Section 1: General Information

Project Name	Cell phone remote for scoring box
Prepared By	Joe and Jane Tester
Date Submitted	April 1, 20xx
Version Number	1
Proposed Start Date	TBD
Anticipated Completion Date	TBD
Testing Level	National Event – RF Environent

Section 2: Objective & Scope

Objective:

National event testing of RF environment. Evaluate connectivity of blue tooth communications with cell phone based app to control the scoring machine in its operational environment.

Scope:

The test will involve connecting a transmitting device to the scoring machine to relay the signals to a paired cellular device and measure the integrity of the signal in an operational environment. Testing will be only done on a single strip and involve running a scoring machine through the various conditions (e.g. start/stop the clock, registering of touches, changing the scoring, etc) during a foil bout and monitoring connectivity to the cellular device and accuracy of the data received. The testing will be performed at various locations relative to the scoring machine. The test will be passive in that the scoring machine will only provide an output data stream.

Section 3: Test Description

Test Type	RF Environment at National Event
Test Environment	Operational environment with many users and RF interferes. A Bluetooth communication protocol will be used to transmit data. Required equipment: scoring box, Bluetooth module to connect to scoring box, cellular receiver equipped with software to monitor connectivity of signal with module, data recorder of signals supplied to the Bluetooth module from the scoring machine, 2 RF spectrum analyzer.
Test Inputs	Input is a data stream from [type or brand] scoring box to be transmitted. Variables being monitored are the connectivity of signal throughout the test, accuracy of received data, and RF environment.
Test Procedure	The connectivity of the Bluetooth signal and the RF environment will be measured at a variety of locations relative to the scoring machine. If there is adequate connectivity the scoring machine will be run through

	various states (i.e. start/stop of the clock, change of score, registering of touches, etc.) while monitoring connectivity, accuracy of data stream received on the cellular device, and RF environment.
Expected Outcomes	It is expected that connectivity will fail outside of 10m from scoring machine. At locations with adequate connectivity it is expected that the Bluetooth signal will maintain 95% connectivity with the cellular device and receive 100% of the scoring machine outputs.
Test Methodology	Measure the connectivity of the Bluetooth signal and data integrity in presence of changing RF environment at a variety of locations around the strip. Assess connectivity at various locations to validate that connectivity can maintained in the areas where the referee will primarily be and where connectivity falls off. Compare timestamped received data with timestamped transmitted data and with timestamped RF environment data to validate accuracy of what is received.

Test Setup:

A diagram of the basic test setup is shown in figure 1. The setup is comprised of two nodes: the base node and a mobile node. The base node is located at the scoring machine is comprised of the Bluetooth module, a spectrum analyzer, and a data recording computer. The Bluetooth module will be fed a data stream from a scoring machine. The spectrum analyzer will be used to measure the RF power levels in the Bluetooth frequency band. The data recording computer will be used to record the connectivity data from the Bluetooth module, the RF power in the Bluetooth spectrum from the spectrum analyzer, and the output data stream from the scoring machine. The computer will be connected to local Wi-Fi or a cellular network to receive a GPS time sync in order to time stamp the recorded data. The mobile node is comprised of a cellular device and a RF spectrum analyzer. The cellular device at the mobile node will be paired with the Bluetooth module at the base node. The data stream will be transmitted to the cellular device. This will be time stamped with synced GPS time signal. The spectrum analyzer will measure the RF power in the Bluetooth spectral band. The cellular device will record the following data at the mobile node: the Bluetooth connectivity, the data received, and RF power in the Bluetooth spectrum from the spectrum analyzer.

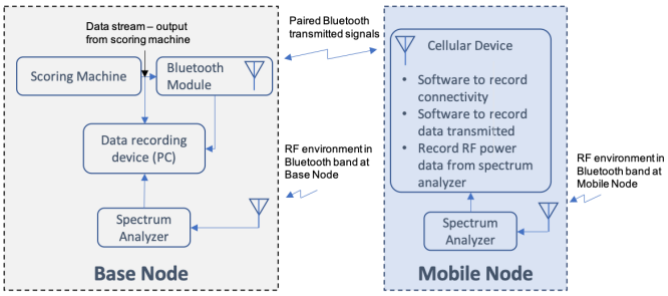

Figure 1. Test setup block diagram showing the components of the base node and the mobile node and the flow of data.

The mobile node will be moved to a variety of locations as shown in Figure 2 and detailed in Table 1. At. Each location the connectivity will be measured. If there is adequate connectivity the scoring machine will run through a series of states as described in a separate excel file included with this packet. An example of the test steps is shown below. The primary changing variables will be the data output stream from the scoring machine and RF environment at each location. The RF environmental conditions will vary as people gather to watch the bout and walk by and around the test area.

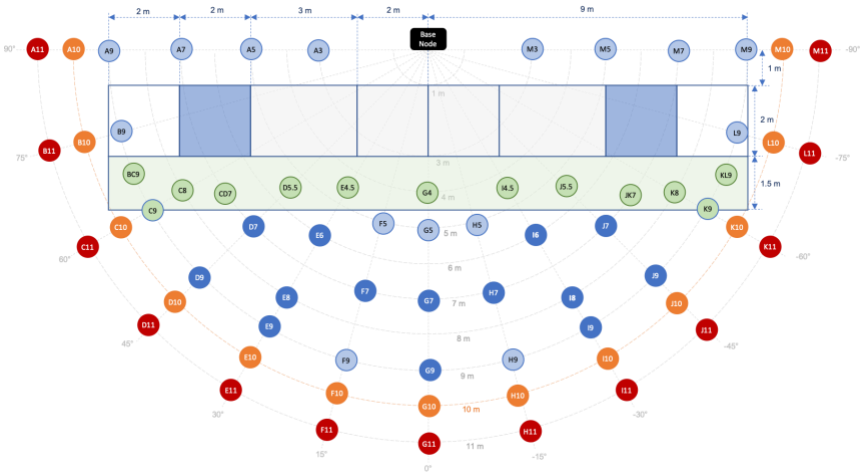

Figure 2. Test locations for the mobile node. Orange represents expected limit of class Bluetooth. Red is expected out of range. Blue and Green is expected good connectivity. Green is primary referee area. Dark blue locations represent audience locations where connectivity data will be taken during a bout.

Table 1. Position of locations for the mobile node relative to the Base node. Orange is the expected max range for connectivity based on previous laboratory testing. Red is expected to not have connectivity. Blue and Green are expected to have connectivity and have all mode test run. Green represents primary location area of the referee. Dark blue locations represent audience locations where connectivity data will be taken during a bout

Distance (m)	Angle																
	90°	75°	67.5°	60°	52.5°	45°	30°	15°	0°	-15°	-30°	-45°	-52.5°	-60°	-67.5°	-75°	-90°
3	A3																M3
4									G4								
4.5							E4.5				I4.5						
5	A5							F5	G5	H5							M5
5.5						D5.5						J5.5					
6							E6				I6						
7	A7				CD7	D7		F7	G7	H7		J7	JK7				M7
8				C8			E8				I8			K8			
9	A9	B9	BC9	C9		D9	E9	F9	G9	H9	I9	J9		K9	KL9	L9	M9

10	A10	B10		C10		D10	E10	F10	G10	H10	I10	J10		K10		L10	M10
11	A11	B11		C11		D11	E11	F11	G11	H11	I11	J11		K11		L11	M11

Data Collection:

Data will be collected every 8 mSec. This is the polling rate of the computer and mobile device of the Bluetooth data.

The scoring machine outputs the following data: time on the clock, period, status of the lights (RWWG), and score (left, right). An example data packet would be [CLK time (in 10ths/sec, period, R, Wleft, Wright, G, score left, score right].

Connectivity of Bluetooth signals is measured using a Received Signal Strength Indicator (RSSI). The RSSI typically is measured in decibels (dBm). A value greater than -40dBm is considered excellent. A value between -40dBm and -70dBm is considered good. A value less than -70dBm will likely cause connection failures. Per the laboratory experiments previously done some connectivity can occur down to -90dBm with intermittent data transferred. Below -90dBm the Blue connectivity completely fails and no data is transmitted. For the purpose of this experiment -90dBm will be considered the no connectivity threshold.

RF power in the band between xxMHz and yyMHz is integrated to provide a total power number measured in mW. Examples of the spectrum content will taken every second.

Section 4: Detailed Test Plan and Schedule

Detailed test plan is as follows:

1. Setup: Setup base node and mobile node.

Test Step	Description	Variable being changed	Data recorded	Responsible Party	Estimated Duration	Dependencies
1)	Setup Base Node	none	none	Joe and Jane Tester	20 min	
1.1)	connect interface module to scoring machine	none	none	Joe and Jane Tester	5 min	
1.2)	Setup and configure RF spectrum analyzer	none	none	Joe and Jane Tester	5 min	
1.3)	Set up and configure data collection computer	none	none	Joe and Jane Tester	5 min	
1.4)	Validate PC is getting data from scoring machine, Bluetooth module, and RF	none	none	Joe and Jane Tester	5 min	

	spectrum analyzer					
2)	Setup Mobile node				30 min	
2.1	Setup and configure cellular device	none	none	Joe and Jane Tester	5 min	
2.2	Setup and configure spectrum analyzer	none	none	Joe and Jane Tester	5 min	
2.3)	Confirm Bluetooth pairing between cellular device and base node	none	none	Joe and Jane Tester	5 min	
2.4)	Validate date is being recorded on cellular device	none	none	Joe and Jane Tester	5 min	
2.5)	Turn on and configure scoring machine	None	none	Joe and Jane Tester	5 min	
2.6)	Confirm data is being sent and received. Verify data recording is working	none	none	Joe and Jane Tester	5 min	Data output from scoring box to module
3)	Mark and label position for mobile node with tape	None	none	Joe and Jane Tester	15 min	

2. At each location in shown in figure 2 and detailed in Table 1 the following process will be used. This will be done in non-bouting conditions and establish base line at each location.
    a. Measure and record connectivity and RF Spectrum data at both base and mobile nodes for 120sec.
    b. If connectivity is greater than -90dBm proceed to run the following test procedures:
        i. Foil mode
        ii. Epee mode
        iii. Saber mode

Example foil mode procedure is shown. Epee and Saber modes are similar and can be found in provided excel workbook.

Test Step	Description	Variable being changed	Data recorded	Responsible Party (min)	Estimated Duration	Dependencies
2)	Test Foil mode – set scoring machine to foil mode	Scoring machine output data & RF environment	- Scoring machine output stream - Connectivity - Received data - RF Environment	Joe and Jane Tester	27	Data output from scoring box to module

2.0)	Begin test - start monitoring data stream being transmitted for connectivity and accuracy	Monitoring connectivity and received data	- Scoring machine output stream - Connectivity - Received data - RF Environment	Joe and Jane Tester	3	
2.1)	Start stop time on scoring machine	Scoring machine output data	- Scoring machine output stream - Connectivity - Received data - RF Environment	Joe and Jane Tester	3	
2.2)	Change score on scoring machine	Scoring machine output data	- Scoring machine output stream - Connectivity - Received data - RF Environment	Joe and Jane Tester	3	
2.3)	Single valid touch registered	Scoring machine output data	- Scoring machine output stream - Connectivity - Received data - RF Environment	Joe and Jane Tester	3	
2.4)	Single off target touch register	Scoring machine output data	- Scoring machine output stream - Connectivity - Received data - RF Environment	Joe and Jane Tester	3	
2.5)	Two valid touches registered	Scoring machine output data	- Scoring machine output stream - Connectivity - Received data - RF Environment	Joe and Jane Tester	3	
2.6)	one valid touch and one off target touch registered	Scoring machine output data	- Scoring machine output stream - Connectivity - Received data - RF Environment	Joe and Jane Tester	3	
2.7)	Reset scoring machine	Scoring machine output data	- Scoring machine output stream - Connectivity - Received data - RF Environment	Joe and Jane Tester	3	
2.8)	Arm disarm scoring machine	Scoring machine output data	- Scoring machine output stream - Connectivity - Received data	Joe and Jane Tester	3	

			- RF Environment			
2.9)	End test	None	n/a	Joe and Jane Tester	n/a	

3. Run tests for actual bouts recorded results will be for locations in green in figure 2 and table 1. Data streams, connectivity, RF power will be recorded as the referee moves through out their area for the entirety of the bout. Ideally there would be a large crowd viewing so that the RF power levels vary during the bouts. See provided workbook for specific steps.
    b. Foil bout.
    c. Saber Bout
    d. Epee bout
4. Run test for bouts with measurements for the mobile taken at the following locations with white numbers in figure 2 and table 1. Data streams, connectivity, RF power will be recorded at both nodes each location for 60 sec before moving to the next location. Recommended order E6, D7, E8, F7, G7, G9, E9, D9, I9, J9, J7, I6, H7, I8. Ideally there would be a large crowd viewing so that the RF power levels vary during the bouts. See provided workbook for specific steps.
    e. Foil bout
    f. Epee bout
    g. Saber bout

Section 5: Risk Assessment

Risk	Likelihood	Impact	Mitigation Strategy
Bluetooth module interferes with scoring machine operation	Low	Prevents bout from proceeding	Remove Bluetooth module, halt testing

Section 6: Resources Required

	Requested	Test Team to provide
Personnel	None	2 operators to run test
Equipment/ Tools	- scoring machine	- transmitter module - cellular device - RF spectrum analyzer - data recording computer - data recording software on cellular device
Facilities/ Environments	strip in a pod at a national event	n/a

Budget Estimate (if applicable)	???	???

Section 7: Data Collection & Reporting

Data to be Collected	- Connectivity - received data - RF Environment
Reporting Format	summary report and graphical presentation of monitored data over time
Responsible Parties for Analysis	Joe and Jane Tester reporting to SEMI Liaison

Section 8: Approval

Name	Role	Signature	Date
Member SEMI	SEMI Tech Lead		April 15, 20xx

Appendix: Summary of previous test results

Bluetooth module has been tested and verified to work with cellular device in a small scale environment with scoring machine XYZ. Data was successfully transmitted and received continuously with 99% connectivity and 100% accuracy over a two-hour period with little RF interference in the Bluetooth frequency bands. The test configuration was identical to that proposed here. See test report attached.