Fast-Track your RF Analysis Advantage

Can you afford blind spots and data loss in your RF analysis system? Your enemies expect it - let's surprise them!

Executive Summary

Radio Frequency (RF) analysis is essential for Intelligence, Surveillance, and Reconnaissance (ISR) and Electronic Warfare (EW) to enhance our militaries' situational awareness, improve targeting and strike precision, reduce the vulnerability of our troops, and by supporting electronic countermeasures and intelligence gathering. As RF sensors generate an overwhelming amount of data, they often exceed the capacity of the analysis systems to reliably store, distribute, and analyze this data.

In this whitepaper, we discuss how Axellio® SensorXpress® innovates the RF analysis approach to allow you to process well over 100 Gbps in real-time through your existing analysis infrastructure without losing data. SensorXpress further stores hours or days' worth of all the captured data in very compact form factors for subsequent in-depth analysis or validation.

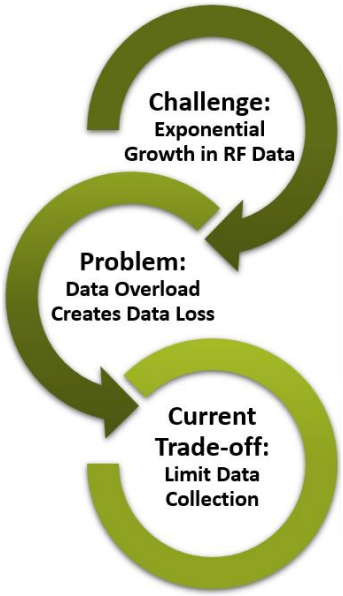
Building on its 20 years' experience in high-speed, high-volume storage systems, Axellio developed a unique storage approach that allows for simultaneous read and write at very high speeds. This overcame decades of shortcomings in storage systems not being able to read and write at the same time without severely constraining read and write speeds or significantly having to limit storage capacity.

Axellio's SensorXpress has dramatically changed the playing field, allowing you to maximize the capabilities and extend the useful life of your existing RF equipment by working seamlessly with your existing analysis infrastructure through this unique approach:

- Software-based RF data recording and distribution solution
- Simultaneous ingest, storage, and distribution from 1 to 100s of Gbps
- Frequency and protocol-agnostic for ingestion, recording, and distribution, including raw I/Q and VITA49
- Multiple analysis streams for simultaneous real-time and on-demand analysis, individually configured for content and speed

The RF Challenge

Our adversaries are using ever more sophisticated electronic counter-countermeasures (ECCM) or electronic protective measures (EPM), including signal spoofing and compression. They're even using artificial intelligence (AI) and machine learning (ML) to manage transmissions or signal behavior, a tactic that can offset countermeasures or detection. To conceal their communication, they are leveraging the power of frequency-hopping spread spectrum (FHSS) to transmit signals across rapidly changing frequencies, across a broad spectrum. This makes their communications especially resistant to jamming and can make them difficult to detect.



All this creates an urgent need for programs supported by EW, signals intelligence (SIGINT), and electronic intelligence (ELINT) teams to make better sense of RF information in real-time. However, the amount of collected RF data has grown to levels these systems cannot reliably store or analyze in real-time. This escalating challenge manifests in several critical areas, each highlighting the urgent need for innovative solutions to process, analyze, and utilize RF data effectively:

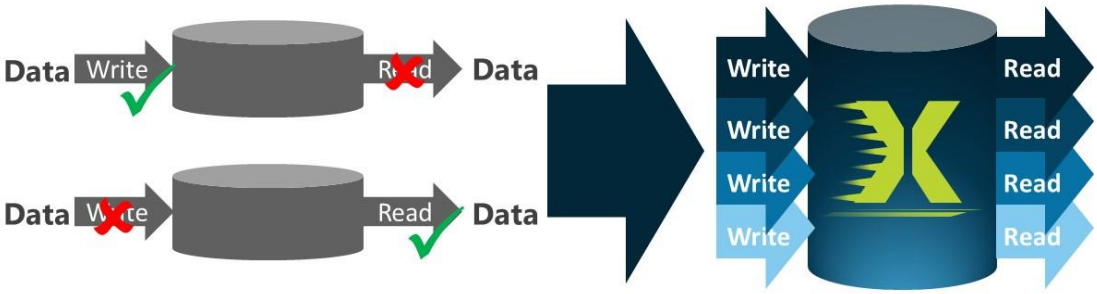
- **Volume**: There's an overwhelming amount of data coming from friendly, adversary, and civilian transmissions. With an ever-increasing number of wireless communication devices, not just from military devices but also vehicles, operational technologies (OT) and everyday civilian usage, the Electromagnetic Spectrum is a crowded space, and systems struggle to account for the sheer volume of data. These days, almost any technical device — from weapons systems to household appliances — is generating RF signals. Within that vast volume of data, it's difficult to extract the information of importance, which is especially true in urban environments, where a multitude of signals overlap.
- **Capacity**: ISR sensors need to continuously expand the bandwidth they collect as communication moves into higher frequency ranges. Similarly, civilian mobile telephony is also expanding its frequency range, with 5G devices operating from as low as 450 MHz to over 52 GHz. This requires scanning wider and higher frequency bands, creating more data to provide superior situational awareness. However, this overloads the signal processing applications analyzing the data in real-time, leading to a loss of valuable information.
- **Storage:** Due to the shortage of human analysis expertise and real-time processing power at the point of collection, data is frequently recorded and stored for post-mission analysis. With limited local storage capacity due to size, weight, and power (SWaP) issues resulting in performance limitations, the amount of data that can be captured, stored, transported, and analyzed later is often insufficient for comprehensive analysis.

As a result, essential or rogue signals can be missed, and vital information could be lost forever. Solutions that work in civilian life, such as streaming data into the cloud to scale storage and processing, often are not an option on the battlefield. During forward tactical missions, connectivity is often insufficient, unreliable, or many times not an option when radio silence is required to avoid detection. And adding more sophisticated processing infrastructure can be expensive and complex, especially at the tactical edge. Yet something needs to change for RF capabilities to meet the current needs.

Axellio - Extreme High-Speed Collection, Storage, and Analysis of Data at Scale

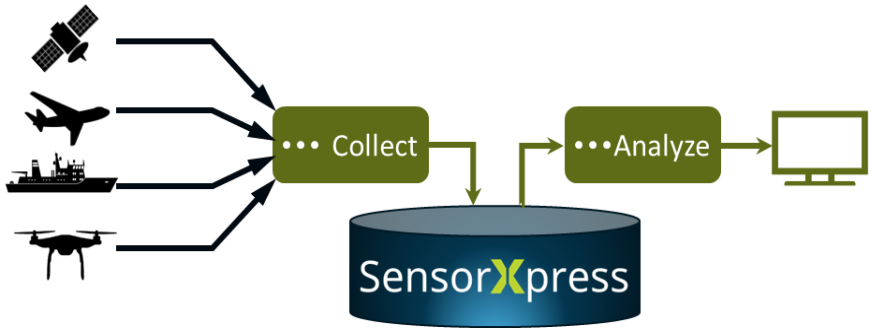
A new approach is required for the military to achieve superior situational awareness and battlefield intelligence. Enhancing the situational awareness is crucial for success and requires data to be collected, stored, retrieved, and analyzed more efficiently and in near real-time. This will provide deeper insights into adversarial action while also extending the useful life of the existing RF analysis infrastructure.

Axellio allows for the capture and distribution of any time-series data at extremely high-speeds reliably, while maximizing storage and minimizing hardware and processing requirements. Traditional storage is no longer adequate for today's high-speed, high-volume RF analysis. Its limited read and write speeds, storage resource constraints, and hardware requirements are often prohibitive, not just in cost but also in size, especially for tactical deployments. Axellio's approach addresses all those challenges, allowing multiple data streams to simultaneously write-to-disk and read-from-disk, all while sustaining speeds at over 100 Gbps in extremely small SWaP.



SensorXpress – The Most Innovative RF Data Storage & Distribution Available

SensorXpress™ delivers scalable, simultaneous high-speed RF data recording and distribution, at any instantaneous bandwidth. Supporting the existing RF collection systems, SensorXpress connects directly with the collection sensors through high-speed interfaces to ingest and store the RF data at speeds exceeding 100 Gbps lossless, for hours or even days. This allows you to maximize the performance and capabilities of your existing collection and analysis infrastructure.



Unlike today's available storage systems, Axellio's patented storage architecture allows for the simultaneous distribution of multiple RF data streams to analysis applications directly from disk, without impacting either read or write performance. Collecting data from any time series-based sources - including RF data, audio, video, and more - extends time-on-target at the widest instantaneous bandwidth possible.

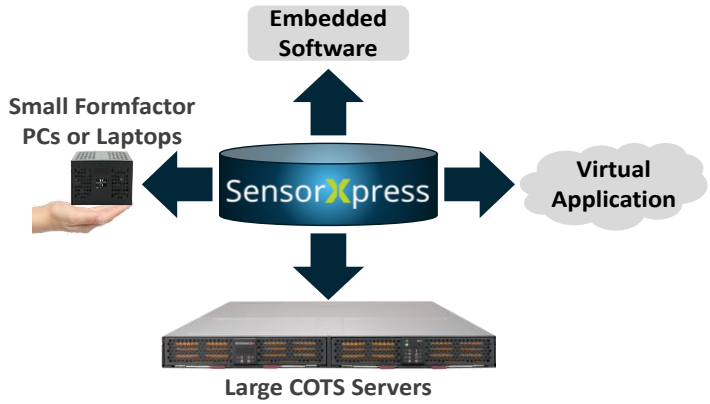
Controlled and repeatable signal data distribution to multiple analysis applications allows for high-speed real-time analysis, as well as the ability to replay and re-analyze any captured data. The system allows for multiple data extraction streams, each individually configured for speed and content. This enables analysts to perform repeated in-depth analysis and validate implementations against the data via standard APIs.

Completely Customizable to Your Mission

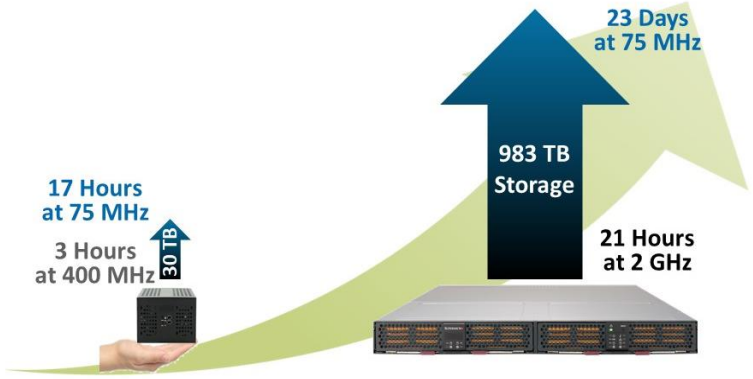
SensorXpress™ is spectrum, sensor, analysis application, and hardware agnostic. It integrates seamlessly with your sensors and analysis systems via standard software APIs either directly on your system or via wired or wireless networks.

With tactical missions requiring often lighter weight form factors, storage often becomes extremely limited. Axellio's architecture is designed for both speed and storage at scale in flexible form factors from mobile operations to static data center deployments, all delivered in a dense footprint for any application:

- As embedded software, it allows for onboard analysis directly on your sensor platform for compact form factors in aerial or mobile platforms
- As a virtual appliance for private, government, or public cloud deployments
- In small, sometimes rugged processing platforms for front-line tactical deployments
- On COTS servers for performance and scalability in large data centers or forward operating bases
- Custom tactical configurations can also be provided to meet your specific mission needs



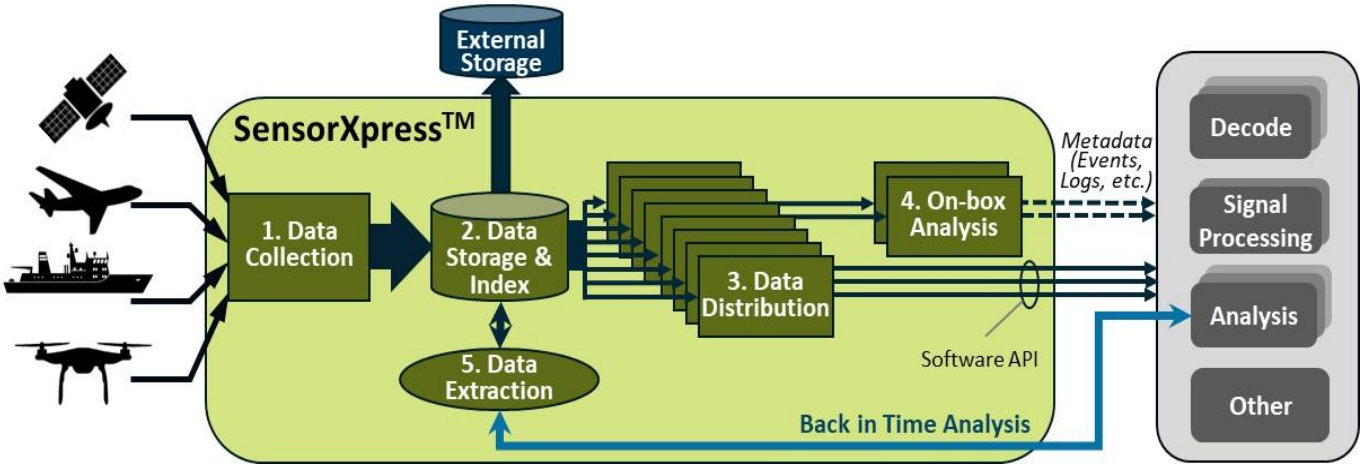
Through its modular design, SensorXpress allows for expandable storage, from hours to months, local or external, utilizing COTS NVMe SSD drives with an onboard storage capacity of over a petabyte in just a single 1U server. To extend storage capacity at a reduced cost, SensorXpress also offers long-term, off-box archive on either more cost effective traditional hard drives, existing storage arrays or even cloud storage where appropriate. Data at rest encryption is available to secure the stored data during transport or storage.



* Assumes 32 Bits Data per Sample for 120 Million Samples per Second (MSPS) for 75 MHz, 640 MSPS for 400 MHz, 3,200 MSPS for 2 GHz

SensorXpress - An Open Platform

Built as a dense, high-performance platform, SensorXpress integrates leading-edge server and storage technologies and a patented file system for a diverse set of use cases and analysis applications. Instead of directly feeding signals from hardware sensors and receivers into signal analysis, decode, or processing systems, SensorXpress acts as a buffer. It captures and stores the RF data, allowing it to distribute this data at controlled rates and with only the specific data the analysis system needs, thus preventing system overload.



High-speed capture & recording – from 1 Gbps to multiple 100 Gbps without losing data:

- Ability to collect data from multiple sensors via physical and wireless networks, and in virtual, containerized, and cloud environments
- Hardware and software-based data filtering, deduplication, and slicing allows for selective capture as necessary while time stamping with nano-second accuracy

Storage – simultaneous read and write with on-disk-storage for days, weeks, or months:

- Scalable storage utilizing NVMe SSD drives with onboard storage capacities well over a petabyte in a 1U server
- Long-term, off-box archival to further extend storage capacity at reduced cost
- Secure data through data at rest encryption

Adaptive traffic distribution – near real-time, content- and rate-controlled traffic distribution directly from disk at over 100 Gbps sustained, not impacting write performance via standard software APIs:

- Multiple data extraction streams can be flexibly and individually configured in both speed and content
- Automatically adjusts data flows to rates the analysis applications can reliably consume
- Open APIs for retrieval for onboard and offboard analysis applications in either physical or virtual environments

Analysis application agnostic – software-based, hardware-agnostic access to data anytime for any event, with direct integration into your existing workflow:

- Application agnostic – deploy any analysis application on-board using any standard Linux OS or distribute to any outside analysis applications

- Ability for dynamic queries without the need to pre-define indexing at time of capture, offering more flexible and dynamic analysis capabilities for the unexpected
- Multi-pass analysis – The ability to rewind, replay, re-analyze for repeated in-depth analysis and mitigation validation

Open platform – scalable and economical with lowest SWaP in the industry:

- Flexible form factors – from mobile operations to static data center deployments, delivered on COTS hardware
- Scalable – Multiple instances can be deployed for even higher performance in data center type applications or for distributed deployment
- Dense footprint and custom tactical configurations to meet your specific mission needs

Use Cases

SensorXpress deployments have resulted in tangible benefits for organizations to:

- Monitor broader electromagnetic spectrum in real-time and extend time-on-target
- Record more spectrum for longer periods of time
- Collect and store more spectrum data in a dense form factor for post-mission analysis during forward tactical missions, allowing for disconnected or non-tethered operation

Axellio has been working with various organizations to integrate SensorXpress for their specific use cases:

Building a real-time distributed display and analysis device that attaches to a wideband RF detection and monitoring system	Actively streaming real-time IQ at 75MHz IBW to a small HW device with multi-TB U.2 drives. This allows for real-time capture of signals to go from seconds to days.
Developing a flexible AI architecture for edge-based RF collection and analysis	This solution demonstrates superior exploitation of available signal data through enhanced ingestion capabilities, high-speed data storage, and operationalized AI-based analysis.
Ingest high-speed SIGINT data into Kubernetes framework for AI/ML processing	SensorXpress ingests stream of VITA49 and distributes into a Kubernetes system to store 24 hours of data or about 175 TB.

About Axellio

Axellio provides extreme high-performance, scalable, compact, economical, and simultaneous time-series data ingest, storage, and distribution solutions for the defense and intelligence community at speeds exceeding 100 Gbps for cybersecurity and for intelligence, surveillance, and reconnaissance (ISR) applications.