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Paper Session II-B - National Launch System Payload Accommodations

Capt James M. Knauf
National Launch System Requirements Officer HQ Air Force Space Command

NATIONAL LAUNCH SYSTEM
PAYLOAD ACCOMMODATIONS

Capt James M. Knauf
National Launch System Requirements Officer
HQ Air Force Space Command
Peterson AFB, CO

ABSTRACT

Early definition, documentation, acceptance, and continuing implementation of a standard system of payload accommodations for space launch systems is essential. Attempts to provide truly standard payload accommodations have not met with significant success in increasing responsiveness or reducing operations costs. The operational philosophy of the National Launch System (NLS) is based on standardization and includes standardized payload accommodations. These must be incorporated into NLS design concepts early in the development phase to ensure the NLS goal of increased responsiveness and reduced operating cost. At the same time, sufficient flexibility will be maintained to accommodate the rare unique payload requirement which cannot meet the standard due to specific mission requirements, safety concerns, or other reasons. Definition of payload accommodation design goals and operational employment scenarios, and their rationale, will be described, as well as methods for ensuring payload community acceptance and continued implementation.

INTRODUCTION

Requirements for NLS/Advanced Launch System (ALS) have previously been described . However, requirements development prior to early 1991 did not concentrate heavily on detailed payload accommodations requirements. Payload related requirements resulted largely from launch vehicle operational philosophy considerations. The impact to payload design and, conversely, the payload impact to the NLS, were not thoroughly considered.

This paper will reemphasize the need for simplified, standard payload accommodations. Although standard payload accommodations are expected to benefit all NLS users, this paper will primarily address DOD payload accommodations. Since detailed interfaces are not yet developed, the paper will instead outline methods being used to begin defining payload accommodations. The status of several payload accommodation definition efforts will be reported. Finally, recommended next steps in NLS payload accommodations development will be discussed.

NLS OPERATIONAL EMPLOYMENT

Implementation of the NLS satisfies current National Space Launch Strategy through development of a new space launch system with improvements in launch system reliability, responsiveness, and mission performance. A concept for a family of launch vehicles and associated infrastructure is emerging from the concept exploration phase of the DOD/NASA NLS program.

As currently conceived, the NLS will consist of three basic configurations making common use of the new Space Transportation Main Engine (STME). Two configurations, NLS-1 and NLS-2, will be based on a common core structure derived from the existing Space Shuttle External Tank. NLS-1 will be augmented with Advanced Solid Rocket Motors from the Shuttle program to provide heavy lift capability for NASA missions. NLS-2 will consist of only the common core, supporting both NASA and DOD missions by providing a 50,000 lb to low earth orbit capability. A third NLS configuration, NLS-3, will use a different core structure to provide a 20,000 lb to low earth orbit capability. Upper stage/cargo transfer vehicles are also envisioned.

Operational employment of the NLS to support DOD missions is based on the need for assured access to space. As clearly demonstrated during Desert Shield/Desert Storm, space systems are crucial to modern military operations. Space system support to the military commander on the ground, in the air, or at sea depends on continuing availability of on-orbit space assets. Availability of satellites on-orbit depends largely on a robust and flexible capability to place them there when needed. Thus, as depicted in Figure 1, responsive spacelift is a primary driver for the requirement for NLS, which in turn drives NLS payload accommodation requirements.

Through a mix of technological and process innovations, NLS will provide the required improvements in launch availability, dependability, reliability, and resiliency. These improvements will improve accessibility to space. Payload accommodations provide an opportunity for improvement over current launch systems. Concomitant with improvements to the launch system, payload changes will be required to ensure that payloads are compatible with NLS both in terms of hardware/software interface and launch operations concepts. These changes will in turn require significant changes in how payload users and developers think about launch base operations and payload design.

NLS PAYLOAD REQUIREMENTS/DESIGN GOALS

Although technical and philosophy changes will be required of NLS payload users and developers, sufficient time exists to allow the payload community to influence NLS system requirements and, ultimately, specifications. However, long satellite development timelines, and the expected NLS-2 ILC in 2002 dictate that NLS payload accommodations development begin now. Efforts to solicit payload requirements are underway. Known top level payload accommodation design goals reflect planned NLS operations philosophy and have evolved from the ALS program.

Developing payload systems also will have operational requirements. When combined with NLS operational requirements they will drive system level requirements essential for complete definition of NLS design criteria. The process is iterative and two way. Just as the concept for NLS requires changes in payload design and launch base operations, the NLS design must satisfy payload requirements (i.e., NLS customer needs). However, the change in launch operations philosophy will require changes in the payload designer's approach. The last few pounds of added payload mass often are not operator requirements but result from the mere availability of a few more pounds of booster performance. This drives payload design, then booster modifications, then integration and launch operations costs. NLS margins must be maintained for truly operational needs.

Specifying detailed payload accommodations for as yet undefined NLS payloads is somewhat difficult. However, the current mix of payload missions can be reasonably extrapolated into the initial NLS operating period, i.e., missions flown today will in general be flown then. On first order examination, the extrapolated NLS payloads can be assumed to have similar requirements since similar missions should drive generally similar solutions. The resulting preliminary NLS requirements are described below.

In the absence of detailed designs for future payloads, dimensional requirements are derived from the extrapolated mission model. A conservative approach applies a margin to the resulting dimensions to provide for possible growth in payload dimensions resulting from uncertainty in actual payload sizes and to accommodate potential future, currently unknown missions. The results are found in Table 1. All NLS payloads will be designed within the dimensions shown, although some method of validating and accommodating rare exceptions will probably be needed.

Mission Orbit	Max. Length (ft)	Max. Diameter (ft)
GEO	65	20
GTO	18	16
Semi-synchronuos Transfer	8	8
Medium LEO	20	13
Heavy LEO	78	20
Medium Polar	20	9
Intermediate Polar	39	16
Heavy Polar	78	20

NLS Payload Dimensions
Table 1

Improved operability and responsiveness on NLS will result partly from the related characteristics of simplified payload integration, standard payload interfaces, and the ability to rapidly change out payloads on a given launch vehicle.

Simplified payload integration refers both to the physical mating of payload hardware to the launch vehicle and to mission integration, the analytical effort to verify the payload can be safely and successfully launched and orbited by the launch vehicle. Complexity of operations, standardization of integration procedures and hardware, operational time lines, and resources required will be designed for improvements.

Integration simplification will be facilitated through the use of standard payload interfaces (SPI). Past standardization efforts have been largely unsuccessful due to loosely controlled user desires for new capabilities and technologies which forced complex, unique, and costly satellite designs. Each satellite design was handled as an independent, new design which did not consider the launch operations mission as whole. In the future, payload unique requirements should be satisfied with adapter systems and/or self contained servicing support. Although this may appear to place the problems of space launch on the payload community instead of the launch vehicle operator, and while it is true that the purpose of spacelift is to launch satellites not launch vehicles, a total spacelift system approach must be taken. The purpose of spacelift is to launch <u>all</u> payloads, not just a particular payload. NLS payload accommodations/interfaces must be approached from this overall space launch system perspective.

Top level standard payload interface requirements are currently in development. Detailed definition of the standard interfaces is an objective of the payload accommodations development activity now just beginning. Standard interface characteristics are shown in Figure 2.

Standard interfaces will facilitate rapid payload change out, which is necessary to provide the operational flexibility to meet changing on-orbit constellation situations and to maximize effective use of the launch system. NLS must allow payload substitution within a given payload class and reference mission up to five days prior to scheduled launch. Following replacement, the launch system must be at the same number of days before launch as when the payload change notification was received. The payload substitution process should take less than five days from notification. NLS payloads, ground systems, and facilities must also be designed to meet the rapid change out need.

NLS must provide the necessary on-pad and boost phase payload services to accommodate both complex and simple payloads. As a goal, these services must be provided from within the NLS payload fairing without taking away from payload lift and volume requirements. Payload developers must provide needs for specific services sufficiently early to impact the NLS design.

NLS will define standards for loads, vibration, acoustics, cleanliness, etc., for each NLS vehicle configuration and will ensure that vehicles operate within those standards throughout their flight profiles. NLS payloads will then be designed to withstand the defined environmental envelope.

Preliminary payload accommodations development results generally confirm previously generated NLS requirements and represent a good start on requirements refinement. Redundancy, simplified payload integration, standardization, minimized booster and payload processing time, and off-line payload processing and encapsulation are important characteristics to be provided by NLS which have resulted from early development working groups. Issues which have been raised include 1) the extent of access to payloads on the launch pad and 2) payloads which, for mission, safety or other reasons are not accommodated by the NLS standard.

NLS, and the ALS before it, has suffered the misconception that it requires a strict, unrealistically simple standard interface; the "four bolt holes" approach. Standards will be developed, and payloads will be required to meet the standards in order to improve overall launch system effectiveness. The potential for new and unique capabilities or special missions, unforeseen today, make it prudent to provide some flexibility to accommodate occasional exceptions to the standard payload accommodations. However, payload developers must first attempt to satisfy their unique requirements without impacting NLS. The key to successful implementation of a standard payload accommodation is really a policy issue; decision making authorities must strictly limit exceptions.

Much of the payload community still depends on access to the payload on the launch pad. NLS will generally prohibit payload processing on the launch pad because it is a cost driver and reduces launch operability. Payload designers must use launch base operability as part of their design criteria. NLS payload design should avoid the need for on pad access.

IMPLEMENTATION

Two working group efforts are underway to ensure payload community involvement in payload accommodation development. One, the NLS Payload Accommodations Working Group (PAWG), is NLS specific and the other, the Future Medium Launch Vehicle Payload Builders and Users' Conference, addresses payload requirements across the spectrum of future launch systems. In addition, on-going update and validation of the NLS operational requirements and SPI mission needs are underway.

Detailed system specific requirements for NLS are under development by the NLS team. Payload generated requirements levied on NLS will result from the Payload Accommodations Working Group. The objectives of the PAWG include 1) preparation of a Payload Planning Handbook (PPH), 2) development of operational processes and timelines for rapid payload change out, and 3) identification of alternative payload integration concepts.

The PPH will collect all payload user needs; analyze payload mission, vehicle and ground services, and access requirements; and define standardized interface and service requirements. The PPH will serve as a link between the NLS and the payload user community.

A primary method of the PAWG is Quality Function Deployment (QFD). QFD objectives include 1) working issues as an integrated payload/booster/contractor team, 2) reaching team consensus on how NLS will meet user requirements, and 3) bringing users into the booster design process at an early stage. Broad participation from the launch vehicle community, payload community, and launch operations and payload processing communities is key. Payload community involvement includes DOD, NASA/civil, and commercial representation. Important participants are the launch base organizations responsible for processing the payloads for launch to ensure process improvements are considered in addition to design improvements. Initial PAWG activities are just underway at the time of this writing, and participation of all needed parties has not yet been fully realized.

The Future Medium Launch Vehicle Payload Builders and Users' Conferences are intended to provide payload builders and users with a top-level understanding of future launch systems and their capabilities, and to begin an on-going dialogue between the launch system operator, launch vehicle developers, and the payload community. Initial focus is on medium class payloads. Future launch systems include NLS, Single-Stage-to-Orbit (SSTO) Delta Clipper, and National Aerospace Plan (NASP) Derived Vehicles (NDV). One or more of these programs is expected to provide future spacelift. The ultimate working group intent, similar to the PAWG, is to ensure that payload requirements as well as operational considerations are incorporated early in the development phases of all future launch systems.

NLS and SPI requirements documentation update and validation is now underway. These requirements documents reflect update and refinement of the ALS operational requirements published in 1990. A primary goal of the current validation process is to provide very robust requirements traceability and rationale.

NEXT STEPS

Recommended next steps in payload accommodation development include update and revalidation of requirements, payload transition plan completion, payload planning handbook development, development of a military standard, and development of detailed NLS system specifications for payload accommodations.

Update and revalidation of NLS/SPI requirements is underway but not yet complete. Near term validation is crucial to the NLS effort as a whole and payload accommodations in particular. Although top level NLS payload accommodations requirements are virtually the same as the validated but outdated ALS requirements, formal validation is needed to form a solid basis for future payload accommodations development efforts.

Refinement of the top level NLS payload accommodations requirements and documentation in the PPH is the next important step. This will provide some needed realism to the NLS from the payload users' perspective, an important facet to the assignment of payloads to NLS and to ensuring integrated NLS/payload development and acquisition schedules. Based on results to date, broader payload community participation must be encouraged.

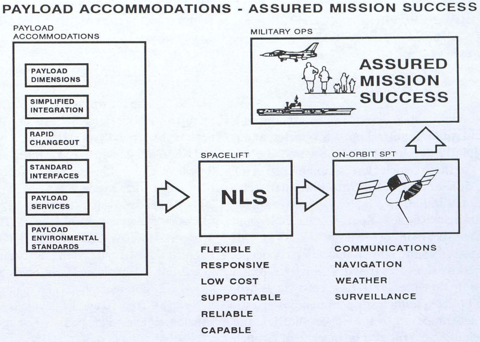
Careful integration of the NLS and payload development and launch schedules is needed to ensure that design requirements are mutually identified and incorporated in a timely, coordinated manner. Deployment of NLS clearly requires a transition plan detailing how payload programs transition from existing launch systems to the NLS. NLS payload transition planning will focus on satellite block changes to minimize development costs and operational impacts. A time phased transition plan for DOD payloads to NLS, along with key acquisition and development milestones should be completed as soon as possible.

The NLS payload accommodations developed should eventually be formalized and documented in a standard, perhaps a military standard. This will further encourage payload users to design for the NLS and more importantly, will help to ensure that any unique, non-standard payload interfaces are rare or non-existent.

Finally, the NLS team must complete development of the detailed design specifications for the NLS, including payload accommodations, leading to production and operations.

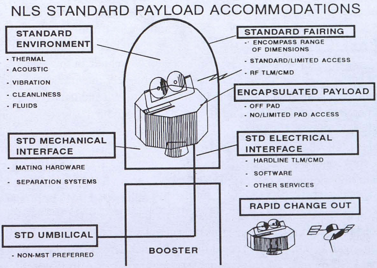
CONCLUSION

The most important aspect of NLS payload accommodation development at this stage is an open minded team approach with participation from all concerned parties. Only through a team approach and instillation of true ownership of the resulting payload accommodations by all parties will total acceptance and continued implementation be attained. Booster and payload communities, developer/acquirer and operator/user, government and contractor alike must set aside old mindsets and embrace new policy, philosophy, management, operations, and design philosophies, while at the same time retaining valuable lessons learned from some thirty-five years of space launch and payload design and processing experience. Although long range planning often falls victim to near term concerns, particularly under conditions of program uncertainty, NLS provides launch vehicle and payload designers with the opportunity to be visionary and move toward creation of ideal, operationally responsive payload accommodations.



PAYLOAD ACCOMMODATIONS - ASSURED MISSION SUCCESS
PAYLOAD ACCOMMODATIONS
PAYLOAD DIMENSIONS
SIMPLIFIED INTEGRATION
RAPID CHANGEOUT
STANDARD INTERFACES
PAYLOAD SERVICES
PAYLOAD ENVIRONMENTAL STANDARDS
SPACELIFT
NLS
FLEXIBLE
RESPONSIVE
LOW COST
SUPPORTABLE
RELIABLE
CAPABLE
ON-ORBIT SPT
COMMUNICATIONS
NAVIGATION
WEATHER
SURVEILLANCE
MILITARY OPS
ASSURED MISSION SUCCESS

Fig. 1



NLS STANDARD PAYLOAD ACCOMMODATIONS
STANDARD ENVIRONMENT
- THERMAL
- ACOUSTIC
- VIBRATION
- CLEANLINESS
- FLUIDS
STANDARD FAIRING
- ENCOMPASS RANGE OF DIMENSIONS
- STANDARD/LIMITED ACCESS
- RF TLM/CMD
ENCAPSULATED PAYLOAD
- OFF PAD
- NO/LIMITED PAD ACCESS
STD MECHANICAL INTERFACE
- MATING HARDWARE
- SEPARATION SYSTEMS
STD ELECTRICAL INTERFACE
- HARDLINE TLM/CMD
- SOFTWARE
- OTHER SERVICES
RAPID CHANGE OUT
STD UMBILICAL
- NON-MST PREFERRED
BOOSTER

Fig. 2