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Dual Spacecraft System

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In this paper, we discuss our work developing the Dual Spacecraft System (DSS). The DSS structure enables the launch of two independent, small-to-medium class payloads on a single United Launch Alliance (ULA) Atlas V launch vehicle. The DSS makes extensive use of existing components with well-understood capabilities. The structure itself consists of two back-to-back Centaur Forward Adapters with the optional addition of between one and four stub adapters to provide flexibility in the volumes of the upper and lower payload envelopes. The Centaur Forward Adapter is a combination of a cylindrical adapter and a conical adapter attached together with a common ring. In the DSS application, the cylindrical halves of the two forward adapters mate together. Besides the simplest solution with no additional plugs, there are several potential configurations available which utilize up to four cylindrical plugs, the stub adapters. This combination of hardware creates a clamshell which contains the lower payload. The Atlas V 14 foot payload fairing completely encloses the DSS. The DSS encloses the lower payload and provides structural support for the upper payload; the DSS reacts loads only from the upper payload during vehicle flight. The forward interface of the DSS is the 62 inch Standard Interface Specification (SIS) payload interface, permitting use of existing payload adapters. The aft interface attaches to the Atlas launch vehicle through a standard cylindrical payload adapter.

We discuss the benefits of utilizing a DSS. The forward adapter and stub adapter are existing Centaur hardware that have successfully flown on many Atlas launches. Using qualified, flight-proven components lowers risk and simplifies the full-scale development of the system. Existing components are fully compatible with the Atlas launch vehicle. A dual-launch capability means more spacecraft deployments in our current busy launch manifest, reduced costs, and maximum flexibility in payload sizes and combinations.

We will present the preliminary designs, payload envelopes, and capabilities for the different configurations of the DSS. The DSS will separate using the existing explosive bolts currently used to separate the 14 foot payload fairing. These bolts are installed in fittings derived from those used on the payload fairing. Along with a discussion of the separation system, we will show a concept of launch operations. We conclude our paper with a discussion of our future work and plan for going forward.

I. Description

The Dual Spacecraft System (DSS) is based on our existing Centaur Forward Adapter (CFA). See Figure 1. The cylindrical and conical sections of the CFA are skin and stringer assemblies, joined together with a shared ring. The CFA is a structurally tested and flight-proven component. To create a DSS, two CFA structures (without most of the avionics and harnessing shown in Figure 1) are joined together to form a clamshell. See Figure 2. If more volume is required by the lower spacecraft, it is possible to insert up to four stub adapter plugs between the two CFAs. The stub adapter is the two-foot cylindrical portion of the CFA and can be seen in Figure 1.

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The DSS concept successfully completed a System Requirements Review (SRR) in June 2008. The system-level requirements and the derived requirements have been identified, and there is a plan in place to verify each of them. To ensure maximum compatibility with a broad range of potential customers, the SRR was performed for generic payloads. Preliminary compatibility and coupled loads analyses for select, specific payloads is being worked.

Figure 1. The Centaur Forward Adapter (CFA) is the structural basis for the DSS

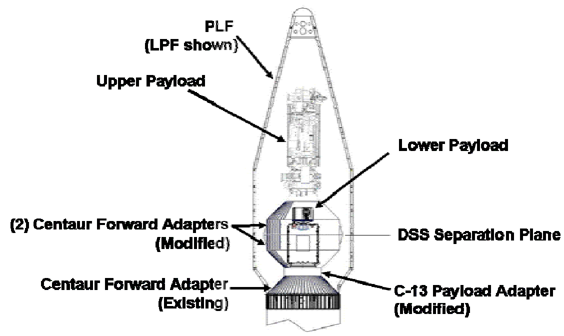

Figure 2. The DSS with two payloads inside the Atlas 4m fairing

II. Advantages to the DSS

There are many advantages in utilizing existing, flight proven components. The hardware is already qualified and structural testing results are available, so the capabilities are well understood and known to be compatible with the Atlas launch vehicle and a large range of payloads. Development is simplified, production tooling exists, and nonrecurring costs and risks will be reduced when compared to those of a brand new development. A dual mission increases manifest flexibility and allows for additional spacecraft deployments for the same number of actual launches. The DSS is well-poised to take advantage of the need to launch a smaller class of payloads. These are small-to-medium class payloads—too big to be considered secondaries, but smaller than the typical Atlas 400 class spacecraft. This class of payloads could find the ride-share opportunities presented by the DSS to be invaluable.

III. Design and Processing Details

The DSS requires three separation systems: one for the upper spacecraft, one for the lower spacecraft, and one to separate the two canisters that make up the DSS itself. The first two separation systems are dependent on the requirements of the selected spacecrafts. The DSS separation system utilizes existing Atlas components. The explosive bolts are identical to those that are used currently to successfully separate the Atlas 14ft payload fairing. These bolts have flown on heritage Atlas launch vehicles as well as all our current Atlas 400 series vehicles. Similarly, the fittings that house the separation bolts are derived from those used on the Atlas 14ft fairing.

The no-plug configuration is being studied to structurally carry as much as a 10,000lb spacecraft in the upper payload position and a 5,000lb spacecraft in the lower position. Versions with more plugs will have a reduced capability in the upper position and an increased capability in the lower position. These weights should be considered preliminary targets, not necessarily maximums or limits, as the analyses are still in the preliminary stages. The exact allowable weights also will depend on the heights of the spacecrafts' centers of gravity and load factors unique to each mission, and they may not be limited to the 10,000lb or 5,000lb currently assumed weights. Combined throw weights, taking into account performance capabilities to specific orbits, are only limited by the Atlas launch capability[1]. For maximum performance flexibility, the DSS is compatible with all versions of the Atlas with or without strap on solid raocket boosters (SRBs). Currently our work has focused on only the Atlas launch vehicle without precluding the possibility of launching on a Delta IV launch vehicle.

The concept of operations is based on existing methodology taking into account the added complexities of integrating a dual manifest. Whenever possible, existing ground and processing activities are used. See Figures 3-8 for a visual description of the payload stacking details.

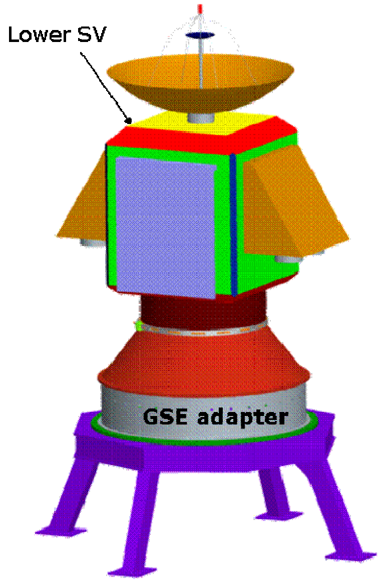

Figure 3. Install lower spacecraft onto Ground Support Equipment (GSE) per the normal process

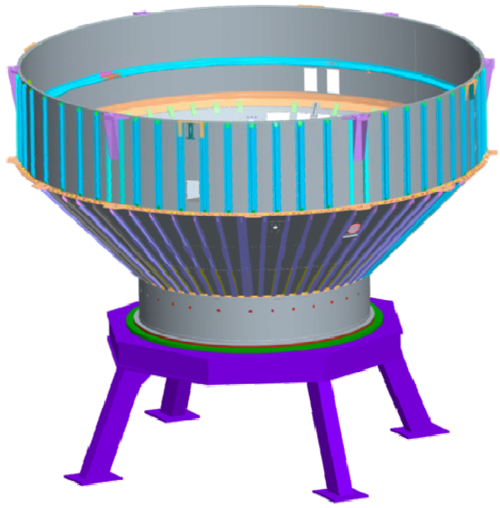

Figure 4. Install lower DSS canister onto GSE

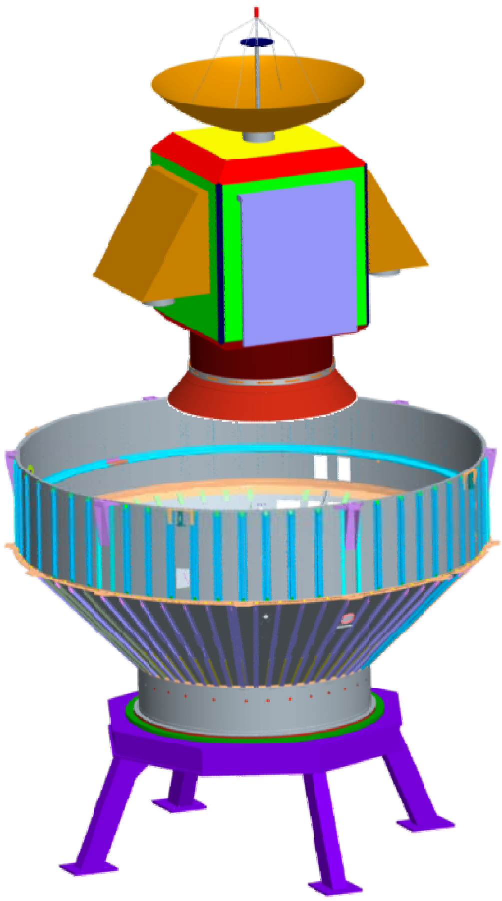

Figure 5. Lift lower spacecraft into lower DSS canister

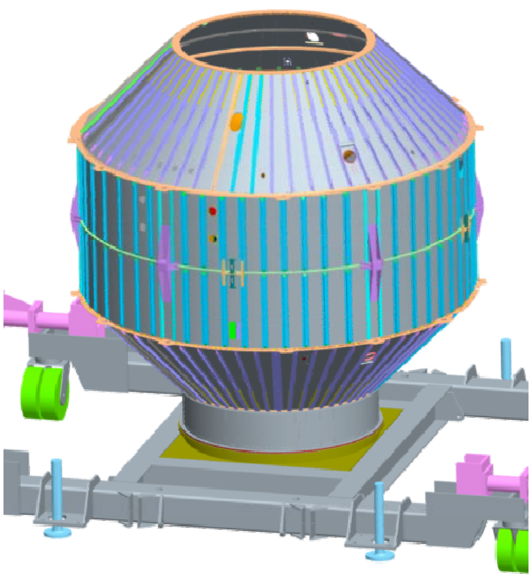

Figure 6. Install DSS upper canister over lower spacecraft

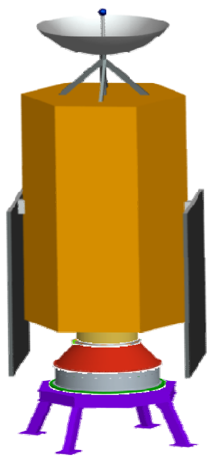

Figure 7. Install upper spacecraft onto Ground Support Equipment (GSE) per the normal process

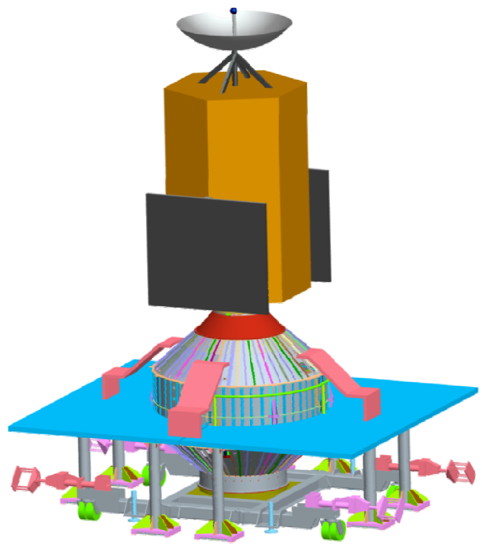

Figure 8. Lift upper spacecraft onto upper DSS canister

Preliminary envelopes have been developed and are shown in Figures 9-13. These envelopes should be used in conjunction with the Atlas Mission Planner's Guide[1] to find AC duct envelope information as well as other envelope details. A full coupled loads analysis is in work. Once that is completed, the static envelopes will be updated to reflect those results.

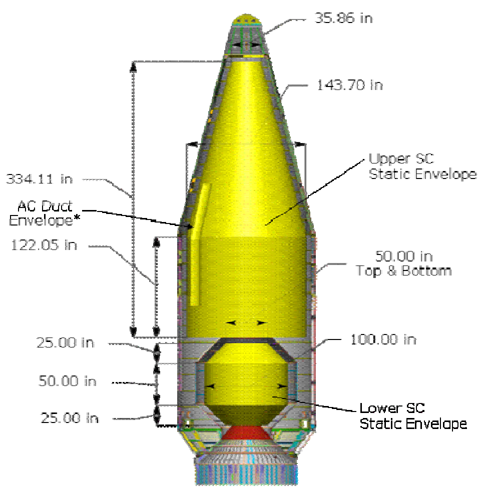

Figure 9. Preliminary payload envelope for 4m XEPF and DSS with no DSS plug adapters

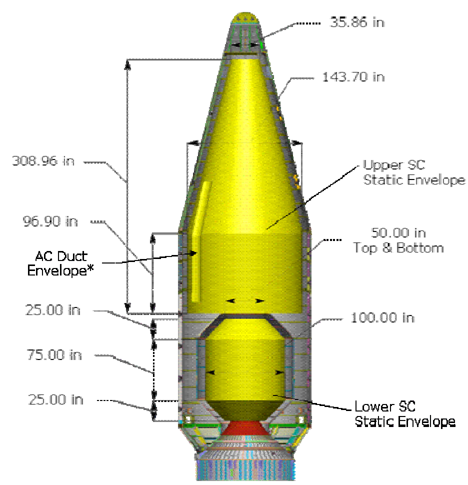

Figure 10. Preliminary payload envelope for 4m XEPF and DSS with one DSS plug adapter

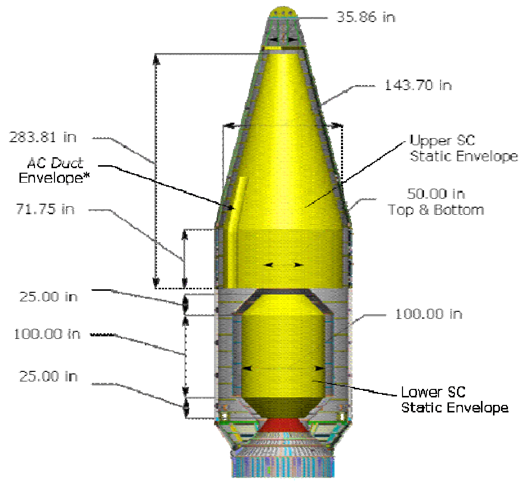

Figure 11. Preliminary payload envelope for 4m XEPF and DSS with two DSS plug adapters

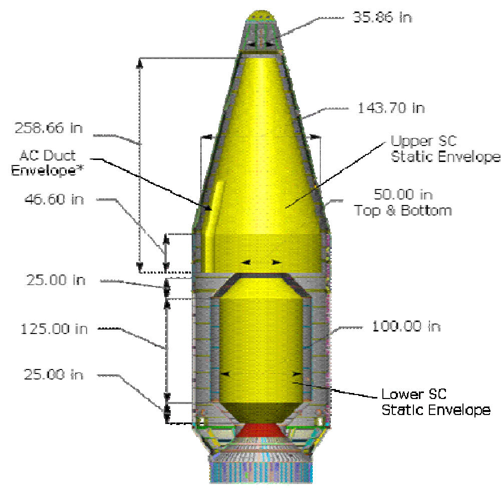

Figure 12. Preliminary payload envelope for 4m XEPF and DSS with three DSS plug adapters

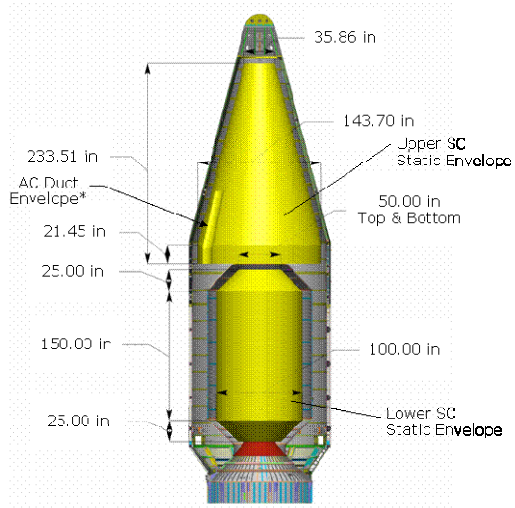

Figure 13. Preliminary payload envelope for 4m XEPF and DSS with four DSS plug adapters

IV. Conclusions and Future Work

The DSS represents a very cost effective opportunity for the small-to-medium class payload market. There are many advantages to using existing, qualified components on a launch vehicle with a proven track record, such as the Atlas. ULA is continuing to fund this work internally through a Preliminary Design Review (PDR), currently scheduled for the end of September 2008. See Figure 14. At the PDR, we will show preliminary design concepts for some of the components (separation system details, and the environmental control system, etc.) and analyses (coupled loads, separation analysis, venting analysis, etc.) that are unique to the DSS. Initial launch capability is planned for 2010.

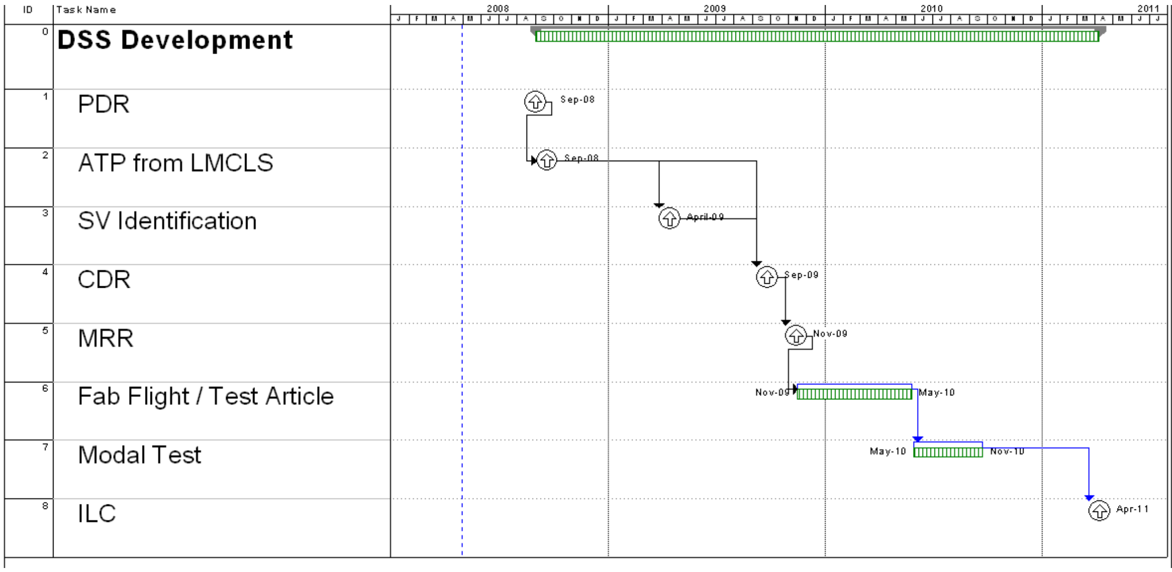

Figure 14. DSS Schedule

References

[1] "Atlas Mission Planner's Guide", URL: http://www.ulalaunch.com/index_products_services.html [cited January 2007].