**SCHEDULE F**

**ACCEPTANCE CRITERIA AND TESTING**

Contents

[1 Acceptance Overview 2](#_Toc35005893)

[2 Pre-Delivery Testing 3](#_Toc35005894)

[2.1 Pre-Delivery Assembly and Testing 3](#_Toc35005895)

[2.2 Factory Trial 3](#_Toc35005896)

[3 Post-Delivery Integration and Testing 4](#_Toc35005897)

[3.1 System Installation 4](#_Toc35005898)

[3.2 Site Integration and Configuration 5](#_Toc35005899)

[3.3 Post-Delivery and Acceptance Testing 5](#_Toc35005900)

[3.3.1 Functionality Demonstration 6](#_Toc35005901)

[3.3.2 System Cycle Test 6](#_Toc35005902)

[3.3.3 System Resilience Test 7](#_Toc35005903)

[3.3.4 Performance Test 8](#_Toc35005904)

[3.3.5 Availability Test 9](#_Toc35005905)

[4 Availability Test Criteria 9](#_Toc35005906)

[5 Failures and Downtime 10](#_Toc35005907)

# Acceptance Overview

Article 17 of the Subcontract’s Terms and Conditions provides the basic terms and conditions of Acceptance. This Schedule provides details on the Acceptance testing methodology and Acceptance criteria; certain key performance and other Acceptance metrics are also identified in Schedule B.

The following provisions apply to the Acceptance of Deliverables:

1. Deliverables subject to acceptance testing are identified in the Subcontract’s Schedule E. Acceptance of a Deliverable shall be contingent upon successful completion of the acceptance test for that Deliverable.
2. The acceptance test period shall begin at a mutually agreed time after the Subcontractor has completed a Deliverable’s installation and any post-installation Subcontractor testing and end when a Deliverable has met the acceptance criteria, as specified below, or UCAR otherwise determines a Deliverable is either accepted or rejected.
3. The Subcontractor will comply with the agreed test procedures and acceptance criteria of all Deliverables as identified and described in Schedules B, D, E, F, G and H, as well as those included by subsequent Modification of the Subcontract. UCAR assumes no contractual obligation to perform any test and/or acceptance for the benefit of the Subcontractor unless specifically set forth elsewhere in the Subcontract.
4. In the event a Deliverable does not meet the acceptance criteria during its initial acceptance test period, the acceptance test period shall, upon UCAR’s sole discretion, either (1) continue on a day-by-day basis until the criteria are met, (2) be halted and restarted, or (3) be abandoned and the Deliverable rejected.
5. A Deliverable must meet the acceptance test criteria within ninety (90) days after installation. UCAR reserves the right to extend a Deliverable’s testing period up to an additional sixty (60) days, to reject the Deliverable, or to terminate the Subcontract in accordance with Article 33, Termination, of the Subcontract’s Terms and Conditions without further obligation by UCAR.
6. All maintenance, support, service and replacement parts shall be furnished by the Subcontractor without charge prior to and during an acceptance test period, unless such maintenance, support, service and replacement parts are required as a result of the fault or negligence of UCAR.
7. In the case of a rejection after testing or inspection, UCAR shall not be liable for any costs for correction. UCAR reserves the right to charge the Subcontractor any additional cost of inspection or testing when the Subcontractor is not ready at the time such test or inspection is requested, or when retest or re-inspection is necessitated by prior rejection.
8. Inspection and/or acceptance by UCAR do not relieve the Subcontractor from responsibility regarding defects which may be discovered prior to acceptance or other failures to meet the Subcontract requirements.
9. In subsequent sections, Deliverables subject to acceptance testing may be referred to as “a system” or “systems”.

# Pre-Delivery Testing

Each Deliverable subject to acceptance testing, or system, provided under the NWSC-3 Subcontract shall undergo pre-delivery testing as described in the following subsections.

The Subcontractor shall demonstrate to UCAR that all hardware is fully functional prior to shipping. If the system is to be delivered in separate shipments, each shipment should undergo pre-delivery testing.

## Pre-Delivery Assembly and Testing

The Subcontractor shall perform the pre-delivery assembly and testing of Deliverables (cf. Schedule E), or agreed-upon sub-configurations thereof, at the Subcontractor’s facility prior to shipment. At its option, UCAR may send representatives to observe and perform testing at the Subcontractor’s facility. Work to be performed by the Subcontractor includes:

1. Assembly of all hardware
2. Burn-in of all components
3. Installation of Subcontractor-supplied software
4. Execution of the Subcontractor’s system integrity tests to validate the functionality, performance, reliability, and quality of the Deliverable

The Subcontractor’s system integrity tests shall be made available to UCAR for post-installation testing at the NWSC.

Additionally, UCAR may request the following additional pre-delivery activities:

1. Implementation of portions of the UCAR-specific production system configuration and programming environment
2. Execution of select benchmarks to demonstrate that the system is capable of meeting performance expectations

## Factory Trial

Prior to the teardown and shipping of a Deliverable or system from the Subcontractor’s facility, the Subcontractor shall provide to UCAR on-site and/or remote access to the system in order for UCAR to assess the system’s prospects for successfully passing its acceptance criteria subsequent to installation within the NWSC.

For each of the activities associated with the Factory Trial, the Subcontractor shall document the recommended sequence of events, including command sequences, and provide that documentation for UCAR’s subsequent use.

The Factory Trial testing shall consist of, but is not limited to, the following tests:

|  |  |
| --- | --- |
| Name of Test | Success Criteria |
| System power up | All components shall power up successfully. |
| System power down | All components shall power down successfully. |
| Power On/Off | Individual components of the system shall be successfully power-cycled from breakers, the system’s administrative interface, and/or remotely. |
| System Management | The management subsystem shall be demonstrated to perform all requisite system management functions correctly, including independent operation of the system and any partitions thereof, if applicable. |
| System Monitoring | The system’s monitoring software shall be demonstrated to indicate the correct status for all components and register status changes appropriately. |
| Hardware RAS | Reliability, Availability, Serviceability (RAS) capabilities and system robustness (e.g. fault injection, disconnect communication cables, power loss to a subsystem, cooling loss to a subsystem) shall be demonstrated successfully; unit tests shall be mutually agreed upon. |
| Software Failover/Resilience | Proper operation of all high-availability, fail-over or resilience software mechanisms shall be demonstrated (e.g. resource manager, job scheduler); unit tests shall be mutually agreed upon. |
| Automatic Failure Reporting | The system’s automatic failure and maintenance request reporting (aka “phone home”) capabilities shall be demonstrated; unit tests shall be mutually agreed upon. |
| Subcontractor System Integrity Tests | All Subcontractor system integrity tests shall run successfully and with expected performance. |
| Benchmarks | The system shall demonstrate the ability to achieve the committed performance criteria and numerical correctness, utilizing the NWSC-3 benchmarks and/or other mutually agreed upon tests. |

# Post-Delivery Integration and Testing

Each Deliverable, or system, subject to acceptance testing provided under the NWSC-3 Subcontract shall undergo post-delivery integration and testing as described in the following subsections.

## System Installation

Each Deliverable, or system, (cf. Schedule E) shall be delivered, assembled, installed, fully integrated with the NWSC infrastructure, and shall undergo the Subcontractor’s stabilization and integrity testing processes. As part of the NWSC-3 project and installation planning (cf. Schedules B and G), the Subcontractor shall work with UCAR personnel on logistics, facility integration and other tasks to assure that the system installation process is successful.

Successful completion of system installation is defined as when all system components are installed within the NWSC, the system can be successfully powered up and pass hardware self-checks, the system’s Availability or File System Availability is above the Acceptance threshold, and the system can successfully run the Subcontractor’s system integrity checks.

## Site Integration and Configuration

Once the Subcontractor has successfully completed a Deliverable’s, or system’s, installation, the Subcontractor shall make the system available to, and work with, UCAR personnel to accomplish site-specific integration (e.g. NWSC LAN integration, NWSC-3 HPC and PFS resource integration, and NCAR GLADE systems integration) and perform any remaining system software installation, configuration and customization. The specifics of this effort shall be mutually developed by UCAR and the Subcontractor as part of the project management activities subsequent to Subcontract award. This effort shall bring the system to its Acceptance testing configuration and as near as possible to its production configuration; i.e., the condition in which it will be deployed to the UCAR user community.

Once a Deliverable or system has undergone UCAR’s integration, configuration and customization, the Acceptance Test Period shall commence.

## Post-Delivery and Acceptance Testing

Post-delivery and Acceptance testing, aka the “Acceptance Test Period,” shall commence when a Deliverable or system (cf. Schedule E) has been delivered, physically installed, and undergone stabilization and site-specific integration, configuration and customization (cf. §4.2).

Post-delivery and Acceptance testing shall consist of the following phases, performed in the order listed, and described in the following subsections:

1. [Functionality Demonstration](#_26in1rg),
2. [System Cycle Test](#_lnxbz9),
3. [System Resilience Test](#_1ksv4uv),
4. [Performance Test](#_44sinio), and
5. [Availability Test](#_2jxsxqh).

All tests shall be performed on a production configuration of the system, as defined by UCAR, and as close as possible to the condition in which the system will be deployed to the UCAR user community.

The Subcontractor shall be responsible for failure to meet the performance, performance reproducibility, or availability metrics set forth in this Subcontract, unless such failure is the direct result of modifications made by UCAR to benchmark or Subcontractor source code, system configuration or tuning parameters. Such suspension of responsibility will be only for those requirements that fail due to UCAR’s modification(s) and only for the length of time the modification(s) result(s) in such failure.

UCAR may run all or any portion of the post-delivery and Acceptance tests at any time, before or after Acceptance, on the system to ensure the Subcontractor’s compliance with, or continued compliance with, the requirements set forth in this and other parts of the Subcontract.

### Functionality Demonstration

The Subcontractor and UCAR will perform the Functionality Demonstration on a dedicated system. The Functionality Demonstration shall show that the system is configured properly within the NWSC environment, can repeat the Factory Trial tests, and functions in accordance with the Subcontract. Functionality Demonstrations shall include, but are not limited to, the following:

1. All items of the Factory Trial Test, except “Benchmarks,” shall be repeated to assure that the system has suffered no regression, component failure or degradation.
2. Validation of remote monitoring, power control, and boot capabilities
3. The External Connectivity Test (cf. Article 1, Definitions, Subcontract Terms and Conditions) shall demonstrate the following:
   1. NWSC LAN and UCAR WAN connectivity
   2. Interoperability of the NWSC-3 HPC and NWSC-3 PFS resources
   3. Interoperability with the NCAR’s GLADE file systems
   4. Interoperability with NCAR’s Globus-based Campaign Storage file systems
   5. Interoperability with the NCAR HPSS Data Archive
4. A description of the programming environment components and software tools that are proposed as part of the programming environment and/or optimized compiler tool suite. These may include: debuggers; performance analysis tools, including those accessing node and fabric hardware counters; I/O analysis tools; event-tracing tools; and stack-tracing tools. The Offeror shall include pricing for these components/tools in the Business/Price volume of the Offeror’s proposal. The Offeror shall recommend additional third-party software and tools required for the efficient use of the full capability of the system.

For each of the activities associated with the Functionality Demonstration, the Subcontractor shall document the recommended sequence of events, including command sequences, and provide that documentation for UCAR’s subsequent use.

### System Cycle Test

The Subcontractor and UCAR will perform the System Cycle Test on a dedicated system. The System Cycle Test shall show that the system is configured, can be successfully power-cycled in the NWSC environment, and functions in accordance with the Subcontract. Demonstrations shall include, but are not limited to, the following:

* Computational Systems: Two successful system shutdowns and cold boots[[1]](#footnote-1) to production state in accordance with required timings, and with no manual intervention to bring the system to a production state. Production state is defined as the System Availability is above the Availability test criteria threshold (cf. §5), the system is running all services required for production use, and it is possible to compile and execute parallel jobs across the system under the control of the system’s job scheduler/resource manager.
* Storage Systems: One successful system shutdown and cold boot to production state in accordance with required timings and with no manual intervention to bring the system to production. Production state is defined as the hosted file systems can be mounted on NWSC HPC system(s) and hosted files can be successfully read and written.

For each of the activities associated with the System Cycle Test, the Subcontractor shall document the recommended sequence of events, including command sequences, and provide that documentation for UCAR’s subsequent use.

### System Resilience Test

Subcontractor and UCAR shall perform the System Resilience Test on a dedicated system. The System Resilience Test shall show that the system is configured, can successfully demonstrate its resilience features, and functions in accordance with the Subcontract.

All system resilience features of the system shall be demonstrated via fault-injection procedures and, for computational systems, concurrent with running test applications on the system. The metrics for resilience operations include correct operation, any loss of data or access to file systems, time to complete a recovery, and time required to restore (fail-back) a normal operating mode for the failed components.

At a minimum, the following tests shall be performed on a **computational system**:

1. Redundant subsystems test: any redundant portion of the system shall survive fault injection and continue to function normally; fault injection includes removal of cables, disk drives, power supplies, power cables, etc. as appropriate to the hardware in question.
2. Single-node power-fail/reset test: Failure or reset of a single node’s electrical power, including system management node(s), shall not cause a system-wide failure. The node shall reboot to production state after reset in accordance with required timings. This single-node test shall be performed on each unique node type of the system, including system management and monitoring nodes.
3. Single computational cabinet power-fail/reset test: Power loss to a single compute cabinet shall not cause a system-wide failure.
4. Redundant power-feed test: All components provided with redundant NWSC facility power feeds shall survive, without interruption, the loss of one power feed.
5. Cooling test: Successful demonstration of system loss-of-cooling and/or over-temperature safeguards due to the loss of cooling, as appropriate for the system’s architecture.
6. High-availability services test: Any portion of the system which is configured to provide resilient system services shall be tested for proper failover/failback functionality. Such testing may include any or all of the above computational system tests.

At a minimum, the following tests shall be performed on a **storage system**:

1. Redundant subsystems test: any redundant portion of the system shall survive fault injection and continue to function normally; fault injection includes removal of cables, disk drives, power supplies, power cables, etc. as appropriate to the hardware in question.
2. Single storage node/controller power-fail/reset test: Failure or reset of a single filesystem server node/controller shall not cause loss of accessibility to the hosted file system(s). A filesystem server node/controller shall reboot to production state after reset in accordance with required timings.
3. Storage component removal: removal and/or power-fail of a resilient/redundant storage component (e.g. disk, drawer, controller) shall not cause loss of accessibility to data stored on, or the ability to write to, the hosted file system.
4. Redundant power-feed test: All components provided with redundant NWSC facility power feeds shall survive, without interruption, the loss of one power feed.
5. Cooling test: Successful demonstration of system loss-of-cooling and/or over-temperature safeguards due to the loss of cooling, as appropriate for the system’s architecture.
6. High-availability services test: Any portion of the system which is configured to provide resilient system services shall be tested for proper failover/failback functionality. Such testing may include any or all of the above storage system tests.

For each of the activities associated with the System Resilience Test, the Subcontractor shall document the recommended sequence of events, including command sequences, and provide that documentation for UCAR’s subsequent use.

### Performance Test

UCAR, with the Subcontractor’s participation, shall be responsible for running the Performance Test. The Performance Test will consist of the following activities:

1. The system shall be successfully powered up from a cold power-off state and pass hardware self-checks.
2. The Subcontractor’s system integrity tests shall be run successfully and achieve their expected performance.

Additional performance testing for a **computational system** shall include:

1. The individual NWSC-3 Homogeneous and Heterogeneous Node Benchmarks produce their expected performance on their respective portions of the system.
2. The individual NWSC-3 Benchmarks produce their expected numerical results.
3. The system shall demonstrate that it can achieve the committed Cheyenne Sustained Equivalent Performance (CSEP) for each of the Homogeneous and Heterogeneous Node portions of the system (cf. Schedule B).

Additional performance testing for a **storage system** shall include:

1. The individual NWSC-3 I/O Benchmarks produce their expected performance.
2. The system shall demonstrate that in can achieve the committed performance metrics (e.g. aggregate bandwidth, IOPs) (cf. Schedule B).

### Availability Test

The Availability Test will commence after successful completion of the Functionality Demonstration, System Test, System Resilience Test, and Performance Test.

During the Availability Test, UCAR shall have full access to the system and shall monitor the system’s availability and utilization, using utilities and methodology provided by, and/or acceptable to, the Subcontractor. UCAR and users designated by UCAR shall submit jobs through the resource management system or otherwise exercise the system in such a manner as to provide a production-like workload on the system, where production-like workload includes not only well-behaved, but potentially ill-behaved, jobs.

The Subcontractor shall adhere to the following Availability Test requirements:

1. Upon the commencement of the Availability Test, Subcontractor personnel will not be permitted to make any changes to the systems’ hardware or software configuration without prior approval of UCAR, with the exception of those needed to effect hardware repair.
2. Should a hardware or software upgrade be required, the time needed to perform the upgrade, including rolling upgrades, shall be considered Null Time. The Subcontractor shall document, and provide such documentation to UCAR, any such hardware or software upgrade and the procedures necessary to effect the upgrade.
3. If any system software upgrade or significant hardware repairs are applied, the Subcontractor shall be required to rerun the Performance Test and demonstrate that the changes incur no loss of performance. At its option, UCAR may also run any tests it deems necessary. Time taken to run the tests shall be Null Time, provided that all tests perform to specifications.
4. Any time required to repair failed hardware or software shall be considered downtime unless it can be repaired without impacting System Availability or File System Availability.
5. Hardware and software upgrades shall not be permitted during the last seven days of the Availability Test.
6. All hardware and software shall be fully functional at the end of the Availability Test, except as mutually agreed by UCAR and the Subcontractor.

# Availability Test Criteria

The **Availability Test Criteria** are as follows (System Availability, File System Availability, Downtime and File System Downtime are defined in Article 1, Definitions, of the Subcontract’s Terms and Conditions):

1. **Duration**

The Availability Test duration shall be thirty (30) contiguous days in a sliding window within the Acceptance Test Period.

1. **Availability**

The System Availability of the computational component of the NWSC-3 HPC production system shall exceed 98%, and the System Availability of the system services component shall exceed 99%.

The File System Availability of the NWSC-3 PFS production system shall exceed 99%.

1. **Correctness**

The system shall demonstrate numerical correctness; namely, each test comprising the Functionality Demonstration, the Performance Test and UCAR-defined workload for the Availability Test shall consistently obtain expected numerical results in both dedicated and non-dedicated modes.

1. **Performance**

All tests run during the Availability Test shall exhibit performance in accordance with that observed for those tests during the Performance Test.

1. **Performance Consistency**

The performance metric for each test run on the system during the Availability Test shall demonstrate a coefficient of variation of less than 3% in dedicated mode, and less than 5% in non-dedicated mode.

# Failures and Downtime

The following specifications shall be used to define and manage activities, failures and downtime during the Acceptance Test period. Additional related definitions are contained in Article 1, Definitions, of the Subcontract’s Terms and Conditions.

1. A node shall be defined as down if a hardware problem either causes Subcontractor supplied software to crash or otherwise causes the node to be unavailable to the system’s job scheduler/resource manager. Failures that are transparent to Subcontractor-supplied software because of redundant hardware shall not be classified as a node being down as long as the failure does not impact node or system performance.
2. A node shall be classified as down if a defect in the Subcontractor supplied software causes a node to be unavailable to the system’s job scheduler/resource manager. Communication network failures external to the system, and user application program bugs that neither impact other users nor the node’s ability to run other work shall not constitute a node being down.
3. A file system shall be classified as down if data residing on it cannot be read, if data cannot be written to the file system, or if metadata for the filesystem is inaccessible.
4. The entire system shall be classified as down, i.e. a “System Interrupt” (cf. Article 1, Definitions, of the Subcontract’s Terms and Conditions), if any of the following conditions occur. Failures due to the UCAR network or other UCAR-supplied subsystems do not contribute to downtime.
   1. For **computational systems**:
      * 1. Full high-speed interconnect bandwidth is unavailable. Failure of a network interface card in a node does not constitute a system-wide failure. However, failure of a switch may constitute failure, even if alternate switch paths were available, if either full bandwidth is not available or more than 10% of the nodes are unreachable.
        2. User applications cannot be launched and/or completed via the system’s job scheduler/resource manager.
        3. Benchmark runs produce incorrect numerical results.
        4. Benchmark runs produce <85% of expected performance (i.e., that previously measured during the Performance Test phase).
        5. Other failures occur in Subcontractor supplied products and services that disrupt work on more than 10% of the system.
   2. For **storage systems**:
      * 1. A POSIX ‘stat' operation cannot be completed within 10 seconds on any unlocked file within the Subcontractor-provided file systems.
        2. The aggregate file system bandwidth is <85% of the expected performance (i.e., that previously measured during the Performance Test phase).
        3. The aggregate IOPs rate is <85% of the expected rate (i.e., that previously measured during the Performance Test phase).
        4. Other failures occur in Subcontractor supplied products and services that disrupt data reads, writes or metadata availability on more than 10% of the storage associated with the hosted file system(s).
5. If there is a System Interrupt, UCAR shall turn the system over to the Subcontractor for service as soon as the Subcontractor indicates its personnel are ready to begin work on the system. All nodes are considered down during a System Interrupt.
6. Downtime shall begin when UCAR notifies the Subcontractor of a problem (e.g. an official problem report is opened) and, for System Interrupts, when the system is made available to the Subcontractor for remedial activities. Downtime shall end when:
   1. For problems that can be addressed by substituting a spare component or by rebooting the component, the downtime shall end when a spare component or the down component is available for production use by the system’s resource manager (computational component) or the hosted file system is available (storage component).
   2. For problems requiring the Subcontractor to repair or replace a failed hardware component, the downtime shall end when the failed component is returned to UCAR and available for production use by the system’s resource manager (computational component) or the hosted file system is available (storage component).
   3. For software downtime, the downtime shall end when the Subcontractor supplies a fix that rectifies the problem or when a copy of the failing software that does not exhibit the same problem is made available.
7. Repeat failures of the same cause occurring within eight hours shall be counted as one continuous failure (downtime from the commencement of the first failure to the end of the last failure).
8. Any event caused by the actions of a regular, unprivileged user (or a user with improperly obtained privileges) which causes a node to become unavailable, or to interrupt another user's job, is a defect for which the Subcontractor bears the responsibility to repair; unless mutually agreed otherwise by the Subcontractor and UCAR.
9. A failure due to UCAR or its actions, or to other causes outside of the Subcontractor's control, shall not be counted against the Subcontractor unless the failure demonstrates a defect in the system or Subcontractor-supplied software.
10. UCAR and the Subcontractor may mutually agree to temporarily suspend Acceptance testing activities. The period of time during the suspension of activities shall be considered Null Time.
11. If there are disputes as to whether a given failure is the fault of the Subcontractor or UCAR, they shall be resolved prior to the end of the Acceptance Test period.

1. In a cold boot, all elements of the system are completely powered off before the boot sequence is initiated. All components are then powered on. [↑](#footnote-ref-1)