Because of large differences between Johnson and the other test-bed centers, an alternate measure was applied to establish a lower bound.

These extrapolations are likely to represent the upper limit of EMS implementation costs for several reasons: first, the three test beds represented Centers with average (Glenn, Stennis) to large (Johnson) gaps between the existing EMS and the E.O./ISO requirements. Centers with smaller gaps will likely incur lesser costs. Second, every effort was made to capture full costs. Third, the lessons learned

[1] The NASA Environmental Staffing Algorithm is a program designed to identify staffing norms in light of the environmental requirements at NASA Centers.

and tools developed by the test beds should enable other NASA Centers to accomplish implementation at less cost. Finally, some NASA Centers (e.g., Kennedy) may be able to use different models allowed by draft NPG 8553 to achieve full EMS implementation.[2]

Maintenance Costs

The study performed the following:

- Identified factors that affect maintenance costs
- Projected maintenance costs based on Core Team discussions

Factors that affect maintenance costs. The Core Team discussed the following factors that can affect maintenance costs:

- Center size
- Center environmental issues
- Gap between existing EMS and compliant EMS

In addition, different approaches to EMS maintenance can affect costs. Likewise, civil servant and contractor labor rates can affect costs. Due to timing, no actual maintenance costs could be tracked at test-bed centers.

The Core Team reviewed and discussed a detailed list of expected and potential EMS maintenance activities. The major components of maintenance costs are the following:

[2] Draft NPG 8553 is the *NASA Environmental Management Procedures Manual*.

- EMS representative's time
- Internal audits
- Training of new internal auditors
- Keeping documentation up-to-date (e.g., as Center management programs change)
- Corrective action
- Management reviews

Projected maintenance costs. The Core Team discussed maintenance costs several times and had varying views on what the potential costs might be. For purposes of projecting costs to other NASA Centers, the Core Team agreed on a value of $200-$250K per year per Center (or 1 to 2 fte's per year). Of this amount, about ½ is for the EMS representative's time and the remainder is for all other activities.

Benefits

The report presents information on the potential benefits of enhanced EMS. The information resulted from several Core Team discussions, including an exercise of projecting future benefits at the test-bed centers. The report addresses benefits solely in a qualitative fashion. In addition, the report notes the following:

- Potential benefits may take time to appear
- Potential benefits may require additional investments, especially for P2 and resource conservation benefits
- Potential benefits may arise without an enhanced EMS
- Potential benefits often are difficult to monetize

The report describes the changes that the Core Team believed could result from an enhanced EMS, as follows:

PARADIGM CHANGES DUE TO ENHANCED EMS

1. Increased awareness, understanding, and planning
2. Source reduction
3. Resource consumption reduction
4. Increased compliance
5. Formalized and optimized EMS
6. Lifecycle analysis

In addition, the Core Team identified a large number of potential benefits associated with the changes listed above. Many of the benefits can flow from more than one of the paradigm changes, as shown in the report itself. For convenience, the potential benefits are listed a single time in the table below:

POTENTIAL BENEFITS FROM CHANGES DUE TO ENHANCED EMS

- ➢ Better NASA reputation (Center and Agency)
- ➢ Better relationship with stakeholders
- ➢ Change order reductions
- ➢ Continual improvement
- ➢ Cost reductions
- ➢ Decreased employee time (fewer inspections)
- ➢ Decreased energy, water, and materials use
- ➢ Decreased number of fines and NOVs
- ➢ Environmental impact reductions
- ➢ Health benefits
- ➢ Increased affirmative procurement
- ➢ Increased compliance (NEPA, etc.)
- ➢ Increased efficiency
- ➢ Increased management support and involvement
- ➢ Increased proactivity
- ➢ Increased number of green building designs
- ➢ Increased number of pollution prevention initiatives
- ➢ Increased number of sustainability projects
- ➢ Increased recycling revenue
- ➢ Increased safety
- ➢ Increased trust and satisfaction from customers
- ➢ Mission delay reductions
- ➢ Prioritization of funding projects
- ➢ Reduced liability
- ➢ Reduced number of inspections
- ➢ Reduced number of regulations
- ➢ Reduced number of spills
- ➢ Reduction of single-point failures
- ➢ Solid waste reduction
- ➢ Written procedures, consistency of process, repeatability

1. INTRODUCTION

1.1 Background

The National Aeronautics & Space Administration (NASA) is a Federal research and engineering agency which conducts its missions through 10 major facilities in 10 states nationwide. These installations vary in size from 150 to 80,000 acres and involve 1,000 to over 10,000 on-site personnel. The installations are complexes that may contain laboratories, test stands, wind tunnels, hangars, and various shops. NASA's budget is over $14 billion and maintains a civil service workforce of over 18,000 FTE. Contractor employees number about 4 for every civil servant, and the NASA complex includes government-owned contractor-operated (GOCO) facilities, such as the Jet Propulsion Laboratory. These resources support NASA's missions in earth science, space flight, aerospace technology, and space science.

Executive Order 13148 Requirements

- **Agency-wide self-assessment in 18 months**
  - NASA benchmarking study was completed in 1998
- **EMS based on Code of Environmental Principles (CEMP) or other EMS framework**
  - NASA EMS based on ISO 14001 plus appropriate CEMP elements
- **Test bed projects in 24 months (April 2002)**
  - Glenn, Johnson, and Stennis
- **Audit program with periodic audits every 3 years**
- **EMS at appropriate facilities by December 31, 2005**

Executive Order (EO) 13148, *Greening of the Government through Leadership in Environmental Management*, requires that all Federal agencies conduct pilot tests of an Environmental Management System (EMS) at selected facilities by 2002, and that all Agency facilities implement an EMS by December 31, 2005. An EMS is a system that (1) incorporates people, procedures, and work practices in a formal structure to ensure that the important environmental impacts of an organization are identified and addressed, (2) promotes continual improvement by periodically evaluating environmental performance, (3) involves all members of the organization as appropriate, and (4) actively involves senior management in support of the environmental

management program. The purpose of the NASA EMS is to have a single overall approach to managing environmental activities that allows for efficient, prioritized program execution.

NASA is solidly in compliance with EO 13148. By 1998, NASA had conducted a public/private benchmarking study, a business case, and a gap analysis (covering 13 NASA facilities). The 1998 business case and gap analysis identified resource requirements and also projected costs and benefits of an EMS based on ISO 14001. It was determined through the business case that the ISO 14001 approach best meets the requirements of EO 13148 and fits well with existing NASA management systems. The ISO 14001 standard was selected as NASA's model because it satisfied most of the specific requirements of EO 13148 and can utilize several of the major elements already established by NASA per requirements of ISO 9000. In December 1998, the NASA Environmental Management Board (EMB), consisting of Center environmental managers and all Institutional Program Officers, approved an initiative to test an EMS based on the ISO 14001 standard at 3 sites: Glenn Research Center in Cleveland, Ohio, Johnson Space Center in Houston, Texas, and Stennis Space Center in Bay St. Louis, Mississippi. The initiative was to include preparation of a report that will verify EMS resource requirements, costs, and benefits.

Draft NPG 8553 *NASA Environmental Management System Procedures Manual* describes NASA's Environmental Management System. The NPG addresses EO requirements (e.g., environmental functional reviews) not mandated by ISO, and activities unique to ISO 14001 (e.g., registration, internal audits) not included in the EO. The EMS procedures were developed to provide maximum flexibility to individual NASA facilities while meeting the EO 13148 requirements and the ISO 14001 standard. Draft NPG 8553 provides overall direction for both NASA-wide EMS documentation and Center-level documentation. NASA-wide documentation – NASA Policy Directives (NPDs) and NASA Procedures and Guidelines (NPGs) – are the minimum EMS performance criteria. Center EMS implementation plans will add content to reflect Center-specific needs.

The NASA EMS includes the following elements:

- Environmental policy
- Planning
- Implementation and operation
- Management review
- Corrective action
- Metrics

The test bed centers conducted a variety of activities to implement a conforming EMS. For example, each Center designated an EMS representative, briefed top management, and gained management support. Each Center established a core team, which received EMS training. After defining the scope of its Center's EMS, the core team developed its implementation plan through frequent meetings with other Center organizations.

A key activity was the identification of priority impacts. Each Center started by identifying its activities, products, and services as well as their environmental aspects and impacts. Then each Center applied risk criteria to identify priority impacts. For each priority impact, objectives and targets were established. Finally, each Center created programs to achieve its objectives and targets.

Training and communication were important elements in EMS implementation. In addition to EMS training for the core teams, training was provided to personnel whose work might create significant environmental impacts. The EMS also required each Center to develop procedures for determining training needs and for verifying and recording EMS training. Internal and external communication also are elements of NASA's EMS. The test bed centers ensured that their environmental policy was communicated to all employees and made available to the public.

EMS performance metrics include the rate of meeting objectives and targets within specified timeframes, the rate of closure of any non-conformances, and verification that centers are conducting management reviews.

1.2 Purpose

This study had two purposes:

(1) compile information on costs and benefits related to EMS implementation at the 3 test bed centers

(2) project costs for EMS implementation at other NASA centers based on the experience of the test beds.

The study achieved both of the above purposes.

1.3 Scope

The scope of the study matched the study purposes listed above. With respect to compiling information on costs and benefits, the study started collecting costs from the inception of EMS implementation at the test beds in May 2000 through completion of implementation in the summer of 2001. (One test bed center, Johnson Space Center, projected costs from May through September 2001 when its EMS implementation phase was to be completed). Hours and money devoted to EMS implementation were collected monthly on a disaggregated basis by activity. The study's scope includes recognition of full costs of EMS implementation. Thus, data were compiled for not only environmental civil servants and their contractor support, but also for other center civil servants and contractor staff. Expenses for EMS implementation likewise were collected. For a variety of reasons, including timing, EMS benefits were handled qualitatively.

With respect to projecting costs of EMS implementation at other Centers, the study extrapolated from the test bed centers' experience. The test beds represented centers with average (Glenn, Stennis) to large (Johnson) gaps between their existing EMS and the EO 13148/ISO 14001 requirements. Implementation costs at other NASA Centers (e.g., Ames Research Center, Kennedy Space Center) with much smaller gaps were not tracked in the study scope, so their projected costs likely are over-estimated. GOCO facilities were not included in the scope of the study (e.g., no projections were made of EMS implementation costs at the Jet Propulsion Laboratory).

2. EMS COSTS

This chapter includes the following: definitions of the types of EMS costs, a presentation of the EMS implementation costs at the test-bed centers, extrapolation of the implementation costs based on test-bed center experience, and information about potential EMS maintenance costs.

2.1 Types of EMS Costs

There are two basic types of EMS costs: costs of implementing the EMS and costs of maintaining the EMS:

- Implementation costs include costs incurred from activities a Center undertakes to comply with Executive Order 13148 (Greening the Government Through Leadership in Environmental Management). If NASA Centers choose to pursue ISO 14001 certification, then implementation costs will include costs incurred not only from activities to meet the Executive Order but also from activities to meet the requirements of ISO 14001.
- Maintenance costs include costs for maintaining the implemented EMS.

2.2 Implementation Costs and Hours at Test-Bed Centers

This section presents EMS implementation costs at the test-bed centers. Implementation costs are composed of Executive Order costs and ISO 14001 costs. Executive Order costs were costs that the Center incurred to achieve compliance with the Executive Order without ISO 14001 registration. ISO 14001 costs represent the additional efforts the Center expended toward ISO 14001 registration. First, a summary of total Executive Order costs and ISO 14001 costs is presented. Next, the Executive Order costs for each test-bed center are divided into civil servant and contractor costs and hours. Finally, the ISO 14001 costs for each test-bed center are divided into civil servant and contractor costs and hours.

The Core Team determined how to group and track the implementation costs. It decided which activities' costs to collect. The test-bed centers tracked EMS implementation costs since May 2000. The

test-bed centers tabulated the costs monthly. Johnson collected actual costs through April 2001 and estimated costs through September 2001 when implementation was expected to be complete. Total implementation costs at the test-bed Centers were as follows.

Exhibit 2-1: Total EMS Implementation Costs

Center	Implementation Costs
Glenn	$445K
Johnson	$1,450K
Stennis	$550K
TOTAL	**$2,445K**

The Core Team decided that the test-bed centers would track separately the dollar costs and hours incurred from implementing an EMS as required by Executive Order 13148 and the costs incurred from implementing an ISO 14001 EMS. Most of the EMS requirements are driven by the Executive Order, with only a few requirements otherwise driven by ISO 14001. The Executive Order required implementation planning, identification and assessment of aspects and impacts, development of management plans, training, communication, documentation, and environmental functional reviews, among other activities. Among the ISO requirements are two that were relatively costly: center-wide communication and the registration process. On average, 80 percent of the total costs were Executive Order costs and 20 percent were ISO 14001 costs. The breakdown of Executive Order costs and ISO 14001 costs per Center is as follows:

Exhibit 2-2: Executive Order Costs and ISO 14001 Costs By Center

	EXECUTIVE ORDER		ISO 14001	
Center	Costs ($)	% of Total Costs	Costs ($)	% of Total Costs
Glenn	370K	83%	75K	17%
Johnson	1,144K	79%	306K	21%
Stennis	444K	81%	106K	19%
TOTAL	**1,958K**	**80%**	**487K**	**20%**

Total hours required for EMS implementation at the test-bed Centers were as follows:

Exhibit 2-3: Total EMS Implementation Hours

Center	Implementation Hours
Glenn	5,243
Johnson	17,628
Stennis	10,521
TOTAL	**33,392**

The Core Team decided that the test-bed centers would track separately the hours required to implement an EMS as required by Executive Order 13148 and the hours required to implement an ISO 14001 EMS. On average, 81 percent of the total required hours were Executive Order hours and 19 percent were ISO 14001 hours, which closely tracks the dollar expenditures. The breakdown of Executive Order hours and ISO 14001 hours per Center is as follows:

Exhibit 2-4: Executive Order Hours and ISO 14001 Hours By Center

	EXECUTIVE ORDER		ISO 14001	
Center	Hours	% of Total Hours	Hours	% of Total Hours
Glenn	4,539	87%	704	13%
Johnson	13,684	78%	3,944	22%
Stennis	8,943	85%	1,578	15%
TOTAL	**27,166**	**81%**	**6,226**	**19%**

Executive Order Activities

Listed below are the Executive Order activities tracked by the test-bed centers as well as examples of tasks that fall under each activity. This information was given to the test-bed centers as guidance. (ISO 14001 activities are presented in the next section.)

➢ **Center-Specific EMS Implementation Planning**
- Designate EMS representative and/or implementation leader
- Establish Center EMS Core Team and participate in meetings
- Provide EMS training to the Core Team
- Define Center-specific scope of EMS
- Develop Center-specific implementation plans
- Provide top management briefings
- Gain management approval
- Develop Statements of Work for local contractors

➢ **Identify Aspects and Priority Impacts, Set Objectives and Targets, and Develop Environmental Management Plans**
- Identify activities, products, and services
- Identify aspect category and impacts for each
- Apply risk criteria
- Set objectives and targets
- Develop Environmental Management Plans

➢ **Training, Awareness, and Competence**
- Establish and maintain procedures for determining environmental awareness training needs
  ~ Includes use of a combination of classroom, web based, and on-the-job training
- Implement EMS awareness/training activities for all employees to ensure they are aware of:
  ~ NASA's environmental policy
  ~ EMS requirements as they apply to their position and responsibilities
- Verify and record that necessary EMS training has occurred
- Revise existing environmental training classes to include information on the EMS

➢ **Communication**
- Receive, record, and respond to relevant communication from external parties
- Provide internal and external parties information on the installation, environmental aspects, and the EMS using existing communication procedures

➢ **EMS Documentation and Document Control**
- Establish and maintain procedures for document control
- Subject documented procedures required by the EMS Procedures Manual to document controls

➢ **Environmental Functional Review**

➢ **Miscellaneous**
- Includes non-conformance and corrective preventative action in addition to any Executive Order activities not listed above

Each test-bed center used a different approach to implementing its EMS. As a result, the percentages of the Centers' total costs that were spent on a given activity vary. For example, as shown in Exhibit 2-5, a greater percentage of Glenn's total costs were incurred from implementation planning

Exhibit 2-5: Executive Order Costs By Center

Executive Order Activity	GLENN		JOHNSON		STENNIS		TOTAL	
	Costs ($)	% of Total Glenn Costs	Costs ($)	% of Total Johnson Costs	Costs ($)	% of Total Stennis Costs	Costs ($)	% of Total Implementation Costs
Implementation Planning	77K	17%	160K	11%	59K	11%	296K	12%
Identify Impacts and Develop Management Plans	93K	21%	348K	24%	107K	19%	548K	22%
Training and Awareness	116K	26%	253K	17%	64K	12%	433K	18%
Communication	38K	9%	156K	11%	19K	3%	213K	9%
Documentation and Document Control	26K	6%	172K	12%	108K	20%	306K	13%
Environmental Functional Review	5K	1%	12K	1%	32K	6%	49K	2%
Miscellaneous	15K	3%	43K	3%	55K	10%	113K	5%
TOTAL	**370K**	**83%**	**1,144K**	**79%**	**444K**	**81%**	**1,958K**	**80%**

(17 percent) than at the other two Centers (11 percent for Johnson and Stennis). Nearly one-quarter of Johnson's costs were incurred from identifying impacts and developing management plans. However, nearly one-quarter of Glenn's costs were incurred from training and awareness. Finally, Stennis spent about an equal percentage of costs on identifying impacts and developing management plans as on documentation and document control.

Similar to Executive Order costs, the following Exhibit on Executive Order hours (Exhibit 2-6) also shows the different approaches taken at each Center. Glenn used a significantly higher proportion of hours on implementation planning (14 percent) and training and awareness (35 percent) than the other two test-bed centers. Johnson used nearly the same proportion of hours to identify impacts and develop management plans as training and awareness (22 percent and 21 percent, respectively). In addition, Johnson used a higher proportion of hours on communication (12 percent) compared to Glenn (8 percent)

Exhibit 2-6: Executive Order Hours By Center

Executive Order Activity	GLENN		JOHNSON		STENNIS		TOTAL	
	Hours	% of Total Glenn Hours	Hours	% of Total Johnson Hours	Hours	% of Total Stennis Hours	Hours	% of Total Implementation Hours
Implementation Planning	733	14%	1,832	10%	938	9%	3,502	10%
Identify Impacts and Develop Management Plans	983	19%	3,932	22%	1,845	18%	6,760	20%
Training and Awareness	1,816	35%	3,657	21%	1,611	15%	7,084	21%
Communication	412	8%	2,085	12%	422	4%	2,919	9%
Documentation and Document Control	294	6%	1,508	9%	2,077	20%	3,879	12%
Environmental Functional Review	120	2%	227	1%	701	6%	1,048	3%
Miscellaneous	181	3%	444	3%	1,349	13%	1,974	6%
TOTAL	**4,539**	**87%**	**13,685**	**78%**	**8,943**	**85%**	**27,166**	**81%**

and Stennis (4 percent). Finally, Stennis used a higher proportion of hours on documentation and document control (12 percent) compared to Glenn (6 percent) and Johnson (9 percent).

ISO 14001 Activities

The test-bed centers also tracked the costs and hours for ISO 14001 related activities. Centers would not perform these activities unless they were implementing an EMS compliant with ISO 14001. The ISO 14001 activities are listed below as well as examples of tasks that fall under each activity. This information was given to the test-bed centers as guidance.

➢ **Center-wide EMS awareness training**

- Banners, posters, pocket cards, etc.

  The Executive Order requires all staff to be aware that there is a NASA Environmental Policy, that there is an EMS, and what their roles in the EMS are. The Executive Order does not require a formal training program. The three test-bed centers elected to use a variety of forms of video, classroom training, and promotional items to both train staff and build overall Center-wide awareness of EMS implementation and to ensure that all staff were aware of their roles. Certain training activities were expanded and repeated to prepare for registration.

➢ **Identify and determine the priority level of all environmental impacts (interactions with the environment) not addressed by Legal and Other Requirements**

➢ **Identify Legal and Other Requirements**
- Develop procedures for identifying applicable state, local, facility-specific, and permit-driven legal requirements and changes to existing legal requirements
  The Executive Order requires staff be made aware of applicable legal requirements but does not require formal written procedures. The three test beds elected to develop and formalize as a part of their EMS how this identification was done.
- Evaluate NASA-wide commitments and agreements

➢ **Identify personnel (including internal contractors) whose job-specific activities may create a priority impact on the environment**

➢ **Use NASA NPGs 1440.6 and 1441.1, and NPD 2800.1 for EMS records**
- Establish a records retention matrix for EMS records
- Maintain and store EMS records in a manner that allows for their ready retrieval and protects them from loss, damage, or deterioration

➢ **Management Review**
- Determine any necessary changes to environmental policy and identify opportunities for continual improvement of the EMS

➢ **ISO 14001 Registration Process**
- Select and train internal auditors
- Conduct internal audits[3]
- Select registrar and schedule review/visits
- Conduct initial review of installation EMS documentation/address identified non-conformances
- Conduct pre-registration audit/address identified non-conformances
- Conduct full EMS documentation review/address identified non-conformances
- Conduct registration audit/address identified non-conformances
- Perform any required corrective actions
- ISO 14001 registration

As shown in Exhibit 2-7, Glenn spent a higher percentage of ISO 14001 costs on Center-wide awareness training (8 percent) and identifying personnel whose job-specific activities may create a priority impact on the environment (5 percent) compared to the other two test-bed Centers. In contrast,

[3] This does not include the support a Center provides to the management component of the Environmental Functional Review.

Exhibit 2-7: ISO 14001 Costs By Center

ISO 14001 Activities	GLENN		JOHNSON		STENNIS		TOTAL	
	Costs ($)	% of Total Glenn Costs	Costs ($)	% of Total Johnson Costs	Costs ($)	% of Total Stennis Costs	Costs ($)	% of Total Implementation Costs
Center-wide Awareness Training	35K	8%	52K	4%	15K	3%	102K	4%
Identify and determine level of all environmental impacts not addressed by Legal and Other Requirements	0K	0%	4K	0%	3K	1%	7K	0%
Identify Legal and Other Requirements	11K	2%	8K	1%	4K	1%	23K	1%
Identify personnel whose job-specific activities may create a priority impact on the environment	16K	5%	16K	1%	6K	1%	38K	2%
Use NASA NPGs 1440.6 and 1441.1, and NPD 2800.1 for EMS records	1K	0%	47K	3%	3K	0%	51K	2%
Management Review	1K	0%	21K	1%	2K	0%	24K	1%
ISO 14001 Registration Process	11K	2%	158K	11%	73K	13%	242K	10%
TOTAL	**75K**	**17%**	**306K**	**21%**	**106K**	**19%**	**487K**	**20%**

both Johnson and Stennis incurred a greater percentage of costs from the ISO 14001 registration process (11 percent and 13 percent, respectively.)

Exhibit 2-8 displays the total ISO 14001 hours by each test-bed center. Glenn used roughly equal percentages of hours on Center-wide awareness training (3 percent), identifying personnel who job-specific activities may create a priority impact on the environment (3 percent), and the ISO 14001 registration process (4 percent). Both Johnson and Stennis used the majority of their ISO 14001 hours on the ISO 14001 registration process (11 percent and 9 percent, respectively). The second greatest percentage for Johnson was Center-wide awareness training (5 percent).

Each of the three test-bed centers used the *NASA Installation EMS Implementation Guide* (draft) in the development of their center-specific implementation plans. These plans outline the sequence of

Exhibit 2-8: ISO 14001 Hours By Center

ISO 14001 Activities	GLENN		JOHNSON		STENNIS		TOTAL	
	Hours	% of Total Glenn Hours	Hours	% of Total Hours	Hours	% of Total Stennis Hours	Hours	% of Total Implementation Hours
Center-wide Awareness Training	176	3%	782	5%	253	2%	1,211	4%
Identify and determine level of all environmental impacts not addressed by Legal and Other Requirements	0	0%	56	0%	58	1%	114	0%
Identify Legal and Other Requirements	118	2%	72	0%	53	1%	243	1%
Identify personnel whose job-specific activities may create a priority impact on the environment	165	3%	224	1%	140	1%	529	2%
Use NASA NPGs 1440.6 and 1441.1, and NPD 2800.1 for EMS records	22	0%	596	3%	60	1%	678	2%
Management Review	23	0%	328	2%	8	0%	359	1%
ISO 14001 Registration Process	200	4%	1886	11%	1,006	9%	3,092	9%
TOTAL	**704**	**13%**	**3,944**	**22%**	**1,578**	**15%**	**6,226**	**19%**

events each Center undertook for EMS implementation and are included with lessons learned by the test-beds in the final *Implementation Guide*. The test-beds both complied with the requirements of the *NASA Environmental Management System Procedures Manual* (Draft NPG 8553) and also used the *Manual*'s content as building blocks for their more detailed procedures and EMS documentation.

Each of the test-beds approached detailed EMS implementation in ways that best fit their organizations. Each had a different approach to and level of integration with existing ISO 9000 quality management systems. Glenn developed an EMS based on a small number of fairly broad definition, high priority environmental impacts aligned with operating units and key documentation fully integrated with the Center's ISO 9000 system and Business Management System. Stennis developed an EMS that has direct participation by all major on-site contractors with the priority impacts being based on key activities across the Center. with EMS awareness fostered by a popular video presentation. Johnson developed an EMS based on each of its directorates. In consideration of the larger overall Center population at JSC,

training on how to implement a JSC-wide consistent EMS was provided to each directorate. In turn, the directorates identified impacts, their priority levels, and programs for priority items. JSC's EMS is integrated with both the ISO 9000 system and portions of the OSHA VPP program at the Center.

The test-bed centers developed a variety of tools and learning that can be transferred to other NASA Centers. One useful tool is the *Implementation Guide* which includes lessons learned from the EMS implementation experiences at the three sites. In addition, training and communication materials may be useful elsewhere in the NASA complex. Re-using spreadsheets for tracking activities, aspects, and impacts may save other Centers from incurring unnecessary costs. Other software and processes (e.g., documentation) developed by the test-bed centers also may be transferable to other Centers. Centers undertaking EMS implementation also may want to review sample management plans and other EMS documents prepared by the test-bed centers. By sharing their materials, experiences, and expertise, the test-bed centers can make it easier for other NASA Centers to implement their EMSs at less cost and with minimal impact to operational activities.

The following is a list of test-bed implementation tools now available to other NASA installations:

- Implementation plan models for Centers of different sizes and different degrees of existing environmental programs
- Aspect, impact, prioritization, and tracking systems ranging from spreadsheets to fully integrated databases
- Center-wide to directorate-based methods for aspect and impact identification followed by program development and improvement
- EMS awareness training programs ranging from lecture and slide presentation formats to video and web-based tools. Training program elements also vary from basic level to more advanced for key program staff
- Examples of integration with Quality and Health and Safety management systems at Centers, both “how to” and “lessons learned” on what did not work

2.3 Extrapolation of Implementation Costs

There are several factors that affect implementation costs, and therefore, affect the extrapolation of implementation costs from the test-bed centers to the rest of NASA: Center size, Center environmental issues, and the gap between the existing EMS and a compliant EMS. (In addition, labor and contractor costs may vary across Centers.) First, a summary of extrapolated implementation costs is presented. Next, results from the extrapolation of implementation costs by Center population are presented. Finally, results from the extrapolation of implementation costs by Center environmental issues are presented. Appropriate data were not available to extrapolate implementation costs by the size of the gap between the existing EMS and a compliant EMS.

Summary of Implementation Cost Extrapolation

The following Exhibit presents the range of implementation costs based on two methods of extrapolation (Center population and Center environmental issues as represented by amount ($) per suggested environmental staff). Based on extrapolating the implementation approaches used by the test-bed centers, total implementation costs at the other NASA Centers could range from $4.8 million to $7.3 million, with an average of $6.1 million. Exhibit 2-9 shows that, based on the average of the two extrapolation approaches, implementation costs could range from a low of $367,000 for Plum Brook to a high of $1,821,000 for Kennedy.

A cost estimate for extrapolating the enhanced EMS program to other Centers should include Headquarters' costs. In the current effort, Headquarters provided guidance and facilitated implementation through monthly meetings (usually teleconferences) where the test-bed centers could discuss progress and issues together. In addition, Headquarters support included efforts by its contractor to support and document the monthly meetings, provide EMS and ISO training, and conduct a series of 3 pre-registration audits (through a subcontractor). Headquarters costs totalled about $96K and contractor costs are

Exhibit 2-9: Summary of Extrapolated Implementation Costs (excluding Headquarters' Costs)

Facility	Based on Population	x $32K per Suggested Staff	x $21K per Suggested Staff	Average
Ames	$710K	$982K	$645K	$779K
Dryden	155K	669K	439K	421K
Goddard	1,531K	678K	445K	885K
Kennedy	1,987K	2,099K	1,378K	1,821K
Langley	645K	608K	399K	551K
Marshall	903K	864K	567K	778K
Plum Brook	19K	653K	428K	367K
Wallops	183K	771K	506K	487K
Total	**$6,133K**	**$7,324K**	**$4,807K**	**$6,089K**

estimated at $154K, for a total of $250K for all three test-bed centers. This averages to about $83K per test-bed center. If a similar process were followed for the other 8 NASA Centers, that would add another $667K to the cost estimate (i.e., about 11% of the total estimate for the Centers). Now that the pilot has been completed, there may be less need for Headquarters involvement and support.

Results of Center Population Extrapolation

In order to extrapolate implementation costs by Center size, the Core Team recommended using Center population as a measure of size. The Core Team considered other measures of size (acres, budget) but decided that population likely would be the best measure of size. Dividing the test-bed centers' implementation costs by the Centers' populations resulted in a per capita average. Extrapolating the per capita average to the remaining NASA Centers resulted in an estimate of total implementation costs.

Exhibit 2-10 shows the test-bed Centers' implementation costs normalized by Center population.

Exhibit 2-10: Implementation Costs Normalized by Center Population

Test-bed Center	EMS Implementation Costs	Population	$ per Capita
Glenn	$445K	4,000	$111
Johnson	$1,450K	10,500	$138
Stennis	$550K	4,500	$122
		Weighted Average	**$129**

Using the weighted average of $129 per capita, implementation costs were extrapolated to the remaining NASA Centers. Based on facility population and the test-bed centers' experience, the costs to implement the EMS at the remaining Centers would be approximately $6.1 million. Exhibit 2-11 shows that the greatest costs would be incurred at Goddard and Kennedy which have the largest Center populations (approximately 12,000 and 15,000 respectively). In contrast, Plum Brook, with a population of 150, would incur the least implementation costs ($19,000).

Exhibit 2-11: Implementation Costs Extrapolated to Remaining Centers Based on Center Population

Facility	Population	x $129 per Capita
Ames	5,500	$710K
Dryden	1,200	155K
Goddard	11,870	1,531K
Kennedy	15,400	1,987K
Langley	5,000	645K
Marshall	7,000	903K
Plum Brook	150	19K
Wallops	1,415	183K
	Total	**$6,133K**

Results from Center Environmental Issues Extrapolation

In order to extrapolate by environmental issues, the suggested environmental staffing levels from the NASA environmental staffing algorithm were used as a proxy. Dividing the test-bed centers' implementation costs by the suggested environmental staffing levels resulted in an average per suggested environmental staff. Extrapolating the per suggested environmental staff average to the remaining Centers resulted in an estimate of total implementation costs.

Exhibit 2-12 shows the test-bed centers implementation costs normalized by suggested environmental staffing levels at each Center. This Exhibit indicates that implementation will cost approximately $32,000 per suggested environmental staff, based on the experience of the test-bed centers.

Exhibit 2-12: Implementation Costs Normalized by Suggested Environmental Staffing Levels

Test-bed Center	EMS Implementation Costs	Suggested Staffing Level	$ per Suggested Staff
Glenn	$445K	23.1	$19.26K
Johnson	$1,450K	28	$51.79K
Stennis	$550K	25.2	$21.93K
		Weighted Average	**$32K**

Using the average of $32,000 per suggested environmental staff, implementation costs were extrapolated to the remaining NASA Centers to calculate total implementation costs. Since two of the three test-bed Centers had approximately $21,000 per suggested environmental staff, implementation costs were also extrapolated based on this figure. Based on the experience of the test-bed centers, the costs to implement the EMS at the remaining Centers were estimated to be between $4.8 million and $7.3 million. Exhibit 2-13 shows that Kennedy has the highest suggested environmental staffing level (65.6) and, therefore, likely would incur the greatest implementation costs (between approximately $1.4 and $2.1 million). In contrast, Langley has the lowest suggested environmental staffing level (19) and likely would incur the least implementation costs (between approximately $400,000 and $610,000).

Exhibit 2-13: Implementation Costs Extrapolated to Remaining Centers Based on Suggested Environmental Staffing Levels

Facility	Suggested Staffing Level	x $32K	x $21K
Ames	30.7	$982K	$645K
Dryden	20.9	669K	439K
Goddard	21.2	678K	445K
Kennedy	65.6	2,099K	1,378K
Langley	19	608K	399K
Marshall	27	864K	567K
Plum Brook	20.4	653K	428K
Wallops	24.1	771K	506K
	Total	**$7,324K**	**$4,807K**

2.4 Costs of Maintaining the EMS

Maintenance costs are the costs incurred from activities necessary to maintain the EMS after it has been fully implemented. These costs will include certain ISO 14001 activities should Centers pursue ISO 14001 certification. Similar to implementation costs, certain factors affect the amount of maintenance costs each Center will incur. These factors include Center size, Center environmental issues, and the gap between the Center's existing EMS and a compliant EMS. The gap will not necessarily be eliminated with the implementation of the EMS. An EMS identifies issues and problems that may not have existed before. An effective EMS will deal with these identified problems and, in the process, will require more resources. There may be new procedures that were not present before the EMS was implemented, and maintaining the new procedures would cost additional money.

Due to the timing of this report, no actual maintenance costs could be tracked at the test-bed centers. However, the test-bed centers identified components of the EMS that would potentially incur the

most costs. (The complete list is included as Appendix B to this report.) The major cost-inducing components include:

- EMS representative's time
- Internal audits
- Training new internal auditors
- Keeping documentation up-to-date (e.g., as Center management programs change)
- Corrective action
- Management review

In addition to identifying cost-inducing components of maintaining the EMS, the Core Team estimated that, on average, maintenance costs would be approximately $200,000 to $250,000 per year per Center (or 1 to 2 fte's per year). Of these costs, about ½ is for the EMS representative's time and the remainder is for all other activities.

3. EMS BENEFITS

This chapter describes the potential benefits of implementing enhanced environmental management systems (EMS) at NASA Centers. The chapter is organized as follows:

- Characteristics of EMS benefits
- Types of changes anticipated at NASA Centers due to enhanced EMS, and
- Potential benefits

3.1 Characteristics of EMS Benefits

Although experience with implementing EMS in the United States[4] is somewhat limited, it indicates that EMS benefits have the following characteristics:

- Some EMS benefits take time to appear and will tend to lag EMS costs over time. Other EMS benefits will accrue with EMS implementation.

- The additional benefits of implementing enhanced EMS at NASA Centers may be difficult to distinguish from the baseline benefits of existing environmental management processes. Centers with many EMS components in place already may be experiencing these benefits. EMS benefits may arise without an enhanced EMS. On the other hand, the frequency and magnitude of benefits may increase due to implementation and/or certification of enhanced EMS.

- EMS benefits often are difficult to monetize, particularly the benefits of having a better reputation, being a better neighbor, and greater customer trust.

- EMS benefits may require additional investments, especially for pollution prevention (P2) and resource conservation benefits. Industry experience suggests $3.5 to $4 of benefits for every dollar spent on P2 and payback of less than 2 years.[5]

Two broad categories of EMS benefits include the following:

(1) Efficiencies in environmental management
(2) Attainment of NASA strategic environmental goals

[4] Experience overseas may not be relevant because the U.S. has more detailed and extensive sets of regulatory requirements.

[5] The return on investment reflects experience in the chemical and pharmaceutical industries. NASA's returns may be less but should be at least $2 for every $1 invested.

Efficiencies. An enhanced EMS can produce efficiencies in environmental management in at least two different ways. First, by better documentation of information and processes, environmental staff can avoid false starts, time-consuming searches for information, and rework. And valuable program knowledge will not be lost when personnel turns over. These efficiencies free up time for more value-added activities, such as compliance assurance.

Second, efficiency is increased by extending environmental responsibility to operations personnel and program/project managers.[6] There are several reasons why this wider involvement in environmental management increases efficiency. First, personnel responsible for operations and maintenance often are less expensive than environmental management personnel, which means a lower hourly cost for environmental management functions. Second, operations and maintenance personnel are closer to their operations and therefore better able to quickly grasp the applicability of environmental laws or opportunities for pollution prevention and resource conservation. Similarly, although program/project managers may be more expensive than environmental staff, their position at the front end of NASA's programs and projects allows them to design compliance and pollution prevention into their programs and projects at the start. That is much more cost-effective for NASA than dealing with problems and missed opportunities later. A similar logic applies with respect to management and conduct of construction projects: early consideration of environmental issues can save time and effort for all concerned.

Thus, an enhanced EMS can be expected to produce efficiencies through a variety of mechanisms.

[6] Granted, time spent on environmental issues by non-environmental staff is time taken away from their other responsibilities. This project has tried to estimate those time commitments so that it accounts for full costs as well as benefits.

Attainment of NASA Strategic Environmental Goals. Although the efficiencies resulting from implementation of enhanced EMS are valuable, progress in meeting NASA's environmental goals is a very significant benefit. Core Team discussions indicated that enhanced EMS are expected to contribute to compliance, pollution prevention, and conservation goals. (Other drivers assure attainment of NASA restoration goals.)

Enhanced EMS can help NASA Centers attain and maintain full compliance with environmental requirements. EMS largely are collections of procedures and documents and sometimes are criticized for that. However, many environmental compliance requirements are themselves procedural and documentation requirements, such as NEPA. Thus, enhanced EMS are well-oriented to help NASA Centers manage many of their compliance obligations. Further, an enhanced EMS must be based on documented knowledge of applicable laws; given the complexity and volume of environmental laws, it may be difficult for Centers to stay on top of compliance obligations in the absence of enhanced EMS or their functional equivalents. Finally, the involvement of non-environmental professionals, from program/project managers to operations and maintenance staff, is important to achieving full and timely compliance; such involvement is a hallmark of enhanced EMS.

Similarly, involvement of non-environmental staff is crucial for attaining pollution prevention goals, as well as certain conservation goals such as water and energy conservation. Thus, an enhanced EMS should contribute to NASA's attainment of these goals by involving the people most familiar with NASA's operation and maintenance processes and the people who rely on those processes to support their programs and projects. The potential benefits of pollution prevention and energy/water conservation, however, often will require that associated costs be incurred by non-environmental programs.

Attainment of resource conservation goals through enhanced EMS is less clear-cut apart from water and energy conservation noted above. On the one hand, an EMS may not identify special resources deserving of management. That is because an EMS starts by looking at aspects of a Center's operations that may have significant environmental impacts; then the EMS requires development of management plans for priority impacts. Thus, an EMS is more of a pollution control scheme than a resource management scheme. On the other hand, as Centers prepare resource management plans, an EMS can ensure that plan commitments are met. During the pilot implementation, the test-bed centers envisioned far more benefits from enhanced EMS in terms of compliance and pollution prevention than benefits for resource conservation.

The test-bed centers did not envision that enhanced EMS would benefit their restoration programs. Those programs already have high visibility and tend to be driven by public and regulatory oversight as well as appropriations.

3.2 Types of Changes at NASA Centers

Exhibit 3-1 was developed by the NASA Core Team as a way to identify the many benefits that can arise from having an enhanced EMS. The left column lists major types of changes expected from an enhanced EMS. The right column lists associated benefits for each type of change. Many benefits appear in more than one category, indicating multiple drivers for achieving those benefits. Prior to developing this chart, the test-bed centers undertook an exercise to visualize anticipated future benefits of their EMS.

3.3 Potential Benefits

The following paragraphs describe the potential benefits of enhanced EMS:

Exhibit 3-1: EMS Changes and Potential Benefits

Changes Due to Enhanced EMS	Potential Benefits from Changes Due to Enhanced EMS
Increased Awareness, Understanding, and Planning	➢ Mission delay reductions ➢ Change order reductions ➢ Environmental impact reductions ➢ Reduced liability ➢ Increased compliance (e.g., NEPA) ➢ Increased management support and involvement ➢ Increased proactivity
Source Reduction (hazardous and toxic wastes, air emissions, etc.)	➢ Increased pollution prevention ➢ Cost reductions ➢ Improved safety ➢ Fewer applicable regulations ➢ Spill reductions ➢ Environmental impact reductions ➢ Reduced liability
Resource Consumption Reduction	➢ Increased affirmative procurement ➢ Increased recycling revenue ➢ Solid waste reduction ➢ Environmental impact reductions ➢ Reduced liability ➢ Decreased use of energy, water, and materials ➢ Increased pollution prevention ➢ Cost reductions ➢ Health and safety benefits
Increased Compliance	➢ Decreased number of fines and NOVs ➢ Better reputation with stakeholders and community ➢ Environmental impact reductions ➢ Mission delay reductions ➢ Change order reductions ➢ Decreased employee time (fewer inspections)
Formalized and Optimized EMS	➢ Reduced number of inspections ➢ Written procedures, consistency of process, repeatability ➢ Increased efficiency ➢ Reduction of single-point failures ➢ Continual improvement ➢ Prioritization of funding projects ➢ Reduced liability
Lifecycle analysis	➢ Environmental impact reductions ➢ Reduced costs ➢ Increased safety ➢ Mission delay reductions, change order reductions ➢ Increased number of green building designs ➢ Increased number of sustainability projects ➢ Increase number of pollution prevention initiatives
Intangibles	➢ Better NASA reputation (Center and Agency) ➢ Better relationship with stakeholders ➢ Increased trust and satisfaction from customers

➢ Mission Delay Reductions. Environmental management is an important mission support function. Mission delays can result from unexpected or poorly managed environmental issues. Implementation of an EMS can allow NASA program and project managers to more fully understand the range of environmental consequences associated with Agency activities and can provide processes to proactively manage environmental responsibilities.

➢ Change Order Reductions. Systematically and fully integrating environmental considerations early in the acquisition process may reduce the number of change orders due to environmental issues. An EMS can contribute to reducing change orders by increasing environmental awareness and understanding of requirements throughout NASA and encouraging integration of environmental requirements into project and acquisition planning processes and contracting.

➢ Environmental Impact Reductions. An EMS utilizes a cyclical management process to achieve continual improvement. Environmental impact reductions result from this process as the implementing organization identifies its significant environmental impacts, sets objectives and targets, implements environmental management plans, trains personnel, defines responsibilities, monitors progress, and reviews performance. Organizational focus on environmental management creates a strong incentive to reduce environmental impacts: what gets measured gets managed. In addition, taking advantage of opportunities for pollution prevention and resource conservation leads to a reduction in environmental impacts.

➢ Reduced Liability. An EMS can lead to a reduction in environmental liabilities through increases in environmental awareness across the organization and improved environmental compliance. Early identification of environmental issues and potential problems, coupled with preventive and corrective procedures, can enable NASA to reduce the potential environmental liabilities associated with both new

and existing projects. Emphasis on compliance, pollution prevention, and emergency response procedures also contributes to a reduction in potential liability.

➢ Increased Compliance. Implementation of an EMS creates a documented procedure for identifying all applicable legal and other requirements including tracking of new requirements as they emerge. This process can help Centers to be aware of all requirements associated with their activities, products, and services. This knowledge is vital for compliance. Enhanced organizational focus on achieving improvements in environmental performance and training all personnel to fulfill their environmental responsibilities facilitates an improved compliance posture. The documentation and records management elements of an EMS also can provide benefits in ensuring that all regulatory paperwork and permitting requirements are followed and that documentation is submitted on time.

➢ Reduced Number of Inspections. Implementation of an enhanced EMS can increase regulatory agency confidence in a facility's ability to manage its environmental responsibilities. This increased confidence can result in a regulatory agency electing to reduce the number of inspections that it conducts. For example, Virginia's Environmental Excellence program offers reduced inspection frequency, enforcement discretion, and reduced reporting requirements to organizations that can demonstrate implementation of a recognized EMS. Several other states are implementing similar programs aimed at encouraging EMS implementation.

➢ Decreased Employee Time (Fewer Inspections). A reduction in the number of inspections conducted by regulatory agencies benefits NASA through the decrease in employee time taken to support such activities. For example, Lockheed Martin Federal Systems estimated in 1998 that headquarter site audits typically cost $100,000-$150,000 in facility time. This time can be applied elsewhere in the environmental management program.

➢ Decreased Number of Fines and NOVs. Improvements in environmental performance and compliance resulting from an EMS will reduce non-compliance occurrences and the number of fines and NOVs. In addition, regulatory agencies may reduce the number of fines and NOVs issued if a strong EMS is in operation. An EMS demonstrates a high level of commitment to improving environmental performance and it establishes written procedures to address non-compliance issues in a proactive manner. This type of commitment is likely to appear favorable to the regulatory community.

➢ Reduced Number of Regulations. Although implementing an EMS by itself does not reduce the number of regulations that apply to a Center, the EMS can lead to changed work processes, better housekeeping, and pollution prevention projects (e.g., material substitutions) that can reduce the number of legal and other requirements triggered by Center activities.

➢ Increased Management Support and Involvement. An important part of EMS implementation is the designation of roles and responsibilities throughout the management structure of a Center, not just within the environmental function. By ensuring that environmental management responsibilities are decentralized, overall environmental awareness, involvement, and motivation at the management level are raised. Another fundamental component of an EMS is senior management support, which is vital for implementation success and for achieving maximum benefits. Senior management commitment is a prerequisite for adequate funding, personnel, and authority to be applied to implementation and maintenance. An EMS also requires senior management to review performance and make adjustments to policy and the management system, as appropriate. This form of senior management involvement ensures that a Center remains focused on achieving its evolving environmental goals and objectives.

➢ More Proactive Management. An EMS is a structured management system that enables a Center to proactively manage its environmental responsibilities, rather than simply react to daily issues. The

systematic, lifecycle approach to environmental management can help NASA to proactively manage environmental issues by identifying, preventing, and correcting problems before they result in compliance violations. Because an EMS can improve the quality of information available and provide date for planning processes and decision-making, it fosters the proactive management of environmental issues.

➢ Increased Number of Pollution Prevention Initiatives. An EMS can help a Center to identify and prioritize opportunities for environmental performance improvement. A major part of this is the identification of pollution prevention opportunities. Bringing operational, maintenance, and management personnel into environmental management taps the knowledge of those closest to the Center's work, who often are best positioned to identify, evaluate, and implement successful (e.g., cost-effective) pollution prevention initiatives.

➢ Cost Reductions. An EMS can help improve the efficiency and effectiveness of existing environmental management processes, which can offset the additional costs of EMS components that may not have existed previously. Many public and private sector organizations have reported cost reductions and savings associated with an EMS that have offset the costs of implementation. Significant cost reductions also can come from improved compliance, reduced regulatory oversight, and fewer spills. The most significant cost reductions will occur in facility operations and maintenance expenses as a result of changed work practices associated with pollution prevention and conservation projects.

➢ Improved Safety and Health. A Center implementing an EMS is likely to experience occupational safety and health benefits because environmental, safety, and occupational health issues may be closely linked in terms of compliance liabilities, potential impacts, and accident and emergency situations. For example, improving procedures for spill response and emergency situations will provide safety as well as environmental benefits. In addition, reducing reliance on hazardous materials and

lowering emissions will provide more healthy and often safer conditions for the work force as well as environmental benefits.

➢ Reduced Number of Spills. Implementation of an EMS should result in fewer accidental spills and a reduction in the environmental impacts of any spills that do occur. An EMS requires an organization to establish and maintain procedures to identify the potential for and respond to accidents and emergencies. These activities include planning to prevent spills from occurring in the first place. Pollution prevention projects stimulated by the EMS also will contribute to reductions in the frequency, scope, and toxicity of spills.

➢ Increased Affirmative Procurement. Although processes are in place to encourage and track affirmative procurement of goods and services with positive environmental attributes, these programs do not necessarily receive proper emphasis. An EMS can foster more systematic consideration of affirmative procurement both as a matter of compliance and also in view of the environmental aspects and impacts of a Center's activities, goods, and services.

➢ Solid Waste Reduction. Attention to solid waste issues often reduces solid waste generation: what gets measured gets managed. As EMS implementation raises environmental awareness across a facility, Center personnel will be motivated to generate less solid waste and identify recycling opportunities. An EMS also can foster more systematic consideration of solid waste reduction in light of the environmental aspects and impacts of a Center's activities, goods, and services; solid waste was considered a priority impact at JSC, for example.

➢ Increased Recycling Revenue. Implementation of an EMS potentially can lead to an increase in the revenue generated from recycling. Identification of recyclable waste streams and finding either an on-

site reuse or off-site sales opportunity can be an objective of EMS implementation. In addition, recycling may increase as a matter of compliance with Executive Order 12873 (October 1993) and Executive Order 13101 (September 1998).

➢ Decreased Energy and Water Consumption. An EMS can focus management attention on achieving energy and water conservation goals and objectives. It also can provide personnel with the responsibility and authority to achieve performance targets, if water and energy conservation are deemed important objectives in light of a Center's other aspects and impacts.

➢ Written Procedures, Consistency of Process, Repeatability. An EMS is underpinned by formal written procedures that define business processes at each organizational level. An EMS documents these procedures and ensures that they are communicated to all applicable personnel. The importance of following the written procedures (and the potential consequences of failure to comply) is conveyed during training sessions. As a result, a Center can conduct its business functions in a consistent and repeatable manner.

➢ Increased Efficiency. The implementation of an enhanced EMS may increase the efficiency of environmental management activities. An EMS provides structure and consistency and can improve the allocation of resources, the assignment of responsibilities, and the ongoing evaluation of procedures and processes. These benefits all add to improvements in efficiency. An EMS also limits the disruptions that can result when procedures and knowledge depend on the availability of individuals. Organizations, such as White Sands, that have implemented EMS report that their environmental staffs can focus on more value-added activities than previously.

➢ Reduction of Single-Point Failures. Development of written EMS procedures can reduce single-point failures in managing environmental issues. The increase in environmental awareness, clear assignments of responsibility, and set procedures can ensure that environmental compliance, spill prevention, and emergency response do not depend on a single individual, but rather result from a system. Thus, disruptions due to staff turnover are kept to a minimum.

➢ Continual Improvement. The underlying philosophy of an EMS is continual improvement. The implementation of a systematic approach to managing environmental responsibilities and the commitment of senior management to continual improvement in environmental performance can bring great benefits. Continual improvement can be expected across all areas of the EMS. Continual performance improvement is likely to provide significant benefits to the environment and the quality of life for NASA employees and surrounding communities.

➢ Prioritization of Funding Projects. Identifying significant environmental impacts through the aspects and impacts analysis of an EMS provides decision-makers with information to aid prioritization. Their evaluations of funding priority can include considerations of both environmental and business concerns. Environmental concerns include the scale of the impact, its severity and duration, and its probability of occurrence, information which is developed in a consistent manner by the EMS for all significant environmental aspects of a Center's activities, goods, and services.

➢ Increased Number of Green Building Designs. An EMS can encourage building designs incorporating energy and water efficiency, utilizing recycled and recyclable materials, and minimizing use of hazardous materials. This depends on the goals and objectives of the organization and its interest in pursuing green building design as a method of improving environmental performance. The impact

identification, prioritization, and planning components of an EMS can improve evaluation of opportunities for green building design.

➢ Increased Number of Sustainability Projects. The implementation of an EMS is consistent with pursuing sustainable development strategies and projects. An EMS can support a goal of improving Center processes and output while reducing environmental impacts. Therefore, an EMS can help identify opportunities for new sustainability projects aimed at improving the quality of the human and natural environment while supporting NASA's missions.

➢ Better NASA Reputation (Center and Agency) and Improved Relationships with Stakeholders. Implementation of an EMS can help build confidence in all stakeholders that NASA places environmental protection high on its list of priorities and has established a system to achieve its environmental policies. An EMS also can demonstrate that NASA emphasizes proactive environmental protection rather than reactive or corrective actions. In both the public and private sectors, EMS implementation has improved relations with stakeholders.

➢ Increased Trust and Satisfaction from Customers. An EMS can provide added confidence among customers that NASA has a system in place to ensure that environmental requirements do not cause mission delays. Implementation of an EMS also may align NASA's environmental approach with those of its customers, who also may have adopted EMS.

In developing the preceding list of potential benefits, the Core Group did not mean to suggest that all of the above benefits will come from an enhanced EMS. They are potential benefits. Moreover, NASA Centers with many components of a compliant EMS already may be experiencing some or all of

the benefits. ISO certification may or may not be a necessary condition for experiencing the benefits of an enhanced EMS. Much depends on the existing situation at a Center.

Industry opinion is divided about whether the benefits of external certification are worth the costs. Ford Motor Company made a senior management commitment to registration and believes it has experienced significant benefits.[7] Other companies have not sought certification, believing that the benefits are not worth the costs.[8] Lockheed Martin Corporation left certification up to its individual sites; its major aerospace facilities have chosen to pursue certification.

[7] Tim O. Brien, *Ford & ISO 14001* (2001).

[8] Pam Parry, *The Bottom Line: How to Build A Business Case for ISO 14001* (2000).

APPENDIX A:
RESULTS FOR INDIVIDUAL TEST-BED CENTERS

The following subsections present Glenn's, Johnson's, and Stennis' Executive Order and ISO 14001 costs and hours separately. These data are divided into civil servant and contractor hours and costs. Total implementation costs were calculated by adding total civil servant costs, total contractor costs, and travel costs. Total civil servant costs were calculated by: (# of environmental civil servant hours x fully loaded hourly rate) + (# of other Center civil servant hours x fully loaded hourly rate) + (fully loaded civil servant expenses). Total contractor costs were calculated by: (# of contractor staff hours x hourly rate) + (fully loaded contractor expenses). Johnson separated total contractor costs into EMS contractor costs and other contractor costs; Glenn and Stennis did not.

GLENN

Exhibit A-1 presents Glenn's total hours and costs to meet the requirements of the Executive Order divided into civil servant and contractor hours and costs. The greatest amount of civil servant hours and costs was spent on training and awareness (1,121 hours and $47K), whereas the greatest amount of contractor hours and costs was spent to identify impacts and develop management plans (884 hours and $88K).

Exhibit A-2 divides the hours Glenn used to implement the Executive Order into hours used by environmental civil servants, other civil servants, and contractors. This Exhibit also shows the proportion of hours used by each category on each activity. The greatest proportions of environmental civil servant hours were used on implementation planning (24 percent) and training and awareness (22 percent). The largest amount of hours spent by civil servants outside the environmental office was used on training and awareness (88 percent). Other civil servants used very few hours on the remaining activities. Finally, the contractor used the greatest proportion of hours to identify impacts and develop management plans

Exhibit A-1: Glenn's Civil Servant and Contractor Hours and Costs to Meet Executive Order 13148

Executive Order Activity	CIVIL SERVANT		CONTRACTOR		TOTAL	
	Hours	Costs ($)	Hours	Costs ($)	Hours	Costs ($)
Implementation Planning	234	10K	499	67K	733	77K
Identify Impacts and Develop Management Plans	99	5K	884	88K	983	93K
Training and Awareness	1,121	47K	695	69K	1,816	116K
Communication	57	3K	355	35K	412	38K
Documentation and Document Control	68	3K	226	23K	294	26K
Environmental Functional Review	40	2K	80	3K	120	5K
Miscellaneous	56	3K	125	12K	181	15K
TOTAL	**1,675**	**73K**	**2,864**	**297K**	**4,539**	**370K**

Exhibit A-2: Glenn's Executive Order Hours by Activity

Executive Order Activity	ENVIRONMENTAL CIVIL SERVANT		OTHER CIVIL SERVANT		CONTRACTOR		TOTAL	
	Hours	% of Total Envtl CS Hours	Hours	% of Total Other CS Hours	Hours	% of Total Contractor Hours	Hours	% of Total Implemen - tation Hours
Implementation Planning	199	24%	35	3%	499	15%	733	14%
Identify Impacts and Develop Management Plans	50	6%	49	5%	884	27%	983	19%
Training and Awareness	187	22%	934	88%	695	21%	1,816	35%
Communication	27	3%	30	3%	355	11%	412	8%
Documentation and Document Control	68	8%	0	0%	226	7%	294	6%
Environmental Functional Review	40	5%	0	0%	80	2%	120	2%
Miscellaneous	44	5%	12	1%	125	4%	181	3%
TOTAL	**615**	**73%**	**1,060**	**100%**	**2,864**	**87%**	**4,539**	**87%**

(27 percent). In addition, Glenn's contractor spent a good deal of hours on implementation planning (15 percent) and training and awareness (21 percent).

Exhibit A-3 divides Glenn's Executive Order costs into civil servant costs and contractor costs. The Exhibit also shows the proportion of costs incurred by each category on each activity. The large majority of costs was incurred from training and awareness (59 percent). The next highest percentage of civil servant costs was incurred from implementation planning (12 percent). An equal percentage of contractor costs was incurred from implementation planning and training and awareness (19 percent). However, the greatest proportion of contractor costs was from identifying impacts and developing management plans (24 percent). In addition, the costs and percentage for this activity is significantly higher for contractors ($88K, 24 percent) than for civil servants ($5K, 5 percent).

Exhibit A-3: Glenn's Executive Order Costs by Activity

	CIVIL SERVANT		CONTRACTOR		TOTAL	
Executive Order Activity	**Costs ($)**	**% of Total CS Costs**	**Costs ($)**	**% of Total Contractor Costs**	**Costs ($)**	**% of Total Implementation Costs**
Implementation Planning	10K	12%	67K	19%	77K	14%
Identify Impacts and Develop Management Plans	5K	5%	88K	24%	93K	19%
Training and Awareness	47K	59%	69K	19%	116K	35%
Communication	3K	3%	35K	10%	38K	8%
Documentation and Document Control	3K	4%	23K	6%	26K	6%
Environmental Functional Review	2K	2%	3K	1%	5K	2%
Miscellaneous	3K	3%	12K	3%	15K	3%
TOTAL	**73K**	**88%**	**297K**	**82%**	**370K**	**87%**

JOHNSON

Exhibit A-4 presents Johnson's total hours and costs to meet the requirements of the Executive Order divided into civil servant and contractor hours and costs. The greatest amounts of civil servant hours and costs were spent on three activities: identifying impacts and developing management plans, training and awareness, and communication. The greatest amount of contractor hours and costs was spent on identifying impacts and developing management plans and training and awareness.

Exhibit A-4: Johnson's Civil Servant and Contractor Hours and Costs to Meet Executive Order 13148

Executive Order Activity	CIVIL SERVANTS		ALL CONTRACTORS		TOTAL	
	Hours	Costs ($)	Hours	Costs ($)	Hours	Costs ($)
Implementation Planning	872	46K	960	114K	1,831	160K
Identify Impacts and Develop Management Plans	1,568	83K	2,364	265K	3,932	348K
Training and Awareness	1,223	64K	2,434	190K	3,657	253K
Communication	1,451	78K	634	79K	2,085	156K
Documentation and Document Control	291	15K	1,217	157K	1,508	172K
Environmental Functional Review	227	12K	0	0K	227	12K
Miscellaneous	169	9K	275	35K	444	43K
TOTAL	**5,801**	**307K**	**7,884**	**840K**	**13,684**	**1,144K**

Exhibit A-5 divides the hours Johnson used to implement the Executive Order into hours used by environmental civil servants, other civil servants, Center contractors, and the EMS contractor. This Exhibit also shows the proportion of hours used by each category on each activity. Almost one-third of environmental civil servant time was spent on communication. Environmental civil servants spent the next highest proportion of hours on implementation planning (21 percent). In contrast, civil servants outside of the environmental office used the greatest proportion of their time on training and awareness

Exhibit A-5: Johnson's Executive Order Hours by Activity

Executive Order Activity	ENVIRONMENTAL CIVIL SERVANT		OTHER CIVIL SERVANT		CENTER CONTRACTORS		EMS CONTRACTOR		TOTAL	
	Hours	% of Total Envtl CS Hours	Hours	% of Total Other CS Hours	Hours	% of Total Center Contractors Hours	Hours	% of Total EMS Contractor Hours	Hours	% of Total Implementation Hours
Implementation Planning	566	21%	306	6%	127	3%	833	14%	1,832	10%
Identify Impacts and Develop Management Plans	164	6%	1,404	29%	651	17%	1,713	28%	3,932	22%
Training and Awareness	130	5%	1,093	23%	2,005	52%	429	7%	3,657	21%
Communication	844	31%	607	12%	52	1%	582	9%	2,085	12%
Documentation and Document Control	211	8%	80	2%	0	0%	1,217	20%	1,508	9%
Environmental Functional Review	218	8%	9	0%	0	0%	0	0%	227	1%
Miscellaneous	66	2%	103	2%	11	0%	264	4%	444	3%
TOTAL	**2,199**	**81%**	**3,602**	**74%**	**2,846**	**73%**	**5,038**	**82%**	**13,684**	**78%**

(29 percent) and communication (23 percent). More than half of the Center's contractors time was spent on training and awareness, whereas, the EMS contractor's time was focused heavily on identifying impacts and developing management plans (28 percent) and documentation and document control (20 percent).

Exhibit A-6 divides Johnson's Executive Order costs into civil servant costs and contractor costs. The Exhibit also shows the proportion of costs incurred by each category on each activity. The greatest proportions of civil servant expenses were incurred on three activities: identifying impacts and developing management plans (21 percent), training and awareness (16 percent), and communication (19 percent). The majority of contractor costs was similarly spent on three activities: identifying impacts and developing management plans (25 percent), training and awareness (18 percent), and documentation and document control (15 percent).

Exhibit A-6: Johnson's Executive Order Costs by Activity

Executive Order Activity	CIVIL SERVANTS		ALL CONTRACTORS		TOTAL	
	Costs ($)	% of Total CS Costs	Costs ($)	% of Total Contractor Costs	Costs ($)	% of Total Implementation Costs
Implementation Planning	46K	12%	114K	11%	160K	11%
Identify Impacts and Develop Management Plans	83K	21%	265K	25%	348K	24%
Training and Awareness	64K	16%	190K	18%	253K	17%
Communication	78K	19%	79K	7%	156K	11%
Documentation and Document Control	15K	4%	157K	15%	172K	12%
Environmental Functional Review	12K	3%	0K	0%	12K	1%
Miscellaneous	9K	2%	35K	4%	43K	3%
TOTAL	**307K**	**77%**	**840K**	**80%**	**1,144K**	**79%**

STENNIS

Exhibit A-7 presents Stennis' total hours and costs to meet the requirements of the Executive Order divided into civil servant hours and costs and contractor hours and costs. The greatest amounts of civil servant hours and costs were spent on identifying impacts and developing management plans (454 hours, $20K) and on documentation and document control (477 hours, $21K). Stennis' contractors spent 1,200 hours or more on each of four activities: identifying impacts and developing management plans, training and awareness, documentation and document control; and miscellaneous. However, the greatest contractor costs were incurred from identifying impacts and developing management plans and from documentation and document control.

Exhibit A-7: Stennis' Civil Servant and Contractor Hours and Costs to Meet Executive Order 13148

Executive Order Activity	CIVIL SERVANT		CONTRACTOR		TOTAL	
	Hours	Costs ($)	Hours	Costs ($)	Hours	Costs ($)
Implementation Planning	160	7K	778	52K	938	59K
Identify Impacts and Develop Management Plans	454	20K	1,391	87K	1,845	107K
Training and Awareness	123	5K	1,488	59K	1,611	64K
Communication	0	0K	422	19K	422	19K
Documentation and Document Control	477	21K	1,600	87K	2,077	108K
Environmental Functional Review	201	9K	500	23K	701	32K
Miscellaneous	149	8K	1,200	47K	1,349	55K
TOTAL	**1,564**	**70K**	**7,379**	**374K**	**8,943**	**444K**

Exhibit A-8 divides the hours Stennis used to implement the Executive Order into hours used by environmental civil servants, other civil servants, and contractors. This Exhibit also shows the proportion of hours used by each category on each activity. The greatest proportion of environmental civil servant time was used to identify impacts and develop management plans (22 percent) and on documentation and document control (23 percent). Other civil servants spent a roughly equal proportion of time on three activities: implementation planning (16 percent), identifying impacts and developing management plans (16 percent), and miscellaneous (19 percent). Finally, contractor time was mainly concentrated on identifying impacts and developing management plans, training and awareness, and documentation and document control (17 percent, 18 percent, and 19 percent, respectively).

Exhibit A-8: Stennis' Executive Order Hours by Activity

Executive Order Activity	ENVIRONMENTAL CIVIL SERVANT		OTHER CIVIL SERVANT		CONTRACTOR		TOTAL	
	Hours	% of Total Envtl CS Hours	Hours	% of Total Other CS Hours	Hours	% of Total Contractor Hours	Hours	% of Total Implementation Hours
Implementation Planning	126	7%	34	16%	778	9%	938	9%
Identify Impacts and Develop Management Plans	418	22%	36	16%	1,391	17%	1,845	18%
Training and Awareness	102	5%	21	10%	1,488	18%	1,611	15%
Communication	0	0%	0	0%	422	5%	422	4%
Documentation and Document Control	450	23%	27	13%	1,600	19%	2,077	20%
Environmental Functional Review	200	10%	1	0%	500	6%	701	7%
Miscellaneous	108	6%	41	19%	1,200	14%	1,349	13%
TOTAL	**1,404**	**73%**	**160**	**74%**	**7,379**	**88%**	**8,943**	**85%**

Exhibit A-9 divides Stennis' Executive Order costs into civil servant costs and contractor costs. The Exhibit also shows the proportion of costs incurred by each category on each activity. More than half of the total civil servant Executive Order costs were incurred from two activities – identifying

Exhibit A-9: Stennis' Executive Order Costs by Activity

Executive Order Activity	CIVIL SERVANT		CONTRACTOR		TOTAL	
	Costs ($)	% of Total CS Costs	Costs ($)	% of Total Contractor Costs	Costs ($)	% of Total Implementation Costs
Implementation Planning	7K	7%	52K	12%	59K	11%
Identify Impacts and Develop Management Plans	20K	21%	87K	20%	107K	19%
Training and Awareness	5K	6%	59K	13%	64K	12%
Communication	0K	0%	19K	4%	19K	3%
Documentation and Document Control	21K	22%	87K	20%	108K	20%
Environmental Functional Review	9K	9%	23K	5%	32K	6%
Miscellaneous	8K	8%	47K	11%	55K	10%
TOTAL	**70K**	**73%**	**374K**	**85%**	**444K**	**81%**

impacts and developing management plans (21 percent) and documentation and document control (22 percent). Similar percentages of total contractor costs were incurred from the same two activities. For contractors, the next highest proportions of cost were incurred from training and awareness (13 percent) and miscellaneous (11 percent).

ISO 14001 Activities by Center

The following subsections present Glenn's, Johnson's, and Stennis' ISO 14001 costs separately. These costs are divided into civil servant and contractor hours and costs. Total implementation costs are total civil servant costs added to total contractor costs plus any travel costs. Total civil servant costs were calculated by: (# of environmental civil servant hours x fully loaded hourly rate) + (# of other Center civil servant hours x fully loaded hourly rate) + (fully loaded civil servant expenses). Total contractor costs were calculated by: (# of contractor staff hours x hourly rate) + (fully loaded contractor expenses). Johnson separated total contractor costs into EMS contractor costs and other contractor costs; Glenn and Stennis did not.

GLENN

Exhibit A-10 presents Glenn's total hours and costs to meet the requirements of ISO 14001 divided into civil servant hours and costs and contractor hours and Costs. Glenn's civil servants spent the greatest amount of time and money on the ISO 14001 registration process (160 hours, $7K), whereas, Glenn's contractors used the largest amount of hours on Center-wide awareness training (160 hours) and identifying personnel whose job-specific activities may create a priority impact on the environment (165 hours). The largest amount of contractor costs was incurred from Center-wide awareness training ($34K).

Exhibit A-10: Glenn's Civil Servant and Contractor Hours and Costs to Meet ISO 14001 Requirements

ISO 14001 Activities	CIVIL SERVANT		CONTRACTOR		TOTAL	
	Hours	Costs ($)	Hours	Costs ($)	Hours	Costs ($)
Center-wide Awareness Training	16	1K	160	34K	176	35K
Identify and determine level of all environmental impacts not addressed by Legal and Other Requirements	0	0K	0	0K	0	0K
Identify Legal and Other Requirements	18	1K	100	10K	118	11K
Identify personnel whose job-specific activities may create a priority impact on the environment	0	0K	165	16K	165	16K
Use NASA NPGs 1440.6 and 1441.1, and NPD 2800.1 for EMS records	16	0K	6	1K	22	1K
Management Review	23	1K	0	0K	23	1K
ISO 14001 Registration Process	160	7K	40	4K	200	11K
TOTAL	**233**	**10K**	**470**	**65K**	**704**	**75K**

Exhibit A-11 divides the hours Glenn used to implement the ISO 14001 EMS into hours used by environmental civil servants, other civil servants, and contractors. This Exhibit also shows the proportion of hours used by each category on each activity. The greatest proportion of environmental civil servant hours was used on the ISO 14001 registration process (19 percent). Other civil servants spent almost no time on the ISO 14001 compliant EMS. About 5 percent of the total contractor hours was spent each on Center-wide awareness training and identifying personnel whose job-specific activities may create a priority impact on the environment.

Exhibit A-11: Glenn's ISO 14001 Hours by Activity

ISO 14001 Activities	ENVIRONMENTAL CIVIL SERVANT		OTHER CIVIL SERVANT		CONTRACTOR		TOTAL	
	Hours	% of Total Envtl CS Hours	Hours	% of Total Other CS Hours	Hours	% of Total Contractor Hours	Hours	% of Total Implementation Hours
Center-wide Awareness Training	16	2%	0	0%	160	5%	176	3%
Identify and determine level of all environmental impacts not addressed by Legal and Other Requirements	0	0%	0	0%	0	0%	0	0%
Identify Legal and Other Requirements	18	2%	0	0%	100	3%	118	2%
Identify personnel whose job-specific activities may create a priority impact on the environment	0	0%	0	0%	165	5%	165	3%
Use NASA NPGs 1440.6 and 1441.1, and NPD 2800.1 for EMS records	16	2%	0	0%	6	0%	22	0%
Management Review	16	2%	7	1%	0	0%	23	0%
ISO 14001 Registration Process	160	19%	0	0%	40	1%	200	4%
TOTAL	**226**	**27%**	**7**	**1%**	**471**	**14%**	**704**	**13%**

Exhibit A-12 divides Glenn's ISO 14001 costs into civil servant costs and contractor costs. The Exhibit also shows the proportion of costs incurred by each category on each activity. Similar to the ISO 14001 hours Exhibit above, the largest percentage of civil servant costs was incurred from the ISO 14001 registration process (8 percent), and the largest percentages of contractor costs were incurred from Center-wide awareness training (9 percent) and identifying personnel whose job-specific activities may create a priority impact on the environment (5 percent).

Exhibit A-12: Glenn's ISO 14001 Costs by Activity

ISO 14001 Activities	CIVIL SERVANT		CONTRACTOR		TOTAL	
	Costs ($)	% of Total CS Costs	Costs ($)	% of Total Contractor Costs	Costs ($)	% of Total Implementation Costs
Center-wide Awareness Training	1K	1%	34K	9%	35K	8%
Identify and determine level of all environmental impacts not addressed by Legal and Other Requirements	0K	0%	0K	0%	0K	0%
Identify Legal and Other Requirements	1K	1%	10K	3%	11K	2%
Identify personnel whose job-specific activities may create a priority impact on the environment	0K	0%	16K	5%	16K	5%
Use NASA NPGs 1440.6 and 1441.1, and NPD 2800.1 for EMS records	0K	1%	1K	0%	1K	0%
Management Review	1K	1%	0K	0%	1K	0%
ISO 14001 Registration Process	7K	8%	4K	1%	11K	2%
TOTAL	**10K**	**12%**	**65K**	**18%**	**75K**	**17%**

JOHNSON

Exhibit A-13 presents Johnson's total hours and costs to meet the requirements of ISO 14001 divided into civil servant and contractor hours and costs. Johnson's civil servants and contractors spent the greatest amount of time and costs on the ISO 14001 registration process. Contractors used the second-highest amount of hours and costs for Center-wide awareness training.

Exhibit A-13: Johnson's Civil Servant and Contractor Hours and Costs to Meet ISO 14001 Requirements

ISO 14001 Activities	CIVIL SERVANTS		ALL CONTRACTORS		TOTAL	
	Hours	Costs ($)	Hours	Costs ($)	Hours	Costs ($)
Center-wide Awareness Training	166	10K	616	42K	782	52K
Identify and determine level of all environmental impacts not addressed by Legal and Other Requirements	24	1K	32	3K	56	4K
Identify Legal and Other Requirements	16	1K	56	7K	72	8K
Identify personnel whose job-specific activities may create a priority impact on the environment	96	5K	128	11K	224	16K
Use NASA NPGs 1440.6 and 1441.1, and NPD 2800.1 for EMS records	248	13K	348	34K	596	47K
Management Review	273	14K	55	7K	328	21K
ISO 14001 Registration Process	945	49K	941	109K	1886	158K
TOTAL	**1,768**	**93K**	**2,176**	**213K**	**3,944**	**306K**

Exhibit A-14 divides the hours Johnson used to implement the ISO 14001 compliant EMS into hours used by environmental civil servants, other civil servants, Center contractors, and the EMS contractor. This Exhibit also shows the proportion of hours used by each category on each activity. The environmental civil servants and other civil servants used the greatest proportion of hours on the ISO 14001 registration process (10 percent and 13 percent, respectively). Center contractors used the majority of the ISO 14001 hours on Center-wide awareness training (16 percent), whereas the EMS contractor used the greatest portion of ISO 14001 hours on the ISO 14001 registration process (12 percent).

Exhibit A-14: Johnson's ISO 14001 Hours by Activity

ISO 14001 Activities	ENVIRON-MENTAL CIVIL SERVANT		OTHER CIVIL SERVANT		CENTER CONTRACTORS		EMS CONTRACTOR		TOTAL	
	Hrs	% of Total Envtl CS Hrs	Hrs	% of Total Other CS Hrs	Hrs	% of Total Center Contractors Hrs	Hrs	% of Total EMS Contractor Hrs	Hrs	% of Total Imple-men-tation Hrs
Center-wide Awareness Training	16	1%	150	3%	600	16%	16	0%	782	5%
Identify and determine level of all environmental impacts not addressed by Legal and Other Requirements	24	1%	0	0%	0	0%	32	0%	56	0%
Identify Legal and Other Requirements	16	1%	0	0%	0	0%	56	1%	72	0%
Identify personnel whose job-specific activities may create a priority impact on the environment	48	2%	48	1%	80	2%	48	1%	224	1%
Use NASA NPGs 1440.6 and 1441.1, and NPD 2800.1 for EMS records	80	3%	168	4%	168	4%	180	3%	596	3%
Management Review	25	1%	248	5%	2	0%	53	1%	328	2%
ISO 14001 Registration Process	304	10%	641	13%	195	5%	746	12%	1886	11%
TOTAL	**513**	**19%**	**1,255**	**26%**	**1,045**	**27%**	**1,131**	**18%**	**3,944**	**22%**

Exhibit A-15 divides Johnson's ISO 14001 costs into civil servant costs and contractor costs. The Exhibit also shows the proportion of costs incurred by each category on each activity. Johnson incurred the majority of ISO 14001 costs from civil servants and contractors in the ISO 14001 registration process.

STENNIS

Exhibit A-16 presents Stennis' total hours and costs to meet the requirements of ISO 14001, separated by civil servant hours and costs and contractor hours and costs. Of the ISO 14001 hours and costs, Stennis' civil servants and contractors spent the greatest amount of time and incurred the greatest amount of costs from the ISO 14001 registration process.

Exhibit A-15: Johnson's ISO 14001 Costs by Activity

ISO 14001 Activities	CIVIL SERVANTS		ALL CONTRACTORS		TOTAL	
	Costs ($)	% of Total CS Costs	Costs ($)	% of Total Contractor Costs	Costs ($)	% of Total Implementation Costs
Center-wide Awareness Training	10K	2%	42K	4%	52K	4%
Identify and determine level of all environmental impacts not addressed by Legal and Other Requirements	1K	0%	3K	0%	4K	0%
Identify Legal and Other Requirements	1K	0%	7K	1%	8K	1%
Identify personnel whose job-specific activities may create a priority impact on the environment	5K	1%	11K	1%	16K	1%
Use NASA NPGs 1440.6 and 1441.1, and NPD 2800.1 for EMS records	13K	4%	34K	3%	47K	3%
Management Review	14K	4%	7K	1%	21K	1%
ISO 14001 Registration Process	49K	12%	109K	10%	158K	11%
TOTAL	**93K**	**23%**	**213K**	**20%**	**306K**	**21%**

Exhibit A-16: Stennis' Civil Servant and Contractor Hours and Costs to Meet ISO 14001 Requirements

ISO 14001 Activities	CIVIL SERVANT		CONTRACTOR		TOTAL	
	Hours	Costs ($)	Hours	Costs ($)	Hours	Costs ($)
Center-wide Awareness Training	80	3K	173	11K	253	15K
Identify and determine level of all environmental impacts not addressed by Legal and Other Requirements	46	2K	12	1K	58	3K
Identify Legal and Other Requirements	0	0K	53	4K	53	4K
Identify personnel whose job-specific activities may create a priority impact on the environment	40	2K	100	4K	140	6K
Use NASA NPGs 1440.6 and 1441.1, and NPD 2800.1 for EMS records	60	3K	0	0K	60	3K
Management Review	2	0K	6	1K	8	2K
ISO 14001 Registration Process	356	15K	650	55K	1,006	73K
TOTAL	**584**	**25K**	**994**	**76K**	**1,578**	**106K**

Exhibit A-17 divides the hours Stennis used to implement an ISO 14001 EMS into hours used by environmental civil servants, other civil servants, and its contractor. This Exhibit also shows the proportion of hours used by each category on each activity. Stennis' environmental civil servants used the largest percentage of ISO 14001 hours on the ISO registration process (16 percent), as did other civil servants (26 percent). In fact, the ISO 14001 registration process was the only ISO 14001 activity other civil servants spent time on. Similarly, two-thirds of the ISO 14001 contractor hours were used on the ISO 14001 registration process.

Exhibit A-17: Stennis' ISO 14001 Hours by Activity

ISO 14001 Activities	ENVIRONMENTAL CIVIL SERVANT		OTHER CIVIL SERVANT		CONTRACTOR		TOTAL	
	Hrs	% of Total Envtl CS Hrs	Hrs	% of Total Other CS Hrs	Hrs	% of Total Contractor Hrs	Hrs	% of Total Implementation Hrs
Center-wide Awareness Training	80	4%	0	0%	173	2%	253	2%
Identify and determine level of all environmental impacts not addressed by Legal and Other Requirements	46	2%	0	0%	12	0%	58	1%
Identify Legal and Other Requirements	0	0%	0	0%	53	1%	53	1%
Identify personnel whose job-specific activities may create a priority impact on the environment	40	2%	0	0%	100	1%	140	1%
Use NASA NPGs 1440.6 and 1441.1, and NPD 2800.1 for EMS records	60	3%	0	0%	0	0%	60	1%
Management Review	2	0%	0	0%	6	0%	8	0%
ISO 14001 Registration Process	300	16%	56	26%	650	8%	1,006	9%
TOTAL	**528**	**27%**	**56**	**26%**	**994**	**12%**	**1,578**	**15%**

Exhibit A-18 separates Stennis' ISO 14001 costs into civil servant costs and contractor costs. The Exhibit also shows the proportion of costs incurred by each category on each activity. As with the ISO 14001 hours, Stennis civil servants and contractors spent more than half of the total ISO 14001 costs on the ISO 14001 registration process (16 percent for civil servants and 13 percent for contractors).

Exhibit A-18: Stennis' ISO 14001 Costs by Activity

ISO 14001 Activities	CIVIL SERVANT		CONTRACTOR		TOTAL	
	Costs ($)	% of Total CS Costs	Costs ($)	% of Total CS Costs	Costs ($)	% of Total Implementation Costs
Center-wide Awareness Training	3K	4%	11K	3%	15K	3%
Identify and determine level of all environmental impacts not addressed by Legal and Other Requirements	2K	2%	1K	0%	3K	1%
Identify Legal and Other Requirements	0K	0%	4K	1%	4K	1%
Identify personnel whose job-specific activities may create a priority impact on the environment	2K	2%	4K	1%	6K	1%
Use NASA NPGs 1440.6 and 1441.1, and NPD 2800.1 for EMS records	3K	3%	0K	0%	3K	0%
Management Review	0K	0%	1K	0%	2K	0%
ISO 14001 Registration Process	15K	16%	55K	13%	73K	13%
TOTAL	**25K**	**27%**	**76K**	**18%**	**106K**	**19%**

APPENDIX B:
EMS MAINTENANCE ELEMENTS

Required EMS Maintenance Activities That Must Be Conducted to Satisfy Executive Order 13148

Note: Does not include activities already required by other NASA NPGs, e.g. Emergency Preparedness.

1. EMS Core Team functions and operations on an ongoing basis (e.g. EMS Co-ordination meetings, regular periodic reviews of program elements and progress)

2. Various Installation staff generating required reports on EMS performance (reports required by the installation or NASA HQ). E.g. Monitoring and measurement of effectiveness of operational controls instituted during EMS development.

3. Document authors and technical experts review existing EMS procedures, documented procedures and other documentation as per regular review schedules.

4. Review legal and other requirements and identify any changes.

5. EMS staff and committees review aspects and impacts and prioritization determination for adequacy. Includes ensuring that input used in existing risk criteria evaluations remains valid and relevant.

6. Identify any changes in personnel (including internal contractors) whose job-specific activities may create a priority impact on the environment.

7. EMS staff and committees review existing objectives and targets, review performance for possible changes in objectives and targets as well as associated management programs and operational controls.

8. Receive, record & respond to relevant communication from external parties in keeping with formal processes established under implementation of EMS.

9. Provide internal & external parties information on the Installation environmental aspects / impacts & the EMS using existing communications procedures.

10. Train all new or transferred staff in applicable EMS related requirements.

11. Annually develop list of training requirements for review or addition.

12. Ensure reviewed EMS documents are updated to reflect review has taken place within the controlled documents system (even if a document is not changed the fact that a review has occurred and a new valid until notation is needed to ensure that the document remains valid).

13. Document calibration and maintenance activities for all M&M equipment related to key characteristics of operations and activities.

14. Identify and manage all existing EMS records.

15. Identify non-conformances with EMS procedures and opportunities for preventive action.

16. Conduct center level internal EMS audit.

17. Conduct tri-annual scheduled functional reviews (Compliance and EMS).

18. Center Director review of Installation EMS for status & viability

19. Report to Center Director & NASA HQ EMD on functional assessment results & status & viability of the EMS

20. Conduct Management Review.

Work Activities That May Be Required

1. Address non-conformances, opportunities for preventive actions and develop and implement Corrective/Preventive Actions.

2. As a result of EMS continuous improvement activities or in association with identified needs in conjunction with corrective actions, corrective/preventive actions, management reviews or special circumstances, generate new and revise (where necessary) existing EMS procedures, documented procedures and other documentation.

3. If changes in legal or other requirements are identified ensure that effect personnel are informed, trained and EMS procedures are revised where needed.

4. If new aspects or impacts are noted, ensure they become part of EMS documentation.

5. If there are any changes in personnel (including internal contractors) whose job-specific activities may create a priority impact on the environment ensure that required training occurs.

6. If there are any revised or new high priority impacts, any new or revised training requirements and programs required.

7. For new priority impacts and when changes are deemed required for existing, develop, and document new objectives and targets.

8. If there are any changes in objectives and targets, develop environmental management programs and operational controls required and implement.

9. If there are any changes in objectives and targets, programs or operational controls, communicate revised roles, responsibilities and authorities.

10. If additional or modified monitoring or measurement activities are identified as needed, develop/modify missing/required procedures to monitor and measure the key characteristics of operations and activities and conduct the required activities.

11. If changes in EMS programs, procedures or documentation occur, identify and manage all related new EMS records.

ISO 14001 Driven EMS Maintenance Activities Beyond Those Required for Executive Order 13148

1. Provide all new staff with EMS Awareness training.

2. Reviewing and updating of formal legal and other requirements procedures and processes and instituting any required changes and including their continued use.

3. Continued use of NASA NPGs 1440.6 & 1441.1, and NPD 2800.1 for EMS records

ISO 14001 Registration-Driven EMS Maintenance Activities

1. Ongoing third-party registrar activities.

2. Installation preparation for registrar visits, staff work during registrar visits and interaction with registrar between visits.

3. Addressing non-conformances identified by registrar.