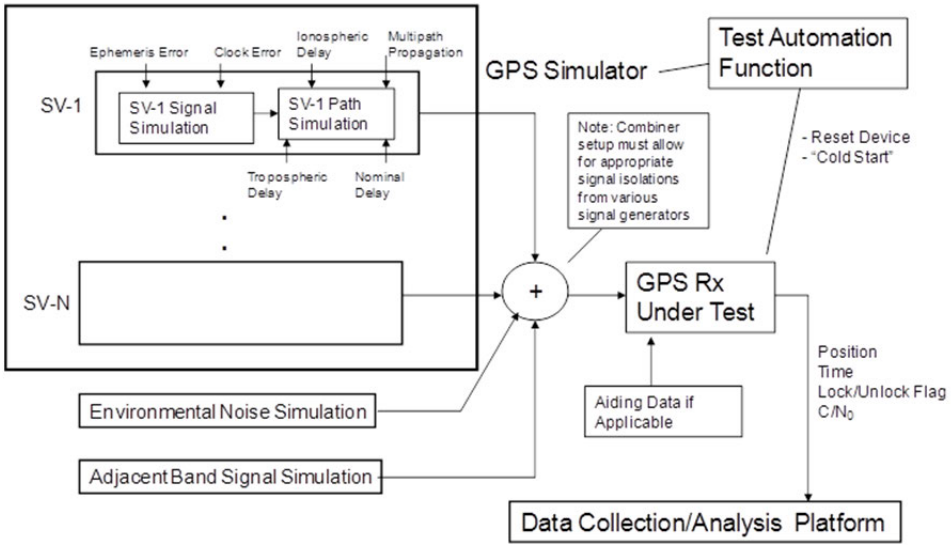
Statement of Work

for Volpe Center Execution of DOT GPS Adjacent Band Compatibility Testing Program

Development of Test Plan	Volpe to produce a finalized test plan document by April 15, 2015, which will contain the following:
	
	• Detailed process for conducted testing or (less preferred) radiated testing of GPS devices within an anechoic chamber, including:
	  o A defined number of satellite vehicles (SVs) presented per test procedure
	  o A single 10 MHz LTE channel from 1526-1536 MHz will be simulated operating at a range of power, measured at the GPS receiver[1], that is sufficient to either cause the device to exceed the highest established threshold of position/timing error and change in C/N_0 as discussed below, or sufficiently large to represent 32 dBW of peak transmit EIRP from a macro-cellular base station antenna, whichever is less.
	  o Use of a large number of position measurements and statistical processing thereof
	  o Definition of accuracy metric: 2D position error
	  o SV signal errors (clock, ephemeris)
	  o Ionospheric/troposhperic delay error models
	  o Multipath profiles
	  o Representative environmental noise
	  o Different distributions of SV signal levels corresponding to different operating scenarios
	  o HDOP (dilution of precision) range: as per defined scenarios
	  o Consideration of time to provide position fix
	• Schematics for the RF-setup and transmit components to emulate GPS signals and LightSquared transmissions concurrently as depicted in the image below:
	 

[1] For conducted testing, this would occur at the device antenna connector; for radiated testing, this point would be at the point closest to the GPS antenna that is most practical to measure.

	• All testing will be performed in the manner prescribed above and will be accomplished either by qualified engineers on staff at Volpe or by a suitably qualified third-party laboratory that has been deemed by Volpe to have no conflicts-of-interest in undertaking all of the assigned tasks. • This test plan should address spectrum in the licensed blocks up to 50 MHz below the GPS L1 center frequency of 1575.42 MHz.

Issues Record	Volpe to create an "Issues Document" that memorializes all questions and issues, in the manner detailed below, that are raised during the course of the public workshops, or otherwise communicated to Volpe and OST-R.
	
	• Description of issue
	• Identity of organization raising issue
	• Submission date
	• Initial qualification of issue by submitter (question, objection, correction, etc.)
	• Expected resolution date
	• Assigned DOT decision-maker
	• Information re: resolution process
	  o Detail any additional information requested by Volpe or DOT to any party
	  o Detail any non-public discussions with external stakeholders by DOT or Volpe
	• Actual resolution, explanation and date entered
	
	The Issues Document will be updated and released by Volpe on a weekly basis.

Conduct of Testing Program	Based on experience in commissioning testing, the following statement of work should lead to the collection of a complete data set and possible recommendations that can be of some use in any appropriate regulatory proceeding at the Federal Communications Commission. Although typically testing of the sort proposed by the Department of Transportation is done under the auspices of the FCC, in the event that the DOT wishes to commission Volpe Center to examine the impact of licensed uses of certain spectrum on GPS devices, the work ought to be done according to the practices described in this document.
Devices to be Tested	DOT should cause GPS firms to produce to Volpe for testing the following devices: • The ten (10) top selling device models in the United States for the calendar year 2014. In addition GPS manufacturers will provide Volpe with the identities of their top selling models for each of the years 2004-14, along with the percentage of these devices that the manufacturer believes are still in operation. To the extent that Volpe determines that a particular receiver still has a significant current user base, Volpe may elect to require the GPS manufacturer to provide such units for testing. Finally, GPS manufacturers shall provide Volpe with test samples for newly released and soon-to-be released devices which the manufacturer reasonably expects to be a top seller within the 2015 calendar year. Estimates, if available, of the number of such devices currently in use. • A statement regarding the intended use of the device and a description of the nominal usage mode (*e.g.*, hand held, mounted on dashboard inside a car, mounted on a farm tractor cab, etc.) • For each device, the band-pass filter will be described in detail.

	• The azimuth and elevation antenna pattern for each model that is submitted for testing. • Sales figures for the above models, attested to by an officer of the manufacturer, which validate the models' position within the top-ten ranking; such information will be treated consistent with the confidentiality policy described further in this document. • Two (2) test-ready devices for each model with a description of how the devices were obtained and a certification stating that the devices are actual production models that have not been damaged or altered in any way. • Additional test devices for the same model may be required to be submitted should the original two devices not produce test results that are consistent among the two devices according to Volpe's tolerance standards which will be detailed in the test plan. • Two (2) test-ready devices for each model that can be tested by LightSquared or any other firm interested in comparing its results with Volpe's.
Device Validation	Confirmation testing will be conducted to ensure that the pair of GPS devices presented for testing deliver similar results within tolerances defined by Volpe in its test plan. If the difference in results exceeds the established tolerances, then the the manufacturer will provide two additional devices for conformational testing with final testing occurring between two devices that produce results within the tolerance difference prescribed by Volpe in its test plan.
Test Measurements	The testing facility will obtain baseline measurements of device position or timing (as appropriate) as well as the device-reported level of C/N_0 in the defined environment absent of LightSquared's LTE signal. For each change in the LightSquared transmit power level, the testing facility will record the LightSquared power level *at the GPS device receive antenna* and the change (if any) in a device's mean position accuracy. The device testing should include sufficient samples of position/time estimates that both the mean value of the 2D position error and its centralized standard deviation have converged. Testing should continue until the mean error, in the presence of the adjacent band signal, has increased by either 25% or 2-sigma, whichever is greater, where the increase is relative to a baseline established in the absence the adjacent band signal. The testing facility will examine the use case for each device and report on whether under test conditions the predicted use for commercial purposes was materially affected by use of adjacent spectrum blocks. Material will mean inaccuracies in positioning or timing that might cause a consumer or user to be unable to use the device for its purpose for reasonably long period of time and while at a reasonable distance from a base station. If the testing facility also will record the LightSquared power level necessary, *at the GPS device antenna*, to cause changes in the signal to noise ratio, then it should measure the device under test to register changes of 1, 3, 6, 10 and 20 dB C/N_0 compared to the baseline measurement. Volpe's test plan will provide additional detail regarding test procedures such as power increments, necessary dwell time, etc.
Confidential Materials	The attached Confidentiality and Non-Disclosure Agreement will be used so all interested parties can protect and access confidential information.

Evaluation of Test Results	• Test results for individual devices will be publicly released on a rolling basis as testing for each device is completed. • Adjacent band power "masks" will be created by Volpe that account for different selections of devices as described below: 1) Results from all devices tested 2) Results from devices that exclude the least-resilient 15% of GPS devices 3) Results from devices that represent the top 50% of devices tested in terms of resiliency to adjacent band power
Timeline	See the attached Gantt Chart for schedule of work.

Project Timeline

March - September 2015

	Begin Date	End By
Test Plan Finalization	**3/16/2015**	**5/4/2015**
Redraft of Test Plan	3/16/2015	4/6/2015
Circulation and Comment	4/6/2015	4/20/2015
Interim Test Plan Preparation and Release	4/20/2015	5/4/2015
Device Selection	**4/6/2015**	**5/18/2015**
Selection Criteria Finalized	4/6/2015	4/27/2015
Manufacturer Device Collection	4/27/2015	5/11/2015
Volpe Device Intake	5/11/2015	5/18/2015
Lab Setup	**3/23/2015**	**5/25/2015**
Software Development for Data Collection	4/20/2015	5/25/2015
Rerserve Lab Facilities	3/23/2015	4/13/2015
Rent Lab Equipment (if Necessary)	4/13/2015	4/27/2015
Lab Setup	4/27/2015	5/11/2015
Test / Fine Tune Lab Setup	5/11/2015	5/18/2015
Issue Final Test Plan	5/18/2015	5/25/2015
Device Testing	**5/25/2015**	**8/24/2015**
Test Group 1	5/25/2015	6/15/2015
Group 1 Results Released	6/17/2015	
Test Group 2	6/15/2015	7/6/2015
Group 2 Results Released	7/8/2015	
Test Group 3	7/6/2015	7/20/2015
Group 3 Results Released	7/22/2015	
Test Group 4	7/20/2015	8/3/2015
Group 4 Results Released	8/5/2015	
Test Group 5	8/3/2015	8/17/2015
Group 5 Results Released	8/19/2015	
Overflow/Retest	8/17/2015	8/24/2015
Overflow/Retest Results Released	8/26/2015	
Analysis of Results	**8/24/2015**	**9/28/2015**
Volpe Analysis of Test Results	8/24/2015	9/28/2015
Volpe Release of Mask Data	9/30/2015	
Transmit to NTIA for Filing with FCC	9/30/2015