CLARISSA: A Conversational User Interface for Democratizing Reservoir Simulation

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Abstract

Reservoir simulation remains underutilized across the full spectrum of reservoir engineering—field development planning, production surveillance, forecasting, reserves booking, and exploration risking—despite decades of software advancement. The barrier is not computational; modern solvers are fast and robust. The barrier is accessibility.

This paper introduces CLARISSA (Conversational Language Agent for Reservoir Integrated Simulation System Analysis), which replaces the GUI paradigm with a Conversational User Interface (CUI). Rather than requiring users to navigate software, CLARISSA enables reservoir engineers to build and iterate on simulation models through natural language dialogue—including voice input for hands-free field operations.

Recent work has demonstrated generative AI assistants that help engineers query existing models (SPE-221987). CLARISSA addresses a different problem: generating complete, validated input decks from natural language specifications. The architecture combines large language models, reinforcement learning for action optimization, and neuro-symbolic components enforcing engineering constraints.

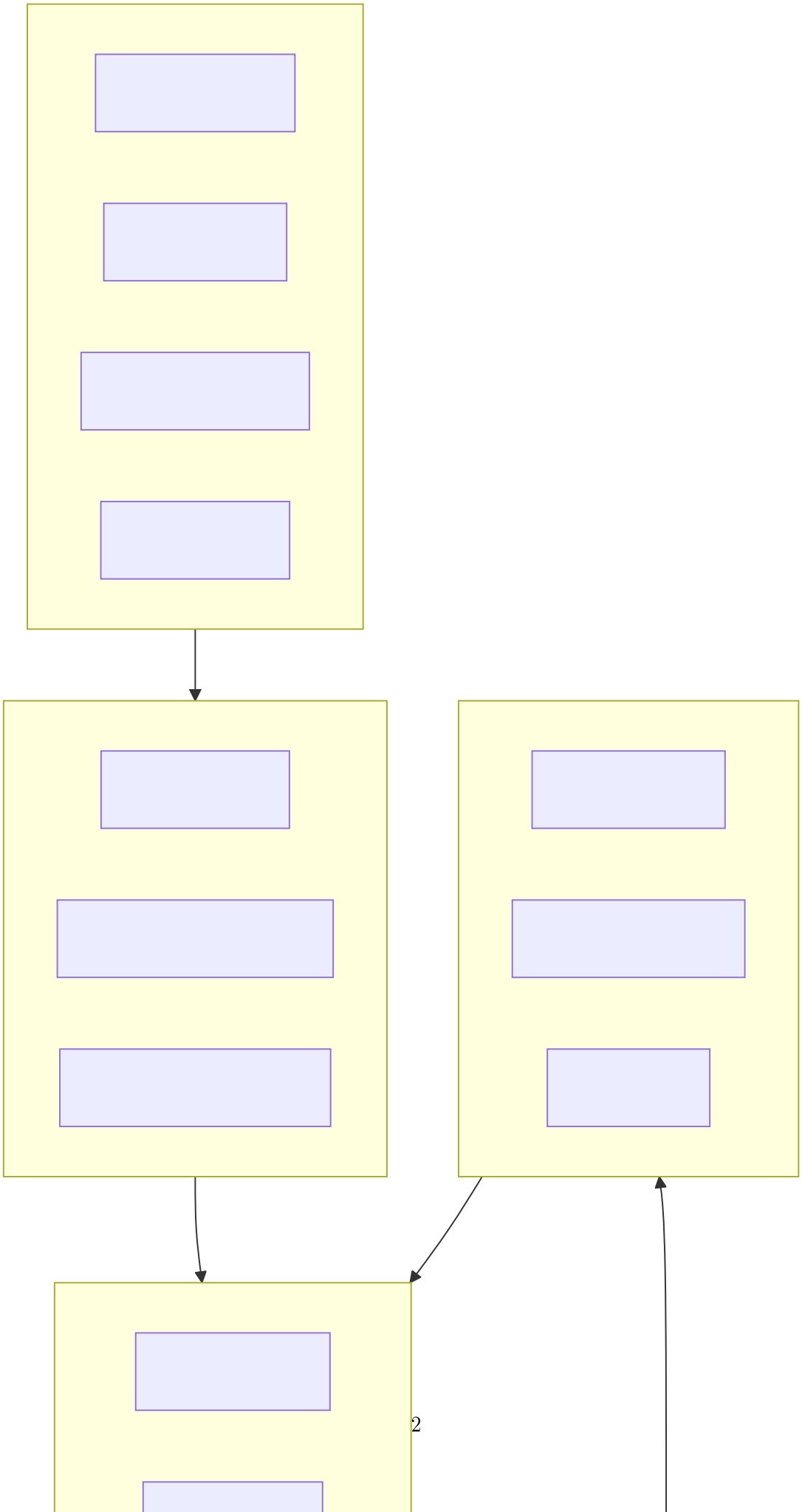
CLARISSA executes simulations via OPM Flow, enabling license-free web-based access. To enable systematic evaluation, we introduce RIGOR (Reservoir Input Generation Output Review), a benchmark framework spanning coreflood models to mid-conversation compositional EOS pivots.

The binding constraint on simulation adoption has never been solver performance. It is human cognitive load and workflow friction. CLARISSA addresses that constraint directly.

Keywords: Reservoir Simulation, Conversational UI, Voice Interface, Generative AI, LLM, OPM Flow, Deck Generation, Reinforcement Learning, Neuro-symbolic AI

1 System Architecture

The CLARISSA architecture comprises six primary layers, each addressing distinct concerns while maintaining loose coupling through well-defined interfaces (Figure 1).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Key Design Principles:

- **Voice-First Design:** Hands-free operation from field tablets during well site visits
- **Graceful Degradation:** Low-confidence interpretations trigger clarification requests; failed validations roll back to last valid state
- **Analog-Informed Defaults:** Missing parameters suggested from basin-specific databases with explicit documentation
- **License-Free Execution:** OPM Flow backend enables operators without commercial licenses

2 Development Phases

CLARISSA evolves through three development phases (Figure 2):

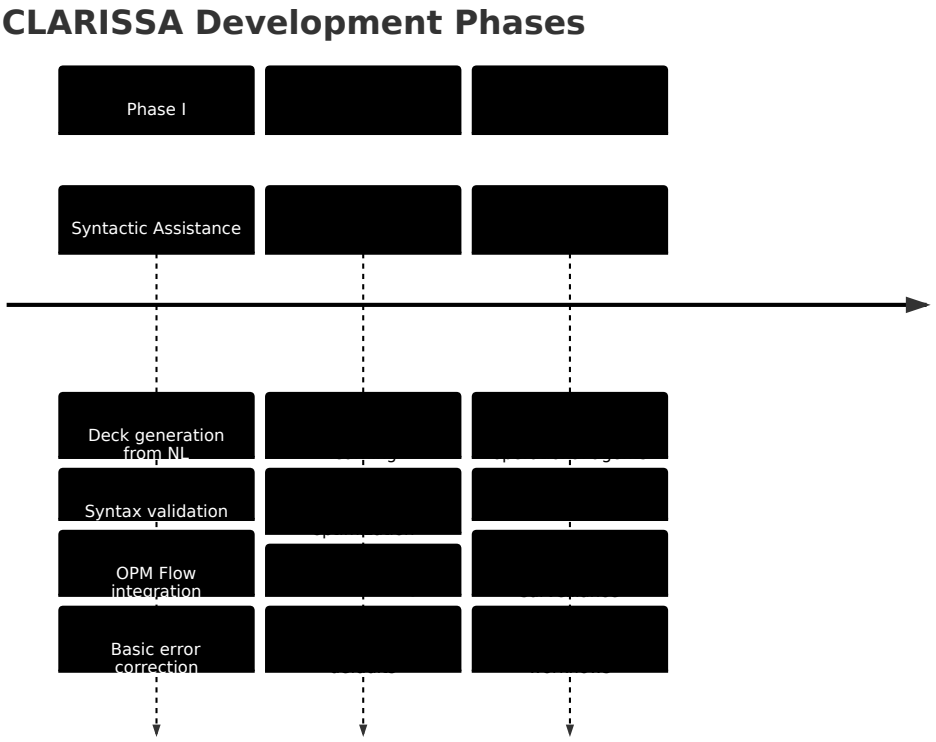

Figure 2: CLARISSA Development Roadmap: Phase I (Syntactic Assistance), Phase II (Physics-Informed), Phase III (Field-Specialized).

3 Comparison with Prior Work

Table 1 and Figure 3 illustrate the evolution from query-based assistants to generation-based systems.

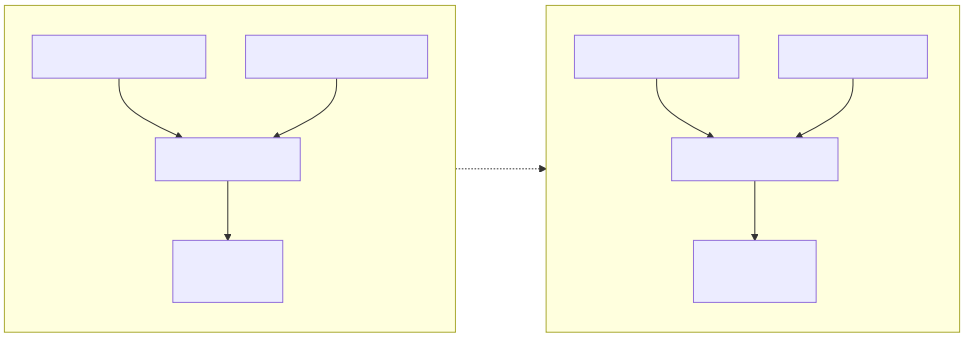

Figure 3: Evolution from Envoy (SPE-221987) to CLARISSA: Query-based vs. Generation-based paradigm.

Table 1: Feature Comparison: Envoy vs. CLARISSA

Aspect	**Envoy (SPE-221987)**	**CLARISSA**
Primary Function	Query existing models	Generate complete decks
Interaction Mode	Text Q&A on loaded model	Voice + Text elicitation
Input Modalities	Text chat only	Voice, Text, Web, API
Simulator	ECHELON (proprietary)	OPM Flow (open source)
Architecture	RAG + Callback Agents	RL + Neuro-symbolic + Feedback
Learning	Static knowledge bases	Adaptive via sim feedback
Error Handling	Manual correction	Auto rollback + clarification
Validation	Post-hoc analysis	Pre-execution physics check
Availability	Commercial license	Web-based, license-free

4 RIGOR Benchmark Framework

To enable systematic evaluation of CUI-based simulation systems, we introduce RIGOR (Reservoir Input Generation Output Review), assessing deck generation across four dimensions (Figure 4):

1. **Syntactic Validity:** Parser acceptance, keyword correctness
2. **Semantic Correctness:** Logical consistency, unit coherence
3. **Physical Plausibility:** Pressure gradients, saturations, rates within bounds
4. **Conversational Efficiency:** Turns to completion, clarification rate

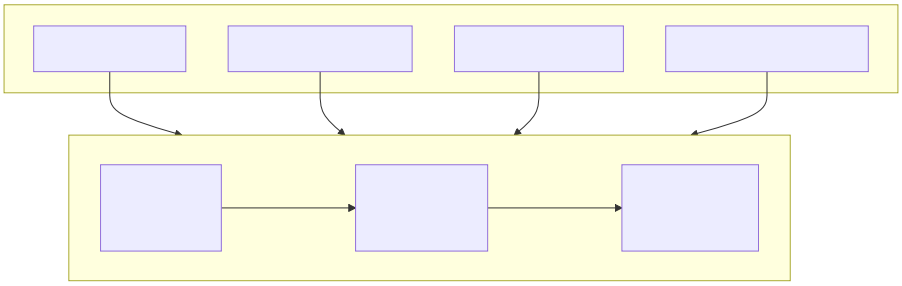

Figure 4: RIGOR Framework: Four evaluation dimensions across three complexity tiers.

Complexity Tiers:

Tier 1 (Foundational): Linear displacement model representing laboratory coreflood
Tier 2 (Intermediate): Pattern flood with 5-spot configuration, 40-acre spacing
Tier 3 (Advanced): Mid-conversation conversion of black-oil waterflood to compositional EOS for tertiary recovery

5 Example Interaction

Figure 5 demonstrates a typical voice-based field interaction sequence.

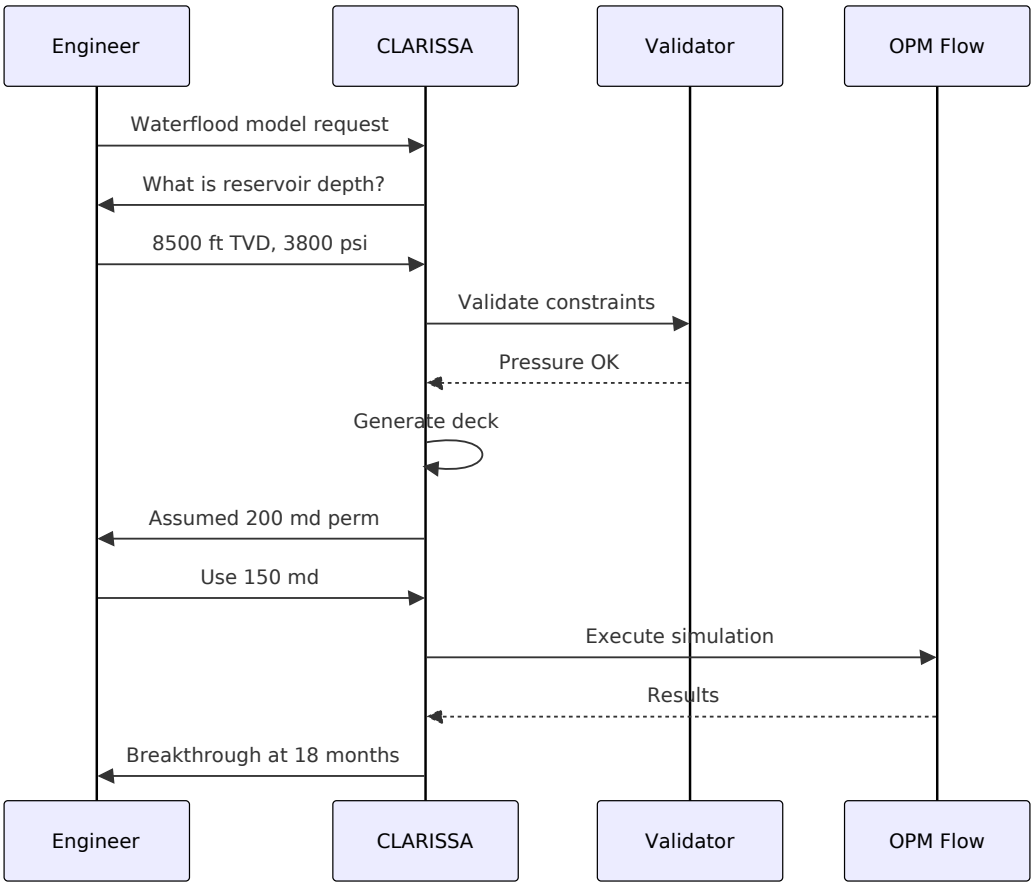

Figure 5: Voice-based field interaction: Engineer specifies waterflood model, CLARISSA validates physics, suggests analog-based defaults, executes simulation, and offers sensitivity analysis.

6 Conclusions

CLARISSA represents a paradigm shift in reservoir simulation accessibility:

- **First CUI-based system** for complete simulation deck generation
- **Voice-enabled field workflows** previously impossible with traditional interfaces
- **License-free execution** via OPM Flow removes barriers for operators
- **RIGOR benchmark** provides first standardized evaluation framework
- **Hybrid AI architecture** combines LLM, RL, and neuro-symbolic components

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References

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[2] Open Porous Media Initiative, "OPM Flow Documentation," https://opm-project.org