Procedures and Guidelines

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COMPLIANCE IS MANDATORY

Responsible Office: 590 / Mission Engineering and Systems Analysis Division

Title: Guidance, Navigation, and Control Systems Development for GSFC In-House Missions

PREFACE

P.1 PURPOSE

This PG establishes guidelines for the roles and responsibilities of personnel involved in the development of Guidance, Navigation & Control (GN&C) Systems for NASA/GSFC in-house missions. GN&C is a broad category of disciplines comprised of attitude control, flight dynamics, and propulsion, including both flight- and ground-based mission elements.

P.2 APPLICABILITY

This PG applies to members of any team developing GN&C systems for NASA/GSFC in-house missions.

P.3 AUTHORITY

GPR 8700.1, Design Planning and Interface Management
GPR 8700.2, Design Development

P.4 REFERENCES

N/A

P.5 CANCELLATION

N/A

P.6 SAFETY

N/A

P.7 TRAINING

N/A

P.8 RECORDS

N/A

Record Title	Record Custodian	Retention
N/A		*
N/A		*

** NRRS – NASA Records Retention Schedule (NPR 1441.1)*

P.9 METRICS

N/A

P.10 DEFINITIONS

ACS Analysis – Attitude Control Subsystem (ACS) Analysis is the discipline in which spacecraft attitude control algorithms are designed, the dynamics of the spacecraft are modeled, and the performance and stability of the control system are verified.

ACS Dynamic Simulator – Development of the ACS Dynamic Simulator is the discipline in which hardware and software are integrated to create a highly capable spacecraft testbed. The ACS Dynamic Simulator is a set of hardware and software, operating in real-time, that simulates the dynamics of the spacecraft (including the effects of environment and actuator activity) and provides stimulaton to the ACS based on these effects. It is used for closed-loop testing of the ACS or elements thereof. It may also be used to test other spacecraft subsystems whose operation is closely linked to the ACS.

ACS Hardware – ACS Hardware is the discipline in which attitude sensors, control actuators, and associated electronics are designed, developed, integrated, and/or tested.

ACS Software – ACS Software is the discipline in which the control algorithms developed by the ACS Analysis Team are implemented in software, which is then verified by test.

Flight Dynamics – Flight Dynamics is the discipline in which the spacecraft trajectory is designed and analyzed, with consideration of launch vehicle performance, communications links, space environments, spacecraft capabilities, and operational issues; tools for orbit determination, attitude determination, and maneuver planning are developed and verified; and these analyses and tools are put into practice during all mission phases.

Product Design Lead (PDL) – The PDL is the manager or leader responsible for managing the design activity, managing the technical and organizational interfaces identified during design planning, and where required, forming and leading the Product Design Team (PDT). This term refers to flight project managers, mission managers, instrument managers, subsystem technical managers, integrated development team leaders, lead engineers, or others who have responsibility for managing a design activity. In the context of this document, PDL refers to a lead engineer.

Propulsion Systems – Propulsion Systems is the discipline in which chemical or electric propulsion systems for spacecraft are designed, developed, integrated, tested, loaded, and operated. These systems may be used for orbit control, angular momentum control, or both. In addition to flight hardware, these systems include all associated ground support equipment.

PROCEDURES

In this document, a requirement is identified by "shall," a good practice by "should," permission by "may" or "can," expectation by "will" and descriptive material by "is."

This PG provides guidance for the development of Guidance, Navigation & Control (GN&C) systems for GSFC in-house missions. This guideline defines roles and responsibilities, and outlines how a team of GN&C engineers working together can develop all of the elements of a GN&C system. It is recognized that there may be exceptions to this guideline based upon the scope of development required.

The GN&C system has elements including the Attitude Control System (ACS), Flight Dynamics, and the Propulsion System. These elements span both flight and ground segment development. GN&C disciplines include ACS Analysis, ACS Hardware, ACS Software, ACS Dynamic Simulator, Flight Dynamics, and Propulsion Systems.

A team of GN&C engineers will be assigned to work on a GN&C system. The team will be comprised of engineers representing all disciplines within GN&C as well as a GN&C Systems Engineer(s). All GN&C Engineers will be assigned by Mission Engineering and Systems Analysis (MESA) Division Branch Heads, with the exception of ACS Software Engineers who will be assigned by an Information Systems Division Branch Head.

A PDL will be assigned for every GN&C element, including the ACS element (which will include the sub-elements of analysis, hardware, software and dynamic simulator), the Flight Dynamics element, and the Propulsion System element.

GN&C Systems Engineer Responsibilities
The GN&C Systems Engineer will be responsible for the systems engineering functions and products for the overall GN&C system. The GN&C Systems Engineer will be a member of the Project Systems Engineering team, and will work with all members of the GN&C engineering team. The GN&C Systems Engineer will be responsible for requirements generation, trade studies, concept selection, verification and validation, risk management and resource allocation for the GN&C system. The GN&C Systems Engineer will be responsible for performing technical, cost and schedule trades across all GN&C elements. The GN&C Systems Engineer should work with the ACS PDL, the Flight Dynamics PDL and the Propulsion System PDL to stay cognizant of current and future budgetary needs for all GN&C elements.

ACS PDL Responsibilities
The ACS PDL will be responsible for ensuring that the ACS effort meets technical, cost and schedule requirements. The ACS PDL will work with his or her team of ACS Analysts, ACS Hardware Engineers, ACS Software Engineers and ACS Dynamic Simulator engineers. The ACS PDL should work with the GN&C Systems Engineer to ensure that interfaces between the ACS element and other GN&C elements are well defined. The ACS PDL should work with the GN&C Systems Engineer and other Project Systems Engineers to ensure that interfaces between the ACS element and other elements outside of GN&C (i.e. C&DH, C&DH Software, Electrical, Mechanical) are well defined.

ACS Analysis Lead Engineer Responsibilities
The ACS Analysis Lead Engineer will be responsible for ensuring that the ACS analytical effort meets technical, cost and schedule requirements. The ACS Analysis Lead Engineer will work with his or her team of ACS Analysts to accomplish this. The ACS Analysis Lead Engineer should work with the ACS PDL and the GN&C Systems Engineer to ensure that interfaces between the ACS analytical effort and other GN&C elements are well defined.

The ACS Analysis Lead Engineer will be responsible for informing the ACS PDL of technical, budget and schedule status. Tasks and Procurement Requests will be initiated and tracked by the ACS Analysis Lead Engineer, with periodic reports to the ACS PDL. The ACS Analysis Lead Engineer should collaborate with the ACS PDL to determine current and future budgetary needs.

The ACS Analysis Lead Engineer also will work with the Flight Dynamics PDL to develop the ground-based attitude determination system.

ACS Hardware Lead Engineer Responsibilities
The ACS Hardware Lead Engineer will be responsible for ensuring that the ACS hardware system (including component embedded software) meets technical, cost and schedule requirements. The ACS Hardware Lead Engineer will work with his or her team of ACS Hardware Engineers and Technicians to accomplish this. The ACS Hardware Lead Engineer should work with the ACS PDL and the GN&C Systems Engineer to ensure that interfaces between the ACS Hardware and other GN&C elements are well defined.

The ACS Hardware Lead Engineer will be responsible for informing the ACS PDL of technical, budget and schedule status. Tasks and Procurement Requests will be initiated and tracked by the ACS Hardware Lead Engineer, with periodic reports to the ACS PDL. The ACS Hardware Lead Engineer should collaborate with the ACS PDL to determine current and future budgetary needs.

ACS Software Lead Engineer Responsibilities

The ACS Software Lead Engineer will be responsible for ensuring that the ACS Software effort meets technical, cost and schedule requirements. The ACS Software Lead Engineer will work with his or her team of ACS Software Lead Engineers to accomplish this. The ACS Software Lead Engineer will work with the ACS PDL and the GN&C Systems Engineer to ensure that interfaces between the ACS Software and other GN&C elements are well defined. The ACS Software Lead Engineer should work with C&DH Engineers and Project Software Engineers to ensure that interfaces between the ACS Software and C&DH and other software are well defined.

The ACS Software Lead Engineer will be responsible for informing the ACS PDL of technical, budget and schedule status. Tasks and Procurement Requests will be initiated and tracked by the ACS Software Lead Engineer, with periodic reports to the ACS PDL. The ACS Software Lead Engineer should collaborate with the ACS Product Lead to determine current and future budgetary needs.

ACS Dynamic Simulator Lead Engineer Responsibilities

The ACS Dynamic Simulator Lead Engineer will be responsible for ensuring that the ACS Dynamic Simulator meets technical, cost and schedule requirements. The ACS Dynamic Simulator Lead Engineer will work with his or her team of ACS Dynamic Simulator Engineers to accomplish this. The ACS Dynamic Simulator Lead Engineer should work with the ACS PDL and the GN&C Systems Engineer to ensure that interfaces between the ACS Dynamic Simulator and other GN&C elements are well defined.

The ACS Dynamic Simulator Lead Engineer will be responsible for informing the ACS PDL of technical, budget and schedule status. Tasks and Procurement Requests will be initiated and tracked by the ACS Dynamic Simulator Lead Engineer, with periodic reports to the ACS PDL. The ACS Dynamic Simulator Lead Engineer should collaborate with the ACS Product Lead to determine current and future budgetary needs.

Flight Dynamics PDL Responsibilities

The Flight Dynamics PDL will be responsible for ensuring that the Flight Dynamics effort meets technical, cost and schedule requirements. The Flight Dynamics PDL will work with his or her team of Flight Dynamics Engineers to accomplish this. The Flight Dynamics PDL should work with the GN&C Systems Engineer to ensure that interfaces between Flight Dynamics and other GN&C elements are well defined. The Flight Dynamics PDL should work with the GN&C Systems Engineer and other Project Systems Engineers to ensure that interfaces between Flight Dynamics and other elements outside of GN&C (i.e. Ground System, Flight Operations) are well defined.

The Flight Dynamics PDL also will work with the ACS Analysis Lead Engineer to develop the ground-based attitude determination system.

Propulsion Systems PDL Responsibilities

The Propulsion Systems PDL will be responsible for ensuring that the Propulsion system meets technical, cost and schedule requirements. The Propulsion Systems PDL will work with his or her team of Propulsion Systems Engineers and Technicians to accomplish this. The Propulsion Systems PDL should work with the GN&C Systems Engineer to ensure that interfaces between the Propulsion System and other GN&C elements are well defined. The Propulsion Systems PDL should work with the GN&C Systems Engineer and other Project Systems Engineers to ensure that interfaces between the Propulsion System and other elements outside of GN&C (i.e. Electrical, Mechanical, Thermal) are well defined.

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	08/18/2008	Initial Release