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Paper Session I-A - Range Support Requirements in the RLV Operations Era

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Range Support Requirements in the RLV Operations Era

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Currently, Expendable Launch Vehicles (ELVs) and the Space Shuttle require substantial support from launch ranges. The Reusable Launch Vehicles (RLVs) forecast to become operational over the next decade will represent completely new vehicles with significantly different operational approaches as well as unique technical characteristics. In addition, the RLVs now being planned will be operated as commercial vehicles with profit as a primary goal; operations costs previously considered as essentially trivial will come under new scrutiny. What will all of this mean to the launch ranges?

Traditional Range Launch Support Activities

In the past, the launch ranges have provided a variety of support directly related to their instrumentation capabilities and their parent organizations' safety responsibilities. In addition, a wide variety of base support has been provided, but this is outside the scope of this paper.

Briefly summarized below, the ranges now provide specific types of support in order to meet both user requirements and nationally imposed safety responsibilities. Telemetry from the vehicle is received, relayed to the appropriate locations, recorded, and displayed in a variety of formats. Telemetry receivers are located at the launch base and at down-range sites as required by the mission trajectory and are operated and maintained by the launch range. On occasion, ground-based receivers have been augmented with shipboard and airborne assets. Traditionally, during the pre-launch processing, launch, and ascent phases the launch vehicle and spacecraft operators have relied on the range to provide a suitable facility to display and analyze the telemetry data; at Cape Canaveral, this capability is provided by NASA.

Ground based radars, and in some cases, Global Positioning System (GPS) translators and processors have been used by ranges to provide independent position measurement (metric) data. Such data is used to supply pointing information to telemetry and command destruct antennas and optics, provide information on vehicle performance to the launch vehicle company, and most importantly, support flight safety analyses and decisions.

The ranges provide optical tracking of vehicles during launch and ascent using both film and video. This data does support range safety decisions, but is primarily done at the request of the launch vehicle operator. Copies of still photos, motion picture film, and videotapes are provided as requested, and real-time video is supplied during the operation.

All launch vehicle operations are restricted by weather conditions to some degree, either due to the physical capabilities of the vehicle or those related to meeting safety requirements. The range provides measurement of weather conditions as well as weather predictions to support pre-launch and launch operations.

An intrinsic responsibility of the launch range is flight safety; in other words, ensuring that errant vehicles do not endanger life and property. To support the flight safety task, the range collects and displays telemetry data, performs radar tracking, analyzes radar data and displays position information, performs data analysis and computations required to predict the flight path of vehicles, performs optical tracking, and sends command destruct radio signals required to destroy errant vehicles. In addition, the range must perform analysis of proposed trajectories to ensure that they meet safety requirements and make weather measurements and predictions as required to address safety concerns. The net result of this is that the flight safety requirements for missions typically are the “envelope driver” in terms of instrumentation capabilities.

In order to perform all of its activities as well as meet specific mission requirements, the range must provide extensive data and voice communications, not only within the range itself but to external organizations as well.

Range Launch Support Activities For Operational RLVs

Operational RLVs will differ in a number of respects from current systems supported by the launch ranges. The RLVs will be autonomous and unmanned but will very likely posses a genuine in-flight abort capability. The RLVs may be very large single-stage vehicles (e.g., Lockheed Martin VentureStar) unlike anything that has been launched before. It is very likely that the RLVs will typically have short mission timelines on the order of 90 minutes (i.e., one orbit), but will also feature landing at the end of that time, which will itself require some degree of range support. The RLVs may well have short turn-around times and as a consequence be capable of launch rates somewhat larger than we have seen recently. Finally, the RLVs will almost certainly be operated as commercial vehicles, which will impose a new and different mindset on all those involved.

Essentially, all current range services will still be required, but specifics will change. The most significant difference will be associated with the fact that, unlike current launch control centers, the RLV launch control center will have to support the entire mission. At present, once the vehicle has lifted off, the launch control center is only an observer. All current vehicles are autonomous with no control exercised by the launch control center following liftoff. During ascent for ELVs, the range has the capability to terminate flight (i.e., destroy the vehicle) but once orbit is achieved the spacecraft operator exercises any control, if any. For NASA Space Shuttle missions, once the vehicle has lifted off, responsibility for the flight shifts to NASA-Houston. For ELV missions, after achieving orbit, the spacecraft and upper stages become the concern of the appropriate early orbit Spacecraft Operations Center (e.g., the Air Force Satellite Control Center for Air Force missions and various private company spacecraft operations centers for commercial payloads).

For RLVs, the government and commercial payload operations control centers likely will retain their current responsibilities, but the RLV will require it’s own control center to monitor ascent, on-orbit, and landing operations as well as issue commands as required in the event of a problem or possibly even as a normal course of operations. There will be no need to shift post-liftoff operations to another center, and powerful practical and financial reasons not to do so. This fact will impose considerable new requirements on the launch range.

Tracking support will still be required, not only to meet safety requirements but also to provide data to the RLV operator. Tracking may be done either by radars or by GPS-based tracking, or more likely a combination of both. However, there may be difficulties with use of GPS-based tracking systems during the re-entry phase, when ionization effects interfere with radio signals going to and from the vehicle.

Telemetry reception support will still be required, and is likely to be of much greater interest to the RLV operator than radar-tracking data will be. A trend already seen is likely to accelerate and be fully developed in RLV operations; the RLV operator will likely not require the use of a telemetry data analysis center. Modern computer systems make the telemetry analysis task relatively cheap and easy to perform. As a result, private launch firms increasingly are planning to use their own dedicated data analysis systems; there is little doubt that RLV operators will use this approach. Operational RLVs will have their own unique data display requirements and the designers will be able to take advantage of modern low cost, high performance computer capabilities to streamline the telemetry analysis task. Therefore, it is almost certain that the range will merely receive telemetry, strip off that data required to support safety analysis, and ship the data to any required destinations. However, owing to the need to expand coverage to on-orbit operations, the telemetry reception task will become significantly more complex than is now.

RLVs will operate autonomously, but will be watched closely by the vehicle control center, which must be able to react appropriately to correct problems before launch, during ascent, on-orbit, and during re-entry and landing. For example, changes in weather conditions at the launch site after launch may require a delayed re-entry or even redirection of the vehicle to an alternate-landing site. While payloads that separate from the RLV will still be handled in much the same way as today, the RLV will require a single pre-launch, launch, on-orbit, and landing operations center. The logical site for such a facility is the launch base. RLV operators will not wish to bear the cost of constructing one operations center for launch and another for orbital activities. This type of capability has not been achieved before at the launch base except for some specialized one-of-a-kind missions such as the Delta 180 Strategic Defense Initiative mission. On order to support RLV operations, the range will be required to provide seamless telemetry data support to the RLV operations center, incorporating multiple sources of telemetry, probably including spaceborne assets.

Commanding will be another challenge for support of RLV operations. First, it will be more complex than the relatively simple "destruct" functions now used. RLV operators will likely require more complex commanding and more options, including both those for post-launch abort as well as for in-flight termination. RLVs autonomous operations, their genuine in-flight abort capabilities, and their very high value will mean that every effort will be made to save and recover rather than destroy an errant vehicle. The signals sent to command the vehicle will be more complex, more varied, and must feature a capability for action by both the range safety organization and the RLV operating organization. Also, since the RLV operations center described above will require continuous access to the vehicle during the mission, the range must provide seamless commanding capabilities as well as telemetry, just as is now done with on-orbit spacecraft.

Safety responsibilities will remain with the launch range for ascent and for landing, but the potentially significant issue of on-orbit safety has yet to be addressed. Currently, once orbit is achieved, each operator is responsible for his own mission safety. Air Force Space Command does provide some data to support collision avoidance decisions but there is no real "Air Traffic Control" for orbital space. This is likely to become an unacceptable situation, not only for RLV operations but also for space activities in general. Increasing international ballistic missile and space launch capabilities will also add emphasis to this issue. Private firms will not accept the possible loss of a virtually irreplaceable asset due to the careless or even hostile launch of a missile by third world countries.

If on-orbit safety responsibilities are accepted by the launch range - and this is by no means certain or inevitable – significantly increased safety analysis capabilities will be required. Range safety display capabilities for the on-orbit phase will be particularly challenging, and there will be a need for a real-time changeover from ascent to on-orbit phases, a totally new capability.

Because of the need for all of the seamless link capabilities, the communications task for RLV launches will be much more complex and require significantly enhanced range capabilities. The NASA Telemetry Data Reception Satellite System (TDRSS) is an example of a system that may be able to provide such capabilities, but the system was not designed or sized to handle such workload. The Air Force Satellite Control Network (AFSCN) has some useful capabilities but at present the launch ranges do not have adequate communication interfaces to handle use of the AFSCN by RLV operators. Commercial communications and commanding assets capable of handling the task do not exist at present, but commercial satellite relay networks will likely be an essential part of any communications solution. In any case, the high launch rate desired by the RLV operators and the likelihood that RLVs will not be the only users of the range will add to the challenge of establishing such a complex and far-flung network.

Summary

To support RLV operations, a launch range will require:

a. Similar telemetry reception, optical tracking, and meteorological support capabilities to those currently used;

b. Reduced telemetry data processing capabilities as compared to current range capabilities;

c. Additional safety analysis and display capabilities;

d. Additional options for commanding in order to support launch and landing flight termination and abort requirements;

e. A mission and range operations control center for pre-launch, launch, ascent, on-orbit and landing phases of RLV operations;

f. Communications capabilities to support the RLV operations control center;

g. Potentially, on-orbit safety analysis capabilities;

h. Probably, capabilities to support launch rates in excess of those experienced in recent years.

Conclusion

The launch range will have to change to meet the requirements imposed by operational RLVs. While it is likely that the range can decrease its capabilities in some areas, such as general-purpose telemetry analysis, in terms of RLV support, it may not be able to do so because of the requirements of other users. Most significantly, the range will have to expand its capabilities to support the on-orbit portion of the RLV mission profile, to meet RLV operator requirements if not actual nationally-imposed responsibilities. The operational RLV launch range must become a true space range.