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LEO PNT: DEVELOPING SIMULATION ENVIRONMENTS ALONGSIDE NEW LEO CONSTELLATIONS

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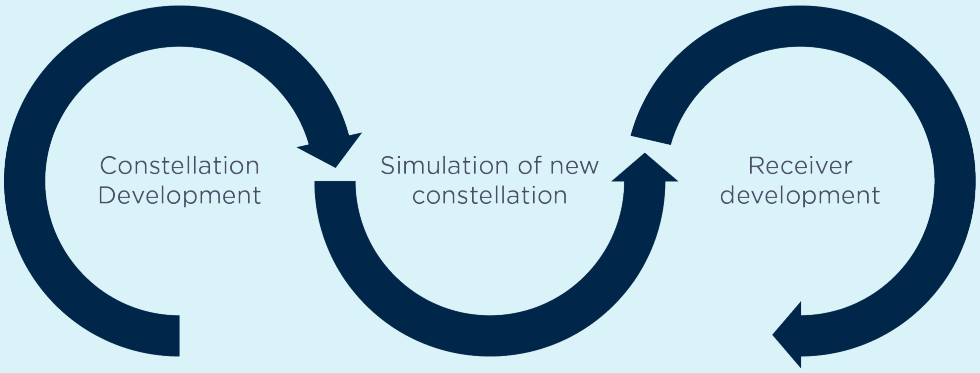
WHITE PAPER

Simulation Environments and LEO PNT

As more technology utilizes satellites for PNT information, it is integral to develop ways to test the functionality of PNT systems before they are deployed.

It has become increasingly useful to develop a test environment for LEO constellations alongside the development of the constellations themselves. A flexible simulation system that can evolve is best equipped for the advent of new LEO constellations.



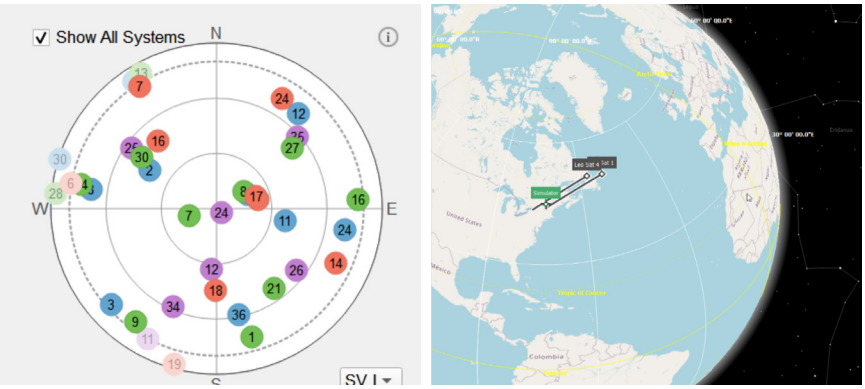
Developing simulation hand in hand with developing the constellation itself has several advantages. Simulation can be implemented at various stages of the process. By developing new constellations and simulation simultaneously, the PNT system can be thoroughly tested before the satellites are deployed. This can further streamline the process between the developers of the constellation and the receivers with quick feedback loops to assist in the design. It can lead to increased communication with the receiver developers and give more insight in addition to modeling. It also means that simulation capability can be available along with the introduction of the constellation itself. In the past, there have been instances of the constellation being deployed but there being few ways for the receiver manufacturers to test their solutions, slowing down the development process. By testing using simulation, developers can test functionality early in the development process, rather than awaiting deployment of the constellation for the chance to field test; receivers and systems can be tested during development for common problem scenarios, such as GPS denied environments via canyons or other outages as well as other types of vulnerabilities. This can give developers a head-start in vetting potentially unforeseen issues the receiver may experience using the new constellation. After implementation simulation can be used to repeat any problems encountered in field tests for faster and more effective testing. Fixes can be implemented in a lab setting before going out again for field testing. This can save time and resources, as there is no need to go all the way to the field test stage every time a problem arises or to test a fix. Using a simulation test bed helps to speed up the development process and to save time and money throughout.

The BroadSim product line provides a dynamic simulator within its software-defined architecture. It is "future-proof" as it can grow and change with new constellations or changes in old ones. It also takes advantage of commercial off-the-shelf (COTS) products to increase system performance. This means two things; one, rather than focusing on hardware improvements, the engineers can focus on the simulation side of the system. Two, upgrade cycles are possible more frequently. BroadSim provides open-source libraries and plug-ins to increase the capability of their simulation solution. One major benefit of software-defined simulation systems regarding LEO constellations is that the GPU can handle the generation of more signals than a traditional FPGA-driven simulation solution. This is because in a true software-defined system there are no fixed hardware channels limiting the number of signals that can be generated. This is especially relevant in LEO constellations as there are more satellites in LEO orbit than there are in the GNSS constellations that have been simulated in the past. Another benefit is that if the limit is ever reached, a GPU can simply be added, and the same simulation tool can continue to be used. This leads to another benefit – the flexibility of the system. New constellations can be incorporated with software instead of additional hardware. This means when new constellations are complete, developers can access those new constellations with a mere software update. Software-defined simulators evolve to support LEO constellations and more rapid development.

How simulation can aid development

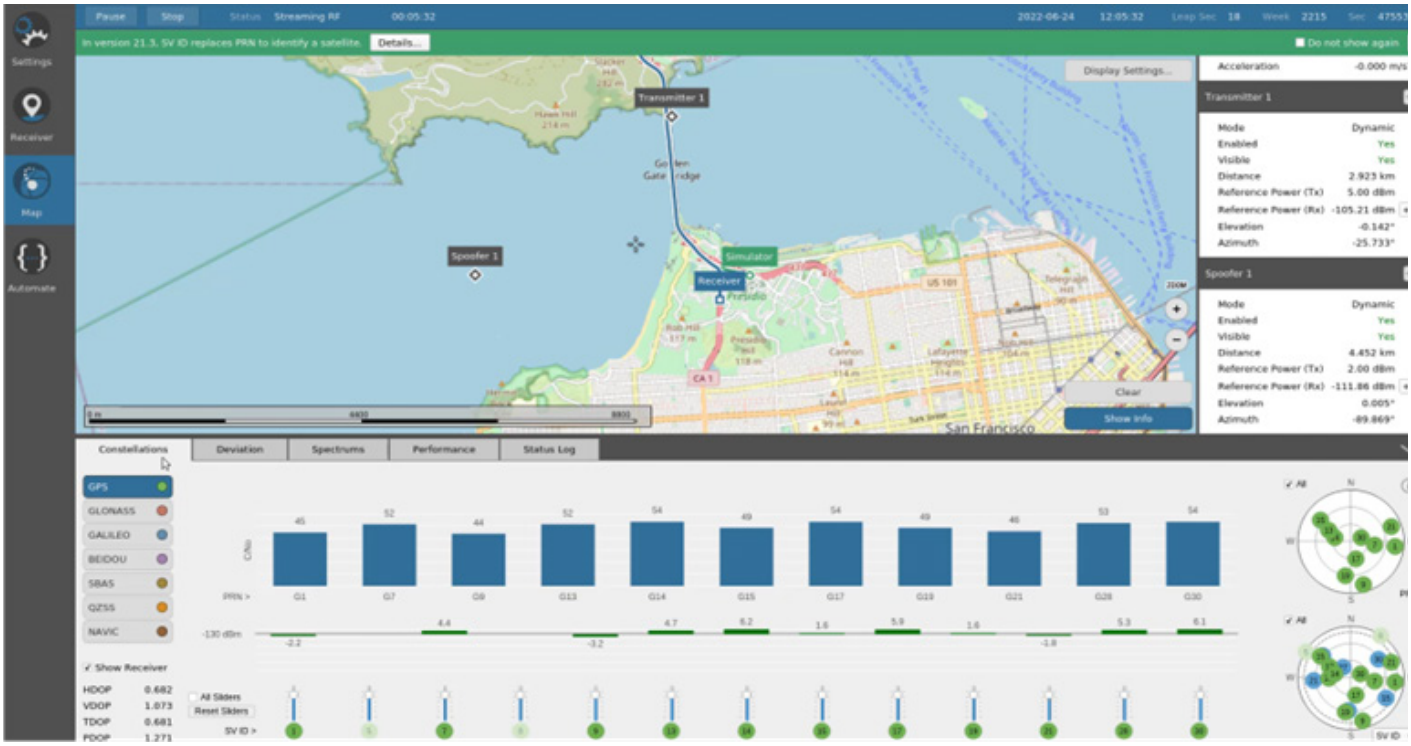
Constellation	Receiver	Systems
• Increase communication • Available for testing ASAP	• View receiver power in GPS denied environments • View acquisition times • Cost savings	• Vulnerability studies • Repeatability • Acceptance/verification testing

Examples of software-defined simulation in BroadSim



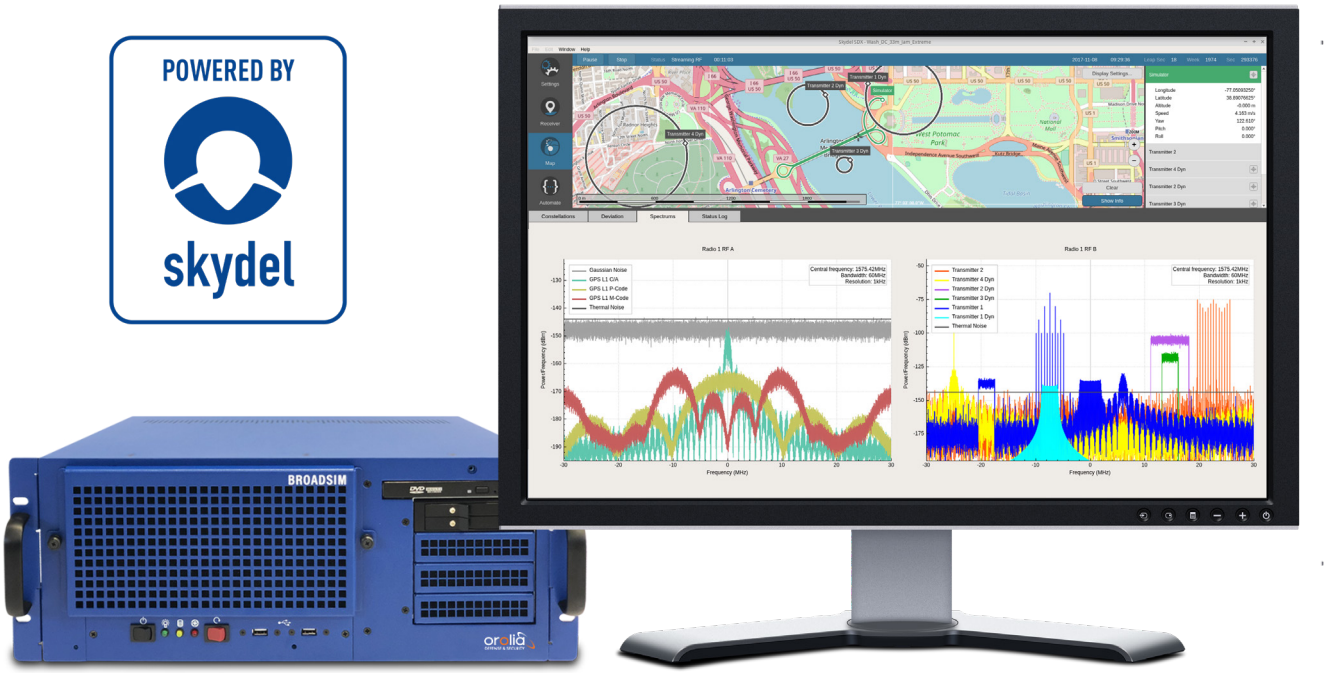
BroadSim is an example of this flexibility in motion. With BroadSim, new constellations and signals become available in the tool as they are introduced or are more commonly used in receivers, such as QZSS, BeiDou, and M-Code. Simulators allow users to thoroughly test how receivers or whole systems work during specific scenarios, giving them the ability to see all-in-sky satellites and terrain effects, and provide refresh rates that translate into real-time processing for fast-moving applications. This makes it possible to test acquisition time, view relative receiver power data, and collect other relevant data to further development, as well as automate commands to speed up testing. The flexibility of the system is demonstrated by its proven ability to simulate existing LEO constellations. Using BroadSim powered by Skydel, there are multiple built-in ways to create LEO constellations. One such way is using BroadSim's plug-in tool, which has already seen success. This tool allows users to develop features and integrate them into the BroadSim user interface and real-time simulation engine. BroadSim also provides the ability to modify existing constellations with custom signals and the addition of data sets to manipulate orbital and ephemeris data. In the future, a growing list of constellations will become available for selection within the tool. Safran Federal Systems is integrating new constellations today, and can help do the same for yours.

BroadSim simulation



Developing simulation capability alongside the development of constellations is to the advantage of the engineer who will be able to test without delay.

Those simulators can aid in the design process by allowing rapid testing and development, speeding up time to market, and increasing cost savings by reducing field test cycles and hours. Software-defined simulators are more equipped to handle LEO constellations. They are not limited in the number of signals they can produce via hardware; they are agile in that they can increase available constellations and capability without needing any hardware upgrades. New features and constellations are available with just a software upgrade, and the user community can create new ways to use the tool using open-source plug-ins to meet their needs. BroadSim already has initial support for LEO simulation using the plugin tool and Safran is actively taking inquiries from users and providers to partner with them and integrate their solution.



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