

## Pros and Cons of Standard Interfaces

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**ABSTRACT:** Standard interfaces and components have the potential for lowering systems engineering costs and reducing time to integrate payloads on small (or large) satellites. In addition, after the first one is built and flown, the risks are reduced when subsequent identical items are built.

For the case of spacecraft interfaces, once a standard interface is designed, it defines a set of all possible payloads that can be mated to it. Over-use and under-use of a standard interface is inefficient. Over-use, or putting a payload which demands more from the interface than what it was designed for, leads to additional system engineering and redesign tasks. Under-use of the interface is also inefficient because the interface provides more capability than what is needed. Given the high value (e.g. \$/kilogram) of a space vehicle, the excess capability will require more mass and more complexity than an optimized interface; thus additional cost and time.

A variety of sizes of payloads come to the Space Test Program (STP) for space flight. STP is in the process of acquiring an ESPA-class Standard Interface Vehicle (SIV). Those payloads that are designed to fit this standard interface are rewarded with a higher probability of flight. For the future, an analysis of the payloads that do not fit the ESPA-class SIV will likely define a new, larger and more capable standard interface; thus leading to quantized standard interfaces.

### INTRODUCTION

The virtues of standard components and interfaces are being praised in the recent technical literature and in conferences like these. This paper attempts to identify the pros and cons that need to be considered when deciding if a standard interface on a space vehicle is to be considered.

#### *Standards and Standard Interfaces*

There exist multiple standards in the satellite arena: Standards for components such as Class S parts, standards for processes (e.g. soldering process), standards for interfaces between boxes (e.g. 1553 data bus), standards for interfaces to ground systems

(e.g. SGLS), while others are more generally accepted standards (e.g. 28 Volt power supply). All of these, and others that have not been mentioned, contribute to the overall specification and performance of the satellite.

Several small satellite developers have made satellites that have varying degrees of standardization in their designs. An extreme example is present in the Iridium satellites that incorporated mass-manufacture. Several developers built standard spacecraft (busses) with varying degrees of success. Others relied on modular concepts to achieve added efficiency. However, given the cost in \$/Kg for space-lift, the contractor is usually forced to “modify” the cherished standard to minimize mass or

volume. The modification is usually done with the full support, if not advocacy, of the customer.

Standards and standard interfaces are not new to the community, but the emphasis that is being placed on them today is increasing. Only time will tell if this is just a temporary vogue or a new reality.

## **STANDARD INTERFACES**

### ***Launch Vehicle Interfaces***

In the small space vehicle arena, when standard interfaces are mentioned, the interface between the space vehicle and the launch vehicle comes to mind. Because there are a limited number of launch vehicles and they are considerably expensive, the standard interface is usually identified by the launch vehicle provider. In the Payload Users Manual, the launch vehicle providers usually define the standard interface (or interfaces) that is provided to the payloads. These interfaces may include a separation system (either as options or as part of the launch vehicle) and the corresponding bolt pattern as well as the static and dynamic envelopes that restricts the size of the space vehicle. In addition, the manuals usually define the number of separation signals and electrical lines that will be provided for the space vehicle (for data transfer or charging of batteries). The environments which the space vehicle will experience are usually also presented. Even with all this pre-defined interface definition, the space vehicles sometimes ask for adapter cones to bring the mechanical interface to match the attach points of the space vehicle.

The existence of several secondary payload adapters has improved the economics for space flight for smaller space vehicles. These additions to the arsenal of the space community have also identified de-facto standards for the small satellite community. If you meet this interface you have a simpler time integrating to the LV. Given the relative simplicity of this interface it is expected that the standardization will continue.

### ***Spacecraft to Experiment Standard Interface***

Identification of standard interfaces between the spacecraft bus and the payloads is the real motivation behind the recent increase in interest in our community. The Space Test Program is going through an acquisition for an ESPA-class Standard Interface Vehicle (SIV). The issues that will be discussed in this paper will address the advantages and shortcomings of these interfaces.

## **ADVANTAGES OF STANDARD INTERFACES**

A well-designed standard interface, once defined and adhered to, allows each side of the interface to design and build hardware and software independently. Once mated, the functionality of the combination is assured.

### ***Pre-designed Interface***

The advantages of a standard interface are many and valuable. The developers of electronic boxes, launch vehicles, busses, and experiments have predefined characteristics to which to design their interface. Each has the foreknowledge that if their interface meets the standard, their box, launch vehicle, buss, or experiment will have an inherent advantage over others that do not. Their unit will be chosen over others because the systems engineering required for integration will be minimized. Those that have to engineer a novel interface to allow their subsystem to work with another subsystem require additional time and money.

### ***Simultaneous design of two adjoining subsystems***

One could argue that all subsystems are designed to meet the requirements of the interface. Problems arise when two separate subsystems are being developed at the same time. Then, any problem-driven design change in one subsystem, may exceed the interface specifications, thereby cascading the problem to the adjoining subsystem. Pre-designing and proving the interface design ahead of time, freezing that design, will prevent subsystem level problems from crossing interfaces.

### ***Reduction in Risk***

Maintaining a constant interface design will allow subsequent identical builds of one side of the interface (e.g. spacecraft) while allowing the payloads to change (as long as they meet the interface design). This will usually result in lower risk and cost, and a shorter schedule. The reduction in risk arises from having a space proven interface.

## **DISADVANTAGES OF STANDARD INTERFACES**

### ***Completeness of Interface Definition***

The design of an interface is considerably easier when the designer has a clear understanding of the characteristics of the two subsystems that will be mated. When one side of the interface (say the payload) is yet to be completely defined, the designer identifies an envelope that will restrict the

characteristics of potential payloads. Restricted items are mass, mass distribution, volume, voltage, power, number and type of signal lines etc. Electromagnetic susceptibility and interference, thermal, deployable components (e.g. antennae), moving objects (gyros, momentum wheels, steerable antennae), peak power, fusing, data flow rates, are characteristics that are sometimes omitted. Payloads have an uncanny ability to meet all the stated interface specifications yet generate a characteristic that is unacceptable to the system. A thorough interface definition may not be the same as a complete definition.

As components evolve and suppliers change, the interface specifications may still be met, however secondary effects may prevent the system from working effectively. Such events occur and can be mitigated if large enough margins are designed to allow for component evolution.

#### ***Obsolescence of Design vs. Frequency of Use***

The old adage that is often heard in the community is that if PCs can develop a standard interface (e.g. USB) why can't space vehicles. The fallacy of that statement becomes evident when one compares the production numbers over which the cost of the development is distributed. The developers of USB can anticipate production numbers in the millions. It takes large efforts to design a thorough standard interface. If the interface is to be used on a handful of systems, then the additional effort to design a standard interface may not be cost effective.

In addition, electronic parts have a short period until they reach obsolescence. This is especially true of complex components such as ASICs, FPGAs, and processors. Thus creating a "standard" spacecraft with a well thought out interface may be useful for a small number of years; thereafter obsolescence will take its toll and redesign is required.

#### ***Stretching of Interface Capabilities***

Once a standard interface is established, it identifies a not-to-exceed envelope of characteristics for whatever is to be mated to it. As was mentioned earlier, payloads often exceed this envelope in one or more of the characteristics. The pressure is then placed on the program manager to stretch this characteristic since the infraction is so "minor". Expediency often rules and the interface is stretched to fill the need. Sometimes this can be done. More often repercussions are experienced and partial redesign is required upstream of the interface.

#### ***Under-Use of Interface Capabilities***

If an interface is not used to its full capabilities in a space asset then the customer is paying for a capability that is not used. At first this may seem a trivial issue. When the \$ per Kilogram or the \$ per volume for space access is considered this issue may become important. If, for example, a payload(s)' mass is one half of the mass that is capable of being carried by the interface, then neither the spacecraft nor the launch vehicle is being used efficiently. The same argument can be used for volume, power, etc.

#### **CONCLUSIONS**

The advantages and disadvantages of designing and building to a standard interface have been presented.

It is obvious that simple interfaces, consisting of mostly mechanical issues, and simple electrical issues, benefit from standardization. The success of the standardization between space vehicles and launch vehicles is clear evidence of this success.

As the sophistication of the interface increases, and the components on either side of the interface become more complex, the tradeoffs become more difficult. Contributing to the difficulty is the possibility for rapid obsolescence of components, the introduction of secondary effects from merged or new suppliers of components, and the introduction of a requirement not envisioned by the interface designers. These uncertainties can be overcome by designing interface thoroughly and with adequate margins to overcome secondary effects from changing components.

The reduction in risk, cost, and time associated with building duplicates of space-qualified spacecraft is a critical advantage. When experimenters conclude that if they design to a predefined interface the likelihood for space flight improved, their community will add their advocacy for standardization of the interface.

In summary, the authors see great potential in the development of standard interfaces. However, the community needs to be wary of the pitfalls that were listed, as well as those that will surprise us.