

SECTION 20 80 00

SYSTEMS INTEGRATION TESTING

January 2013 **PART 1 - GENERAL**

1.01 SECTION INCLUDES

- A. Specifications for all phases of systems integration testing.

1.02 RELATED SECTIONS

- A. Section 01 20 00 Price and Payment Procedures
- B. Section 01 33 00 Submittal Procedures
- C. Section 01 35 14 Operating System Interface
- D. Section 01 43 00 Quality Assurance and Quality Control
- E. Section 01 52 00 Construction Facilities.
- F. Section 20 72 25 Factory and Field Testing Requirements
- G. Section 27 21 00 Unified Optical Network
- H. Section 34 21 80 Traction Power System Field Acceptance Testing

1.03 MEASUREMENT AND PAYMENT

- A. The work specified in this Section will be paid for under the applicable Bid Items based on the locations where work is performed, as identified in the Form – Description of Bid Items, in accordance with Contract Specifications Section 01 20 00, Price and Payment Procedures.

1.04 ABBREVIATIONS

AC	-	Alternating Current
AFC	-	Automatic Fare Collection
ATC	-	Automatic Train Control
ATO	-	Automatic Train Operations
BARTnet	-	BART Communications Network
CPUC	-	California Public Utilities Commission
DC	-	Direct Current
EBP	-	Emergency Backup Panel

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ET	-	Emergency Telephone
ETP	-	Emergency Trip Panel
ETS	-	Emergency Trip Station
ETTS	-	Emergency/Transfer Trip System
FACP	-	Fire Alarm Control Panel
FT	-	Fire Telephone
ICS	-	Integrated Control System
I/O	-	Input/Output
IP	-	Internet Protocol
IPR	-	Integrated Protection Relay
IPPBX	-	Internet Protocol Private Branch Exchange
IRAT	-	Integrated Remote ATO Terminal
LAN	-	Local Area Network
LCD	-	Liquid Crystal Display
LMA	-	Lake Merritt Administration
MPR	-	Multifunction Protection Relay
OCC	-	Operations Control Center
PSTN	-	Public Switched Telephone Network
PA	-	Public Address
PIDS	-	Portal Intrusion Detection System
PLC	-	Programmable Logic Controller
PTS	-	Platform Trip Station
PTC	-	Project Test Center
QC	-	Quality Control
SAB	-	Station Agent Booth
SCADA	-	Supervisory Control and Data Acquisition

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SFO	-	San Francisco
SRST	-	Survivable Remote Site Telephony
SSWP	-	Site-Specific Work Permit
TCH	-	Train Control House
TCR	-	Train Control Room
UON	-	Unified Optical Network
UPS	-	Uninterruptible Power System
VCP	-	Ventilation Control Panel
VOIP	-	Voice over IP

1.05 PROJECT TEST CENTER (IF APPLICABLE)

- A. Provide and install a temporary Project Test Center (PTC) in the vicinity of a train control room (TCR) on the project alignment to facilitate systems integration testing and minimize interference with the Operations Control Center (OCC) and revenue operations.
- B. House the PTC in a double-wide construction trailer as specified in Contract Specifications Section 01 52 00, Construction Facilities. Divide the trailer into two main areas; a test area and a conference room. Provide sufficient tables and chairs to accommodate 20 people in the conference room. In the test area, provide and/or install the following equipment:
 1. Provide equipment tables, chairs, filing cabinets, convenience outlets and additional lighting as required.
 2. Provide essential power for all specified workstations and LMA headend equipment from the uninterruptible power system (UPS) in the adjacent TCR.
 3. Install and connect all Central equipment being furnished by the project.
 5. Provide and/or install the following workstations as applicable for the project:
 - a. Two District-furnished, ICS workstations.
 - b. Four temporary Contractor-furnished workstations with 22 inch LCD screens, including two for EBP and two for IRAT functions. The application software for these workstations is provided by BART and shall be used by the Contractor to perform end-to-end system testing of the communications and train control systems respectively. Application software testing will be performed by BART with Contractor support as required.
 - d. One video workstation (relocated from the TCR).

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- e. One temporary, Contractor-furnished workstation equipped with manufacturer-furnished software for the remote monitoring of diagnostic information in multifunction and integrated protection relays (MPRs and IPRs) associated with AC and DC traction power circuit breakers, AC substation circuit breakers and ventilation fan starters if applicable.
 6. Provide a minimum of two connections to the public switched telephone network (PSTN).
 7. Install IPPBX, ET and FT handsets as needed.
 8. Provide portable radios to communicate with the above and below-ground radio system as applicable.
- C. Following the installation of all equipment in the PTC, test all equipment for proper connectivity and operation prior to the commencement of any other systems integration testing.
- D. Upon completion of all systems integration testing, ship all communications equipment to LMA where the equipment will be installed by the District with Contractor support as needed. The PTC shall then be demobilized.

1.06 DESCRIPTION OF SYSTEMS INTEGRATION TESTING

- A. The term "system(s)" as used in this Contract Specifications Section shall mean individual equipment or devices or groups of equipment or devices forming a subsystem or system as specified in Contract Specifications Divisions 14 through 34.
- B. Systems integration testing shall begin only after the successful completion of applicable installation verification and functional system testing requirements for a given system or section of the Work. The requirements for equipment and systems installation verification and functional testing shall be as defined in Contract Specifications Section 20 72 25 - Factory and Field Testing Requirements and the field testing requirements as defined in each system or equipment specification section.
- C. Systems integration testing shall be performed by the Contractor and/or BART, as specified herein, to verify the operation and performance of all systems provided as part of this contract, systems provided by the District, and the existing BART system, as one complete and integrated work. Testing shall be performed in three phases as follows:
1. Inter-system, intra-facility functional testing will, in most cases, be performed locally rather than from a centralized location. Examples include interfaces between:
 - a. PA, fire alarm and SCADA systems at the project station(s).
 - b. Video surveillance, PA and IPPBX systems at the project station(s).
 - c. Circuit breaker multifunction relays (MPRs) and network switches at various locations.

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2. Inter-facility, systems integration testing will be performed at the PTC and includes the following systems as described in PART 3:
 - a. SCADA system end-to-end testing.
 - b. Communications systems end-to-end testing.
 - c. 34.5 KV subtransmission system.
 - d. Auxiliary substations.
 - e. Ventilation system (if applicable).
 - f. Traction power system.
 - g. Automatic train control testing.
 3. Final configuration testing at the OCC: Following the completion of all systems integration testing at the PTC, the LMA headend equipment shall be transferred to Central for installation by the District. Upon completion of the installation, each system shall be tested to verify correct operation with existing equipment at Central. This work will be performed by the District with Contractor support. The District will also conduct testing of all OCC workstations and the "big board" display prior to beginning up to 12 weeks of pre-revenue operations to familiarize BART personnel with the new Extension.
- D. Perform systems integration testing with all systems configured as they would be under revenue service with the exception of the LMA equipment located in the PTC during phase 2 of systems integration testing. Systems integration testing shall include all interfaces between systems provided as part of this Contract and the existing BART system.
- E. Adopt and implement an approved safety program during systems integration testing. In addition:
1. Coordinate which sections of the traction power system will be energized.
 2. Grant work access to non-energized areas for its own forces and the District.
 3. Operate a District-approved red tag procedure in accordance with Contract Specifications Section 01 35 14 - Operating System Interface.

1.07 TEST RESPONSIBILITIES OF THE CONTRACTOR

- A. Perform all system integration tests that are specified as the Contractor's responsibility. Provide support for District testing as specified. However, the Contractor will not be responsible for any other aspect of District testing.
- B. Conduct all system integration testing under the direction of the Contractor's quality control (QC) group. Individual subcontractor test directors shall report directly to the Contractor's QC group.

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- C. Comply with all quality assurance and control requirements as specified in Contract Specifications Section 01 43 00, Quality Assurance.
- D. Furnish all test instruments and any other equipment and materials necessary to perform the tests.
- E. Assume full responsibility for the repair or replacement of any equipment damaged as a result of tests and bear all associated costs.

1.08 TEST RESPONSIBILITIES OF THE DISTRICT

- A. During systems integration testing, the District will perform the following tasks:
 - 1. Review and approve test plans, procedures and results.
 - 2. Monitor and witness tests performed by the Contractor.
 - 3. Conduct tests that are the responsibility of the District. Contractor support shall be provided as needed during tests performed by the District. An allowance will be set-aside to cover the cost of testing support to the District.
 - 4. Furnish revenue vehicles according to the following availability schedule:
 - a. Up to 10 cars, as required, forming any combination of train consists from one 10-car train to multiple trains with the minimum train consist being three cars in length.
 - b. Any additional cars will be furnished on Sundays from 0130 hours to 0700 hours.
 - 5. Furnish District staff as required to perform the following tasks:
 - a. Operate vehicles.
 - b. Protect test trains operating in an assigned test area.
 - c. PTC and OCC control operations.
 - d. Any other District responsibility.
 - 6. Coordinate attendance of witnesses from other agencies including the CPUC, Fire Marshals and other governing and regulating agencies.

1.09 SYSTEMS INTEGRATION TEST PLANS, PROCEDURES, DATA SHEETS AND RESULTS

- A. Except as modified herein, submittals requirements and procedures shall be as specified in Contract Specifications Section 01 33 00, Submittal Procedures.
- B. The systems integration test program plan, schedule, procedures, data sheets and results shall be prepared in accordance with Contract Specifications Section 20 72 25 - Factory and Field Testing Requirements.

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- C. Submittals specified herein will be reviewed by the District and returned to the Contractor within 30 days after receipt of the submittals. Prepare documents and schedule their submittals such that documents should have been approved by the District according to the following schedule:
1. Systems integration test program plan - 240 days prior to start of any systems integration test.
 2. Systems integration test schedule - 180 days prior to start of any systems integration test.
 3. Systems integration test procedures and generic data sheets - 90 days prior to start of applicable test.
 4. Site-specific data sheets - 45 days prior to start of applicable test.

PART 2 – PRODUCTS

Not used

PART 3 - EXECUTION

3.01 TESTING GENERAL REQUIREMENTS

- A. Use of District Facilities and Equipment: Access to District facilities or use of District operating equipment (e.g., in-service equipment rooms or Central Control facilities) shall be identified in the applicable test procedures and coordinated through the District Representative. Access and the availability of District facilities and equipment, when required, will be provided only upon District approval of a site-specific work permit (SSWP), as defined in Contract Specifications Section 01 35 14, Operating System Interface.
- B. PTC Test Manager and Directors: Assign a Test Director under the direction of the QC Manager for each systems integration test. The Test Director shall be responsible for the overall performance and safety of the test.
- C. Perform the start-up, operation, and shutdown activities of each test in accordance with the District-approved Contractor's red tag procedures.
- D. Utility charges for electrical power demand and energy during systems integration testing will be the responsibility of the Contractor, per Contract Specifications Section 01 20 00, Price and Payment Procedures, Allowance for Utility Services.
- E. Where actual fault or abnormal conditions cannot be produced to operate protective relays or other devices, tests shall be performed by applying a short across the contacts at the device locations, or by simulating the applicable inputs to the devices.
- F. Procedure for Conducting Tests: During systems integration testing, test personnel will be stationed at the PTC and at field devices/equipment as appropriate for the test being conducted.

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Systems integration testing may require up to four individuals (BART and/or Contractor personnel) as follows:

1. Two people will be stationed at the PTC (Test Director and one assistant) and they will direct the testing and monitor the workstations to verify that status and alarm inputs are correctly displayed on the appropriate displays and that appropriate commands are correctly executed.
 2. As each step in a test procedure is successfully completed, the test director and a witness at the PTC will initial the test. If a District representative is present during a Contractor-conducted test, he/she shall initial the test as the "witness". If a problem is detected, make a notation in the comments column and record the problem on the punch list. Repeat the test when the problem is corrected and before submitting the test results to the District for approval. When testing is completed and all punch list items have been corrected, the appropriate parties shall sign the test report cover sheet.
- G. A typical systems integration test related to inter-system functional testing from the SFO Extension Project is given in Attachment A.

3.02 SCADA SYSTEM END-TO-END TESTING

- A. End-to-end tests shall be performed using the EBP workstations to verify the correct operation of all SCADA I/O points and associated indications on the workstation displays. Because BART is configuring the EBP workstation display software, testing shall be a shared responsibility with each party responsible for correcting problems associated with their work.
- B. BART may choose to concurrently test the ICS workstation SCADA I/O point displays.

3.03 COMMUNICATIONS SYSTEMS END-TO-END TESTING

- A. Communications systems that interface to LMA headend equipment installed in the PTC shall be tested end-to-end after the BARTnet and Security networks on the UON have been successfully tested. These systems include all telephone systems, the station PA system, the video surveillance system, and the access control system.
- B. BART will furnish the headend access control server software to the Contractor. Install this software on one of the LMA video servers to perform end-to-end testing of the access control system.
- C. Testing of the administrative network devices shall be deferred until the LMA equipment is installed at Central. End-to-end testing with the existing access control server will be performed by the District with Contractor field support.

3.04 34.5 KV SUBTRANSMISSION SYSTEM

- A. Energization Test: The energization test shall be performed only after successful completion of the following:
 1. Field installation test of the 34.5 kV cable system.

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2. Energization of the applicable high voltage substation.
 3. Verification that the applicable sectionalizing station and traction power substations for the traction power system are ready for energization.
 4. Verification that applicable auxiliary substations for the line electrical power distribution system are ready for energization.
- B. The test shall be performed to verify the integrity of the 34.5 kV cable system under energized conditions.

3.05 AUXILIARY SUBSTATIONS

- A. General: The following tests shall include:
1. End-to-End Tests: Verify that all substation remote monitoring and control points that are accessible from the ICS and EBP workstations at the PTC function correctly. In addition, verify the correct access and receipt of diagnostic data from the AC breaker MPR relays. The manufacturer's MPR monitoring software shall be loaded on to a PTC workstation to perform this test.
 2. Energization Tests: The energization test shall be performed only after successful completion of the following:
 - a. Field testing and energization of the applicable switching station and section of 34.5 kV cable system supplying power to the auxiliary substations (Applicable to portions of the auxiliary substations receiving power from the traction power 34.5 kV system).
 - b. Testing and energization of the electric utility feeder line, and verification by the electric utility that the applicable auxiliary substation is ready for energization. (Applicable to auxiliary substations or portions thereof receiving power from the electric utility).
 - c. Field tests of the auxiliary substation equipment.
 - d. Remote control and indication tests for the auxiliary substations as specified above.
 3. Perform the energization test to verify the integrity of each item of equipment in the power distribution system under energized conditions.
 4. The energization test shall cover all equipment, devices, and electrical loads in the 34.5 kV to 480 V range and other low voltage systems in the power distribution system including those in auxiliary substations, other wayside facilities and on the trackways.

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3.06 TRACTION POWER SYSTEM

- A. General: Perform the following system integration tests after completion of the system-specific and equipment-specific field tests of the traction power facilities, 34.5 kV sub-transmission and 1000 VDC distribution systems, contact rail system, and related communications systems.
- B. Remote Monitoring and Control Point Testing: Verify the proper operation of all monitoring and control points between each traction power facility's CO2 panel and the ICS and EBP workstations at the PTC. In addition, verify the correct access and receipt of diagnostic data from each AC breaker integrated protection relay (IPR) and each DC breaker MPR. The manufacturer's MPR and IPR monitoring software shall be loaded on a PTC workstation to perform this test.
- C. Energization Test:
1. Verify the integrity and proper operation of all equipment in the traction power system under energized conditions. Perform this test shall after the successful completion of the field tests on the standalone systems involved, and the remote control and indication test specified above.
 2. Perform the energization test on the entire traction power system including the AC system comprising of the 34.5 kV sub-transmission feeders and sectionalizing stations; and the 1000 VDC system comprising the traction power substations, gap breaker stations and contact rail system. The traction power system may be divided and tested in sections in accordance with the completion of installation for each system and facility. Continue the energization test until all sections of the traction power system have been tested, up to and including every section of the contact rail system.
- D. Emergency/Transfer Trip System (ETTS) Test: Verify the correct functioning of the ETTS equipment in all of its emergency and transfer tripping modes and the proper integration of the ETTS with the following:
1. The DC feeder breakers' control circuits and MPRs.
 2. The emergency trip panels (ETPs) associated with the platform trip stations (PTSs) at the project station(s).
 3. The emergency trip stations (ETSS) in the wayside blue light stations (BLSs).
- Activate each PTS and ETS to verify that the correct contact rail section(s) is/are de-energized. Simulate ETTS equipment failures to confirm that all alarms and status indications function correctly and simulate breaker fault conditions to confirm the correct operation of all transfer tripping functions.
- E. Short Circuit, Ground Fault and Train Start Tests: Perform these tests as specified in Contract Specifications Section 34 21 80 – Traction Power System Field Acceptance Testing.

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3.07 AUTOMATIC TRAIN CONTROL TESTING

- A. Perform ATC field and dynamic testing using the ICS and IRAT workstations in the PTC, including train control station to station “Vital” integration testing as specified in BFS Appendices, “BART FUNCTIONAL SPECIFICATION, MICROPROCESSOR BASED INTERLOCKING”, Section 2.8 TESTING.

END OF SECTION 20 80 00

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ATTACHMENT A TO SECTION 20 80 00

PA / FIRE ALARM / TELEPHONE / SCADA SYSTEM INTERFACE

FUNCTIONAL TEST

1.01 TEST OBJECTIVES

- A. To verify that the PA system/fire alarm/telephone/SCADA interface performs correctly in response to various fire alarm and phone system conditions
- B. Repeat the tests for each station and record the results in the test report.

1.02 PREREQUISITES

- A. The PA system installation verification is completed.
- B. The installation verification for the PABX and courtesy phone systems is completed.
- C. All elevators and escalators are operational.

1.03 TEST PROCEDURE

Step #	Description
1	A. Activate the “manual pull station” alarm input point at the FACP. B. Verify that the alarm is reported on the SAB control panel but do not acknowledge the alarm. C. Verify that 15 seconds later that the message “Escalator about to be stopped” is announced once over the PA system. D. Verify that the 4-chime code call is broadcast and repeats every 15 seconds (Note – this is typical for all SAB alarms). E. After one minute, acknowledge the alarm and verify that the 4-chime code call stops. F. Repeat step A and acknowledge the alarm immediately. G. Verify that the message is not broadcast over the PA system and that the 4-chime code call is not initiated.

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2	<ul style="list-style-type: none"> A. At a PABX phone outside of the SAB, make a call to the SAB. B. Verify that the PABX phone in the SAB rings but do not answer it C. Verify that 15 seconds later, the 3-chime code call is broadcast and repeats every 15 seconds. D. After one minute, answer the phone in the SAB and verify that the 3-chime code call stops. E. Repeat step A and acknowledge the PABX phone call immediately. F. Verify that the 3-chime code call is not initiated.
3	<ul style="list-style-type: none"> A. Press the courtesy phone call button in an elevator. B. Verify that a single 2-chime code call is broadcast over the PA system. C. Verify that the courtesy phone in the SAB rings but do not answer it D. Verify that 15 seconds later, the 2-chime code call is broadcast and repeats every 15 seconds. E. After one minute, answer the courtesy phone in the SAB and verify that the 2-chime code call stops. F. Repeat step A and acknowledge the courtesy phone call immediately. G. Verify that the 2-chime code call is not initiated.
4	<ul style="list-style-type: none"> A. Activate the “seismic sensor activated” alarm input point by shorting out the associated terminals in cabinet 44A in each TCR B. Verify that the alarm is reported on the SAB control panel but do not acknowledge the alarm. C. Verify that 15 seconds later that the message “Escalator about to be stopped” is announced once over the PA system. D. Verify that the 6-chime code call is broadcast and repeats every 15 seconds. E. After one minute, acknowledge the alarm and verify that the 4-chime code call stops. F. Repeat step A and acknowledge the alarm immediately. G. Verify that the message is not broadcast over the PA system and that the 4-chime code call is not initiated.

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Test Report - PA System-SCADA Interface

Step #	W20	W30	W40	Y10	Comments
1					
2					
3				N/A	
4					

Enter a check mark if acceptable; enter N if unacceptable.

Tested by: _____ Date: _____

Witness initials: _____; _____; _____

END OF ATTACHMENT A TO SECTION 20 80 00