TR1018
17 October 1997

INTERIM TECHNICAL REPORT

BANTAM SYSTEM TECHNOLOGY PROJECT GROUND SYSTEM REQUIREMENTS DOCUMENT

Contract NAS8-97319

Prepared by:
J.M. Moon
J. R. Beveridge

Prepared for:
National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

1.0 INTRODUCTION

The Low Cost Booster Project (LCBP), also known as Bantam, is an element of the Advanced Space Transportation Program focused on Low Cost Booster Technologies. During FY 99 flight demonstrations are planned to demonstrate the feasibility of producing a booster capable of inserting a 150 kg payload into low earth orbit. The ground support system is an element of the full launch system. The ground support system provides for integration of the payload with the launch vehicle, preparation of the vehicle for launch (including maintenance, integration and test of the vehicle flight software), monitor and control of the launch sequence, range safety during launch, and collection of telemetry during the flight up to payload release. The ground support system is intended to make the maximum possible use of Government Off-the-Shelf (GOTS) or Commercial Off-the-Shelf (COTS) hardware and software to obtain the best value in terms of development operations support and ultimate life cycle cost for the launch system.

1.1 PURPOSE

The purpose of this document is to define the design, performance and verification requirements for the Bantam ground support system in support of the flight demonstration program. Based on the trends in other major space launch systems, the demands of the actual operational system will be significantly less stringent. Thus a system which satisfies the flight demonstration requirement can be expected to meet and exceed the needs of the operational user.

1.2 SCOPE

The elements covered in this document are the ground support systems, hardware, software and personnel required to perform the direct launch support activities for the Bantam development vehicle. The requirements for the production system will be derived and refined based on the support provided to the development project. Because one of the fundamental ground rules of the program is to produce a low cost launch capability, it is assumed that products generated to support the development activity will be reused to the maximum extent possible during the operational phase. Unless otherwise specifically stated, all products developed to satisfy this requirement will be assumed to be made available for use in the operational system. Where such considerations result in tradeoffs between costs to the demonstration program and long term costs to the operational system, they will be identified and quantified. In most cases the intent should be to minimize the lifecycle cost of the entire program.

2.0 APPLICABLE DOCUMENTS

LCBT-PP	LCBT Program Plan
MSFC-RQMT-2674A	Low Cost Booster Program (LCBP) Propulsion Test Article (PTA1) Systems Requirements Document
MSFC-SPEC-2675	LCBT Fastrac 60K Engine Specification
MSFC-DOC-2678	LCBT Fastrac 60K Engine Interface Definition Document

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3.0 REQUIREMENTS

The following paragraphs define the ground support system requirements. A database of these requirements, which facilitates detailed documentation and tracking, is included as Appendix A.

3.1 PROGRAM REQUIREMENTS

To support the objectives of the LCBT program, the Bantam ground support system shall provide the capabilities defined below during the developmental test phase of the program. For the operational program an appropriate subset of these capabilities shall be utilized.

3.1.1 GROUND SUPPORT SYSTEM COMMONALITY

The ground support system as defined in this document shall be provided as a standard capability for all demonstration flights.

3.1.1.1 Launch Site Certification

The ground support team shall certify each launch site for the Bantam program prior to its being scheduled for a Bantam launch. This certification shall ensure that the site has the required level of services for the standard ground system.

3.1.1.2 Site Unique Procedures

The ground support team shall develop and maintain the Bantam program launch procedures. These shall include specific procedures accounting for launch site unique activities and customer unique requirements, to include compliance with Department of Defense (DOD), NASA, and commercial launch practices.

3.1.2 PAYLOAD ACCOMMODATION COMMONALITY

All flight articles shall provide identical interfaces for payload accommodations as defined in Interface Control Document (ICD-TBD).

3.1.3 DEVELOPMENT FLIGHT INSTRUMENTATION (DFI)

To ensure commonality of interfaces and reduce development costs to vehicle contractors, a design reference payload containing the DFI shall be provided to perform the on board collection and downlink of vehicle performance data for all development flights.

3.2 GROUND SYSTEM PERFORMANCE REQUIREMENTS

3.2.1 LAUNCH PREPARATION

The ground support team shall provide integration services to include mission and site scheduling, analysis of payload conformance with safety requirements, and coordination of required data for launch planning.

3.2.1.1 Interface Checkout

The ground system shall provide the capability to test payloads for compliance with the interface standard (ICD-TBD). As a minimum the following interfaces shall be tested:

a. Physical connection to the launch vehicle

b. Electrical power connection to the launch vehicle

c. Data connections for launch vehicle sensors

d. Radio Frequency (RF) connections for telemetry downlink from the payload

e. RF connections for telemetry downlink from vehicle, if required

f. Umbilical connections for prelaunch uplink and downlink

g. Range safety interfaces uplink and downlink (telemetry, command destruct, transponders)

3.2.1.2 Flight and Simulation Software Preparation

3.2.1.2.1 Flight Software

All flight software shall be delivered by the vehicle contractor as a configuration management item to the ground support team.

3.2.1.2.2 Mission Simulation Software

A simulation capability shall be provided to allow the ground support team to perform a checkout of the delivered flight software against specified mission performance parameters. The simulator shall be capable of loading and executing the mission flight software without modification.

3.2.1.2.3 Flight Software Load

The ground support team shall be responsible for upload of the mission configuration to the launch vehicle and appropriate checkout of the system prior to launch.

3.2.1.3 Payload Integration

The launch facility shall provide the following capabilities to support payload handling and integration with the flight vehicle:

a. A clean room capability appropriate for handling payload articles such as optics

b. Access to the payload up to 48 hours prior to launch

3.2.1.4 Prelaunch checkout

The ground system shall provide the capability to monitor launch vehicle and payload data during prelaunch activities. As a minimum the following parameters shall be monitored:

a. Launch vehicle health and status

b. Launch vehicle internal sensors

c. On board computer performance

d. Payload health and status

e. Payload on board computer performance

f. RF downlink interfaces for payload and vehicle

3.2.1.5 Vehicle Servicing

3.2.1.5.1 Servicing Procedures

The ground support team shall provide a detailed servicing procedures manual which shall include Bantam normal operations and safety procedures for each launch site to be utilized.

3.2.1.5.2 Prelaunch Servicing

The ground support team shall supervise all servicing operations for the launch vehicle.

3.2.1.6 Prelaunch Vehicle Control

The ground system shall provide the capability to control critical vehicle and payload functions during the prelaunch phase. As a minimum the following functions shall be provided:

a. Initiation of critical phases of the launch sequence

b. Capability to automatically pause or abort the launch sequence when significant anomalies exist in sensed data

c. Manual pause or abort of the launch sequence up to the point of final ignition system initiation

d. Standard range safety required command sequences for the launch vehicle during the prelaunch phase

e. Checkout and update of critical instrumentation (e.g. final gyro alignment)

3.2.1.7 Prelaunch Ground System Monitoring

The ground system shall provide the capability to monitor appropriate ground support systems as necessary. As a minimum the following functions shall be available:

a. Pad electrical systems

b. Launch site weather data

c. Voice and video setup

d. Pad fire suppression

3.2.1.8 Data Retention

All recorded data shall be time tagged.

3.2.1.8.1 Command Log

The ground system shall retain an automated log of all commands and responses.

3.2.1.8.2 Data Log

The ground system shall retain a record of all telemetry gathered during the prelaunch phase.

3.2.2 LAUNCH SUPPORT

3.2.2.1 Launch Vehicle Monitoring

The ground system shall provide the capability to collect, store and distribute data acquired by developmental flight instrumentation during the launch phase of the mission, defined as the time from the end of prelaunch monitoring until payload release. As a minimum the following parameters shall be monitored:

a. Site provided performance parameters, i. e. range telemetry

b. Predefined performance parameters for the vehicle needed to support post flight analysis

3.2.2.2 Launch Vehicle Control

The ground system shall support standard range safety required command sequences for the launch vehicle during the flight phase.

3.2.3 DEVELOPMENT FLIGHT INSTRUMENTATION

The design reference payload shall perform the following functions:

a. Data collection from all vehicle unique instrumentation

b. Data recording as necessary to provide for telemetry download

c. Data acquisition for all generic performance data (e.g. temperature, g-forces, vibration, etc.)

d. Data transmission for all specified real time telemetry

e. Non real time data playback and transmission for all stored data

3.2.4 SAFETY

3.2.4.1 Ground Safety

The ground support team shall prepare a standard ground safety plan with site specific information for each planned launch facility.

3.2.4.2 Range Safety

The range safety function shall be the responsibility of the individual launch site. The ground support team shall prepare a Bantam specific safety plan to be approved by the launch site range safety function.

3.3 COST GOALS

This section addresses cost goals for the Bantam ground operations system, including the flight software verification simulator. These estimates are intended as preliminary goals, and the driving figures should be the cost rollups rather than individual cost elements. That is, labor costs may be traded for non-labor costs where appropriate. The most important long term cost driver for the system is the recurring cost for the operational program. This cost element should be considered of primary importance when cost tradeoffs are made in the development area. The following table provides these goals for the demonstration and operational phases of the program:

Cost Element	Cost goal (dollars)
Ground System Development	
Display and Control System	
Labor	430K
Non Labor	540K
Simulator	
Labor	710K
Non Labor	120K
Operations (per year)	
Labor	450K
Non Labor	290K

The development costs are totals for the demonstration program, assumed to be of two years total duration, including launch support activities for all demonstration flights. Operational phase costs are per year and include no development cost recovery. The cost elements for the operational phase are based on a single launch team supporting up to 6 launches per year. The estimate considers that an established permanent launch team is required to meet the needs of the program during this period. The assumption is made that a high degree of automation has been built into the ground system, allowing a small launch team. The cost for this team is constant up to a certain number of launches per year. Reducing the number of launches increases the cost per launch. Increasing the number of launches decreases the cost per launch. At a certain point the size of the launch team must be increased, which results in increases in the total yearly cost, the primary change being additional personnel on the launch team. This is anticipated to be a relatively small

incremental increase. Supporting two launch teams, one per vehicle manufacturer, increases the overall cost significantly, but there may be some efficiencies which could be realized by sharing personnel within the manufacturers organization in this case.

3.4 SCHEDULE REQUIREMENTS

The schedule requirements discussed in this section are for an end-to-end Bantam launch sequence during the operational phase of the program. These establish goals for the design to use as a framework. The general assumption has been made here that during the operational phase a shorter turnaround reduces all program costs. If a case is encountered where relaxation of one of these goals could result in cost savings, then cost should continue to be the prime consideration. The following table provides a preliminary timeline for a Bantam mission during the operational phase of the program:

Element	Timeframe	Activities
Initial Mission Definition	L -60 days	High level definition of mission requirements
Formal Definition of Mission Requirements	L -45 days	Detailed mission requirements and payload specification
Flight Software delivery	L -30 days	Flight software verification, software placed under configuration management, mission simulations conducted
Vehicle Delivery	L -30 days	Launch vehicle delivered to launch site
Payload Delivery	L -30 days	Vehicle interface verification, final weight determinations
Vehicle/Payload Integration	L -48 hrs	Payload mated to vehicle, end to end test of interfaces, flight software uploaded
Vehicle servicing	Day of launch	Final consumables loaded, final systems checkout
Orbital insertion		Ground system mission complete

4.0 VERIFICATION

The verification addressed in this section is that activity required to qualify the ground support system to support the development flight test program. Where there are no development specific changes to the ground system it will also qualify the system for support of the production launch vehicle.

4.1 VERIFICATION METHODS

Verification shall be accomplished by one or more of the following methods:

a. Test

b. Analysis

c. Demonstration

d. Inspection

e. Similarity

4.2 DEVELOPMENT TESTING

This requirements document is focused on the development test flights for the Bantam program. However, in line with the overall system goal of reducing production system costs, testing of the ground system in accordance with this requirement shall be assumed to be the equivalent of test of the production ground support system unless specifically defined otherwise.

APPENDIX A

VERIFICATION REQUIREMENTS DATABASE

GENERAL INFORMATION

The Verification Database is established with this document. Data on Traceability and Verification will be expanded as the requirements mature.

Requirement

Requirement number	Requirement description	Element
3.0	Requirements	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: No content

Requirement

Requirement number

3.1

Multiple verifications

No

Requirement description

To support the objectives of the LCBT program the Bantam ground support system shall provide the capabilities defined below during the developmental test phase of the program. Operational program uses an appropriate subset of these capabilities.

Element

Traceability

Parent Requirement

Child Requirement

Verification

Verification Method

Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts

Non Conformances

Compliance data

Comments/Remarks

Status:

Rationale: The document is designed to define the fullest possible set of requirements, the operational system is a subset

Requirement

Requirement number	Requirement description	Element
3.1.1	The ground support system as defined in this document shall be provided as a standard capability for all demonstration flights.	

Multiple verifications: No

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: By maximizing commonality and enforcing standard interfaces program costs can be driven to the lowest possible levels. Reduces cost of replicating ground support and simplifies training and documentation

Requirement

Requirement number	Requirement description	Element
3.1.1.1	The ground support team shall certify each launch site for the Bantam program prior to its being scheduled for a Bantam launch. This certification shall ensure that the site has the required level of services for the standard ground system	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Certification ensures enforcement of ground system standards and forms basis for procedures

Requirement

Requirement number	Requirement description	Element
3.1.1.2	The ground support team shall develop and maintain the Bantam program launch procedures. These procedures shall include specific procedures accounting for launch site unique activities and customer unique requirements, including DOD, NASA and commercial	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Team needs to tailor standard procedures to non standard situations

Requirement

Requirement number	Requirement description	Element
3.1.2	Payload accommodation commonality. All flight articles shall provide identical interfaces for payload accommodations as defined in (TBD).	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: A single, standard predefined payload interface saves time and money for the vehicle and the payload. Do it during the development phase rather than as an add on for production vehicles.

Requirement

Requirement number	Requirement description	Element
3.1.3	To ensure commonality of interfaces and reduce development costs to vehicle contractors, a design reference payload shall be provided to perform the on board collection and downlink of vehicle performance data for all development flights.	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Single standard payload for all test flights (possibly recoverable)

Requirement

Requirement number	Requirement description	Element
3.2	Ground System Performance requirements	

Multiple verifications: No

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: na

Requirement

Requirement number	Requirement description	Element
3.2.1	The ground support team shall provide integration services to include mission and site scheduling, analysis of payload conformance with safety requirements, and coordination of required data for launch planning.	

Multiple verifications: No

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: This is the flight planning for launch. The operations concept goes into this in much more detail

Requirement

Requirement number	Requirement description	Element
3.2.1.1	Interface checkout The ground system shall provide the capability to test payloads for compliance with the interface standard (ICD-TBD). As a minimum the following interfaces shall be tested	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Standard test hardware would be mockup of physical, electrical and data interfaces

Requirement

Requirement number	Requirement description	Element
3.2.1.1.a	Physical connection to the launch vehicle	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location
Demonstration	

Verification Description

Payload interface test mockup is mated to design reference payload.

Criteria/Specifications	Remarks/Constraints
Mockup mates to payload	

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Mockup capability

Requirement

Requirement number	Requirement description	Element
3.2.1.1.b	Electrical power connection to the launch vehicle	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location
Demonstration	

Verification Description:

Payload interface test mockup is mated to design reference payload

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Mockup

Requirement

Requirement number	Requirement description	Element
3.2.1.1.c	Data connections for launch vehicle sensors	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location
Demonstration	

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: This is a development unique requirement for DFI

Requirement

Requirement number	Requirement description	Element
3.2.1.1.d	RF connections for telemetry downlink from the payload	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location
Demonstration	

Verification Description:

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: For telemetry handled by DFI

Requirement

Requirement number	Requirement description	Element
3.2.1.1.e	RF connections for telemetry downlink from vehicle, if required	

Multiple verifications: No

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: For any telemetry not handled by DFI, launch vehicle contractor unique. We need to discourage this

Requirement

Requirement number	Requirement description	Element
3.2.1.1.f	Umbilical connections for pre launch uplink and downlink	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location
Demonstration	

Verification Description

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Umbilical connections during pre launch phase.

Requirement

Requirement number	Requirement description	Element
3.2.1.1.g	Range safety interfaces uplink and downlink (telemetry, command destruct, transponders)	

Multiple verifications

No

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale:

Requirement

Requirement number	Requirement description	Element
3.2.1.2	Flight software preparation	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Mission planning for the launch vehicle is based on simply a definition from the payload sponsor of the desired orbital parameters.

Requirement

Requirement number	Requirement description	Element
3.2.1.2.1	All flight software shall be delivered by the vehicle contractor as a configuration management item to the ground support team	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: The initial thought was that the manufacturer has better knowledge of the system performance than the ground support team. It may be good for the manufacturer to provide the mission planning s/w.

Requirement

Requirement number	Requirement description	Element
3.2.1.2.2	A simulation capability shall be provided by the launch vehicle contractor to allow the ground support team to perform a checkout of the delivered flight software against specified mission performance parameters using actual S/W.	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: A detailed simulation, preferably with a vehicle flight control computer in the loop. Can also provide realistic data out for ground team launch monitoring training.

Requirement

Requirement number	Requirement description	Element
3.2.1.2.3	The ground support team shall be responsible for upload of the mission configuration to the launch vehicle and appropriate checkout of the system prior to launch	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Designed to make the launcher a commodity, that is, all launchers are the same, only the flight software is changed to fly the mission.

Requirement

Requirement number	Requirement description	Element
3.2.1.3	The launch facility shall provide the following capabilities to support payload handling and integration with the flight vehicle:	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Spaceport facilities

Requirement

Requirement number	Requirement description	Element
3.2.1.3.a	A clean room capability appropriate for handling payload optics	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Some payloads need this capability. Most spaceports currently have this capability.

Requirement

Requirement number	Requirement description	Element
3.2.1.3.b	Access to the payload up to 48 hours prior to launch	

Multiple verifications

Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: The time frame here is not necessarily satisfactory for payloads with volatile material or biological experiments. Less time means more cost in launch facilities.

Requirement

Requirement number	Requirement description	Element
3.2.1.4	The ground system shall provide the capability to monitor launch vehicle and payload data during pre launch activities	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: This is the ground support facility central function, primarily supplied by umbilicals

Requirement

Requirement number	Requirement description	Element
3.2.1.4.a	Launch vehicle health and status	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Standard set of data from the launcher

Requirement

Requirement number	Requirement description	Element
3.2.1.4.b	Launch vehicle internal sensors	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Developmental instrumentation which may not be needed on operational missions, or may only need a subset of DFI only downlinked in case of launch anomaly

Requirement

Requirement number	Requirement description	Element
3.2.1.4.c	On board computer performance	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: This may be part of health and status, monitors how the OBC is functioning prior to launch. This is a primary monitoring function

Requirement

Requirement number	Requirement description	Element
3.2.1.4.d	Payload health and status	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Very little is needed for payload sponsors, they currently get nothing. This assumes that the payload ICD gives good data on expected launch conditions so payload can be properly designed and packaged

Requirement

Requirement number	Requirement description	Element
3.2.1.4.e	Payload on board computer performance	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: For DFI this may be important, not a requirement for standard payloads in operational timeframe

Requirement

Requirement number	Requirement description	Element
3.2.1.4.f	RF downlink interfaces for payload and vehicle	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: All RF links must be operational prior to flight

Requirement

Requirement number	Requirement description	Element
3.2.1.5	Vehicle servicing	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale:

Requirement

Requirement number	Requirement description	Element
3.2.1.5.1	The ground support team shall a detailed servicing procedures manual which shall include Bantam normal operations and safety procedures for each launch site to be utilized	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Standard operating procedures on a site by site basis, and probably on a vehicle by vehicle basis as well (2 different vehicles during operational phase)

Requirement

Requirement number	Requirement description	Element
3.2.1.5.2	The ground support team shall supervise all servicing operations for the launch vehicle.	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: The division of responsibility needs to be coordinated with the spaceport operators. This may actually be their function.

Requirement

Requirement number	Requirement description	Element
3.2.1.6	The ground system shall provide the capability to control critical vehicle and payload functions during the pre launch phase	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Launch processing

Requirement

Requirement number	Requirement description	Element
3.2.1.6.a	The ground system shall control initiation of critical phases of the launch sequence	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: This is the specific launch control function

Requirement

Requirement number	Requirement description	Element
3.2.1.6.b	The ground system shall provide the capability to automatically pause or abort the launch sequence when significant anomalies exist in sensed data	

Multiple verifications

Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Automation is required to perform the launch function with minimum personnel. Tradeoffs are required on degree of automation

Requirement

Requirement number	Requirement description	Element
3.2.1.6.c	The ground system shall support manual pause or abort of the launch sequence up to the point of final ignition system initiation	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Should always have a manual backup or override to the automated sequencing.

Requirement

Requirement number	Requirement description	Element
3.2.1.6.d	The ground system shall support standard range safety required command sequences for the launch vehicle during the pre launch phase	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: The range safety function may be independent, but there may be some room for tradeoffs

Requirement

Requirement number	Requirement description	Element
3.2.1.6.e	Checkout and update of critical instrumentation (e.g. final gyro alignment)	

Multiple verifications: No

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Immediate prelaunch data updates

Requirement

Requirement number	Requirement description	Element
3.2.1.7	The ground system shall provide the capability to monitor appropriate ground support systems as necessary	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: In addition to the vehicle, other functions are important.

Requirement

Requirement number	Requirement description	Element
3.2.1.7.a	Pad electrical systems	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Sufficient to support GSE and on board systems prior to switch to on board batteries

Requirement

Requirement number	Requirement description	Element
3.2.1.7.b	Launch site weather data	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Also required by range safety

Requirement

Requirement number	Requirement description	Element
3.2.1.7.c	Voice and video setup	

Multiple verifications

Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale:

Requirement

Requirement number	Requirement description	Element
3.2.1.7.d	Pad fire suppression	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale:

Requirement

Requirement number	Requirement description	Element
3.2.1.8	Data retention All recorded data shall be time tagged.	

Multiple verifications

Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: For post flight analysis time tagging is needed to ensure that data can be correlated

Requirement

Requirement number	Requirement description	Element
3.2.1.8.1	The ground system shall retain an automated log of all commands and responses.	

Multiple verifications

Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Command sequence record for post flight analysis and anomaly resolution.

Requirement

Requirement number	Requirement description	Element
3.2.1.8.2	The ground system shall retain a record of all telemtetry gathered during the pre launch phase.	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description:

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: For post flight anomaly resolution.

Requirement

Requirement number	Requirement description	Element
3.2.2	LAUNCH SUPPORT	

Multiple verifications

Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale:

Requirement

Requirement number	Requirement description	Element
3.2.2.1	The ground system shall provide the capability to monitor vehicle performance from liftoff to payload release	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: This is the data collection function during the launch, needed in case of a vehicle malfunction. Without this real time data analysis might not be possible

Requirement

Requirement number	Requirement description	Element
3.2.2.1.a	Site provided performance parameters, i. e. range telemetry	

Multiple verifications

Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale:

Requirement

Requirement number	Requirement description	Element
3.2.2.1.b	Predefined performance parameters for the vehicle needed to support post flight analysis	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale:

Requirement

Requirement number	Requirement description	Element
3.2.2.2	LAUNCH VEHICLE CONTROL The ground system shall support standard range safety required command sequences for the launch vehicle during the flight phase	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Range safety is probably a spaceport responsibility, but must be taken into account by ground system procedures

Requirement

Requirement number	Requirement description	Element
3.2.3	DEVELOPMENT FLIGHT INSTRUMENTATION The design reference payload shall perform the following functions:	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: This is the basic requirement for a standard DFI package

Requirement

Requirement number	Requirement description	Element
3.2.3.a	Data collection from all vehicle unique instrumentation	

Multiple verifications

Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Collects, stores and forwards data from vehicle

Requirement

Requirement number	Requirement description	Element
3.2.3.b	Data recording as necessary to provide for telemetry download	

Multiple verifications

Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: Storage of data

Requirement

Requirement number	Requirement description	Element
3.2.3.c	Data acquisition for all generic performance data (e.g. temperature, g-forces, vibration, etc.)	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications

Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: These are common elements for data for all flight vehicles

Requirement

Requirement number	Requirement description	Element
3.2.3.d	Data transmission for all specified real time telemetry	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale:

Requirement

Requirement number	Requirement description	Element
3.2.3.e	Data transmission for all stored data	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications | Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: This is to provide a single download stream from the vehicle (exclusive of any range safety required telemetry)

Requirement

Requirement number	Requirement description	Element
3.2.4	Safety	

Multiple verifications

Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale:

Requirement

Requirement number	Requirement description	Element
3.2.4.1	The ground support team shall prepare a standard ground safety plan with site specific information for each planned launch facility	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale: To account for site unique requirements, and clarify roles and responsibilities with the spaceports

Requirement

Requirement number	Requirement description	Element
3.2.4.2	The range safety function shall be the responsibility of the individual launch site.	

Multiple verifications: Yes

Traceability

Parent Requirement	Child Requirement

Verification

Verification Method	Verification Location

Verification Description

Criteria/Specifications	Remarks/Constraints

Compliance

Compliance Data Contacts	Non Conformances

Compliance data	Comments/Remarks

Status:

Rationale:

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Jesse M. Moon
James R. Beveridge

7. PERFORMING ORGANIZATION NAME(S) AND
New Technology, Inc.
700 Boulevard South, Suite 401
Huntsville, AL 35802-2176

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13. ABSTRACT *(Maximum 200 words)*

Requirements for the Bantam data and commanding ground system are defined in terms of objectives, environment, constraints and measures of effectiveness. The objectives address those capabilities which are needed to successfully and reliably conduct Bantam operations leading up to and through launch and continuing to the point of payload release. These objectives take into consideration aspects such as operability, safety, insurability and applicability to the vehicle developers and potential customers. We have specifically avoided the inclusion of solutions as being called requirements; solutions will be addressed in other deliverables. The environment of the Bantam operations is considered to be commercial, highly competitive and relatively high volume. Thus, each capability defined must necessarily be justifiable by the costs associated with implementation and maintenance. The constraints on the ground support system emanate from the highly competitive environment and specifically the goal of offering launch services for $1.5 million or less. Requirements are constrained to address the ground system itself, considering those systems and procedures with which the ground system must interface and integrate. The measures of effectiveness associated with each capability requirement are defined to identify the best value in terms of completely satisfying the requirements while maintaining lowest overall cost.

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