



# Enhancing KomaMRI with a Pulseseq I/O Interface for Reproducible Sequence Workflows

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## SUMMARY

A complete **Pulseseq** interoperability layer was implemented in **KomaMRI**, enabling **import, export and construction of Pulseseq-compatible MRI sequences**. To bridge the differences between KomaMRI internal sequence representation and the Pulseseq specification, a Pulseseq-like sequence construction API and an event-mapping framework were introduced. During export, scanner-specific hardware validation, timing checks and raster-time quantization ensure Pulseseq-compliant sequence generation. The implementation was validated through round-trip conversion tests, Pulseseq v1.5.1 compliance checks and comparison against equivalent MATLAB Pulseseq implementations.

## MOTIVATION

Pulseseq [1] has become a widely adopted standard for MRI sequence exchange. While KomaMRI [2] provides a flexible framework for MRI sequence design and simulation, its internal representation differs from the Pulseseq data model, preventing direct interoperability. In addition, KomaMRI previously lacked complete Pulseseq import/export capabilities, limiting integration with Pulseseq-based tools and restricting the functionality of external applications such as MRSeqStudio [3].

This work addresses these challenges by introducing a unified sequence construction paradigm and a bidirectional Pulseseq interoperability framework for KomaMRI.

## PULSESEQ-LIKE SEQUENCE CONSTRUCTION



KomaMRI	MATLAB Pulseq	PyPulseq
<pre>seq = Sequence() @addblock seq += (rf, zg)</pre>	<pre>seq = mr.Sequence(); seq.addBlock(rf, zg)</pre>	<pre>seq = pp.Sequence() seq.add_block(rf, zg)</pre>

- Block-oriented sequence representation (new `@addblock` macro)
- It maps closely to MATLAB Pulseq/PyPulseq functions (`addBlock/add_block`)
- RF, Gradient, ADC and extension events grouped into sequence blocks
- Reusable sequence modules (readout, prephaser, preparation...)
- Built-in sequence transformations (scaling, rotation, phase shifts)

## PULSESEQ EVENT MAPPING

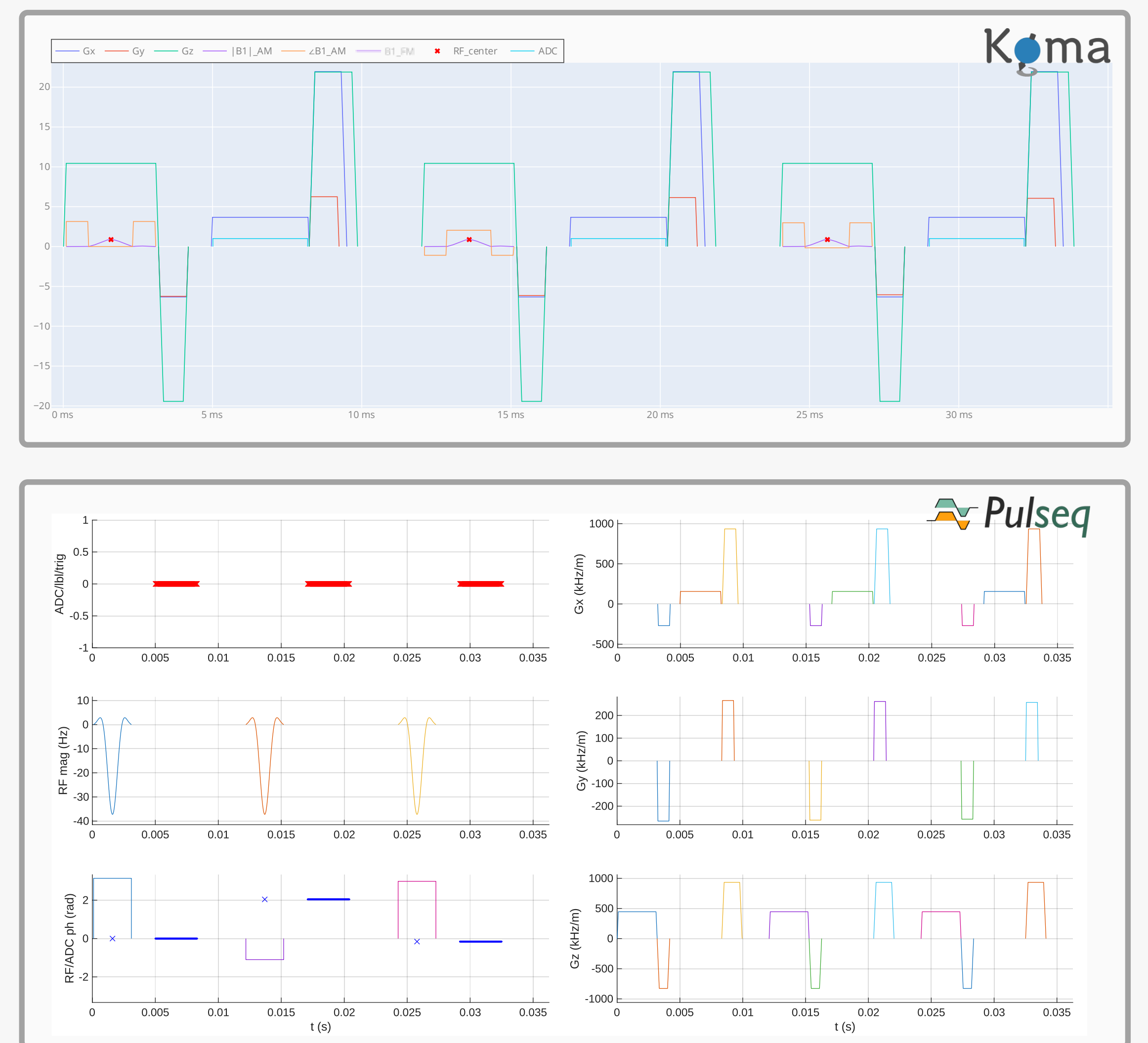
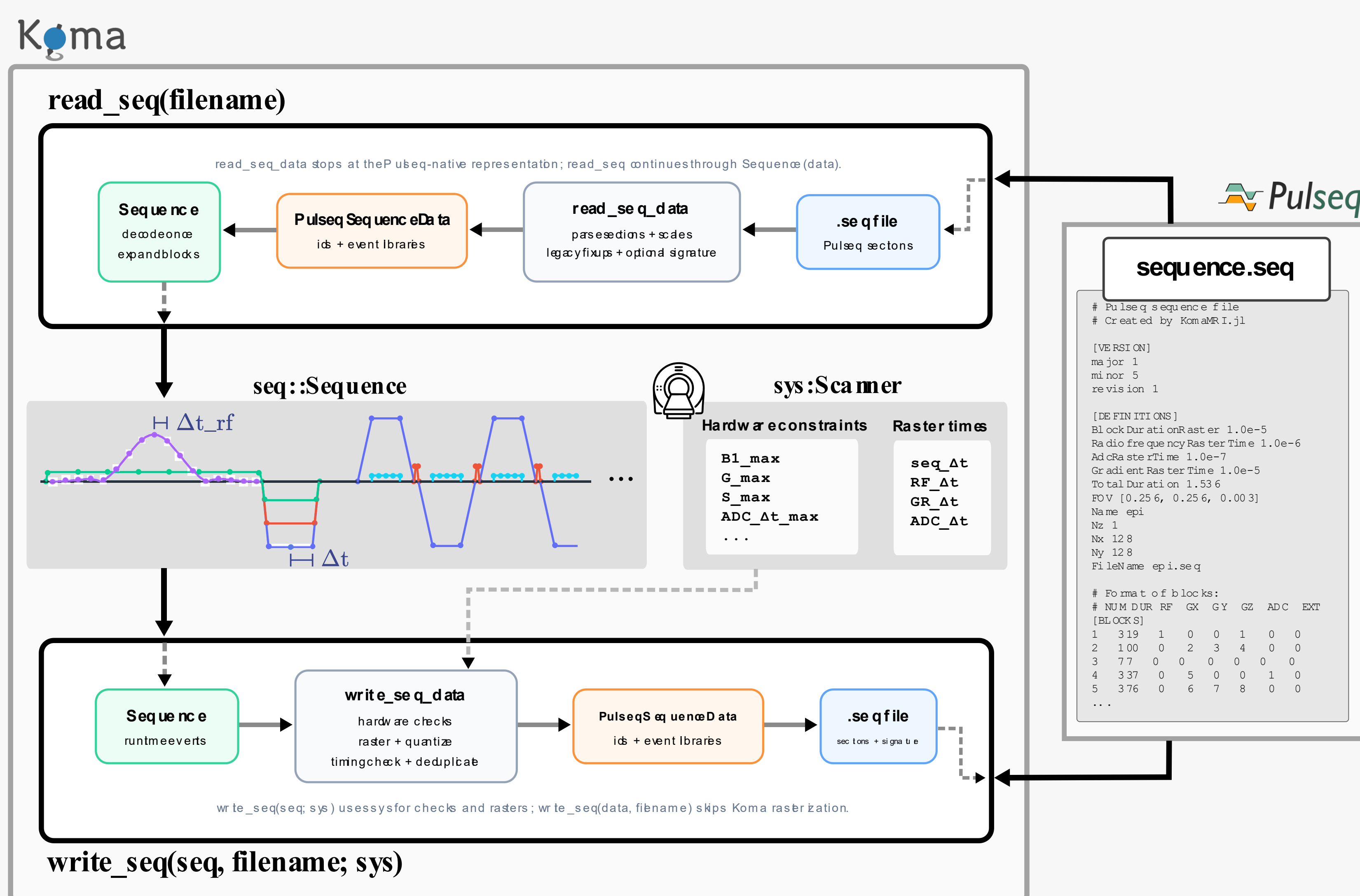


	PulseseqSequenceData	Sequence
Representation	Event-based structure following the Pulseseq specification	Block-based structure for simulation
Organization	RF, gradients, ADC, and extensions stored as separate event definitions	Events grouped into time-aligned sequence blocks
Purpose	Sequence description and interoperability with Pulseseq	Efficient Bloch simulation and plotting

KomaMRI uses two sequence representations:

- **PulseseqSequenceData**: the Pulseseq-native intermediate used by the reader and writer. It stores **[BLOCKS]** rows, event libraries, definitions, the Pulseseq version, and the optional signature.
- **Sequence**: the runtime representation used for simulation and plotting. It stores repeated blocks events as **RF, Grad, and ADC**.

## I/O PIPELINE & VALIDATION



## CONCLUSION

- A bidirectional Pulseseq I/O framework has been implemented in KomaMRI
- Enables standardized import and export of Pulseseq sequences
- Provides compatibility with external tools, including MRSeqStudio

## REFERENCES

- [1] Layton, K.J., Kroboth, S., Jia, F., Littin, S., Yu, H., Leupold, J., Nielsen, J.-F., Stöcker, T. and Zaitsev, M. Pulseseq: A rapid and hardware-independent pulse sequence prototyping framework. *Magn. Reson. Med.* 2017;77: 1544-1552.
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- [3] Villacorta-Aylagas P, Castillo-Passi C, Irarrazaval P, Simmross-Wattenberg F, Rodríguez-Cayetano M, Alberola-López C. A Free and Open-Source Web Application for Pulse Sequence Development and Simulation. *J Med Syst.* 2026;50: 65.

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