Satellite and Aerospace Channel Emulation Toolset

S8825A

Contents

CHAPTER 1

Validate the Real-World Performance of 5G NTN Technology

Today's complex communication systems are under development to meet the growing levels of broadband data in aerospace, satellite, and airborne applications. One of the main driving factors is converging the cellular and satellite networks and introducing the non-terrestrial networks (NTN) in 5G. For 6G and beyond, the relevance of satellite links becomes essential in quantum communications.

A failure in a communication link can lead to the loss of life-critical data, which is why aerospace, satellite, and airborne radio devices need to meet stringent reliability requirements. It is often challenging and expensive to virtually repair aerospace and satellite-type devices. Therefore, it is crucial to emulate the various phenomena that may affect a radio device in its real-world environment. This process is the only way to guarantee the reliability of the communication links and radio systems.

5G NTN Solution Testing

The introduction of 5G NTN shifts the focus of satellite communication (SATCOM) into testing with multi-channel transfer and multiple transponders per satellite. The convergence of terrestrial and aerospace networks is becoming an essential part of cellular service. The need for bandwidth is growing, and so is the number of satellites.

Keysight's S8825A Satellite and Aerospace Channel Emulation Toolset offers industry-leading features that fulfill the high demands of today's SATCOM testing.

CHAPTER 2
Solutions for New Test Challenges

Keysight's S8825A Satellite and Aerospace Channel Emulation Toolset provides the foundation for covering the most advanced test requirements. Testing in a controlled laboratory environment using a vast range of use case scenarios provides wireless communications systems' developers a reliable and cost-effective solution for testing air-to-air and air-to-ground communication links.

The laboratory setup allows air and space applications to experience actual environmental conditions, such as high Doppler, long delays, high dynamic range variations, power amplifier-related impairments, and phase noise.

The S8825A Satellite and Aerospace Channel Emulation Toolset combines Keysight's PROPSIM channel emulator with its aerospace channel emulation engine (ACE) to test aerospace, satellite, and airborne radio systems in a laboratory environment (Figure 1). The advanced functionalities include the mixed-use of cellular links combined with long delay aerospace links, enabling the implementation of test scenarios for 5G NTN.

Figure 1. F8800A PROPSIM F64 and F8820A PROPSIM FS16 channel emulators

The PROPSIM channel emulator enables real-time emulation of wireless radio channels. With the most superior signal integrity in the industry, PROPSIM's file-based emulation of test scenarios guarantees accurate, realistic, and repeatable test conditions for wireless aerospace, telemetry, satellite, and mobile broadband communication applications.

With the S8825A Satellite and Aerospace Channel Emulation Toolset, you can integrate an advanced terrestrial channel emulator with a satellite channel emulator to form one compact and affordable unit. Create realistic real-time propagation test environments for aerospace, satellite, and airborne radio links testing to:

- Test radios in aerospace, airborne, terrestrial, and indoor propagation environments including mixed-use cases of different types of solutions.
- Test full satellite constellations and massive low Earth orbit (LEO).
- Create test environments that meet requirements for the highest levels of Doppler and acceleration.
- Emulate store and forward type links, power amplifier non-linearity, and phase noise of satellite hardware.

The S8825A Satellite and Aerospace Channel Emulation Toolset provides you the highest levels of channel emulation performance and accuracy available on the market. You can easily test airborne gateway links and cellular communication such as LTE and 5G New Radio (NR) with a single instrument.

The result is the most reliable and cost-effective solution for radio channel testing to:

- Provide realistic end-to-end conditions for testing communication networks and network interlinking.
- Minimize overall testing costs and shorten development time by reducing the need for field testing.
- Achieve smooth interoperability between different systems.
- Improve the quality of service and end-user experience.

Resolve issues early in the development process

By identifying issues at an early stage in the development process, the PROPSIM channel emulator ensures your products are more mature and have fewer errors before field verification. This type of approach accelerates cycles and significantly reduces your development and testing costs.

Some applications in locations that are difficult to get to, are challenging to test in the field. The accurate and precise laboratory test environment created by PROPSIM enables you to initiate performance testing of early prototypes that are not yet ready for testing in a real environment. As a laboratory-based test solution, the PROPSIM channel emulator is a flexible, cost-effective, and reliable alternative to time-consuming and expensive field-based testing.

Improve system integration

Use the operational environment emulated by PROPSIM during the system integration phase to verify the functionality of various parts of a system in any given condition. The verification against conditions is critical when various organizations execute development projects due to harmonizing the test conditions. Get guaranteed end-product quality verification for each subsystem to comply with agreed specifications. The operational lifecycle of satellite and airborne radio systems is longer than that of commercial radios. The S8825A Satellite and Aerospace Channel Emulation Toolset ensures the compatibility of new components before installation into a live system.

Create Realistic Test Scenarios for Aerospace Propagation Conditions

The PROPSIM aerospace channel emulation engine lets you create realistic aerospace propagation conditions for different test scenarios (Figure 2). The tool's graphical editing functionality makes it easy to visualize stationary and moving objects, observe the link conditions, and process the PROPSIM test scenarios.

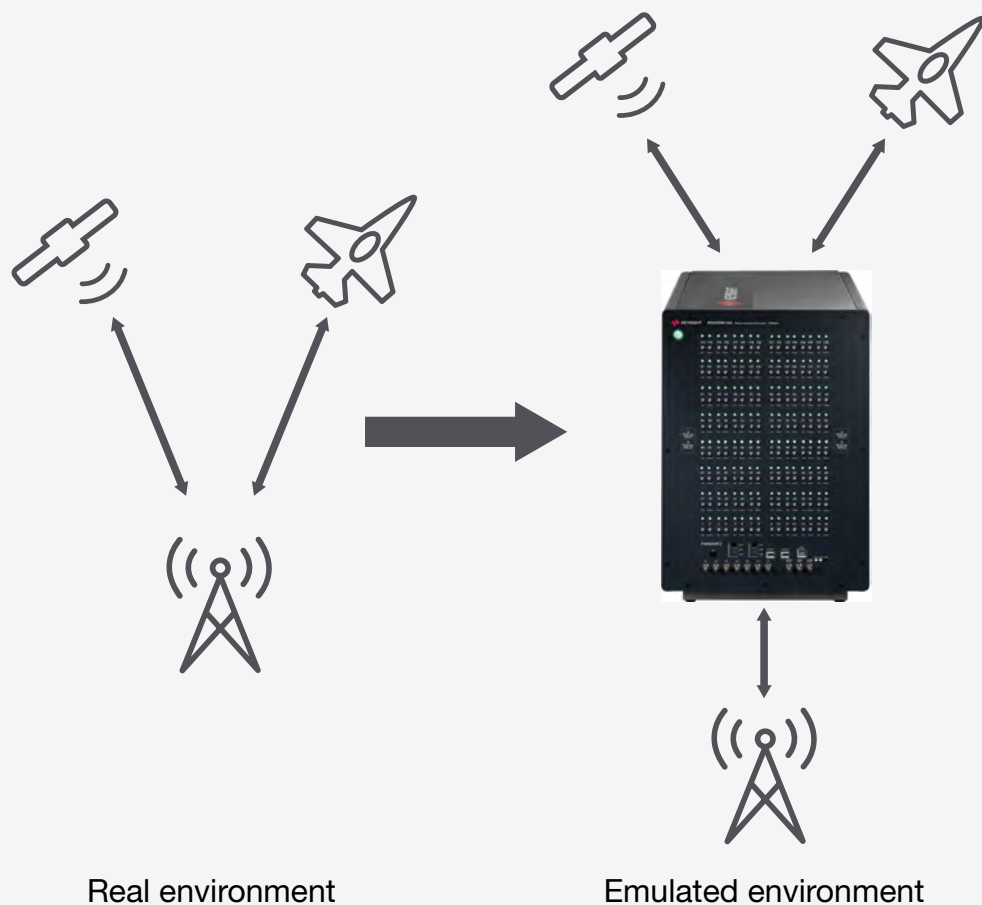Real environment   Emulated environment

Figure 2. Bring real-world radio channel conditions into the lab with the S8825A Satellite and Aerospace Channel Emulation Toolset

With the S8825A Satellite and Aerospace Channel Emulation Toolset, you can test more efficiently at the critical points in your procedure and rely on the accuracy and reliability of the results.

Create aerospace and satellite scenarios

You can easily create aerospace and satellite scenarios using the Aerospace Model Editor (ASO) editor tool or data import functions. The ASO editor supports the creation of dynamic multipath scenarios. It provides a file interface to enable the import of customer-specific data from third-party scenario tools. PROPSIM delivers seamless integration with the AGI systems tool kit (STK) (Figure 3).
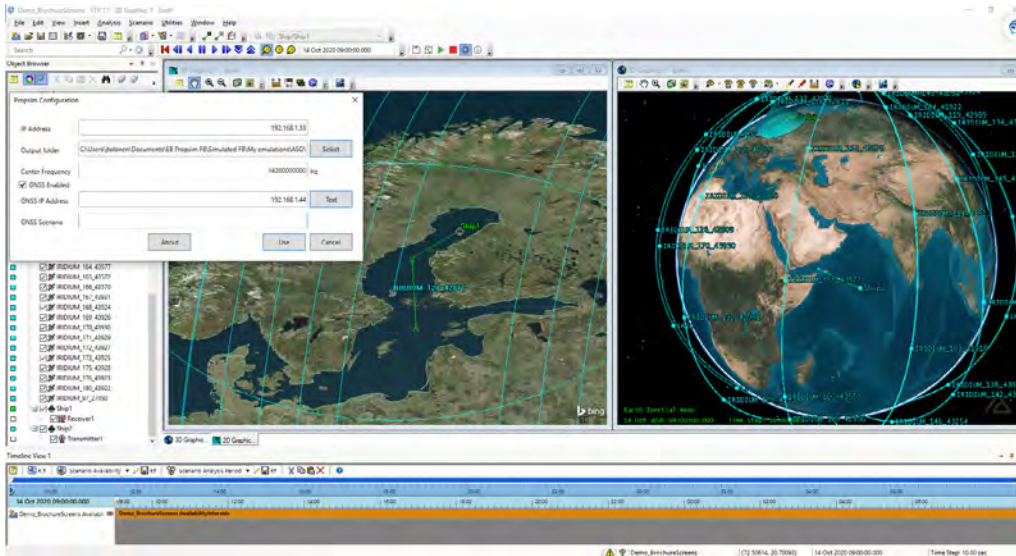

Figure 3. Keysight's PROPSIM channel emulator provides seamless integration with the AGI STK software

Define the test setup

The editor tool allows linking and connecting multiple radios into one scenario. It also enables adding additive white Gaussian noise (AWGN) interference sources for each channel independently if necessary. All the device interconnections can be freely defined in the software by the user.

Run the model in the emulator

Time and RF phase-coherent results are guaranteed and repeatable due to PROPSIM's single-unit integrated platform architecture (Figure 4). Storing the emulations in a file-based format ensures the repeatability of testing and guarantees consistent results between test executions.
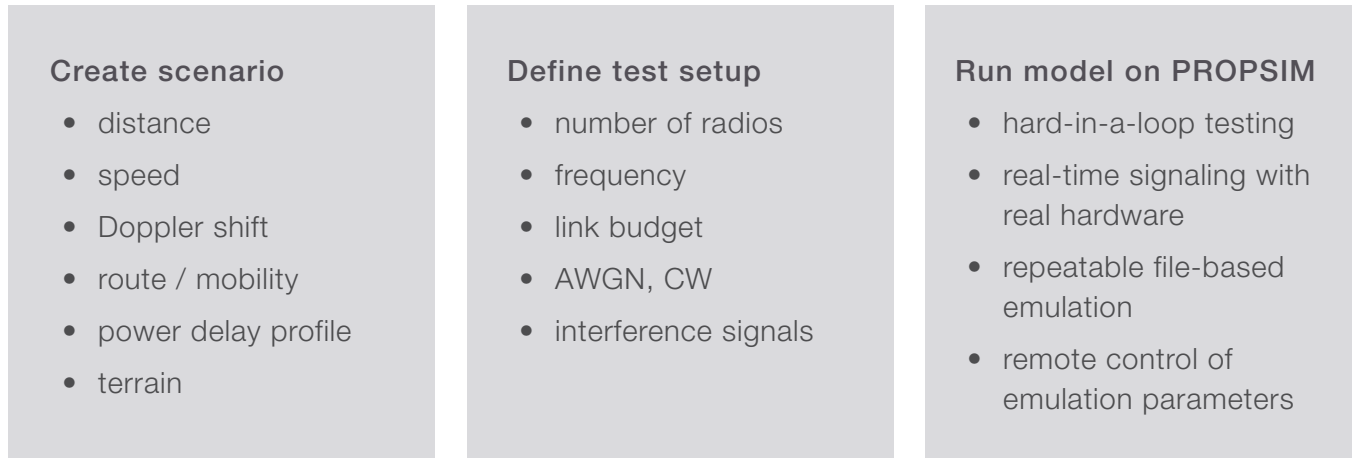
Create scenario

- distance
- speed
- Doppler shift
- route / mobility
- power delay profile
- terrain

Define test setup

- number of radios
- frequency
- link budget
- AWGN, CW
- interference signals

Run model on PROPSIM

- hard-in-a-loop testing
- real-time signaling with real hardware
- repeatable file-based emulation
- remote control of emulation parameters

Figure 4. Test at key points in your process with the PROPSIM aerospace modeling tool

CHAPTER 4

Emulate Doppler, Delay and Range Rate in a Laboratory

The PROPSIM aerospace channel emulation engine integrates with the wideband fading emulator F8800A PROPSIM F64 or F8820A PROPSIM FS16. The process enables you to emulate aerospace and terrestrial channels in a single device using advanced channel modeling tools, standard model libraries, and MIMO emulations up to 8x8.

Multichannel emulation capability

The S8825A Satellite and Aerospace Channel Emulation Toolset can emulate scenarios where a wide range of different applications communicate with each other or where several systems use the same radio channels. The communicating devices may be point-to-point or point-to-multipoint. The tested applications may contain for instance high-speed data, broadcasting, radar, jamming, or counter jamming.

Accurate aerospace channel emulation

Get realistic emulation of all relevant radio channel phenomena using the S8825A Satellite and Aerospace Channel Emulation Toolset. This solution includes emulating long delay satellite links with realistic Doppler based on the satellites' movement. The high dynamic range enables realistic path loss and link power variations.

High Doppler

The Doppler shift is proportional to the velocity and carrier frequency in use. PROPSIM channel emulator with the aerospace channel emulation engine independently emulates Doppler phenomena for each channel's path while consistently maintaining the phase continuity in dynamic delay variations. The procedure preserves realistic chip rate variations, which are necessary when testing satellite receiver performance.

Long delays

Compared to terrestrial links, aerospace links generally have longer link spans. Precise emulation of delay is essential in ranging telemetry applications. Extreme accuracy is a requirement in many applications, such as object guidance or tracking, because it is crucial to know the device's location at the time when the signal was transmitting to estimate its new location. PROPSIM channel emulator with the aerospace channel emulation engine emulates delays and positions between moving objects and reflectors with extremely high accuracy.

Range rate

High range rate creates dynamic effects on radio link amplitude, delay, and Doppler. Depending on the application, the rate range can be function-based, linear, sinusoidal, or completely arbitrary.

For example, the PROPSIM aerospace channel emulation engine accurately and synchronously emulates radio links when a fighter aircraft changes direction and acceleration, causing sudden changes in Doppler, delay, and amplitude values to ± 1.5 MHz maximum Doppler and up to 100G acceleration.

CHAPTER 5
Application Scenarios

Tactical data links

Military communications networks use tactical data links for communication between aircraft, ships, and ground platforms. Tactical data links are capable of providing secure and jam-resistant high throughput connections over relatively long distances.
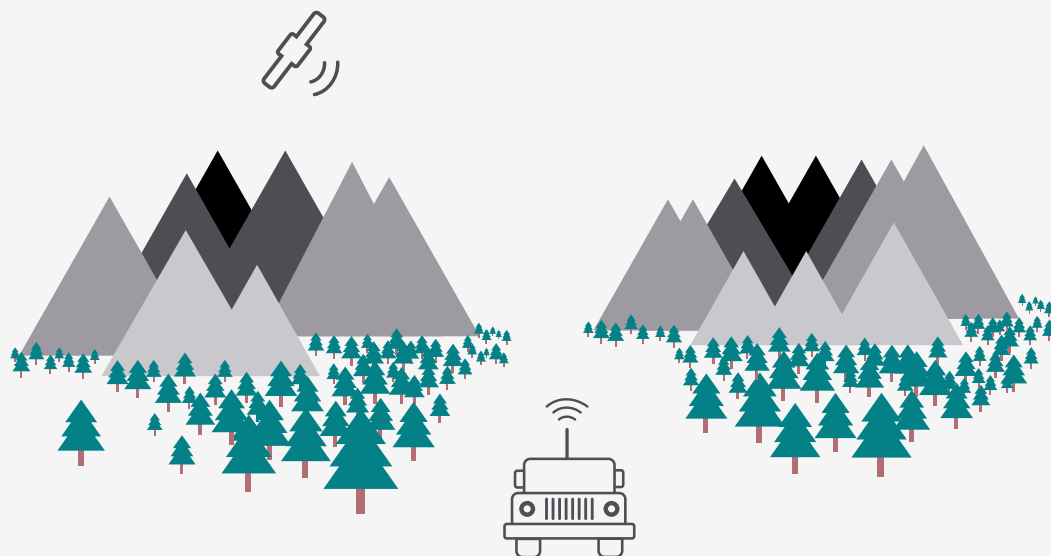
Figure 5. Emulate real-world tactical data links in the lab with the S8825A Satellite and Aerospace Channel Emulation Toolset

Commercial aviation

Broadband data to commercial aircraft transmits and receives through ground stations. Situations similar to a terrestrial cellular network occur at higher velocities and over longer distances.
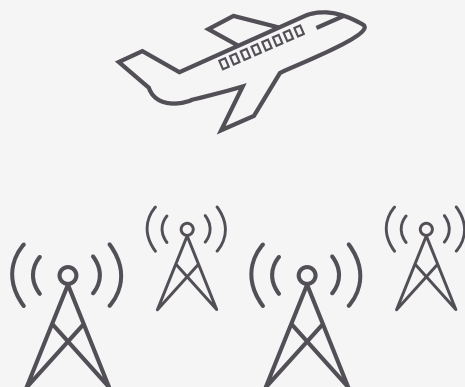
Figure 6. The S8825A Satellite and Aerospace Channel Emulation Toolset provides full support for the high requirements of avionics communication testing

Satellite communications

The accuracy in modeling path loss, delay, Doppler, and multipath plays a vital role in evaluating satellite service coverage and quality. The S8825A Satellite and Aerospace Channel Emulation Toolset provides the required accuracy for any system-level evaluation. The PROPSIM channel emulator can handle network-level connections, such as 5G NTN system-level integration, to reveal any subsystem performance shortages.

CHAPTER 6
Key Features
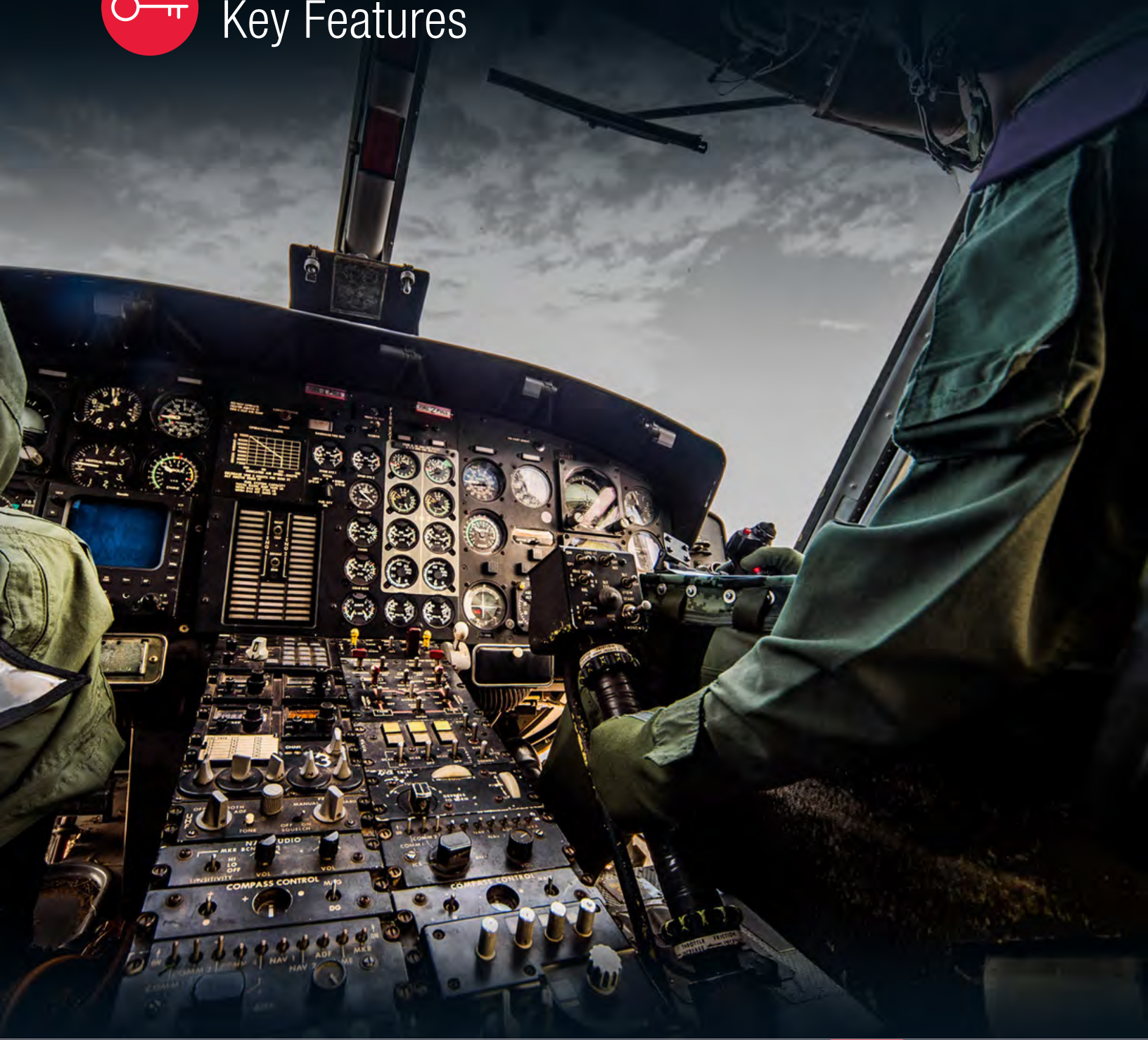
Superior RF and digital performance

The S8825A Satellite and Aerospace Channel Emulation Toolset has a channel modeling interface with up to 64 RF channels and up to 1200 MHz signal bandwidth. RF signal frequency range of 30 MHz to 6 GHz reduces the need for RF down / up conversion. However, systems operating on up to 100 GHz are supported with external RF down / up conversion hardware. This solution provides propagation delay emulation capability of up to 1000 ms.

Specifications

Capability / feature	F8820A PROPSIM FS16	F8800A PROPSIM F64
Number of radio channels	2 to 16 channels	8 to 64 channels
Number of digital channels	256 terrestrial	1024 terrestrial
	16 aerospace	64 aerospace
EVM	< -50 dB	< -50 dB
Doppler shift	± 1.5 MHz	± 1.5 MHz
Maximum delay	1000 ms (1s)	1000 ms (1s)
Maximum bandwidth	1200 MHz (1000 MHz ACE)	1200 MHz (1000 MHz ACE)
Frequency range	3 MHz to 6 GHz (30 MHz to 6 GHz ACE)	3 MHz to 6 GHz (30 MHz to 6 GHz ACE)
Internal interference	AWGN, CW	AWGN, CW

F8820A

F8800A

Open text-based file format

The PROPSIM aerospace channel emulation engine supports any user-defined routes or built-in functions for periodic models. The open text-based file format enables importing customer-specific radio channel and location parameters for satellite orbital information or any airborne route information.

This solution takes input from software, scenario creation, and simulation tools. You can easily define and emulate the communications links of flight routes or test the wireless connection on an aircraft with link emulations based on virtual links or recorded link databases.

The PROPSIM aerospace channel emulation engine enables you to create and edit various types of channel models with periodic curves.

| **Coordinate-based model**	**Function-based model**	**Arbitrary model**

• Define coordinate points and gain values for the transmitter, receiver, and reflectors.
 	
 • Calculate delay, range rate, and Doppler parameters from the movement between given coordinate points.
	• Specify Doppler from the linear, sinusoidal, or triangular function.
	
	 • Set minimum and maximum values for gain.
		• Define time stamped values for the transmitter / receiver link characteristics, with:
		   - Doppler
		   - Delay
		   - Gain

Visualization

The PROPSIM aerospace channel emulation engine enables you to create and illustrate user-defined emulation models. The visualization of the links between transceivers and receivers comes from the locations of the radios and multipath reflectors. The graphs display the channel parameter changes according to the defined scenario.

Validation

You can import the scenario data to the PROPSIM in Keysight's .aso file format. It is easy to check the integrity of the imported data to validate the model format and data values. The input data from third party tools can also easily be modified to fit into the channel emulator.

Replay

The playback functionality enables viewing the model evolution as a time series demonstration and repeats as many times as needed. For example, you can create a radio channel environment once and replay it in the laboratory to improve the live wireless network's performance and functionality at different cruising altitudes.
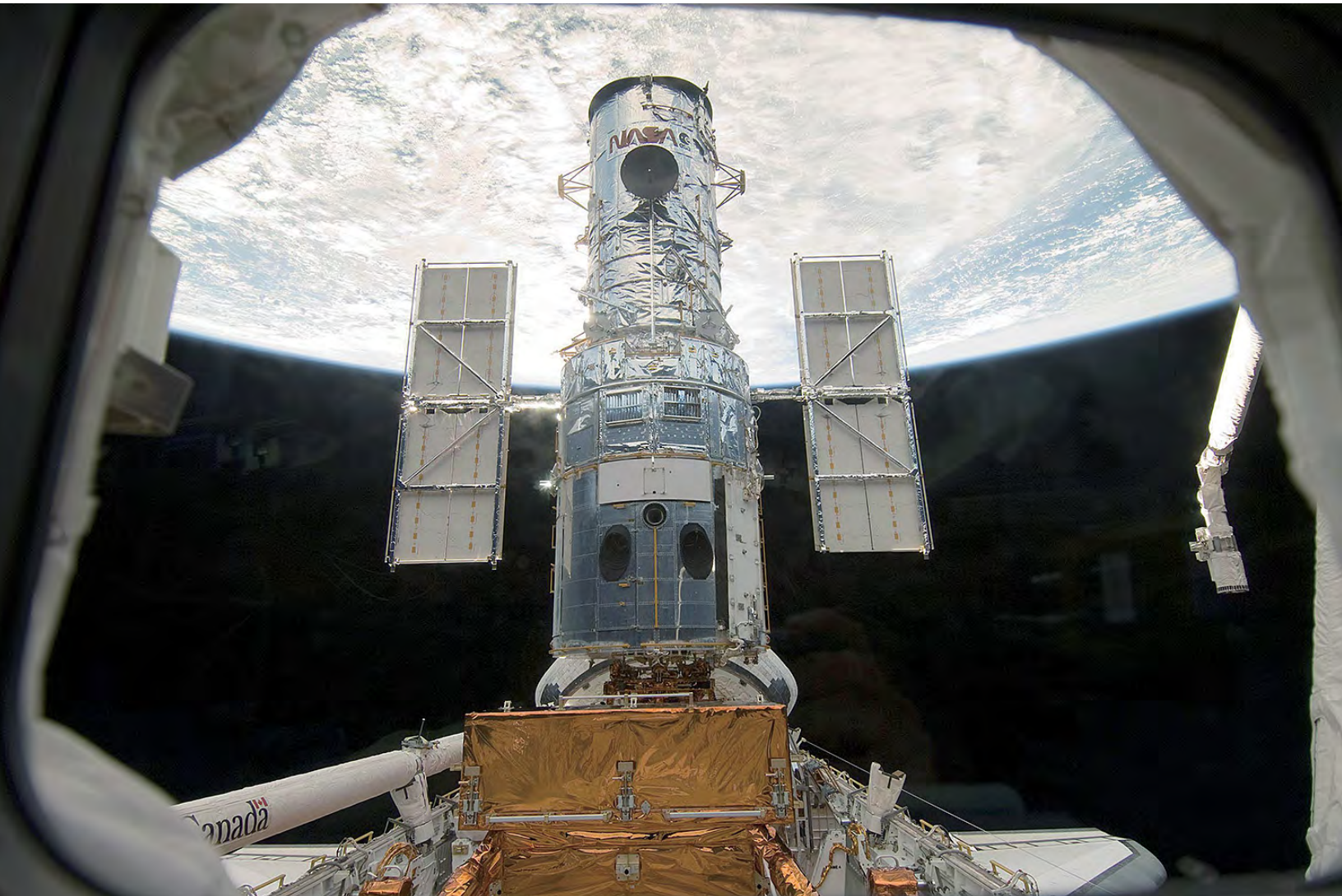
CHAPTER 7

Ready to Take the Next Step?

Keysight's S8825A Satellite and Aerospace Channel Emulation Toolset delivers advanced and cost-efficient performance assessment of satellite and ground networks for the expanding satellite communications market.

Our industry-leading performance validation solutions enable the aerospace industry to capitalize on opportunities to establish commercial success and deliver innovative technology breakthroughs in space exploration, scientific research, and satellite communications.

Keysight can tailor PROPSIM solutions to fit your requirements. This flexibility ensures you get what you need to finish the task. The PROPSIM platform's scalability makes it a future-proof solution as your requirements change.

For more information about Keysight's PROPSIM F64 and FS16, visit keysight.com/find/propsim.

Learn more about Keysight's PROPSIM aerospace testing at keysight.com/find/s8825a.

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