

University of Wollongong

Building Monitoring and Control Systems Commissioning Standard
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3. BUILDING MONITORING AND CONTROL SYSTEMS

Building monitoring and control systems (BMCS) provide monitoring and control of mechanical, electrical and environmental services installed at the University of Wollongong (UOW). The BMCS comprises a network of field processing units (FPU) to which field devices are connected.

The field devices are connected with the FPUs which, from a series of hardware and virtual points receive and transmit data. These points are digital inputs, digital outputs, analogue inputs or analogue outputs.

System monitoring and programming is performed from the system operator terminal. As a minimum three access levels are provided, these being operator, system administrator and technician.

3.1. OVERVIEW

Due to the BMCS being a control system that controls plant and equipment, it may be efficient for the BMCS commissioning tests to be run concurrently with the testing of the plant and equipment being controlled. This is particularly relevant on large projects.

The quality control process for BMCS equipment involves the following stages:

Stages	Description	Parties Involved
Stage 1	Unit Testing - Performed by the manufacturer at a component level.	Manufacturer
Stage 2	Preliminary offsite testing (If specified)	Contractor
Stage 3	Installation Inspections - Performed by the BMCS project manager and the UOW project manager during the installation process. The objective is to identify poorly installed equipment or parts of the installation that do not comply with the provisions of the design specifications. Provided the defect is identified at an early stage, the cost of remedial work and delays to the project program can be minimised.	BMCS Project Manager, UOW Project Manager
Stage 4	Final Commissioning - Performed by the installation contractor and witnessed by the BMCS project manager and the UOW project manager or their representative.	Contractor, BMCS project manager and the UOW Project Manager
Stage 5	Quarterly reviews during DLP - Performed by the installation contractor and witnessed by the BMCS project manager and the UOW project manager or their representative.	Contractor, BMCS project manager and the UOW Project Manager

Table 1 - Commissioning Stages

Final commissioning and Quarterly reviews during DLP are the most important part of the quality control process. It is at these stages of the project that the project manager will determine whether the system is ready to be approved for Practical Completion.

All commissioning tests are critical and shall be performed to ensure that all field devices will operate correctly. It is UOW's objective to complete the commissioning tests with zero defects remaining in the system.

The BMCS commissioning tests will be designed to verify and record the correct operation of all field devices, sensor calibrations and graphical functionality.

Field devices shall be tested under normal, alarm and fault conditions.

3.2. COMMISSIONING PROCESS

The following flow diagram depicts the commissioning process:

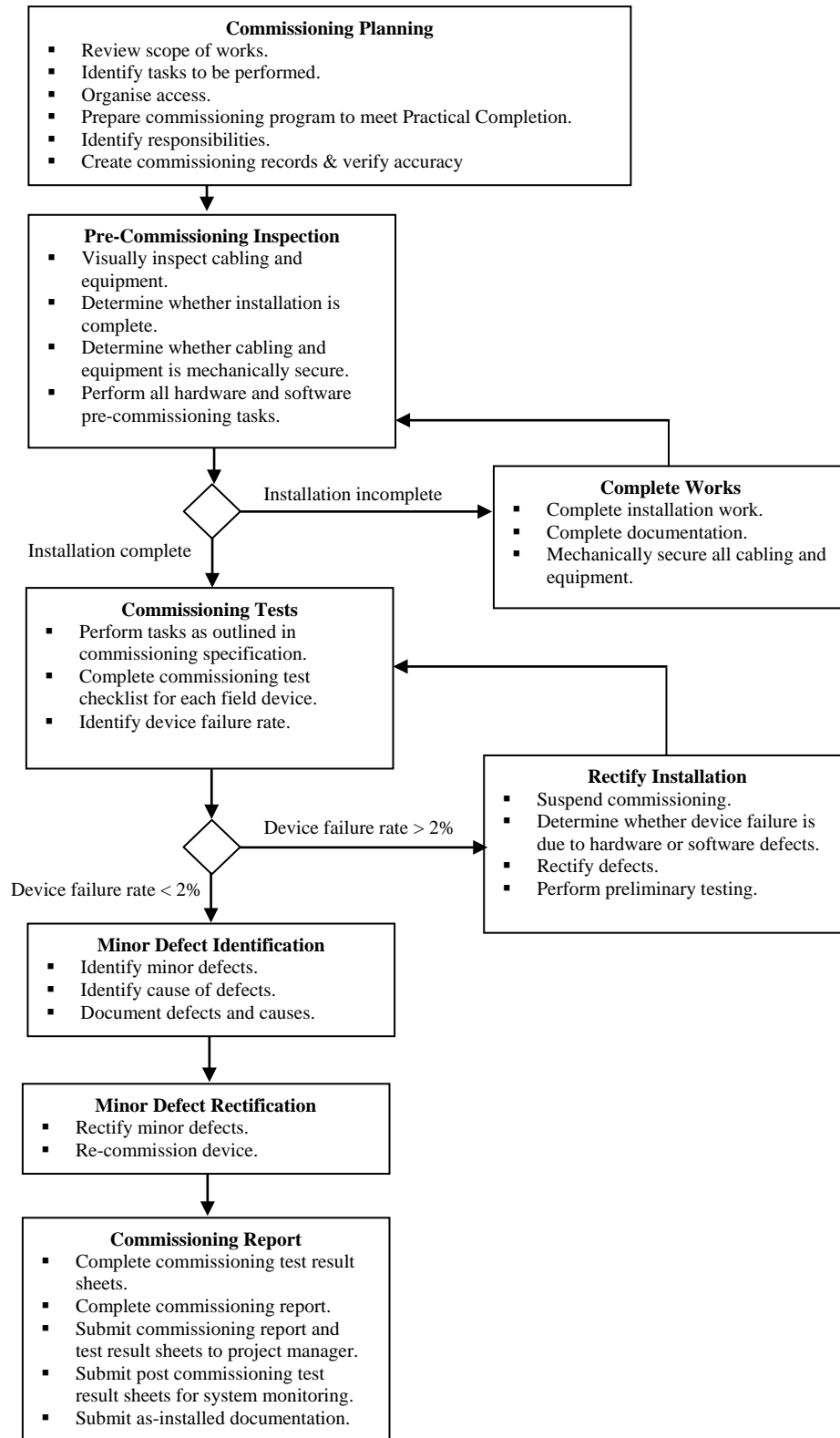


Figure 1 - Commissioning Process Flowchart

3.3. PRELIMINARY OFFSITE TESTING (if specified)

Preliminary testing of all programming including alarm limits, time sequencing and consequential events programming shall be carried out at the contractor's premises prior to installation of the software on site. Following completion of each section of the program, the Contractor shall demonstrate the software and completely simulate the plant operation to the Engineer's satisfaction.

The Contractor shall provide all necessary labour, materials and equipment to simulate field conditions.

The Contractor shall provide graphics pages for each software routine to facilitate the simulation and testing off site of the software. The graphics pages shall show all involved input points and values, generally on the left, all intermediate stages of the program, i.e., time delay relays, interlocks, thermostats, etc., and all derived outputs, generally on the right. The graphics page shall indicate where practical via connecting lines, the relationship of each component to each other. The graphics pages shall be interactive, allowing the operator to change input values from the graphics page to check the operation of the program.

The above graphics pages shall form part of the graphics package provided to the Principal. Individual pages shall be set up for each conditioner, etc., even though they may operate in an identical manner.

3.4. PRE-COMMISSIONING HARDWARE INSPECTION

At the completion of the installation and prior to the commencement of the commissioning tests, the contractor shall inspect all hardware and verify that the following tasks have been completed in accordance with the design specifications:

- (a) Electrical cables have been appropriately sized and selected to ensure that they will support currently installed and future equipment;
- (b) Mechanical protection has been provided to minimise the likelihood of physical damage to cabling;
- (c) Cabling has been concealed where possible in ceiling spaces, wall cavities or risers;
- (d) Sensors have been configured, mounted, positioned and insulated to ensure accurate readings;
- (e) All specified field devices have been installed at the locations specified in the design documentation;
- (f) Ducting, conduit and cable trays have been effectively secured to ensure that they can support currently installed and future cabling;
- (g) Field devices have been properly secured to protect against operational damage and ensure stability for continuous use;
- (h) Connections have been correctly terminated and insulated to ensure perfect connectivity and protect against faults and interference;
- (i) Field devices have been recessed where possible;

- (j) Weather resistant external devices have been installed to ensure protection against moisture and other environmental conditions;
- (k) Field processing units (FPU) have been installed in designated service areas with adequate access and ventilation;
- (l) FPUs have been installed at locations that maintain separation from other building services such as electrical and fire systems;
- (m) FPUs have been properly secured to protect against operational damage and ensure stability for continuous use;
- (n) Operator terminal CPU, LCD screen and peripheral devices have been installed at the specified location. Interconnecting cables have been protected from mechanical damage and have been permanently connected;
- (o) FPUs and other major system components have been clearly labelled using black lettering on white background self-adhesive permanently engraved Traffolyte labels, attached to a suitable fixed part of the equipment;
- (p) FPUs and other major system components have been identified with equipment labels that are in accordance with UOW's asset register convention;

All devices must be installed and must pass the pre-commissioning inspection before commencing the commissioning tests.

3.5. PRE-COMMISSIONING SOFTWARE INSPECTION

Prior to the commencement of the commissioning tests, the contractor shall verify that the correct application software has been installed and configured on both the operator terminal and the FPUs.

As a minimum the contractor shall confirm the following:

- (a) All software modules specified in the design documentation or the modules required to perform all specified operation functions have been installed and configured to meet UOW's system requirements;
- (b) The latest release version of all software modules has been provided;
- (c) The operator terminal CPU and FPU, memory and hardware resources have sufficient capacity to support the software routines and functions under worst case demand conditions;
- (d) All analogue inputs and outputs and digital inputs and outputs, system reports, screens and menus are fit for purpose and have been programmed.

If any of the above has not been completed, the commissioning tests shall be suspended and re-scheduled.

3.6. DOCUMENTATION

The contractor shall submit a complete set of documentation to the project manager no later than four (4) weeks prior to the planned commissioning date. As a minimum the documentation shall comprise:

- (a) Inspection and test plan for each sub-system;
- (b) Draft commissioning records;
- (c) Programming schedules;
- (d) A revised listing of all analogue inputs and outputs and digital inputs and outputs.
- (e) The contractor shall obtain written approval of the documentation before commencing the commissioning tests.

3.7. COMMISSIONING TIME AND DATE

The contractor shall submit a program to the project manager containing the proposed time and date for each commissioning test at least four (4) weeks prior to the planned commissioning date. The program must contain allowances for defect rectification and remedial works.

The contractor shall obtain written approval of the program from the project manager before commencing the commissioning tests.

3.7.1. On-Site Commissioning

Commission the system on site in co-ordination with the commissioning work of other services contractors. Submit a program itemising the systems and the proposed dates for conducting acceptance tests.

Commission equipment supplied by other trades in co-operation with the relevant trade representative. Attend the site as required to complete the commissioning.

Check control systems for correct sequence of operation.

Calibrate field devices with a NATA (or equivalent) certified instrument relevant to the device being calibrated. Certificates of currency are to be provided.

When a system is operating satisfactorily, test the system and submit a copy of the recorded commissioning test results. Acceptance tests will be witnessed when the commissioning test results are considered to be satisfactory.

Provide labour, materials and instruments for carrying out acceptance tests.

Instruments shall be calibrated not more than twelve months prior to use, by a testing authority, NATA (or equivalent) certifier to test the particular instrument. If there is reasonable doubt as to the accuracy of an instrument, the instrument shall be recalibrated, or alternatively, any quantities measured with the disputed instrument shall be re-measured with another approved instrument.

Two tests of equipment will be witnessed, if necessary. If the equipment fails the second test and no serious endeavour has been made to correct the fault, witnessing of further tests will be charged at current hourly rates plus expenses and such charges will be deducted from payments.

Tests shall include the following:

- Verification that input and output points are correctly connected, e.g. by manual intervention in outputs and inputs while observing system operation.
- Verification of analogue inputs by comparison of actual measured values displayed on workstation terminals.
- Verification of analogue outputs by comparing position commands issued via a workstation with operation of end devices.
- Verification of correct sequences of operation by simulating appropriate inputs.
- Demonstration of software functions.

3.8. TEST PREPARATION

Commissioning tests shall be performed to assess the overall functionality of the BMCS and the individual control strategies. Each commissioning test is an end-to-end test where each function is initiated under normal operating conditions and its performance verified with inspection and test plans.

The commissioning tests require at least two testers. One tester shall be located at the operator terminal and the other at the equipment that the BMCS monitors or controls. Portable communication devices, such as handheld radios, shall be used for communication between the two testers.

As each commissioning test is performed, the results shall be recorded on the appropriate commissioning test result sheets and inspection and test plans. Any comments regarding abnormal operation in particular to failed tests shall be recorded in the comments section of the commissioning test result sheets.

If the test failure rate is greater than 2% after conducting the first 10 tests, then the commissioning process shall be abandoned. The contractor shall determine the cause of the defects and retest the routines. A report shall be provided to the project manager outlining the cause of the failures and action taken to ensure that the remainder of the installation shall not experience the same failure rate.

3.9. COMMISSIONING TESTS

The contractor shall test each routine under each mode of operation, i.e. normal hours, after hours and holidays.

All monitoring and control routines shall be documented and submitted to the project manager. Each routine shall be initiated by the control parameters that are set manually, and tested. Following is a list of tasks to be performed, in order, for each monitoring and control commissioning test. Inspection and test plans are below;

- (a) Establish the desired mode of operation for testing, e.g. after hours operation;
- (b) Initiate the routine that is being tested, e.g. optimum start routine;
- (c) Observe the operator terminal display, test graphic points are correct and record the results in the commissioning schedule;
- (d) Observe the plant equipment and/or field devices to ensure that they function as expected and record results in commissioning schedule/inspection and test plans;
- (e) Change the mode of operation and repeats tasks 'c' and 'd'.
- (f) Terminate the routine and repeat tasks 'c' and 'd'.
- (g) At the conclusion of testing, establish the appropriate mode of operation for the BMCS.

The logical control process should be followed for each item of plant or equipment being monitored and controlled. This means that the sequence for testing digital and analogue points is determined by the nature and configuration of the actual equipment.

Following are the individual tests that shall be performed for each digital output, digital input, analogue output and analogue input associated with each of the monitoring and control routines.

3.9.1. Digital Outputs

For each routine the digital outputs shall be tested in both manual and automatic modes.

- (a) Generate the appropriate control command to run the equipment under normal operating conditions.
- (b) If the digital output point displays the status and condition for normal operating conditions then this test has been successful and "S" should be recorded in the commissioning schedule/inspection and test plans. If the digital output point does not display the status and condition for normal operating conditions then this test has failed and "F" should be recorded in the commissioning test result sheets.

At the conclusion of the test return the equipment and the BMCS to displaying the status and condition for normal operating conditions.

- (c) While the digital output point is displaying the status and condition for normal operating conditions activate the command from the operator terminal to change the status of the equipment to cease normal operating conditions.

If the digital output point changes state from normal operating conditions to the expected status change then this test has been successful and "S" should be recorded in the commissioning schedule/inspection and test plans. If the digital output point does not change to expected status then this test has failed and "F" should be recorded in the commissioning schedule/inspection and test plans.

At the conclusion of the test return the equipment and the BMCS to displaying the status and condition for normal operating conditions.

- (d) While the digital output point is displaying the status and condition for normal operating conditions simulate a fault condition at the equipment or the FPU. e.g. open circuit a data cable. (This test need only be performed on one point per virtual group).

If the digital output point changes state and reports a fault condition and an alarm is generated on the alarm summary then this test has been successful and "S" should be recorded in the commissioning schedule/inspection and test plans. If the digital output point does not change to fault condition or if an alarm is not generated on the alarm summary then this test has failed and "F" should be recorded in the commissioning schedule/inspection and test plans.

At the conclusion of the test return the equipment and the BMCS to displaying the status and condition for normal operating conditions.

3.9.2. Digital Inputs

For each routine the digital inputs shall be tested in both manual and automatic modes.

- (a) Control the equipment being monitored to run under normal operating conditions by generating the appropriate control command.

If the digital input point displays the status and condition for normal operating conditions then this test has been successful and "S" should be recorded in the commissioning schedule/inspection and test plans. If the alarm point cannot be programmed to be active/normal then this test has failed and "F" should be recorded in the commissioning schedule/inspection and test plans.

At the conclusion of the test return the equipment and the BMCS to displaying the status and condition for normal operating conditions.

- (b) While the digital input point is displaying the status and condition for normal operating conditions activate the command from the operator terminal to change the status of the equipment to cease normal operating conditions.

If the digital input point changes state from normal operating conditions to the expected status change then this test has been successful and "S" should be recorded in the commissioning schedule/inspection and test plans. If the point does not change to expected status then this test has failed and "F" should be recorded in the commissioning schedule/inspection and test plans.

At the conclusion of the test return the equipment and the BMCS to displaying the status and condition for normal operating conditions.

- (c) While the digital input point is displaying the status and condition for normal operating conditions simulate a fault condition at the equipment or the FPU. e.g. open circuit a data cable. (This test need only be performed on one point per virtual group).

If the digital input point changes state and reports a fault condition and an alarm is generated on the alarm summary then this test has been successful and "S" should be recorded in the commissioning schedule/inspection and test plans. If the digital input point does not change to fault condition or if an alarm is not generated on the alarm summary then this test has failed and "F" should be recorded in the commissioning schedule/inspection and test plans.

At the conclusion of the test return the equipment and the BMCS to displaying the status and condition for normal operating conditions.

3.9.3. Analogue Output Point

Each test should be performed in both automatic and manual modes.

- (a) Generate the appropriate control command to run the equipment under normal operating conditions.

If the analogue output point displays the desired value then this test has been successful and "S" should be recorded in the commissioning schedule/inspection and test plans. If the analogue output point does not display the desired value or the equipment does not operate correctly then this test has failed and "F" should be recorded in the commissioning schedule/inspection and test plans.

- (b) While the analogue output point displays the desired value, generate a change of value signal from the operator terminal.

If the analogue output point changes value to expected value and the equipment responds accordingly then the test has been successful and "S" should be recorded in the commissioning test result sheets and the time taken for the analogue output point to change value. If the analogue output point does not change to the expected value or the equipment does not operate correctly the test has failed and "F" should be recorded in the commissioning schedule/inspection and test plans.

At the conclusion of the test return the equipment and the BMCS to displaying the status, condition and desired values for normal operating conditions.

- (c) While the analogue output point is displaying the desired value simulate a fault condition at the equipment or the FPU. e.g. open circuit a data cable. (This test need only be performed on one point per virtual group).

If the analogue output point changes state and reports a fault condition and an alarm is generated on the alarm summary then this test has been successful and "S" should be recorded in the commissioning schedule/inspection and test plans. If the analogue output point does not change to fault condition or if an alarm is not generated on the

alarm summary then this test has failed and "F" should be recorded in the commissioning schedule/inspection and test plans.

At the conclusion of the test return the equipment and the BMCS to displaying the status, condition and desired values for normal operating conditions.

3.9.4. Analogue Inputs

Each test should be performed in both manual and automatic modes.

- (a) Control the equipment being monitored to run under normal operating conditions by generating the appropriate control command. Verify the value of the analogue input point against the control criteria and verify the operational performance of the equipment.

If the analogue input point displays the desired value then the test has been successful and "S" should be recorded in the commissioning schedule/inspection and test plans. If the analogue input point does not display the desired value then the test has failed and "F" should be recorded in the commissioning schedule/inspection and test plans.

At the conclusion of the test return the equipment and the BMCS to displaying the status, condition and desired values for normal operating conditions.

- (b) While the analogue input point displays the desired value adjust the device or equipment that the point is monitoring, e.g. increase the temperature setting on the thermostat.

If the analogue input point changes its value to the expected value then the test has been successful and "S" should be recorded in the commissioning schedule/inspection and test plans. If the analogue input point does not change to the expected value then this test has failed and "F" should be recorded in the commissioning schedule/inspection and test plans.

At the conclusion of the test return the equipment and the BMCS to displaying the status, condition and desired values for normal operating conditions.

- (c) While the analogue input point displays the desired value, generate an alarm (where applicable).

If the analogue input point changes state from normal operating conditions to alarm condition then this test has been successful and "S" should be recorded in the commissioning schedule/inspection and test plans. If the point does not change state to alarm condition then this test has failed and "F" should be recorded in the commissioning schedule/inspection and test plans.

At the conclusion of the test return the equipment and the BMCS to displaying the status, condition and desired values for normal operating conditions.

- (d) While the analogue input point displays the desired value, simulate a fault condition at the equipment or the FPU. e.g. open circuit a data cable. (This test need only be performed on one point per virtual group).

If the analogue input point changes state and reports a fault condition and an alarm is generated on the alarm summary then this test has been successful and "S" should be recorded in the commissioning schedule/inspection and test plans. If the analogue input point does not change to fault condition or if an alarm is not generated on the alarm summary then this test has failed and "F" should be recorded in the commissioning schedule/inspection and test plans.

At the conclusion of the test return the equipment and the BMCS to displaying the status, condition and desired values for normal operating conditions.

3.9.5. Operator Terminal

The operator terminal is the human interface between the building monitoring control system and the operational building management team. The operator terminal shall be configured to run the monitoring and control routines that monitor and control the status and condition of all devices and equipment.

The specified operator terminal functions and graphics shall be tested and the results recorded in the commissioning test result sheets.

3.10. TRAINING

Provide training courses suitable for attendance by up to six operators of the digital control systems. Provide one course at the time of commissioning and provide sufficient training to allow the operators to operate the system on a normal day-to-day basis. Provide a further course approximately three months after practical completion and extend the training to cover system operation and maintenance. The minimum total period of instruction shall be seven working days.

Conduct courses on-site or off-site as required to ensure that operators receive adequate training to operate the system, as installed.

The training courses shall be conducted by trained persons totally familiar with the systems installed and with an ability to understand and explain all features of the systems.

3.11. MINOR DEFECTS

As minor defects are identified during the commissioning tests, each defect shall be rectified before proceeding to the next test. The plant, associated cabling or ducting, control equipment or software that was found to be defective will be recorded in the commissioning report.

Once rectification is complete, the control and monitoring routine shall be retested and the results recorded in the commissioning test result sheets.

3.12. POST COMMISSIONING MONITORING

The Contractor shall monitor the control system at regular intervals following its commissioning to verify that the system is operating in the intended manner. Any control system faults detected shall be rectified. Any adjustments to set points, timers, etc., deemed necessary, shall be made subject to them being first referred to the Engineer.

The system shall be monitored daily (in person or by trended points), until such time as no faults are detected and thereafter monitored monthly during the defects and liability period.

The Contractors shall make all minor adjustments to the set points and program as directed by the Engineer or UOW representative to tune the system for optimum performance and energy efficiency.

3.13. COMMISSIONING TEST RESULT SHEETS/INSPECTION AND TEST PLANS

The commissioning test result sheets/inspection and test plans shall be completed in accordance with this specification. Where monitoring and control routines need to be retested, the retest results shall be recorded. At the completion of the commissioning tests/inspection and test plans, UOW shall have one complete set of commissioning test result sheets/inspection and test plans containing all monitoring and control routines that function correctly.

The commissioning test result sheets shall contain the following information.

- Campus descriptor
- Building number
- Required completion date
- Technician carrying out the commissioning test
- Signature of the technician carrying out the commissioning test
- Date that the technician carried out commissioning test
- Name of the person approving the commissioning test
- Signature of the person approving the commissioning test
- The name or description of the controller associated with the points being commissioned

Each point being tested shall have the following information recorded in the commissioning test result sheets.

- System name of the point
- Type of point (LDI, LDO, etc)
- Description of the point
- Function of the point (Status, Value, etc)
- System address of the point
- Wiring pass/fail
- Physical function pass/fail
- Operational function pass/fail
- BMCS value
- Actual value
- Any calibration carried out on the point
- A column for the technician to add any additional comments about the point being commissioned
- Each sub-system inspection and test plan will list individual functions as pass or fail as well as an overall sub-system pass or fail.