National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

May 13, 2013

Reply to Attn of: Integrated Asset Management Division

TO: Center Operations Points of Contact

FROM: Director, Integrated Asset Management Division

SUBJECT: NASA Handbook for Master Planning

Enclosed is the first formal draft of the NASA Handbook for Master Planning for your information and use. Supporting the requirements delineated in NASA Policy Directive 8810.2A, Master Planning for Real Property and NASA Procedural Requirements 8810.1A, Center Master Planning the Handbook identifies best practices to help Centers fulfill their master planning responsibilities.

Prepared by and for the master planning community of practice, the Handbook draws from sources within and beyond NASA. Master Planning Program Manager Kim Toufectis and I are grateful to the many Center staff who contributed time and expertise to the development of this product.

Though now formally issued and soon to be posted on our website, the Handbook is not intended to be final. Instead, it will be updated periodically to reflect NASA's commitment to continuous improvement. As the community continues its work to add value by improving the utility and efficiency of services and products, sections of the report will be revised accordingly.

Calvin F. Williams

Enclosure

Center Operations Points of Contact

Ames Research Center
- Mr. Duff

Dryden Flight Research Center
- Mr. McKee

Glenn Research Center
- Dr. Shyne

Goddard Space Flight Center
- Mr. Paprocki

Jet Propulsion Laboratory
- Mr. Develle

Johnson Space Center
- Mr. Walker

Kennedy Space Center
- Ms. Bray

Langley Research Center
- Ms. Mangum

Marshall Space Flight Center
- Mr. Doering

Stennis Space Center
- Mr. Glorioso

cc:
Environmental Management Division
- Ms. Groman

Integrated Asset Management Division
- Ms. Jones
- Mr. Toufectis

Ames Research Center
- Ms. Dianati

Dryden Flight Research Center
- Ms. Fregoso

Glenn Research Center
- Mr. Ahmed
- Mr. Morris

Goddard Space Flight Center
- Mr. Abernathy
- Mr. Ramon
- Mr. Richardson
- Mr. Stanley

Jet Propulsion Laboratory
- Mr. Gutman
- Mr. Owen
- Mr. Uyeki

Johnson Space Center
- Mr. Kennedy
- Ms. Kolkmeier
- Mr. Noel
- Mr. Ugalde

Kennedy Space Center
- Ms. Altman
- Mr. Busacca
- Mr. Carlson
- Mr. Moeller
- Mr. Schoen

Langley Research Center
- Mr. Harris
- Mr. Mastaler
- Mr. Mouring

Marshall Space Flight Center
- Mr. Green
- Mr. McKinstry

Stennis Space Center
- Mr. Griffey
- Mr. Hamilton
- Mr. Pierce

NASA HANDBOOK FOR MASTER PLANNING

CONTENTS

1. INTRODUCTION 1
   - 1.1 Background 1
   - 1.2 Purpose 1
   - 1.3 Organization 2

2. MASTER PLANNING STRATEGY AND PHILOSOPHY 3
   - 2.1 NASA Strategic Planning 3
   - 2.2 Center Strategic Planning 3
   - 2.3 Goals 4
   - 2.4 Process Summary 4

3. CENTER MASTER PLAN PROCESS AND PRODUCTS 5
   - 3.1 Planning Phases 6
   - 3.2 Overview 6
   - 3.3 Phases in Detail 7
     - 3.3.1 Initiate 7
     - 3.3.2 Set Goals 7
     - 3.3.3 Initial Approach 7
     - 3.3.4 Existing Conditions: What Do We Have? 8
     - 3.3.5 Develop and Evaluate Alternatives 9
     - 3.3.6 Select Future Development Concept and Obtain Concurrence 10
     - 3.3.7 Develop Detailed Plan 10
     - 3.3.8 Plan Communication 11
     - 3.3.9 Revise and Amend Plan (Are We Still Going in the Right Direction? 12

4. DOCUMENTS, APPROVALS, AND STANDARDS 13
   - 4.1 Planning Documentation 14
     - 4.4.1 Preliminary Products 14
     - 4.4.2 Final Master Plan Document 14
   - 4.2 Approval and Endorsement Process 15
     - 4.2.1 Basic Sequence 15
     - 4.2.2 Formulation Planning 15
     - 4.2.3 Interim Review(s) 16
     - 4.2.4 Future Development Concept Briefing 16
   - 4.3 Organization of Center Master Plans 16

5. MASTER PLANNING STANDARDS AND GUIDANCE 19
   - 5.1 Introduction 19
   - 5.2 Sustainability Planning 19

5.2.1 Compact, Mixed-Use Development 19
5.2.2 Infill Development 20
5.2.3 Multimodal Transportation 20
5.2.4 Sustainable Landscape Elements 20
5.2.5 Low-Impact Development 20
5.2.6 Climate Change Forecast 21
5.2.7 Resource Management 21
5.3 Natural and Cultural Resource Preservation 22
5.3.1 Land Preservation 23
5.3.2 Mission Compatibility 23
5.3.3 Historic Preservation 24
5.4 Real Property Management 24
5.4.1 Utilization 24
5.4.2 Mission Dependency 24
5.4.3 Condition Data 25
5.5 Health and Safety Campus Planning 25
5.5.1 Planning for a Healthy Campus 25
5.5.2 Planning for Walking and Biking 26
5.5.3 Planning for a Safe Campus 26
5.6 Protection Planning 26
5.6.1 Physical Security Planning 27
5.6.2 Natural Surveillance 27
5.7 Capacity Planning and Area Development Planning 27
5.7.1 Campus Growth Boundary 27
5.7.2 Area Development Planning 28
5.7.3 District Focus 28
5.7.4 Incremental Development 28
5.8 Horizontal Infrastructure Network Planning 28
5.8.1 Utilities Infrastructure Network Planning 29
5.8.2 Roads and Bridges Infrastructure Network Planning 29
5.9 Campus Design Standards 30
5.9.1 Illustrative Plans 30
5.9.2 Regulating Plans 31
5.9.3 Building Standards 32
5.9.4 Circulation Standards 32
5.9.5 Landscape Standards 32
5.9.6 Implications for Plan Implementation 32
5.10 Development Program 33
5.10.1 Program Requirements 33
5.10.2 Program Documentation 33

6. KEY PERFORMANCE INDICATORS 35
6.1 Introduction 35
6.2 Master Plan Compliance Metrics 35
6.2.1 Tier 1: Development Compliance 37
6.2.2 Tier 2: Documentation Compliance 38
6.2.3 Tier 3: Communication Compliance 38

7. EMPLOYEE DEVELOPMENT 39
7.1 Career Path 39
7.2 Development Drivers 39

7.2.1 Technical Competencies 39
7.2.2 Nontechnical Competencies 40
7.3 Development Tools 40
7.3.1 On-the-Job Training 40
7.3.2 Mentoring 41
7.3.3 System for Administration, Training and Educational Resources for NASA (SATERN) 41
7.3.4 Individual Development Plan 41
7.3.5 Academy of Program and Project and Engineering Leadership (APPEL) 42
7.3.6 The Community of Practice 42

APPENDICES

A. Abbreviations 43
B. Glossary 44
C. Selected Best Practices 45
D. Training Opportunities 49
E. Planning Principles 50
F. References 51

Chapter 1.

INTRODUCTION

1.1 Background

The master planning process for building out, adjusting, or decommissioning Agency assets and property flows down from the Strategic Plan of the Agency. Center Master Plans (CMPs) are the localized Implementation of this Agency strategy informed by the strategic vision of each Center. The master planning process is the responsibility of the Center Director, as specified in NPD 1000.0, NASA Governance and Strategic Management Handbook. But the process occurs interactively with NASA Headquarters to synchronize the master planning across the Agency.

1.2 Purpose

The focus of this handbook is the Center master planning process and Center Master Plan. The handbook provides some context for that process, a description of the process and best practices, elements of a master plan, and standards. The handbook also discusses resources for master planners, including support for the career path of master planning.

A Center Master Plan (CMP) is the Center's statement of its concept for the orderly management and future development of the Center's real property assets, including land, buildings, physical resources, and infrastructure. It provides a narrative, statistical, and graphic record of current capabilities and conditions (natural features, buildings, structures, utilities, transportation systems, and other improvements), as well as necessary changes to support program and institutional activities and NASA's strategic and business planning.

CMPs are authorized by NPD 8810.2, Master Planning for Real Property and required by NPR 8810.1, Center Master Planning. This handbook draws largely on those fundamental documents to specify the process for development, documentation, and communication of master plans by NASA Centers and the Jet Propulsion Laboratory (JPL) and their approval by NASA Headquarters.

The master planning process is also supported by these additional Agency policy documents, which set the standard for the planning process:

- 42 U.S.C. 2473(c)(1), Section 203(c)(1), National Aeronautics and Space Act of 1958, as amended
- NPD 1000.0, NASA Governance and Strategic Management Handbook
- NPD 1000.3, The NASA Organization
- NPD 1001.0, NASA Strategic Plan
- NPD 8800.14, Policy for Real Estate Management
- NPD 8810.2, Master Planning for Real Property

CMPs also must respond to the following:

- NPD 8820.2, Design and Construction of Facilities
- NPR 8510.1, NASA Cultural Resources Management
- NPR 8580.1, NASA National Environmental Policy Act Management Requirements
- NPR 8590.1, Environmental Compliance and Restoration Program
- NPR 8820.2, Facility Project Requirements

1.3 Organization

The handbook starts with an overview of the master planning strategy, process, and planning. Subsequent chapters go into the process and activities in more detail. A sample of the contents of a master plan and examples are included. Then performance and standards are elucidated with details and examples of best practices. Finally, information is presented on master planning as a career.

Chapter 2.

MASTER PLANNING STRATEGY AND PHILOSOPHY

2.1 NASA Strategic Planning

The 2011 NASA Strategic Plan sets out the Agency's vision, mission, and values (Box 2.1). Master planners are responsible for ensuring that a Center master plan is consistent with the NASA Strategic Plan as described in NPD 1001.0, NASA Strategic Plan and that future improvements at the Center level will fulfill the Agency's vision, mission, and core values. Center master plans reflect the strategic vision of the Center, but align with the Agency strategy through a collaborative process between the Center master planners and the Office of Strategic Infrastructure at Headquarters. This chapter elaborates on this process.

2.2 Center Strategic Planning

Because master planning is based on the NASA Strategic Plan and builds the framework on which future project planning will take place, solutions developed in a CMP should advance the goals stated in the Strategic Plan. Careful consideration should be given to current NASA policies and guidance, applicable statutory and regulatory requirements, and other Federal Government performance objectives and initiatives (Box 2.2) It should offer specific direction for the future development of the site, but be flexible enough to allow for unforeseeable changes in the Center's situation (e.g., a change in funding or mission). For these reasons, the plan is considered a living document, continually cycling through the phases of the master planning process.

Every Center has a unique history and mission that give it a signature identity. The CMP embodies that strategic identity and gives it a practical, measurable course. The Center mission is highly dynamic, and as such, its master plan must be a living document. It must be rooted in fundamental requirements to guide the management of real property, yet be sufficiently flexible to absorb adjustments in mission, technology, or funding. Some of the fundamental principles of master planning to consider are elucidated in the NASA Real Property Asset Management Plan.

BOX 2.1 NASA Vision, Mission, and Values

The NASA Vision

To reach for new heights and reveal the unknown, so that what we do and learn will benefit all mankind.

The NASA Mission

Drive advances in the sciences, technology, and exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of Earth.

NASA's Core Values

- Safety
- Integrity
- Teamwork
- Excellence

2.3 Goals

In developing, documenting, and communicating its master plan, each Center must try to achieve several challenging goals:

- **Sustainability**—striving to use resources responsibly and maintaining a resilient, productive, safe, secure, and healthy work environment.
- **Inclusivity**—engaging Center and program leadership, NASA program customers, tenants, institutional stewards at the Center and Agency, the workforce, and the external community to the appropriate degree and at the appropriate time.
- **Thoroughness**—taking appropriate care to understand and document current conditions (capabilities, opportunities, constraints), and current and proposed facilities requirements.
- **Equity**—defining evaluation criteria that include the full range of stakeholder interests that can be used to assess and select among alternative actions and priorities.
- **Comprehensiveness**—addressing all real property assets, including land and improvements, all sites the Center owns or manages, assets constructed or occupied by NASA or others, and assets stewarded by programs or institutions.

2.4 Process Summary

The next chapter will develop a process to help accomplish these goals. In summary, master planners integrate a comprehensive facility strategic process that integrates and interrelates many separate objectives, the master plan itself, and implementation projects with a Center's real property assets.

BOX 2.2 Master Planning Guidance

Guidance for CMPs comes from, but is not limited to, the following sources:

- NASA Strategic Plan and mission
- Center strategies and initiatives
- NASA guidance, including:
  - NPD 8810.2, Master Planning for Real Property
  - NPR 8810.1, Master Planning Procedural Requirements
  - Crew return vehicle reduction goals
  - Water conservation goals
  - Energy conservation goals
  - Climate change goals
- Applicable regulations, including:
  - Presidential executive orders
  - Federal legislation
  - State law
  - Local comprehensive plans and land use regulations
  - Building codes and standards
- External stakeholders, including:
  - Federal agencies (e.g., the Environmental Protection Agency, Federal Emergency Management Agency)
  - State agencies (e.g., department of transportation, state historic preservation office)
  - Local municipality and county governments
  - Reimbursable customers
  - Commercial lessees/tenants
  - Interested parties of Space Act agreements

Chapter 3.

CENTER MASTER PLAN PROCESS AND PRODUCTS

As illustrated in Figure 3-1, the "Mission and Guidance" element describes the vision and requirements that describe "Where we are going." The infrastructure element at the bottom of the diagram represents the Center's real property assets and encompasses "What we have." Having defined the desired and current states, the master planner performs a gap analysis and proposes a plan to bridge the gap. The result is captured as "How we get there." Thus the master plan can inform the development and prioritization of implementation projects. The master plan strategies and objectives provide the criteria against which facility projects are prioritized and facility programs are formulated. Implementing these projects, in turn, changes the Infrastructure element. As this changes the gap analysis over time, the planning process is ongoing and iterative with periodic revalidation or revision.

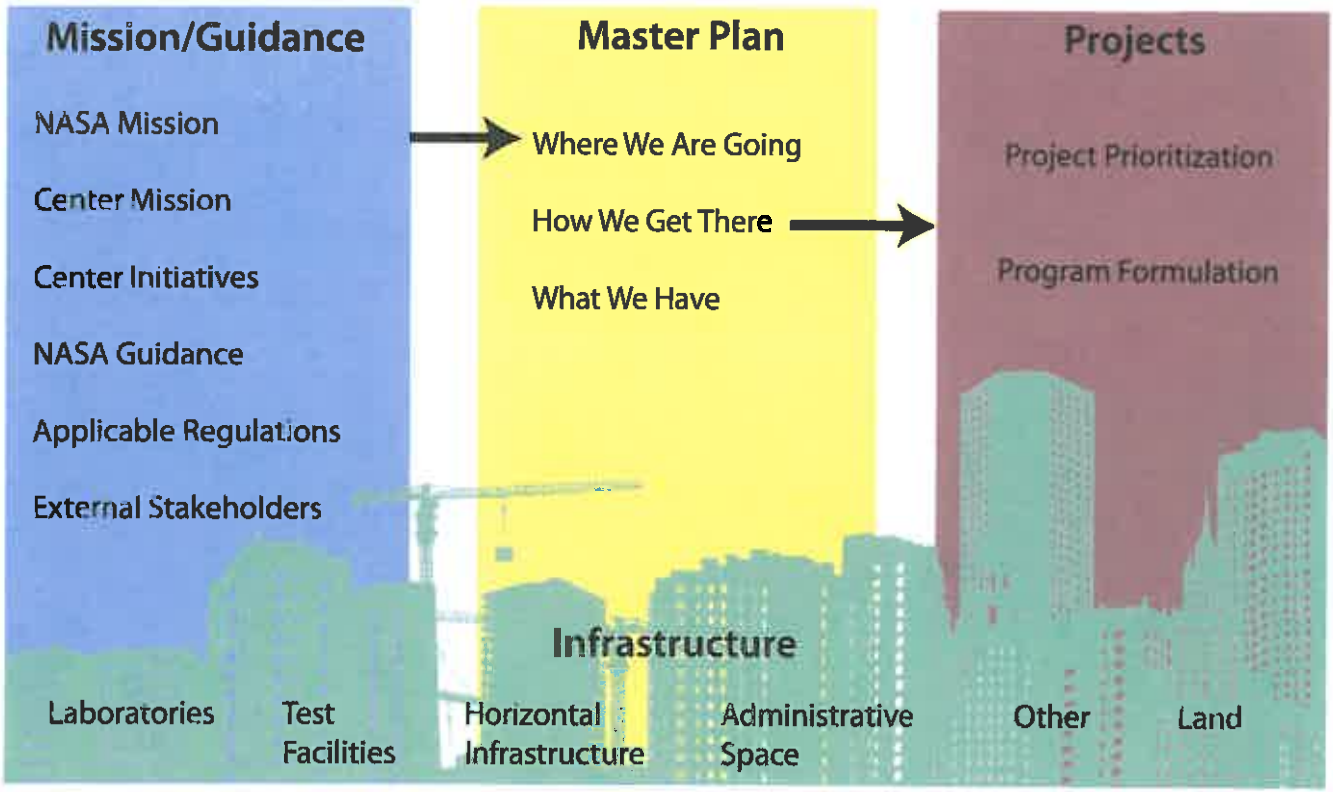

FIGURE 3-1 The Center Master Planning Process

3.1 Planning Phases

All NASA Centers have developed master plans. NPR 8810.1, Master Planning Procedural Requirements defines triggers that require evaluating the need to update an existing CMP (Box 3.1).

BOX 3.1 Triggers Initiating Evaluation of CMP Update

- Change in Agency facilities strategy or funding
- Change in Center's mission assignments
- Significant other changes, for example in technology that changes facilities requirements or changes in a facility's surrounding community
- Five years lapse since last update

Whether developing a master plan for the first time or updating and existing master plan, the following activities provide a model of the basic phases in the process. Since the CMP is a living document, the phases are essentially circular: the loop is closed with the completion of the CMP, but can be started again with any of the triggers that initiate an update.

3.2 Overview

- **Initiate.** Establish a leadership group representing all key participants to oversee development of the CMP. Assemble a planning team to support the process.
- **Set goals.** Identify the vision, goals, and measurable planning objectives that will guide the detailed planning.
- **Collect and analyze data.** Collect relevant data to identify and understand constraints and opportunities within the Center.
- **Develop and evaluate alternatives.** Prepare and evaluate development alternatives for all scales of planning, from individual districts to the overall Center. This is routinely an iterative process in which stakeholder feedback leads to a subsequent set of alternatives.
- **Select Future Development Concept.** Evaluate mature alternatives against the goals and objectives, and recommend the best alternative to Center leadership. The alternative that represents the best path forward is selected and becomes the FDC.
- **Obtain concept concurrence.** Brief Headquarters on the FDC to ensure Agency understanding of and support for the preferred alternative. Briefing materials include a draft CIPP and a summary data table; these will feed into the CMP's final technical documentation.
- **Develop detailed plan.** Once Headquarters and other stakeholders, such as the community, have concurred with the concept, develop the planning down to a more detailed level. The major product of this detailed planning phase will be the Center Master Plan.
- **Communicate CMP and detailed planning.** Inform stakeholders of the details of the master plan.
- **Obtain CMP and detailed plan concurrence.** Provide final draft CMP documentation to the Headquarters Director, Technical Capabilities and Real Property, for formal concurrence. The plan should be in line with the FDC, except where analysis has dictated modification of the plan.

- **Revise and amend plan.** Monitor the CMP and amend as necessary.

Each of these phases in the process have specific activities, Center-Headquarters interactions, and products associated with them.

3.3 Phases in Detail

3.3.1 Initiate

A CMP presents a vision—supported by policies, guidelines, and priorities—to guide the development and furtherance of the Center's mission informed by the Agency's vision. The team that will create or update the master plan should include participants (stakeholders and staff) drawn from all aspects of Center operation. This involvement is crucial in gaining an understanding of Center operations and needs, and in developing ownership or "buy-in" of the final CMP.

The planning team should include individuals from the senior leadership of the various Center components to oversee the CMP's development. It should include representatives from the major programs supported at the Center. Key non-NASA tenants should also participate.

3.3.2 Set Goals

Before a master plan can begin to take shape, the planning team and/or outside consultants must determine a common vision for the future of the Center. Planners should meet with key management and appropriate stakeholders to develop the overall vision and goals for the planning process. Planners should be prepared to help the Center leadership understand how to develop a vision to ensure priorities for future development are met.

Gain an understanding of the Center's mission. Set priorities and a basis for evaluating priorities In an equitable manner. Establish measurable objectives to evaluate forward progress and for the end desired.

During this phase in the process Center master planners will consult with Headquarters to agree on the process and stakeholders, the scope and development schedule for the revision to the master plan, participants in the process for reviewing the master plan, and the products that will be produced.

3.3.3 Initial Approach

When approaching the development of the concept for the master plan, it can be helpful to analyze the Center's current state against a desired future state. (See Figure 3-1.) Where are we today? Answering this question will require an existing conditions analysis of Strengths, Weaknesses, Opportunities, and Threats (SWOT). It will also start to define the current

course the Center is on for better or worse (e.g., infrastructure running to failure, recent progress in water conservation).

- **Where do we want to go?** Answering this question allows a Center to establish its vision for its Future Development Concept (FDC). The question can be answered for different time periods (e.g., 0–5 years, 5–10 years, 10–20 years).
- **What do we have?** To develop a master plan, an inventory of existing physical resources and limitations at a specific site is needed, along with an analysis to provide an accurate snapshot of existing conditions at the Center.
- **How do we get there?** The answer to this question is an Implementation Plan that outlines phasing, cost estimates, and funding alternatives. It will include the Capital Improvement Program Plan (CIPP).
- **Are we still going in the right direction?** A master plan is a living document that is continuously updated. It must include achievement metrics and milestones to ensure that Center goals are achieved over time. Measuring progress will allow adjustments to be made, if needed, to get back on course.

3.3.4 Existing Conditions: What Do We Have?

A primary step toward developing a master plan for the future is to inventory existing resources and limitations the site possesses. This requires collecting information on populations served, existing facilities, land uses, transportation, utilities, and mission operations, as well as environmental information regarding natural resources (wetlands, floodplains, endangered species, topography), cultural resources (historic sites), and the man-made environment (hazardous materials, waste sites). In addition to Center-specific data, it is important to include data on adjacent areas and surrounding regions that further contribute to a comprehensive understanding of the Center. This data is primarily captured on maps and diagrams that provide accurate snapshots of existing conditions at the Center.

It is necessary to analyze the data in terms of facility use and expansion and organize data layers into thematic maps that portray a complete picture of current conditions. These composite maps should readily reveal areas where development may be possible and where it is limited or restricted. Evaluating environmental regulations associated with each layer is also helpful, to determine protected areas or sites that may restrict development.

Products from this step should include:

- Land-use analysis
- Facility analysis
- Utility analysis

- Environmental analysis
- Natural resource analysis
- Cultural resource analysis
- Circulation analysis (sidewalks, roads, public transportation)
- Off-center property holdings (leases, easements, etc.)
- Existing public/commercial partnerships
- Constraints and opportunities maps
- Developable area map
- Framework plan

3.3.5 Develop and Evaluate Alternatives

Some considerations/activites that go into the development of alternatives in the planning process:

- Performing an analysis and inventory of the existing site, including its natural features (landform, vegetation), cultural aspects (history, relation to the broader region), environmental traits (climate, relation to larger landscape, environmental regulations), and existing infrastructure
- Establishing a coherent site development strategy, which will provide a sense of order and continuity throughout the site
- Developing an implementation schedule and investment strategy
- Planning traffic patterns and shaping those circulation patterns to useful effect (e.g., efficiency, collaboration, reduced energy footprint) for employees and visitors
- Determining the number, size, and use of facilities to be included on the site, based on needs and budget availability
- Interim reviews between Headquarters and the Center master planners are conducted to align with Headquarters stakeholders (e.g., the Office of Strategic Infrastructure, the Mission Support Directorate, other Mission Directorates) and Center stakeholders.

It is wise to develop and evaluate alternative versions of how the Center should be spatially and functionally organized relative to its facilities and land use and analyze facility allowances, requirements, deficits, and excesses as they relate to the mission of the Center. This analysis can be based on information collected during interviews, data on existing real property assets, and existing/future Center mission and population. Conducting a functional and spatial analysis is important to produce a land-use plan. Analysis of constraints, opportunities, and facility needs can help incorporate previously established vision, goals and objectives to develop options for future development. Evaluate each alternative. Identify the planning principles that will be used to measure the effectiveness of each alternative. Work with facility, environmental, cultural resource staff and other proponents to rate and validate the effectiveness and disadvantages of each. Document the decision process and considerations made.

As part of the master development process consideration should also be given to:

- Acquisitions (in-house or contract) to develop or expand capabilities
- Partnerships with other organizations
- Optimal utilization of intellectual capital inside and outside the Center
- Environmental and cultural resources reviews and analyses
- Significant changes in management structure
- Changes in the Center's context with the host community

3.3.6 Select Future Development Concept and Obtain Concurrence

Once a preferred alternative is selected for the long-term future development plan, it should be further refined, to offer a broad-brush approach to the Center's future organization and layout of facilities, and should offer guidance on overall siting and expansion capacity. This plan should be used to develop specific plans and actions for transportation, utilities, environmental impacts, as well as visual and design aspects of the Center layout. The plans selected should reflect responsible choices among the alternatives and show that they are consistent with Agency risk-management practices.

It is also wise to develop area development plans (ADPs) for areas requiring closer analysis.

Products from this step should include:

- Multiple alternatives
- Documented evaluation, validation, and selection process
- The preferred alternative (long-term future development plan)

Once a best approach is selected, Center master planners brief Agency leadership to give them a broad understanding of the Future Development Concept and the process for developing it, any significant issues, elements of the plan forward such as schedule and scope. This briefing will enable an Informed Agency concurrence once the concept is fully developed.

3.3.7 Develop Detailed Plan

Once the Long-Range Development Plan has been selected, strategies, actions, and specific projects should be developed to identify phases or timelines to achieve the full build-out. Careful consideration should be given to linking anticipated funding resources to project phases as well as linking project timelines with anticipated mission schedules and requirements.

Not all goals can be realized this year, next year, or perhaps at all.To ensure coherency in future development of the Center, it must be decided which programs, and facilities will be emphasized on the site. Many of these priori-

ties may have been recognized in the strategic plan, but in the master plan, they must be given their specific place in space and time. Priority features are often given prime real-estate within the site, a high allotment of space and funding, and may be scheduled to be developed first. Work with the Center Construction of Facility (CoF) Manager, Maintenance and Operations Officer, Utilization Officer, HQ Project Managers, Center Management and other proponents to validate the CIPP, Reference Figure 3.1 for a typical CIPP team configuration. A number of things need to be considered when prioritizing projects:

- Will the project contribute to the long-term development of the Center in accordance with the Vision, Goals, and Objectives?
- Does the project resolve a current problem or critical need?
- Will the project contribute to other projects on the Center that are necessary or already under way?
- Can the project be funded within programmed levels or otherwise available amounts?

Products from this step should include:

- Center Illustrative Plan
- Implementation/Phasing Plans
- CIPP
- Proposed Public/Commercial Partnerships
- Environmental Documentation (analysis of the anticipated environmental impacts of plan implementation)
- Regulating Plans
- Street and Transit Plan
- Sidewalk and Bikeway Plan
- Green Infrastructure Plan
- Amenity/Open Space Plan
- Master Utility Plan

Campus planning standards should also be attended to:

- Campus Character
- Street Envelope Character
- Landscape Character
- Energy Standards

3.3.8 Plan Communication

The final publication of a CMP will have many uses, in addition to providing an obtainable plan for future development. Well done plans and presenta-

tions are especially helpful for "selling" the Center. Because of their wide readership, master plans are generally succinct, clear, and logical in their presentation. They typically contain numerous drawings, tables, maps, and other visual illustrations of the plan to quickly convey information. In other words, a quick glimpse of the future of the Center is made accessible to NASA leadership and employees, governing boards, businesses, government agencies, and the community, in addition to the future designers of the Center.

However, CMPs should convey current circumstances and the program of needs clearly and fully enough that their implementation can be traced against a baseline and provide accountability.

Products from this step include:

- Leadership Briefing (Executive Summary)
- CIPP
- Print or Web-based documentation

3.3.9 Revise and Amend Plan (Are We Still Going in the Right Direction?

Master planning is an iterative process in which a completed CMP is re-assessed at least annually to determine whether the plan is achieving the goals originally established at the outset of the planning process. Either the Center or Headquarters may request an update based on their collective determination that the current plan is out of date. In addition, a change in mission or other conditions may require a re-examination of the goals to be achieved by the CMP.

At least every five years, the Center Director reviews the CMP and determines whether it needs to be updated. Otherwise he or she verifies in writing to the Director of Technical Capabilities and Real Property that the plan remains valid.

The planning process is cyclic, dynamic, and ongoing. NASA requires that the CMP be updated to keep plans relevant and functional. Certain components are updated more frequently than others i.e., CIPP annually.

Chapter 4.

DOCUMENTS, APPROVALS, AND STANDARDS

This chapter goes into the CMP in more detail and specifies the content, process, and products.

Figure 4-1 shows the key interactions between Headquarters and the Center as the CMP cycles through the phases of the master planning process.

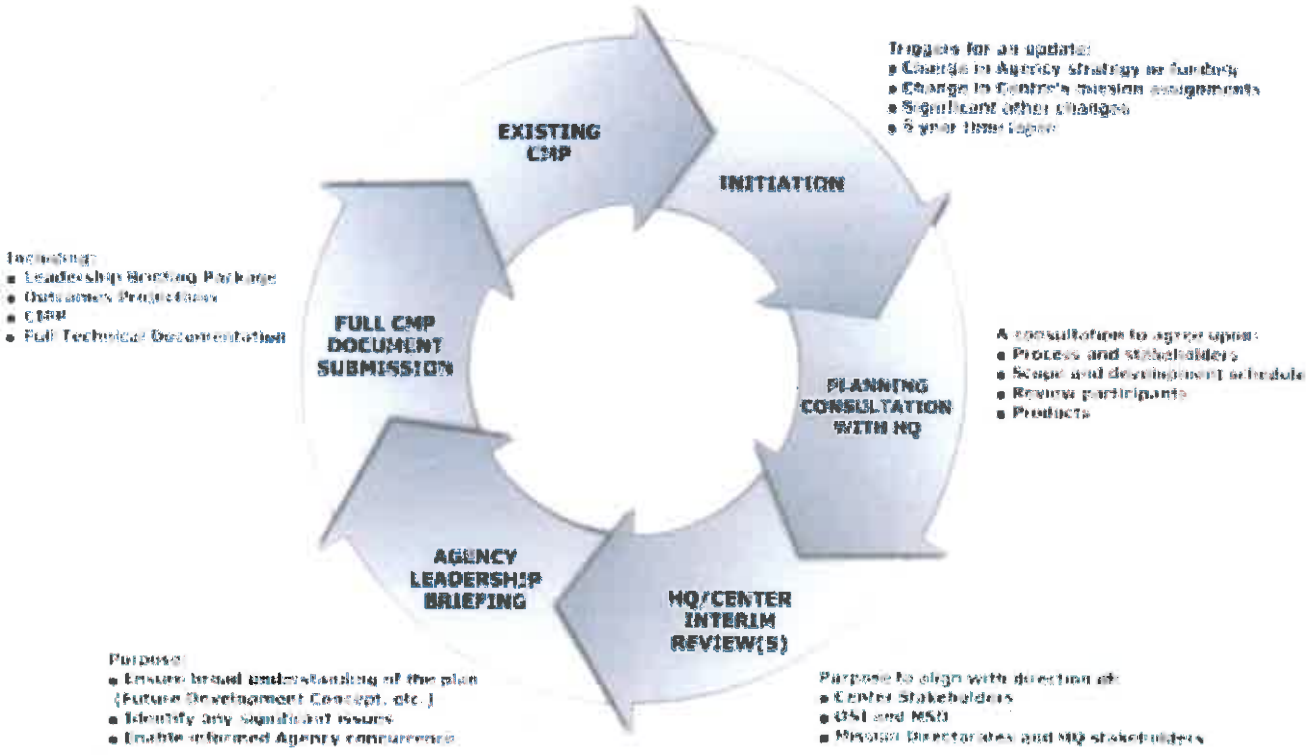

FIGURE 4-1 Phases of the Center Master Plan Process

4.1 Planning Documentation

4.4.1 Preliminary Products

- A leadership briefing
- A CIPP
- A summary data table
- The technical document to capture the many specifics that flesh out the prior documents

4.4.2 Final Master Plan Document

The final master plan document is the most elaborate and is organized as follows. The content elements of the document include the following.

Executive Summary

An executive summary is an overview. The purpose of an executive summary is to condense key points of a document for its readers, saving them time and preparing them for the upcoming content. It is typically a brief and concise description of key points, produced once the other sections of the document are complete. It is sometimes called the leadership briefing package.

Introduction

This section provides general contextual information about the Center, including its location and history; and an overview of the planning methodology, planning strategies, and leadership, stakeholder, and team involvement in the CMP process.

Center Mission Capabilities: Where Are We Today?

This section describes the Center mission and capabilities as well as the Center's relationship to missions performed at component facilities and other NASA Centers. This step requires an analysis and understanding of the Center's missions and business lines in order to develop facilities requirements that address their needs.

Center Vision, Goals, and Objectives: Where Do We Want to Go?

The vision and ultimately the CMP should be integrated and support NASA's Strategic Plan, Mission Directorate strategies, NASA's Real Property Strategic Plan, and Center strategy. If a Center Strategic Plan has been developed, it will offer important input to the master plan. The strategic plan states the mission of the Center and describes how this mission will be achieved.

Goals and objectives should be clearly stated and directly related to the Center vision and consistent with the Strategic Plan. Goals facilitate vision

and are far reaching. Objectives are attainable and measurable actions that support a goal. Each goal may have multiple objectives.

This section should include:

- Center Mission Statement
- Center capabilities and business lines
- Vision statement
- Planning goals and objectives

Future Development Concept: Where Do We Want to Go?

- ADPs

4.2 Approval and Endorsement Process

4.2.1 Basic Sequence

The process begins with the initiation of the planning process and proceeds with a consultation on the initial concept and resources with Headquarters, development of the plan, briefing of stakeholders, and full submission as explained below. The interim products include a briefing of the FDC to Headquarters leadership with supporting information. The final product is a technical document commonly known as the CMP. By the end of the process, the planning team will have developed products that include, but are not limited to, the following:

- A leadership briefing summarizing the plan
- An executive summary describing the process and results of the CMP
- A CIPP, a spreadsheet including implementation proposal funding sources, costs, and dates
- A Web- or paper-based document detailing all pertinent information (with links to supporting documents and analyses as appropriate)
- Other supporting tables summarizing plan baselines and projected outcomes

4.2.2 Formulation Planning

The planning begins with a planning session with the Director of the Technical Capabilities and Real Property Management Division (TCRPMD), who must agree with the individual Centers about the approach to the CMP, including scope (products to be developed), planned investment profile, schedule, participants (civil servant or contractor), and stakeholders. The approach will outline the general strategy for developing the plan.

4.2.3 Interim Review(s)

In accordance with plans made in consultation during formulation planning, Centers shall conduct one or more interim reviews to ensure coordination with mission program and institutional leadership to enable a responsive FDC briefing.

4.2.4 Future Development Concept Briefing

With Headquarters' concurrence on the approach, the Center then develops the FDC and briefs it at Headquarters. This briefing ensures broad alignment before detailed technical documentation is developed. It includes a CIPP to detail all the investments and other resources. This briefing may include a variety of items:

- Acquisitions (in-house or contract) to develop or expand capabilities
- Partnerships with other organizations
- Optimal utilization of intellectual capital inside and outside the Center
- Environmental and cultural resources reviews and analyses
- Significant changes in management structure
- Changes in the Center's context with the host community

The Headquarters briefing of the development concept offers Agency Mission Directorates and functional leadership the opportunity to understand and comment on the concept. The outcome of this briefing may be concurrence, redirection, or acceptance with additional guidance. Concurrence indicates Agency understanding and general support of the concept, enabling the Center to develop the technical documentation.

4.3 Organization of Center Master Plans

All CMPs must have all of the sections and subsections shown in Table 4-1. These sections and subsections may be augmented by others at the Centers' discretion.

TABLE 4-1 Master Plan Table of Contents

Section 1. Introduction
Section 2. Center Mission and Capabilities
Section 3. Center Goals and Objectives
Section 4. Existing Conditions
- 4.1 Community Setting
- 4.2 Natural Features
- 4.3 Built Systems
  - 4.3.1 Buildings and Structures
  - 4.3.2 Utilities, Communications Systems, and Environmental Facilities
  - 4.3.3 Transportation Systems and Improvements
  - 4.3.4 Campus Amenities and Landscape Design
  - 4.3.5 Emergency Response, Safety, and Security Management
- 4.4 Cultural Resources
- 4.5 Public/Commercial Partnerships

Section 5. The Primary Development Concept
- 5.1 Built Systems
  - 5.1.1 Buildings and Structures
  - 5.1.2 Utilities, Communications Systems, and Environmental Systems
  - 5.1.3 Transportation Systems and Improvements
  - 5.1.4 Campus Amenities and Landscape Design
  - 5.1.5 Emergency Response, Safety, and Security Management
- 5.2 Long-Range Analysis
- 5.3 Site Development and Regional Land Use Analysis
- 5.4 Utilities Analysis
- 5.5 Transportation Management Plan
- 5.6 Environmental, Climate Change, Cultural, and Natural Resources Analysis

Section 6. The Development Strategy
- 6.1 Phasing

Section 7. Re-examining and Updating the CMP
Section 8. Appendices and References

Chapter 5.

MASTER PLANNING STANDARDS AND GUIDANCE

5.1 Introduction

Master planning establishes the framework on which future project planning should take place. Each CMP therefore should strive to meet the Agency's standards of sustainability; natural and cultural resource preservation; health and safety;security protection planning; capacity planning and area development planning; horizontal infrastructure network planning; campus design standards; and campus design. This chapter has drawn from the Department of Defense (DOD) Unified Facilities Criteria (UFC) document titled Installation Master Planning UFC 2-000-02, reader should reference that document for further details.

5.2 Sustainability Planning

NASA's 2011 Strategic Sustainability Performance Plan states that

> NASA's sustainability policy is to execute NASA's mission without compromising our planet's resources so that future generations can meet their needs. Sustainability involves taking action now to enable a future where the environment and living conditions are protected and enhanced. In implementing sustainability practices, NASA manages risks to mission, risks to the environment, and risks to our communities, all optimized within existing resources.

Center master plans should play a key role in the Agency's ability to meet its sustainability goals. Planners should use the concepts below, where practical and possible, in order to develop sustainable master plans.

5.2.1 Compact, Mixed-Use Development

Centers should conserve their land resources. A compact built environment uses less water and energy, reduces traffic trips, generates less stormwater runoff, and needs less infrastructure. Centers are encouraged to build at high intensities (intensity-building area/land area) in order to realize these benefits. That goal can be achieved with multistory buildings, mixed land uses, limited building setbacks, reduced spacing between buildings, and flexible parking requirements.

Mixing land uses allows a person to walk from one place to another without needing a vehicle. It reduces traffic trips, fuel use, gas emissions, and the need for off-street parking spaces. Land uses can be mixed both vertically, within a building, and horizontally, across different buildings.

5.2.2 Infill Development

Centers should use previously developed or disturbed areas whenever possible. Infill areas generally have access to existing infrastructure including utilities and roads leading to reduced upfront construction and long term operational costs. Use of infill areas reduces disturbance of native vegetation and may limit stormwater quality remediation costs. Using previously disturbed sites, grey fields, and brown fields is encouraged under the Leadership in Energy and Environmental Design (LEED) system and should enable designers to gain site selection points.

5.2.3 Multimodal Transportation

Transportation design should provide for multiple modes where possible, including walking, biking, individual vehicles, and public transportation. Planners should work with local communities to provide public transportation to and from Centers where practical, to try to reduce use of individual vehicles. Land uses should be mixed, to reduce individual vehicle use once cars are on-site. Development intensity should be greatest along roadways where transit stops are located.

Planners should ensure that land uses within each Center area are thoroughly connected by roads, sidewalks, and bikeways. A connected network of streets should be based on a grid or modified grid pattern that affords multiple route options for vehicles, bicyclists, and pedestrians; cul de sacs should only be used on a limited basis. The gridded network should use appropriately scaled roads to accommodate transportation needs. Short blocks are encouraged as they are known to increase walking and biking.

5.2.4 Sustainable Landscape Elements

Planners should ensure that plans incorporate appropriate use of street trees, shrubs, and ground cover. These landscape elements can control soil erosion, reduce the heat island effect, absorb and filter storm water, improve air quality, and provide comfortable places for recreation. Plant materials should be native and appropriate for the Center's climate. Xeriscaping concepts should be incorporated where possible.

5.2.5 Low-Impact Development

The Department of Defense (DOD) United Facilities Criteria (UFC) Design Manual defines Low Impact Development in the following way:

Low Impact Development (LID) is a stormwater management strategy concerned with maintaining or restoring the natural hydrologic functions of a site to achieve natural resource protection objectives and fulfill environmental regulatory requirements. LID employs a variety of natural and built features that reduce the rate of runoff, filter out its pollutants, and facilitate the infiltration of water into the ground. By reducing water pollution and increasing groundwater recharge, LID helps to improve the quality of receiving surface waters and stabilize the flow rates of nearby streams.

LID incorporates a set of overall site design strategies as well as highly localized, small-scale, decentralized source control techniques known as Integrated Management Practices (IMPs). IMPs may be integrated into buildings, infrastructure, or landscape design. Rather than collecting runoff in piped or channelized networks and controlling the flow downstream in a large stormwater management facility, LID takes a decentralized approach that disperses flows and manages runoff closer to where it originates. Because LID embraces a variety of useful techniques for controlling runoff, designs can be customized according to local regulatory and resource protection requirements, as well as site constraints. New projects, redevelopment projects, and capital improvement projects can all be viewed as candidates for implementation of LID.

NASA Centers are encouraged to plan and design using LID principles where feasible. National design manuals are available for LID design assistance.

5.2.6 Climate Change Forecast

Most climate scientists agree that the main cause of the current global warming trend is human expansion of the "greenhouse effect"—warming that results when the atmosphere traps heat radiating from Earth toward space (http://climate.nasa.gov/causes/). Center planners should work with the NASA Climate Adaptation Science Investigators (CASI) Workgroup to help in the development of Climate Change Adaptation strategies, to ensure that Center master plans address climate change proactively. Center plans should be as carbon neutral as possible. Center master plans should prepare for results of global warming such as sea rise and extreme weather where appropriate.

5.2.7 Resource Management

Campus Energy

Campus energy planning should look at both the supply and demand sides of energy use. Center plans should address how energy demand should be reduced and how renewable energy sources can provide supply. Centers may have opportunities to produce renewable energy through use of wind, solar, geothermal, biomass, and other sources. Centers are responsible for fulfilling the goals associated with Executive Orders, which set various Federal energy and environmental management goals, including reduction of energy intensity, increasing the use of renewable energy, and designing and

operating sustainable buildings. Plans should also meet the requirements of NPR 8570.1, Energy Efficiency and Water Conservation. Center planners should work with their local group representing the NASA Environmental Management Division (EMD) to assist in the development of energy strategies to ensure that Center master plans address climate change proactively.

Reliability Centered Building and Maintenance systems and equipment should also be considered as part of the master planning process. The proper use of this tool is a cost efficient way for a Center to manage and reduce energy consumption. Center master planners should coordinate with the appropriate personnel to implement sustainable energy strategies as appropriate.

Water Management

Centers should meet federal (e.g., Executive Orders) and agency requirements (NPR 8570.1, Energy Efficiency and Water Conservation) for water management. Water is a vital resource and should be used responsibly. Water management should be planned at the individual building level (i.e., waterless toilets) and at the plant wide level (i.e., Center landscaping irrigation, water system leakage).Water management also involves water quality and should incorporate the LID concepts discussed above.

Waste Management

Waste management should be based on the recycling triangle of reduce, reuse, recycle. Master plans should outline how Centers should reduce the amount of waste delivered to local landfills. Centers should follow sustainable procurement practices and reuse products and materials where feasible. Centers should plan to work with contractors for waste streams that can be recycled into new products.

Building Reuse/Repurposing

Much of NASA's building infrastructure is reaching its design life. An important element of a Center's master plan should be to address how older buildings should be reused and repurposed to continue NASA's mission. Reusing existing buildings can be an important way for Centers to meet program goals, while addressing the realities of declining construction funding within the Agency.

5.3 Natural and Cultural Resource Preservation

The purpose of NASA's Cultural Resource Management (CRM) Program is to manage cultural assets that are owned by NASA. The Agency manages those assets that are considered historically significant to the local community, to the state, or to the entire nation and deemed worthy of preserving, cornerstone to NASA's contribution to America's history in aeronautics,

planetary, and space exploration. NASA's CRM Program is managed by the Agency's Federal Preservation Officer (FPO), Environmental Division, NASA Headquarters, and implemented by NASA's Center Historic Preservation Officer (HPO) at NASA's 13 Centers and component facilities. The Agency-wide program provides the policy and procedures to ensure NASA complies with applicable CRM regulations, such as the National Historic Preservation Act (NHPA)

All NASA locations have natural and cultural resources that may deserve special protection. Natural resources can include threatened and endangered species, wetlands, habitat areas, forests, undisturbed land, and important viewsheds. Cultural resources may include historic structures, cultural landscapes, and heritage monuments. The planner should coordinate planning decisions with the NASA Center's Historic Preservation Officer (HPO), and (with the help of the Center HPO), the NASAHQ Federal Preservation Officer, the appropriate State Historic Preservation Officer (SHPO), and the Advisory Council on Historic Preservation (ACHP), to ensure protection of these resources. In addition, various environmental laws, requirements, and policies drive action that should be considered and prioritized throughout the planning process.

The Center Master Planner should coordinate any proposed land-use development with the HPO of that Center. The development and implementation of a Center-specific Programmatic Agreement with the appropriate SHPO is an effective means for both the Center Master Planner and HPO to greatly streamline the regulatory process required by the NHPA. (The HPOs complete the consultation process required under the NHPA to minimize the risk CRM issues pose to mission.)

5.3.1 Land Preservation

Land is a valuable natural resource to NASA for Field center sustainability and future viability. Center master planners should employ policies and plans that preserve land to the maximum extent possible. All NASA Centers should include land stewardship as a primary consideration in campus master planning.

5.3.2 Mission Compatibility

Another important function of land preservation is to provide and maintain a buffer between the local community and key functions of a NASA Center, to include range impact areas, airfields, and maneuver areas. NASA's land requirements are constantly changing, but it is becoming increasingly difficult to acquire new land to meet expanding requirements. Whether the goal is to preserve valuable land for future campus development, or to conserve irreplaceable environmental habitat, land stewardship should be a key objective of the master plan.

5.3.3 Historic Preservation

When historic properties are involved, planning should comply with the requirements of NPR 8510.1, NASA Cultural Resources Management, and should consider the economic feasibility of renovation or reuse of the historic properties.

5.4 Real Property Management

Master planning is intimately linked with NASA's Real Property Program. The Real Property Division is ultimately responsible for the renewal, disposal, or demolition of real property. In addition, they are responsible that property is appropriate to the mission, environmentally sound, high quality, efficient and effective for its purpose. Master planning is a support function of real property to develop plans that meet these stated objectives.

Each Center Real Property Officer is responsible for updating the Real Property Management System (RPMS).This system is designed to capture key information such as utilization, mission dependency, and condition consistently across all NASA Centers.

Utilization, mission dependency, and condition are the primary factors driving NASA' decisions on whether to maintain, repair, consolidate, outlease, sell, or demolish assets. Because of this the Master Planner needs to work closely with their Real Property Team to develop plans that best reflect information contained in the system. In addition to this the system will also capture location, operating status, value and maintenance costs; all necessary to develop effective master plans.

5.4.1 Utilization

Facilities may be designated in the RPMS as (1) Overutilized, (2) Utilized, (3) Underutilized, or (4) Not Utilized. NASA regulations require Centers to identify utilization rates for all real property assets annually. To determine utilization, officials review each asset to determine a percentage of space used in comparison with the total space available or a usage level based on a comparison with the number of days the facility is available. Based on a comparison of each asset's usage with NASA and Federal thresholds, Center officials record the corresponding utilization rate in the RPMS. NASA guidance requires facility usage rates to exceed 50 percent.

5.4.2 Mission Dependency

Mission dependency identifies the relative importance of real property assets in relation to NASA's mission. NASA collaborated with the Navy and Coast Guard to develop a method for measuring mission dependency in 2001 and began collecting data in 2004. Mission dependency data is intended to help NASA managers better manage risks to programs and guide

investment and divestiture decisions. NASA Centers are required to assess and update mission dependency scores for all assets every 3 years. Asset assessments are based on the responses to two questions related to the asset's impact on mission:

- How long could the functions supported by your infrastructure be stopped without adverse impact to the mission?
- If your facility was not functional, could you continue performing your mission by using another facility or by setting up temporary facilities?

Each asset is given a mission dependency score on a scale of 1 to 100. Assets with mission dependency scores of 71 to 100 are considered "Mission Critical," 10 to 70 are "Mission Dependent," and 0 to 9 are "Not Mission Dependent." "Mission Critical" assets are those assets that would compromise the Agency's mission if unavailable. Assets that are "Not Mission Dependent" would have no effect on the Agency's mission if unavailable. "Mission Dependent" assets are those assets that are neither "Mission Critical" nor "Not Mission Dependent."

5.4.3 Condition Data

Condition data provide information on the physical condition of the Agency's real property assets at a specific point in time. To measure the condition of each asset, NASA hires contractors to perform annual condition assessment surveys of all facilities. For each asset, the contractor rates nine major systems: structure; exterior; roof; heating, ventilation, and air conditioning; electrical; plumbing; conveyance systems (e.g., elevators); interior; and equipment. NASA calculates a condition index score using a five-point scale for each asset using the contractor-provided ratings. According to the *NASA Real Property Asset Management Plan*, assets rated as a five are newer facilities with little or no repairs needed, assets rated lower than three are considered in poor condition, and any asset rated as a one should be condemned.

5.5 Health and Safety Campus Planning

5.5.1 Planning for a Healthy Campus

NPR 1800.1, NASA Occupational Health Program Procedures, calls for "Fitness programs encompass activities such as organized walking events... fun runs...". Regular physical activity is critically important for the health and well-being of people of all ages, and reduces the negative impact from many chronic diseases. Planners should incorporate health considerations and opportunities for physical activity based on advice from representatives from the Center's medical and fitness staff. When feasible, planners should include Center's health and fitness representatives in visioning sessions and planning Charrettes.

5.5.2 Planning for Walking and Biking

Effective planning can create conditions that encourage physical activity, connect land uses and facilities, and provide safe, protected pathways for physical fitness training for Personnel. High connectivity, mixed land uses, and well-designed pedestrian and bicycle infrastructure decrease auto dependence and increase levels of walking and cycling. Pedestrians and cyclists require continuous and safe pathways that connect origins and destinations. These transportation plans should address all the users of the Center.

Pedestrians and cyclists require continuous and safe pathways that connect origins and destinations. The master plan should incorporate wide sidewalks (minimum 5 feet) separated from vehicle traffic by a tree-lined buffer or planting strip (minimum 5 feet). The transportation plans should address all the users of the Center transportation system to include walkers and bicyclists and not only motor vehicle users.

5.5.3 Planning for a Safe Campus

NPR 8810.1, Master Planning Procedural Requirements, requires that "Master Planners should: Strive to address plan requirements in a sustainable fashion (using resources responsibly and maintaining a resilient, productive, safe, secure, and healthy work environment)."

Improve pedestrian safety, enhance stormwater management, and provide locations for regularly placed street trees by using planting strips between the curb and sidewalks. Planting strips should be a minimum of five feet wide and located on both sides of all streets where sidewalks are used.

When establishing the transportation network, planners should incorporate concepts that maximize safety for all users and take in consideration safety constraints, including the following:

- Airfield constraints
- Security restrictions
- Quantity-distance arcs (explosion safety zones)
- Noise contours
- Safety buffers (test/operations safety zones)
- Chemical storage areas
- Floodplains
- Environmental contamination
- Surface and subsurface hazardous material storage

5.6 Protection Planning

The master plan should incorporate security analysis to minimize risk to the Center's strategic infrastructure and networked assets that support the critical missions at the Center. Where risk exists, the plan should have contin-

gencies to mitigate or remediate the risk. Critical infrastructure may include buildings, bridges, facilities, and utility and transportation systems.

Master Planners should use the following NASA guidance in developing the master plan:

- NPR 1620.2, Facility Security Assessments, to establish NASA requirements for conducting physical security vulnerability risk assessments for NASA facilities and property.
- NPR 1620.3, Physical Security Requirements for NASA Facilities and Property, to establish physical security requirements and responsibilities for safeguarding NASA assets.
- NPR 8820.2, Facility Project Requirements, stating that "NASA has adopted the Interagency Security Council (ISC) criteria for use in planning and designing new construction and major renovation."

5.6.1 Physical Security Planning

Planners should incorporate NASA and Interagency Security Committee (ISC) security elements to ensure Center protection from internal and external threats. Managing risk in the built environment is critical to the planning process. The ISC "Physical Security Criteria for Federal Facilities" standards and NPR 1620.3, Physical Security Requirements for NASA Facilities and Property, provide specific criteria and should be followed. Planners should coordinate with the Center Security Office early in the planning phase to assure proper security consideration is incorporated.

5.6.2 Natural Surveillance

To enhance physical security, buildings should be sited and oriented to allow for natural surveillance of the built environment. Entry placements and window locations can be designed to give occupants opportunities to observe the built environment. Buildings should be sited within view of other occupied facilities.

5.7 Capacity Planning and Area Development Planning

5.7.1 Campus Growth Boundary

An urban growth boundary (UGB) is a regional boundary set in an attempt to control urban sprawl by mandating that the area inside the boundary be used for higher density urban development and the outside be used for lower density development.

An urban growth boundary circumscribes an entire urbanized area and is used by the Center Master Planner as a guide to zoning and land use deci-

sions. The UGB should be developed in collaboration with internal stakeholders at the Center and external stakeholders affected by such a plan (i.e., surrounding communities, utilities providers, etc.). The UGB should identify development patterns including land areas set aside for future development, protected areas as an environmental resource, scenic areas, historic areas, etc. The boundary should be officially adopted by holding public hearings and obtaining concurrence from Head Quarters. The boundary should be periodically re-evaluated as necessary to permit ongoing gradual expansion of the urbanized area.

5.7.2 Area Development Planning

As part of the NASA master planning process, Center campuses will be divided into identifiable and connected districts based on geographical features, land use patterns, building types, and/or transportation networks. An ADP should be then be prepared for each district. This leads to developing the master plan in logical planning increments. The master planner determines the number of ADP districts.

5.7.3 District Focus

By focusing on districts, planners can identify areas that need planning attention due to changes in mission, requirement, or other priority. These are the districts that should have new ADPs completed or existing ADPs updated. Revisions or additional ADPs can be integrated into CMP updates. With the introduction of form-based coding, Illustrative and Regulating Plans will be developed for each ADP. These elements can be added to each ADP incrementally. Figure 4-2 is a schematic representation of the planning process and products.

5.7.4 Incremental Development

Over time, and as resources allow, Centers can target specific districts for new ADPs and update the master plan accordingly. This approach ensures that the master plan is a living document that is relevant to both current needs and future requirements. This incremental approach to updating the master plan recognizes the resource limitations and district development priorities that are common across all Centers.

5.8 Horizontal Infrastructure Network Planning

While significant planning is completed at the ADP level, these ADPs are also linked through network planning. These networks consider linkages and systems that span ADP district boundaries. They include Center-wide utility systems, transportation networks, and open space networks. All Center master plans should plan at both the district scale and the Center scale. Network

plans should also consider holistic approaches to energy-efficient development.

Once ADPs have been completed for the priority districts at the Center, the relevant information can be easily combined into appropriate Network Plans. Network Plans show the future development of the Center as whole, and should, at a minimum, consist of the Center Illustrative Plan, Regulating Plan, Street and Transit Plan, Sidewalk and Bikeway Plan, Green Infrastructure Plan, and Primary Utility Plan. Network Plans are also an appropriate place to identify "net zero" planning strategies and forecasts for energy, waste, and water.

5.8.1 Utilities Infrastructure Network Planning

Center Primary Utility Plan

This network plan should identify all current and proposed primary utility lines across the Center and, as such, should form the preferred end state for the Center primary utility network. Primary utilities include but are not limited to lines for water, wastewater, storm sewer, electricity, natural gas, steam, telephone, and cable systems. The plan should also show all granted easements and rights of way for utilities, as well as central, alternative (e.g., solar, wind), and renewable energy sites.

5.8.2 Roads and Bridges Infrastructure Network Planning

Planners should ensure (through programming projects as appropriate) that uses within each district as well as the districts themselves are thoroughly connected by roads, sidewalks, and bikeways. A connected network of streets is based on a modified grid pattern that affords multiple route options for vehicles, bicyclists, and pedestrians. The grid network uses appropriately scaled roads to define smaller block sizes that can accommodate a mix of compatible uses. Multi-way boulevards, parkways, boulevards, main streets, and streets are examples of street types appropriate for integration into grids and for use on Centers. When these streets are built with integrated bikeways and continuous sidewalks buffered from the street by planting strips, users should have more and safer transportation options. A connected transportation network of streets with sidewalks, pedestrian pathways, and bicycle trails reduces the distance between origins and destinations and increases transportation alternatives. Center gates should be considered part of the transportation network. It is essential to coordinate the Transportation Plan with local/state/regional government agencies, to ensure the Center's transportation network is appropriately linked with surrounding transportation access and systems.

Center Street and Transit Plan

This network plan should identify and map all current and proposed streets across the Center and should form the preferred end state for the Center

street network. This plan should also identify how the street network is connected to the network outside the Center, and how street networks outside the Center affect the Center network. Center street types should be keyed to the Center Planning Standards. Additionally, this plan should identify current or proposed transit routes and transit stops.

Center Sidewalk and Bikeway Plan

This network plan should identify and map all current and proposed sidewalks and bikeways across the Center and should form the preferred end state for the Center sidewalk and bikeway networks. The sidewalk and bikeway types should be keyed to the Center Planning Standards.

Center Green Infrastructure Plan

This network plan should identify and map all current and proposed major park, open space elements riparian corridors, wetlands, and significant bodies of water.

Street Envelope Standards

These standards illustrate typical configurations for all street types at a Center through Street Envelope Standards (SES). Each SES should address vehicular traffic-lane width, curb radii, sidewalk and tree planting area dimensions, and on-street parking configurations. An SES should be established for every type of street specified on the Center. After a street (or section of a street, as an entire street need not follow the same standard throughout its length) is selected, the characteristics desired for that street section should be documented in plan and section. The street types should be coded to the Regulating Plan developed for each ADP and for the Center.

Landscape Standards

Landscape standards show the appropriate type and placement of landscape elements, which may include natural landscape features (trees, ground cover, etc.), man-made landscape features (street furniture, signage, lighting, etc.), and landscape-related force protection standards. Landscape standards identify the Center's landscape theme(s), addressing both design intent and allowable plant materials and site furnishing

5.9 Campus Design Standards

5.9.1 Illustrative Plans

These graphic plans illustrate potential development that supports the overarching planning vision. The Illustrative Plan graphically illustrates development within a district that conforms to the Regulating Plan. The Illustrative Plan should, at a minimum, show all relevant project sitings for known projects, building footprints for unspecified long-term development in order

to facilitate capacity analysis, as well as existing and proposed roads, sidewalks, bicycle networks, street trees, open spaces, and parks. The various facility requirements should be translated into building "footprints," utilizing appropriate siting considerations. Short-term stopgaps and recommended long term solutions should be identified to satisfy mission, land-use and real property requirements.

5.9.2 Regulating Plans

These graphic plans regulate only the most important elements of the Illustrative Plan such as build-to lines, required entry and/or parking locations, minimum and maximum building heights, and acceptable uses. They are like enhanced land-use plans since they define allowable uses as well as form requirements. The Regulating Plan is a natural evolution of and replacement for the traditional land-use plan because it addresses land uses and building form together. In addition, the Regulating Plan provides specific guidance that shapes development to conform to the Center Campus planning vision.

The Regulating Plan guides the development of the area and is created iteratively with the Illustrative Plan. The Regulating Plan allows for more flexibility than a typical Illustrative Plan, and serves as an underlay to the Illustrative Plan.

The Regulating Plan provides specific information on permitted development for each building parcel within a district and acts as an enhanced land-use plan. This plan designates the locations where different uses or building form standards apply. But instead of specifically defining only uses, as land use plans do, this method defines building form (e.g., height and frontage) while allowing for a range of possible uses.

Regulating Plan Designations

The Regulating Plan establishes development regulations for specific parcels within the Center. Existing and planned roads, permanent fence lines and borders, as well as natural features and riparian corridors should be used to establish parcel lines. Each ADP district should be composed of developable parcels defined by these parcel lines. Oftentimes, these parcels may correspond to entire blocks. In some cases, blocks may be subdivided to create smaller parcels in response to site-specific design requirements. These parcels, whether they are entire blocks or portions of a block, have accompanying regulations governing building form, placement, and use. When a building is proposed for a specific parcel, designers should refer to the criteria established for that parcel to guide the design process.

Regulating Plan Functions

The Regulating Plan ensures facilities, parks, parking, and other uses are sited in alignment with the overall master planning vision. The Regulating

Plan specifies allowable building types on individual parcels in a district; assigns development standards to specific physical locations; shows how each parcel relates to public spaces and the surrounding community; and references the more detailed building, circulation, and landscape standards that are contained in the Center Campus Planning Standards.

Regulating Plan Components

Only the most important aspects of the master plan should be regulated—these include building setback, minimum and maximum building heights, key entry locations, appropriate uses, and parking and roadway configurations.

5.9.3 Building Standards

Acceptable massing, height, fenestration, exterior envelopes, and uses should be regulated through Building Standards. Building Standards should be Center-specific but should be written to ensure compliance with NPR 8820.2, Facility Project Requirements.

5.9.4 Circulation Standards

Circulation standards describe and graphically present allowable street types and circulation elements in plan and section. Circulation standards should be Center-specific but should be written to ensure compliance with NPR 8820.2, Facility Project Requirements.

5.9.5 Landscape Standards

These standards show, at a minimum, appropriate type and placement of major landscape elements (street trees). These standards may also include other natural landscape features (trees, ground cover, etc.) and man-made landscape features (e.g., street furniture, signage, lighting.).Landscape Standards should be Center-specific but should be written to ensure compliance with NPR 8820.2, Facility Project Requirements.

5.9.6 Implications for Plan Implementation

The key standards are tied to parcels identified on the Regulating Plan. When development is proposed for a particular parcel, the standards are given to the designer/developer to ensure that any proposed project conforms to the overall Center planning vision.

5.10 Development Program

5.10.1 Program Requirements

Analysis of Needs (What We Need)

Facility planners analyze the gap between existing facility conditions (where we are) and the Center's vision (where we are going) to identify facility and infrastructure needs. Facility utilization records are reviewed to identify underutilized facilities that may hold potential for repurposing. Facility Condition Index (FCI) metrics are assessed to identify maintenance and repair needs, the costs of operation and the potential life span of facility. This information is evaluated to determine whether a facility should be rehabilitated or demolished and replaced. Mission Dependency Index (MDI) metrics are reviewed to assess the Center's need for the function enabled by the facility. Mission-related program offices are consulted, to confirm programmatic future needs for specific facilities. Center Operations, Facilities Management and support organizations are consulted to identify infrastructure and operational deficiencies.

Funding Sources

Planners consult with HQ to identify the realistic funding levels expected for the Center projects within the Recapitalization CoF Program; and consult with the Construction of Facilities (CoF) Program Manager to identify expected funding levels for the Institutional CoF Program, and the Demolition CoF Program. Center Operations and Facilities Management are consulted to determine the anticipated Center Maintenance and Operations funding available for facility improvements. And Mission Program offices are consulted to identify other program-direct funding sources that would support mission-required facility projects.

Development Program Strategy

The Development Program is the overall Center strategy for using and investing in real property. Program requirements include all facility needs required to enable mission support. Facilities and projects should be validated against the master plan and the planning strategies before they are programmed. Planners should capture facility requirements and propose solutions to meet those requirements from the options available: better utilization of existing facilities; rehabilitation of existing facilities; leasing sof off-site facilities; and new construction to replace facilities that will be demolished.

5.10.2 Program Documentation

The CIPP is the master plan's documentation of the Development Program. It includes a list of currently known projects needed to support the Center's work. The CIPP organizes the projects within 5-year periods, and prioritizes projects according to their need and implementation sequence. Projects are

arranged within three categories; Sustainment for repair work, Renewal for recapitalization work and Transition for construction of new capabilities. The anticipated funding source is assigned toward the projected project cost estimate.

The projects listed in the near-term years within the CIPP are submitted within the CoF Program process and the Planning, Programming, Budgeting and Execution (PPBES) resource management system. The PPBES ties planning, programming, and budgeting together. It forms the basis for building a comprehensive plan in which budgets flow from programs, programs flow from requirements, and requirements from plans and missions. It supports budget preparation from Center to departmental level. During execution, it provides feedback to the planning, programming, and budgeting process.

The Development Program is expected to be dynamic as facility needs and priorities and funding sources change, and the list of CIPP projects is updated as necessary.

Chapter 6.

KEY PERFORMANCE INDICATORS

6.1 Introduction

A CMP must meet all relevant codes, statutes, regulations, policies, and guidance regarding training and certification opportunities. This chapter reviews these elements of compliance.

6.2 Master Plan Compliance Metrics

This chapter of the handbook is intended to help Centers troubleshoot their plans against the NASA and other federal policies to which they must respond. At each stage—from Development to Documentation to Communication—plans must strive to address comprehensively all real property assets (including land and improvements, all sites the Center owns or manages, constructed or occupied by NASA or others, stewarded by program or institution).

The master planning process must interact successfully with the Agency administrative processes described in the NASA Policy Directives (NPD) and Procedural Requirements (NPR) that most affect Agency CMP development. They are listed below:

- NPD 8800.14, Policy for Real Estate Management
- NPD 8810.2, Master Planning for Real Property
- NPD 8820.2, Design and Construction of Facilities
- NPR 8820.2, Facility Project Requirements
- NPR 8831.2, Facilities Maintenance and Operations Management
- NPR 8580.1, NASA National Environmental Policy Act Management Requirements
- NPR 8590.1, Environmental Compliance and Restoration Program
- NPR 8510.1, NASA Cultural Resources Management

This is achieved by developing the master plans in a manner that helps to accomplish the respective core objectives of each of these NPD's and NPR's, as briefly summarized by the excerpts below:

NPD 8800.14, Policy for Real Estate Management: "It is NASA policy to promote the efficient and economical utilization of its real property assets. The effective management of NASA real property is integral to NASA's mission."

NPD 8810.2, Master Planning for Real Property: "It is NASA's policy that each Center prepare and maintain a Center Real Property Master Plan (CMP). A CMP is the Center's statement of its concept for the orderly management and future development of the Center's real property assets, including land, buildings, physical resources, and infrastructure. It is the overall plan for Center development."

NPD 8820.2, Design and Construction of Facilities: "NASA will retain only those assets required to conduct NASA programs, maintain the Agency's core capabilities, and meet national responsibilities. NASA will purchase, construct, and/or operate new real property only when existing capabilities (including those owned by NASA and other external entities) cannot be used or modified cost-effectively. When new construction is needed, facilities built and operated to support NASA's mission shall be planned, budgeted, designed, and constructed in compliance with current Federal laws and regulations."

NPR 8820.2, Facility Project Requirements: "The annual facility program is part of the Agency's five-year budget described in NPD 1000.0, Strategic Management & Governance Handbook. The five-year budget includes the Construction of Facilities (CoF) program under the Institutional Investment account. NASA Centers and Headquarters formulate the CoF program through a collaborative process."

NPR 8831.2, Facilities Maintenance and Operations Management:"NASA's facilities operation and maintenance philosophy is to support NASA's mission by aggressively and proactively pursuing and adopting the safest, most cost-effective, and best blend of Reliability Centered Maintenance (RCM) techniques, sustainability, safety procedures, and other best practices to provide safe, sustainable, efficient, and reliable facilities."

NPR 8580.1, NASA National Environmental Policy Act Management Requirements: " NEPA requires all Federal agencies to consider, before an action is taken, environmental values in the planning of actions and activities that may have a significant impact upon the quality of the human environment. NEPA directs agencies to consider alternatives to their proposed activities. In essence, NEPA requires NASA decision makers to consider environmental, technical, and economic factors. NEPA is also an environmental disclosure statute. It requires that available information be adequately addressed and made available to NASA decision makers in a timely manner so

they can consider the environmental consequences of the proposed action or activity. Environmental information must also be made available to the public as well as to other Federal, State, and local agencies."

NPR 8590.1, Environmental Compliance and Restoration Program: "By policy, NASA is committed to planning, developing, and implementing programs and projects to minimize the release of hazardous substances into the environment, to restore impacted natural resources, and to maintain environmental compliance in concert with the Agency's mission..."

NPR 8510.1, NASA Cultural Resources Management: "NASA is committed to be a steward of cultural resources, and implementation of this NPR will ensure preservation of their significance to NASA's mission, communities, and the history of our Nation in accordance with The Secretary of the Interior's Standards and Guidelines for Federal Agency Historic Preservation Programs Pursuant to the National Historic Preservation Act, 63 Federal Register."

NPR 8810.1, Master Planning Procedural Requirements, summarizes a definition of master planning as follows:

> Master planning is an analytical process undertaken to evaluate the numerous factors that affect a NASA Center and insure that the future real property development of the Center effectively and efficiently supports the missions carried out and supported by the Center. The product of this analytical process is a Center Master Plan (CMP), which establishes the Center's concept for the future.

The interaction and work flow between the master planning process and the Agency's administrative requirements as defined by key NPR's and NPD's is diagrammatically represented by Figure 6-1.

6.2.1 Tier 1: Development Compliance

In developing their CMPs, Centers must strive to be:

- Inclusive, engaging Center and program leadership, NASA program customers, tenants, institutional stewards at the Center and Agency, the workforce, and the external community, each to the appropriate degree and at the appropriate time
- Thorough, taking appropriate care to understand and document current conditions (capabilities, opportunities, constraints), and current and proposed facilities requirements
- Analytical, identifying gaps between current and desired states, and developing a range of alternatives to address those gaps
- Equitable (defining evaluation criteria that span the full range of stakeholder interests, and prioritizes against evaluation criteria to evaluate and select among alternatives)

- Traceable to required Agency risk-management practices (documenting the development process enough to show that resulting proposals are responsible choices among the alternatives)
- Sustainable (striving always to use resources responsibly, maintaining a resilient, productive, safe, secure, and healthy work environment

6.2.2 Tier 2: Documentation Compliance

In documenting their CMPs, Centers must demonstrate that they are:

- Comprehensive (addressing all real property assets (land and improvements, all sites the Center owns or manages, constructed or occupied by NASA or others, stewarded by program or institution)
- Traceable to required Agency risk-management practices(documenting the development process enough to show that resulting proposals are responsible choices among the alternatives)
- Predictive of projects' costs and risks over a long enough term that NASA may have confidence in its projection (over a planning horizon of not less than 20 years)
- Compliant with NASA policies and guidance.

6.2.3 Tier 3: Communication Compliance

At the communication stage, CMPs must be:

- Clearly written and organized
- Accessible to a broad audience
- Accountable to Center stakeholders (allowing them to see how and why NASA makes real property asset decisions that support NASA's mission)
- Traceable to required Agency risk-management practices (documenting the development process enough to show that resulting proposals are responsible choices among the alternatives)
- Responsive to NASA policies and guidance, statutory and regulatory requirements, and other Federal Government performance objectives

Chapter 7.

EMPLOYEE DEVELOPMENT

7.1 Career Path

Staffed separately at each major field installation, NASA master planning can be successfully performed by individuals from many disciplines. While a formal land use or regional and urban planning background is desirable, architects, engineers, and other facilities-related professionals have proven highly successful in the role.

As important as any particular discipline background is the aptitude for integrating diverse stakeholder viewpoints in the context of NASA's complex organizational dynamics and an understanding of Federal real property, environmental, and facilities stewardship policies, procedures, and resources. Since many will advance beyond planner positions to other leadership roles, the community of practice is always in transition, making the integration of new members critical.

NASA master planners continually adapt to changing program requirements; steward unusually complex inventories of natural and constructed assets; and coordinate with Agency strategic guidance and initiatives. Proactive individuals will to draw not only from organizational resources for their professional development, but also from their personal experiences and initiative.

7.2 Development Drivers

Planners need both "hard" and "soft" skills. The hard skills pertain to specific competencies associated with the job, and soft skills add the ability to navigate within a complex, diverse organization; planners should work with their supervisors to assess their development requirements to respond to both skill sets.

7.2.1 Technical Competencies

NASA defines the competencies for master planning as:

- Knowledge of strategic and long-term planning for operations, research, or development activities at the Center level

- Knowledge required to develop functional and overall Center requirements, including fit of specific facility needs and requirements as well as workflow and long-term scheduling
- Knowledge required to coordinate and incorporate the necessary facilities and other building and infrastructure to satisfy all functional, institutional needs to meet mission requirements
- Specialized knowledge of transportation modeling as well as broad aspects of community interfaces for emergency services and other requirements of large complex industrial installations

NASA's Competency Management System (CMS) measures and monitors the Agency's corporate skill set. Because the competencies are used to categorize the capabilities of an employee, the CMS is a good tool for employees and supervisors to determine the knowledge areas specific to the job.

7.2.2 Nontechnical Competencies

Since successful employees demonstrate a range of skills beyond their technical competencies, NASA's Leadership Model can help individuals by organizing and guiding expectations. The model groups "soft" skills (personal effectiveness, discipline competency, managing information & knowledge, business acumen, and leading people) and defines expectations at successive steps along a career ladder from staff employee ("influence leader") through executive. Used with accompanying assessment tools and formal leadership development programs, the model can help employees identify development needs and avenues for addressing such needs.

7.3 Development Tools

7.3.1 On-the-Job Training

As is true of many complex positions, aspects of master planning cannot be fully anticipated, but must be adapted to on the job. It follows that on-the-job training is important. The responsibility for on-the-job training lies with the supervisors and managers to ensure the trainee has available resources to train, qualify, and continually develop them. For best results, on-the-job training should be customized to individual circumstances, but would certainly include understanding across the topics listed in Table 7-1.

NASA uses the System for Administration, Training and Educational Resources for NASA (SATERN), described below, to create an orientation training program.

TABLE 6-1 On-the-Job Training Topics

	Topic
Agency overview	NASA Strategic Plan
	NASA Budget
	NASA's Strategic Sustainability Performance Plan
	NPD 8800.14, Policy for Real Estate Management
	NPD 8810.2, Master Planning for Real Property
	NPR 8810.1, Master Planning Procedural Requirements
	Construction of Facilities Program
Center-specific information	Agency products cited above often have analogs at Center-, Directorate-, and Branch-level organizations
Personal and position-specific information	Individual Development Plan (see Section 6.3.4)
	Position description

7.3.2 Mentoring

Mentoring is a relationship between two people in which a more experienced person helps guide a less experienced individual's professional and personal development. Mentoring may occur informally (arising naturally based upon mutual affinity, often among long-term colleagues) or formally (organized by a NASA organization, with more structured program and selection process, usually for a defined time period).

There are many factors to consider when matching a mentor and protégé, including professional and personal experiences; education/skills; culture; age; personality; and interests. For both parties, maintaining effective, honest communication is paramount. The mentor-protégé relationship can benefit the mentor, the protégé and the organization. As a mentor serves as a sounding-board for exploring protégé roles, challenges, and opportunities, the protégé draws from the expertise and perspective of a recognized performer.

7.3.3 System for Administration, Training and Educational Resources for NASA (SATERN)

NASA employs SATERN as a learning management tool. SATERN provides access to training products and processes to support learning and development. It provides desktop access to enrollment, learning plans, in-house curriculum, personal learning history and tracking, and continuous learning 24 hours a day, 7 days a week. SATERN can be accessed from on- or off-site.

7.3.4 Individual Development Plan

NASA encourages each employee to have an Individual Development Plan (IDP), a learning plan used by employees and supervisors to chart a suc-

cessful career path. As the plan is built, the employee and supervisor review developmental objectives, discuss development goals, and select learning activities for satisfying those objectives and goals.

The IDP is proficiency-driven, serving several purposes: ensuring the employee maintains current proficiencies; helping chart a career path; identifying knowledge, skill and ability gaps; and aligning employee goals and objectives with Agency needs.

7.3.5 Academy of Program and Project and Engineering Leadership (APPEL)

NASA's Academy of Program and Project and Engineering Leadership (APPEL) strives to assist NASA employees in maintaining professional excellence through engineering and project management training.APPEL pursues their vision through the application of learning strategies, methods, models, and tools, and is thus a rich resource for personal and professional development.

APPEL strives to:

- Promote communications and transfer of wisdom through knowledge sharing events and publications
- Create opportunities for project management collaboration through research and exchange with universities, government agencies, professional associations, and industry partners
- Serve as a clearinghouse of world-class expertise for projects teams through performance enhancement services and tools
- Develop project leadership maturity through career development and programs

7.3.6 The Community of Practice

As with any formal discipline, developing and maintaining proficiency involves continuing awareness of trends in the profession, and in evolving Federal, Agency, and local policies and requirements. NASA's master planning community of practice seeks to promote awareness of relevant development and alignment opportunities via:

- Meetings, including monthly video teleconferences and at least one annual community gathering
- Teams tasked with refining aspects of master planning policy and practice
- Networking, in person and virtually (often building on relationships developed when meetings and teaming with colleagues)

Appendix A.

ABBREVIATIONS

ADP	area development plan
CIPP	Capital Improvement Program Plan
CMP	Center master plan
CoF	Construction of Facilities
ECR	Environmental Compliance and Restoration
FDC	Future Development Concept
NASA	National Aeronautics and Space Administration
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
UGB	Urban Growth Boundary

Appendix B.
GLOSSARY

Capital Improvement Program Plan. The CIPP is a tabular listing of projects required to implement a CMP over a 20-year period. Investments are organized by date and by the nature of the investment (sustainment, renewal, or transition).The listing identifies projects by title, date, and proposed funds source, whether from NASA or other parties.

Center master plan. The CMP is the Center's statement of its concept for the orderly management and future development of the Center's real property assets, including land, buildings, physical resources, and infrastructure. It provides a narrative, statistical, and graphic record of current capabilities and conditions (natural features, buildings, structures, utilities, transportation systems, and other improvements), as well as necessary changes to support program and institutional activities and NASA's strategic and business planning.

Future Development Concept. The FDC is a diagram illustrating key changes proposed for a Center over 20 or more years. Briefed to Agency leadership, and together with supporting documentation, it enables Agency concurrence with the direction the Center proposes for facilities development and redevelopment prior to the more rigorous and detailed full technical master plan documentation.

Renewal. Investments intended primarily to remedy facilities degradation resulting from usage at or beyond reliable asset service life. Such renewal generally occurs through asst replacement, but in some cases through a substantial rehabilitation project.

Sustainment. Investments intended to keep a facilities asset in proper working order during its service life. Projects include maintenance, repairs, and normal component systems replacements to keep assets performing properly during their expected service life.

Transition. Investments intended primarily to respond to changes other than renewal or sustainment. Projects respond either to changes in program requirements or to natural disasters that interfere with reliable facilities performance.

Appendix C.

SELECTED BEST PRACTICES

This appendix presents best practices in the master planning community drawn from the achievements of individual NASA Centers. These achievements are grounded in the Centers' individual core competencies (Table C.1).

TABLE C-1 Core Competencies of NASA Centers

Center	Core competencies
Ames Research Center	Entry, Descent, and Landing Air Traffic Management Astrobiology Space, Earth, and Life Science Advanced Computing and IT Systems Intelligent/Adaptive Human & Robotic Systems Aerosciences End-to-End Low Cost Aerospace Missions
Dryden Flight Research Center	Atmospheric Flight Research and Test Flight Operations & Engineering Staff Experimental and Testbed Aircraft Unmanned Aircraft Systems Airborne Science Platforms Range and Aircraft Test Facilities
Glenn Research Center	Air-Breathing Propulsion Communications Technology and Development In-Space Propulsion and Cryogenic Fluids Management Power, Energy Storage and Conversion Materials and Structures for Extreme Environments Physical Sciences and Biomedical Technologies in Space
Goddard Space Flight Center	Astrophysics Communications and Navigation Earth Science Heliophysics Planetary and Lunar Science Suborbital Platforms and Range Services

TABLE C-1 Core Competencies of NASA Centers

Center	Core competencies
Jet Propulsion Laboratory	Mission definition and design Deep space telecom, navigation, frequency and timing, and GPS Robotics Electric propulsion Entry, descent and landing Advanced optics and telescopes Focal planes Visible/IR/Submillimeter, in-situ and remote sensing instruments Active radar instruments Distributed spacecraft formation
Johnson Space Center	Human Spaceflight Design, Development and Testing Hazardous & High Energy Testing Operations and Training Human Health and Performance Human Rating Orbital Debris Imagery Analysis Safety & Risk Management Multimedia Services
Kennedy Space Center	Acquisition and management of launch services and commercial crew development Launch vehicle and spacecraft processing, launching, landing and recovery, operations, and sustaining Payload and flight science experiment processing, integration, and testing Designing, developing, operating, and sustaining flight and ground systems, and supporting infrastructure Development, test and demonstration of advanced flight systems and transformational technologies Developing technology to advance exploration and space systems
Langley Research Center	Aerosciences Research for Flight in all Atmospheres Aerospace Structures & Material Concepts Aerospace Systems Analysis Characterization of Atmospheres Entry, Decent and Landing
Marshall Space Flight Center	Space transportation/launch vehicle technology & development Propulsion systems technology & development Space systems technology, development, & integration Scientific research
Stennis Space Center	Rocket Propulsion Testing Earth Science

TABLE C-1 Core Competencies of NASA Centers

Center	Core competencies
White Sands Test Facility	Rocket Propulsion Testing and Analysis Oxygen Systems Testing and Analysis Propellants and Aerospace Fluids Testing and Analysis Hypervelocity Impact Testing Composite Pressure Systems Testing and Analysis

Appendix D.

TRAINING OPPORTUNITIES

Appendix E.

PLANNING PRINCIPLES

Appendix F.

REFERENCES

CMPs are specified under the following NASA authorities:

- 42 U.S.C. 2473(c)(1), Section 203(c)(1), National Aeronautics and Space Act of 1958, as amended
- NPD 1000.0, NASA Governance and Strategic Management Handbook
- NPD 1000.3, The NASA Organization
- NPD 1001.0, NASA Strategic Plan
- NPD 8800.14, Policy for Real Estate Management
- NPD 8810.2, Master Planning for Real Property
- NPD 8820.2, Design and Construction of Facilities
- NPR 8820.2, Facility Project Requirements
- NPR 8510.1, NASA Cultural Resources Management
- NPR 8580.1, NASA National Environmental Policy Act Management Requirements
- NPR 8590.1, Environmental Compliance and Restoration Program

In addition, the following laws and administrative authorities may apply:

- 16 U.S.C. 470, National Historic Preservation Act of 1966
- EO 12423, Federal Leadership in Environmental, Energy, and Economic Performance
- National Environmental Protection Act