Downtown Traffic Management System Enhancements

System Verification and Acceptance Plan

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Table of Contents

1. Introduction

The City of St. Paul is seeking to improve traffic operations in the downtown area. The management of traffic in this area involves transportation agencies at the city, county and state levels, as well as local law enforcement and businesses that generate traffic for large events. Upgrades to the traffic management system include optimized signal operations and communications capabilities, actively managing traffic incidents, providing event traffic management, and upgrading the existing traffic management center. Improving these areas are critical to maintaining a modern transportation system. These improvements would be achieved with the installation of new traffic signal controllers, fiber optic communications, Dynamic Message Signs (DMS), and traffic management center upgrades.

A general concept of operations was prepared to identify challenges with the current situation and develop corresponding needs. The needs were identified by St. Paul key stakeholders and documents relevant to the project. A system requirements document has also been developed to further identify how the stakeholder needs have been correlated with requirements that explain what the TMS must do as the basis for further design, procurement, installation, testing and operation. **This document presents a verification and acceptance plan that will be used during the design and construction phases to ensure that the system is procured, installed, and operating as specified by the system requirements.**

Testing for this project will consist of two phases: verification testing, and acceptance testing. Verification testing will be performed on system components as they are identified for procurement and incorporated into design. This will confirm that the current products meet the system requirements and will be done mainly through researching product specification documents before the system is purchased. Once the product is purchased and system integration is complete, additional testing will verify that the components have been successfully integrated before being installed in the field. The second phase, acceptance testing, will take place after the initial system components are installed. System acceptance will confirm that the purchased products fulfill the envisioned use and will be performed when the system is in its final operational environment to allow for demonstrations as the main form of testing. Once the first initial installation is accepted, all remaining installations may proceed.

The City of St. Paul will oversee all verification and acceptance testing, some of which will be led by the design team and others by the Construction Contractor(s). Five test cases are suggested for this system:

Verification Testing

1. Product Specification Review
2. Plan Set Review
3. Integration Documentation

Acceptance Testing

4. Functional Demonstration (1-Day)
5. Reliability Demonstration (30-Day)

For each test case, a recommended test environment is noted. Test procedures and validation instructions then describe which system components will be tested or demonstrated to verify the

corresponding system requirements. The test procedures also identify who will lead and recommends who should participate in each test case. Some system components will be validated at more than one point and are noted as such in the validation instructions. Test log details are also included to use during testing as formal documentation of whether the system passed or failed to meet requirements. Comments about each validation step should be entered in the log with enough detail for the Contractor(s) to make product, design, or installation modifications as necessary.

2. Verification Testing

Components for the TMS will be procured according to the system requirements and final design specifications approved by the City of St. Paul. Verification testing will occur as the components are identified for procurement to ensure requirements are met. Any items failed during verification testing will be corrected and then presented again to the City of St. Paul for final approval. Once this stage of testing is completed and approved by the City of St. Paul, product procurement may proceed. Each product should also be accompanied by manufacturer documentation of successful Factory Acceptance Testing prior to shipping. The following tables present three test cases, environment, procedures, verification instructions, relevant system requirements and logs that will be used for verification testing.

Test Case 1: Product Specification Review

Environment: Office

Procedure: As system components are identified and assessed prior to procurement, the Design team and City of St. Paul will review product specifications for requirements verification and approval. Once approved, procurement may proceed. *Most steps described in the validation instructions below will be repeated during Test Case 4. The test log has been separated to reflect multiple instances of testing.*

Participants: This test case will be led by the Design team with participation from City of St. Paul.

Validation Instructions	System Requirement	Test Log	
		Pass/ Fail	Comments
1a. Confirm that control software is **accessible via Internet Explorer or Google Chrome**. *In Test Case 4, Internet Explorer or Google Chrome browser should be opened, and software accessed via designated URL.*	1.1	**Test Case 1 Results**	
		Test Case 4 Results	
1b. Confirm that control software is a **multi-user software**. *In Test Case 4, five or more users should access the software simultaneously.*	1.2	**Test Case 1 Results**	
		Test Case 4 Results	
1c. Confirm that control software and databases are **accessible to users 24/7/365**. *In Test Case 4, users should access software during a variety of times/days of the week.*	1.3	**Test Case 1 Results**	
		Test Case 4 Results	

1d. Confirm that control software is **compatible with PostgreSQL database management**. *Reference product specifications to verify this.*	1.4	**Test Case 1 Results**
1e. Confirm that control software is **accessible to users with authorized LAN access via desktop and portable computers**. *In Test Case 4, users should access software from both desktop, laptop, and tablet (if applicable).*	1.5, 1.6	**Test Case 1 Results** **Test Case 4 Results**
1f. Confirm that control software is **accessible to authorized users via virtual private network (VPN) access**. *In Test Case 4, users should access software from outside the City of St. Paul firewall.*	1.7	**Test Case 1 Results** **Test Case 4 Results**
1g. Confirm that control software allows **authorized users to perform concurrent operation**. *In Test Case 4, two or more users should perform operations concurrently.*	1.8	**Test Case 1 Results** **Test Case 4 Results**
1h. Confirm that control software can **communicate using an Ethernet based network over fiber to communicate with field devices**. *In Test Case 4, control software should be connected to DMS via fiber.*	1.9, 1.10, 2.7	**Test Case 1 Results** **Test Case 4 Results**
1i. Confirm that control software and DMS use **NTCIP center to field communication protocols to communicate with field devices**. *Reference product specifications to verify this.*	1.11, 2.8	**Test Case 1 Results**
1j. Confirm that control software can **simultaneously monitor a minimum of 75 field devices**. *Reference product specifications to verify this.*	1.12	**Test Case 1 Results**

1k. Confirm that control software allows the **addition of field devices to accommodate future deployments**. *In Test Case 4, step through process to add a field device.*	1.13	**Test Case 1 Results** **Test Case 4 Results**
1l. Confirm that control software **controls user access with individual user identities and passwords**. *In Test Case 4, a minimum of three user identities and passwords should be established across the three specified levels of user access.*	1.14	**Test Case 1 Results** **Test Case 4 Results**
1m. Confirm that control software **maintains a record of access according to user identities for a minimum of 365 days**. *In Test Case 4, check the control software access log and verify that the access records for multiple users can be queried for up to 365 days.*	1.15	**Test Case 1 Results** Test Case 4 Results
1n. Confirm that control software allows for **three levels of operating privileges to be established**. *In Test Case 4, a minimum of three user identities and passwords should be established across the three specified levels of user access.*	1.16, 1.17, 1.18, 1.19	**Test Case 1 Results** **Test Case 4 Results**
1o. Confirm that control software **displays field device locations in a tabular format**. *In Test Case 4, confirm control software has button or toggle to show field device locations in tabular format.*	1.20	**Test Case 1 Results** **Test Case 4 Results**
1p. Confirm that control software **displays field device operational status in a table**. *In Test Case 4, confirm control software has button or toggle to show field device operational status in a table.*	1.21	**Test Case 1 Results** **Test Case 4 Results**
1q. Confirm that control software **displays field device locations on a map**. *In Test Case 4, confirm control software has button or toggle to show field device locations in map format.*	1.22	**Test Case 1 Results** **Test Case 4 Results**

1r. Confirm that control software **displays field device operational status on a map**. *In Test Case 4, confirm control software has button or toggle to show field device operational status in map format.*	1.23	**Test Case 1 Results**	
		Test Case 4 Results	
1s. Confirm that control software allows **pan and zoom capabilities of the map.** *In Test Case 4, confirm that pan and zoom functions are allowed with the map.*	1.24	**Test Case 1 Results**	
		Test Case 4 Results	
1t. Confirm that users can **define view preferences by geography and zoom level.** In Test Case 4, confirm that view preferences can be set by geography and zoom level.	1.25	**Test Case 1 Results**	
		Test Case 4 Results	
1u. Confirm that users can **view field device information by clicking on the device.** *In Test Case 4, clicking on a field device should show the following: Device Identification number, geographic location latitude and longitude, date and time stamps of last TMS communication with device, and device operational status according to active operational plan.*	1.26	**Test Case 1 Results**	
		Test Case 4 Results	
1v. Confirm that control software allows **for users with the first and second highest levels of operating privileges to click on DMS and access control functions**. *In Test Case 4, first tier users should be able to click on a DMS and create/modify operational plans that specify device actions. Both first and second tier users should be able to click on a DMS and be able to activate/deactivate operational plans.*	1.27, 1.28, 1.29, 1.30, 1.31, 1.32	**Test Case 1 Results**	
		Test Case 4 Results	

1w. Confirm that **software maintains a record of operational plan activations/deactivations according to user identities for a minimum of 365 days**. *In Test Case 4, users should be able to query a date range up to 365 days in the past showing specific user activations and deactivations of operational plans.*	1.33	**Test Case 1 Results**	
		Test Case 4 Results	
1x. Confirm that DMS comply with Minnesota Manual on Uniform Traffic Control Devices, Part 2. Signs, Chapter 2L. Changeable Message Signs, Section 2L.3. **Legibility and Visibility of Changeable Message Signs**. In Test Case 4, confirm that DMS messages are visible/legible at the distances stated in MNMUTCD Sec. 2L.3	2.1	**Test Case 1 Results**	
		Test Case 4 Results	
1y. Confirm that DMS comply with Minnesota Manual on Uniform Traffic Control Devices, Part 2. Signs, Chapter 2L. Changeable Message Signs, Section 2L. 4. **Design Characteristics of Changeable Message Signs**. In Test Case 4, confirm that DMS messages comply with MNMUTCD Sec. 2L.4	2.2	**Test Case 1 Results**	
		Test Case 4 Results	
1z. Confirm that DMS utilize a **full matrix display area**. *Reference product specifications to verify this.*	2.3	**Test Case 1 Results**	
1aa. Confirm that DMS display **full color**. *Reference product specifications to verify this.*	2.4	**Test Case 1 Results**	
1bb. Confirm that DMS have a **pixel pitch of 16 mm**. *Reference product specifications to verify this.*	2.5	**Test Case 1 Results**	
1cc. Confirm that DMS use **fiber to communicate with control software**. *In Test Case 4, confirm DMS is connected to control software via fiber.*	2.7	**Test Case 1 Results**	
		Test Case 4 Results	
1dd. Confirm that DMS uses **NTCIP center to field communication protocols to communicate with software**. *Reference product specifications to verify this.*	2.8	**Test Case 1 Results**	

1ee. Confirm that DMS allow users to **post and remove DMS messages remotely**. In Test Case 4, confirm that a remote desktop, laptop, or tablet is allowed to post and remove DMS messages.	2.11, 2.13	**Test Case 1 Results** **Test Case 4 Results**
1ff. Confirm that DMS allow users to **preview messages before posting them to the sign**. In Test Case 4, confirm that a window shows a preview of the DMS message before being posted to the DMS.	2.12	**Test Case 1 Results** **Test Case 4 Results**
1gg. Confirm that DMS allow users to **post pre-defined messages**. *In Test Case 4, "TEST MESSAGE" should be added as a pre-defined message, and then selected and posted to the DMS.*	2.14	**Test Case 1 Results** **Test Case 4 Results**
1hh. Confirm that DMS allow users to **post free-text messages**. *In Test Case 4, "TEST MESSAGE" should be entered as a free-text message, and then posted to the DMS.*	2.15	**Test Case 1 Results** **Test Case 4 Results**
1ii. Confirm that control software **automatically captures and stores City of St. Paul-operated DMS messages posted for a minimum of 365 days without operator intervention**. *Reference product specifications to verify this.*	2.16	**Test Case 1 Results**
1jj. Confirm that control software **automatically pushes email alerts to user-defined distribution lists as operational plans are activated and deactivated**. In Test Case 4, setup a distribution list with multiple emails, then activate an operational plan and confirm emails are received.	3.1, 3.2	**Test Case 1 Results** **Test Case 4 Results**
1kk. Confirm that control software allows **automatic push email alert feature to be turned on or off**. In Test Case 4, identify toggle or setting that allows automatic push email alerts to be turned on/off.	3.3	**Test Case 1 Results** **Test Case 4 Results**

1ll. Confirm that control software allows **manually pushed email alerts to user-defined distribution lists as needed**. In Test Case 4, verify that a user-distribution list is able to be selected when manually pushing email alerts.	3.4	**Test Case 1 Results** **Test Case 4 Results**
1mm. Confirm that control software allows **creation of user-defined distribution lists for push email alerts**. In Test Case 4, confirm ability to create a custom distribution list in control software.	3.5	**Test Case 1 Results** **Test Case 4 Results**
1nn. Confirm that signal performance measure software allows **data logging of SPMs from traffic controller**. *In Test Case 4, user should be able to toggle data logging on/off and receive a log of signal performance measures from the traffic controller.*	4.1	**Test Case 1 Results** **Test Case 4 Results**
1oo. Confirm that signal performance measure software allows **automatic analyzing of signal performance measures and reporting**. *In Test Case 4, user should be able to toggle automatic analyzing of signal performance measures.*	4.2	**Test Case 1 Results** **Test Case 4 Results**
1pp. Confirm that signal performance measure software is **accessible via Internet Explorer or Google Chrome**. *In Test Case 4, Internet Explorer or Google Chrome browser should be opened, and software accessed via designated URL.*	4.3	**Test Case 1 Results** **Test Case 4 Results**
1qq. Confirm that signal performance measure software is a **multi-user software**. *In Test Case 4, five or more users should access the software simultaneously.*	4.4	**Test Case 1 Results** **Test Case 4 Results**
1rr. Confirm that signal performance measure software and databases are **accessible to users 24/7/365**. *In Test Case 4, users should access software during a variety of times/days of the week.*	4.5	**Test Case 1 Results** **Test Case 4 Results**

1ss. Confirm that traffic signal controller includes **support for Bus Rapid Transit operations.** In Test Case 4, confirm that traffic controller has additional inputs/programming that can be utilized for Bus Rapid Transit operations.	5.1	**Test Case 1 Results** **Test Case 4 Results**
1tt. Confirm that traffic signal controller includes **support for Light Rail Transit operations.** In Test Case 4, confirm that traffic controller has additional inputs/programming that can be utilized for Light Rail Transit operations.	5.2	**Test Case 1 Results** **Test Case 4 Results**
1uu. Confirm that traffic signal controller has capability to **record high resolution data that is recorded in at least 0.1 second increments.** In Test Case 4, confirm data obtained from traffic signal controller shows data points in at least 0.1 second increments.	5.3	**Test Case 1 Results** **Test Case 4 Results**
1vv. Confirm that traffic signal controller **supports Signal Performance Measures/Metrics by providing high resolution data logging capabilities**. In Test Case 4, confirm traffic controller allows signal performance metrics to be collected in high resolution increments.	5.4	**Test Case 1 Results** **Test Case 4 Results**
1ww. Include traffic signal controllers that are **compatible with Econolite Centracs software**. In Test Case 4, use Econolite Centracs software to interact with traffic signal controller.	5.5	**Test Case 1 Results** **Test Case 4 Results**

Test Case 2: Plan Set Review

Environment: City of St. Paul Meeting Room

Procedure: After detailed design is complete, the City of St. Paul will review with the design team a completed plan set for the system installation to validate requirements and approve. Once approved, procurement may proceed. Review and approval of plan sets will occur in preparation for a bid letting that will procure equipment for the integration demonstration. This test case emphasizes the need for all plans to be reviewed and approved prior to field installation of equipment. *All of the validation steps in this test case will be repeated in Test Case 4. The test log has been separated to reflect both instances of testing.*

Participants: This test case will be led by the Design Contractor and should include, at a minimum, City of St. Paul. Additional participants may include Minnesota Department of Transportation (MnDOT), Ramsey County, and Metro Transit.

Validation Instructions	System Requirement	Test Log	
		Pass/ Fail	Comments
2a. Confirm that DMS will **be overhead mounted to accommodate installation site characteristics.** In Test Case 4, visually confirm that DMS are overhead mounted.	2.6	**Test Case 2 Results**	
		Test Case 4 Results	
2b. Confirm that DMS operates on **120/240 Volts AC**. *In Test Case 2, power from local utility should be verified on plan set. In Test Case 4, confirm in cabinet/breaker that DMS is using 120/240V AC power.*	2.9	**Test Case 2 Results**	
		Test Case 4 Results	
2c. Confirm that DMS is **protected from degradation of power with voltage surge suppression**. In Test Case 4, verify that DMS is powered through a surge suppression device.	2.10	**Test Case 2 Results**	
		Test Case 4 Results	

Test Case 3: Integration Demonstration

Environment: City of St. Paul Facility

Procedure: Once the system components have been procured and integrated, the Construction Contractor(s) will demonstrate the system integration for City of St. Paul prior to initial installation. The demonstration will take place at a St. Paul facility to simulate the installation environment. The Construction Contractor(s) will integrate at least one DMS, at least one traffic signal controller, and the corresponding control and signal performance measure software. All system features (e.g. posting DMS messages, analyzing signal performance measures, etc.) should be activated and observed for requirements validation and approval during the demonstration. Once approved, the remaining integration may proceed. *All of the validation steps in this test case will be repeated in Test Case 4. The test log has been separated to reflect both instances of testing.*

Participants: This test case will be led by the Construction Contractor(s) and should include, at a minimum, City of St. Paul. Additional participants may include Ramsey County.

Validation Instructions	System Requirement	Test Log	
		Pass/ Fail	Comments
3a. Confirm that control software allows **authorized user access to field devices operated by City of St. Paul**. *Access to DMS should be demonstrated.*	1.9	**Test Case 3 Results**	
		Test Case 4 Results	
3b. Confirm that control software **displays field device locations in a tabular format**. *In Test Case 3 & 4, confirm control software has button or toggle to show field device locations in tabular format.*	1.20	**Test Case 3 Results**	
		Test Case 4 Results	
3c. Confirm that control software **displays field device operational status in table**. *In Test Case 3 & 4, confirm control software has button or toggle to show field device operational status in a table.*	1.21	**Test Case 3 Results**	
		Test Case 4 Results	
3d. Confirm that control software **displays field device locations on a map**. *In Test Case 3 & 4, confirm control software has button or toggle to show field device locations in map format.*	1.22	**Test Case 3 Results**	
		Test Case 4 Results	
3e. Confirm that control software **displays field device operational status on a map**. *In Test Case 3 & 4, confirm control software has button or toggle to show field device operational status in map format.*	1.23	**Test Case 3 Results**	
		Test Case 4 Results	

3f. Confirm that control software allows **map pan and zoom capabilities**. *In Test Case 3 & 4, confirm that pan and zoom functions are allowed with the map.*	1.24	**Test Case 3 Results**	
		Test Case 4 Results	
3g. Confirm that control software allows users to **define view preferences by geography and zoom level**. In Test Case 3 & 4, confirm that view preferences can be set by geography and zoom level.	1.25	**Test Case 3 Results**	
		Test Case 4 Results	
3h. Confirm that control software **displays the following details when a user clicks on a device**: • Device identification number • Geographic location of device by latitude and longitude • Date and time stamp of last TMS communication with device • Device operational status according to active operational plan	1.26	**Test Case 3 Results**	
		Test Case 4 Results	
3i. Confirm that control software allows **users with the first and second highest levels of operating privileges to click on a device to access its control functions**. *In Test Case 3 & 4, first tier users should be able to click on a DMS and create/modify operational plans that specify device actions. Both first and second tier users should be able to click on a DMS and be able to activate/deactivate operational plans.*	1.27, 1.28, 1.29, 1.30, 1.31, 1.32	**Test Case 3 Results**	
		Test Case 4 Results	
3j. Confirm that control software **maintains a record of operational plan activations and deactivations according to user identities for a minimum of 365 days**. *In Test Case 3 & 4, users should be able to query a date range up to 365 days in the past showing specific user activations/deactivations of operational plans.*	1.33	**Test Case 3 Results**	
		Test Case 4 Results	
3k. Confirm that signal performance measure software allows **data**	4.1	**Test Case 3 Results**	

logging of SPMs from traffic controller. *In Test Case 3 & 4, user should be able to toggle data logging on/off and receive a log of signal performance measures from the traffic controller.*		**Test Case 4 Results**	
3l. Confirm that signal performance measure software allows **automatic analyzing of signal performance measures and reporting.** *In Test Case 3 & 4, user should be able to toggle automatic analyzing of signal performance measures.*	4.2	**Test Case 3 Results**	
		Test Case 4 Results	
3m. Confirm that signal performance measure software is **accessible via Internet Explorer or Google Chrome.** *In Test Case 3 & 4, Internet Explorer or Google Chrome browser should be opened, and software accessed via designated URL.*	4.3	**Test Case 3 Results**	
		Test Case 4 Results	
3n. Confirm that traffic signal controller **supports Signal Performance Measures/Metrics by providing high resolution data logging capabilities.** In Test Case 3 & 4, confirm traffic controller allows signal performance metrics to be collected in high resolution increments.	5.4	**Test Case 3 Results**	
		Test Case 4 Results	

3. Acceptance Testing

This stage of testing will include a functional (1-day) test and a reliability (30-day) test to be conducted at the initial installation. The functional test will be conducted to demonstrate that all system requirements are adequately met. For the remaining installation, reliability tests will be conducted to validate that the systems are properly installed and operate as required. The following tables present two test cases, environment, procedures, validation instructions, relevant system requirements and log that will be used for system acceptance testing.

Test Case 4: Functional Demonstration (1-Day) **Environment:** Installation Sites **Procedure:** Once the installation is complete, the Construction Contractor(s) will schedule 1-day functional demonstration to allow for City of St. Paul observation under dawn/dusk lighting and peak/off-peak traffic conditions. The demonstration will require at least one vehicle to drive around the installation sites and observe component activations for requirements validation and approval. Authorized access from computers at City of St. Paul will be required to operate and observe control software performance for validation and approval. *All of the validation steps in this test case will be conducted first in Test Case 1, Test Case 2 or Test Case 3. The instructions and test log have been included in the previous test cases respectively to reflect the multiple instances of testing.* **Participants:** This test case will be led by the Construction Contractor(s) and should include City of St. Paul. Additional participants may include Ramsey County.
Validation Instructions
4a. **Repeat validation steps 1a-1c, 1e-1h, 1k-1y, 1cc, 1ee-1hh, and 1jj-1ww** as described in Test Case 1. Record results in test log also provided under Test Case 1.
4b. **Repeat ALL validation steps** as described in Test Case 2. Record results in test log also provided under Test Case 2.
4c. **Repeat ALL validation steps** as described in Test Case 3. Record results in test log also provided under Test Case 3.

Test Case 5: Reliability Demonstration (30-Day)

Environment: Installation Sites

Procedure: Following completion of Test Case 4, City of St. Paul will continue operation of the system for another 30 days to demonstrate reliability and validate the associated requirements. During this period, signs may be unavailable for driver interaction. Each day City of St. Paul will validate default operation of all DMS, traffic signal controllers, and the corresponding control and signal performance measure software. City of St. Paul will also activate at least one operational plan to validate the prescribed operation of all DMS. *All of the validation steps in this test case have been conducted in previous test cases. Because these steps must be completed each day for 30 days, the instructions and test log entries are provided to accommodate documentation of pass/fail status for each day.*

Participants: This test case will be led by City of St. Paul with participation from the Construction Contractor(s).

Validation Instructions	System Requirement
5a. Confirm that control software allows **users with the first highest level of operating privileges to create, modify, activate and deactivate operational plans**.	1.27, 1.28, 1.29, 1.30, 1.31, 1.32

Test Log

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21	Day 22	Day 23	Day 24	Day 25	Day 26	Day 27	Day 28	Day 29	Day 30
Comments																														
Pass/Fail																														

Validation Instructions	System Requirement
5b. Confirm that control software allows **users to post and remove DMS messages remotely**.	2.11, 2.13

Test Log

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21	Day 22	Day 23	Day 24	Day 25	Day 26	Day 27	Day 28	Day 29	Day 30
Comments																														
Pass/Fail																														

Validation Instructions	System Requirement
5c. Confirm that signal performance measure software allows data logging of SPMs from traffic controller.	4.1

Test Log

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21	Day 22	Day 23	Day 24	Day 25	Day 26	Day 27	Day 28	Day 29	Day 30
Comments																														
Pass/Fail																														