Ramtera LVR

Technical Correlation Report
and Industry Collaboration Proposal

Pre-Signoff Physical Verification

Prepared by:	Ramtera Inc.
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Contents

1 Executive Summary

Ramtera has developed **LVR**, an integrated physical verification platform covering DRC, density verification, LVS, ERC, XOR, connectivity, rule execution, reporting, regression automation, and multithreaded processing. This report summarizes recent physical-verification correlation results and proposes industry collaboration for controlled evaluation and pre-signoff deployment.

The results show that LVR is already highly mature for non-density DRC correlation. On the evaluated cell-design workload, LVR recovered 7,510 of 7,511 golden markers by overlap, corresponding to **99.9867% recall**. Exact-coordinate recall was **99.9334%**, and scored precision was **98.5392%**. Density verification is also operational: implemented comparable outputs achieved **100% precision**, with remaining gaps concentrated in known layer-scoping and completeness items.

99.9867%	99.9334%	100.0%
Golden-marker overlap recall Cell non-density DRC	Exact golden-marker recall Cell non-density DRC	Overlap precision Implemented density checks

LVR is positioned as a **highly correlated pre-signoff physical verification engine**. It is intended to complement established signoff flows by enabling more frequent DRC and density iterations during implementation, reducing late-stage surprises, improving engineering productivity, and lowering dependence on scarce signoff licenses for intermediate runs.

The purpose of this document is to invite collaboration with semiconductor companies, design service providers, technology partners, and implementation teams in the following areas:

- controlled pilot deployment on customer designs;
- joint correlation and benchmarking;
- rule-deck enablement and validation;
- production pre-signoff integration;
- runtime and scalability optimization;
- broader technology-node qualification.

2 Industry Need and Collaboration Objective

Modern implementation flows require repeated physical verification throughout floorplanning, placement, routing, ECO closure, and final tapeout preparation. Final signoff tools remain essential, but using them for every intermediate iteration can create licensing constraints, long queues, and limited access across large engineering teams.

A highly correlated pre-signoff engine addresses this gap by allowing implementation engineers to identify the overwhelming majority of violations earlier and more frequently. The commercial objective is not to replace the final foundry-qualified signoff run. Instead, LVR is designed to reduce the number of expensive signoff iterations required before closure.

Ramtera is therefore seeking collaboration with organizations that have active semiconductor implementation programs, customer access, implementation expertise, or interest in deploying a complementary verification platform. Design service providers are especially well positioned to evaluate LVR because they support multiple customer programs and can measure productivity improvements across real implementation workflows.

3 Product Overview

3.1 LVR Physical Verification Platform

LVR is designed as an integrated physical verification environment supporting production rule-deck execution and correlation-driven validation.

Table 1: LVR capability overview

Capability	Description	Status
DRC	Geometric and connectivity-based design-rule checking	Available
Density	Window-based density checks, stepping, layer filtering, and marker reporting	Available / expanding
LVS	Layout-versus-schematic extraction and comparison	Available
ERC	Electrical rule checking and device/connectivity validation	Available
XOR	Layout comparison and discrepancy localization	Available
Rule Execution	Production-scale command evaluation and derived-layer processing	Available
Multithreading	Parallel execution for rule and region workloads	Available
Regression	Automated multi-design execution and result comparison	Available
Reporting	Rule-level and marker-level result reporting	Available
GUI Debug	Marker review and verification workflow	Available

3.2 Correlation Philosophy

Ramtera uses correlation as a central engineering metric rather than relying only on rule execution success. The correlation flow evaluates whether LVR reproduces the geometry reported by the golden implementation and whether LVR introduces additional unsupported geometry.

The principal metrics used are:

- **Exact recall**: fraction of golden markers reproduced with identical coordinates.
- **Overlap recall**: fraction of golden markers overlapped by an LVR marker.
- **Precision**: fraction of LVR markers supported by overlap with golden geometry.
- **Per-rule recall**: recovery rate calculated separately for each comparable rule.
- **Per-rule precision**: degree to which LVR output remains within the golden result set.

4 Confidentiality and Controlled Disclosure

This report contains detailed rule-level correlation results for technical evaluation by authorized customer, partner, and engineering teams. The identifiers are anonymized to protect proprietary process information while preserving the complete numerical results, status classifications, and engineering conclusions.

The document must be handled as confidential technical material. It should not be published, posted publicly, or redistributed beyond approved evaluation teams. Any associated layouts, result databases, rule decks, screenshots, or customer-specific observations should remain subject to applicable confidentiality agreements.

Confidential technical material. Share only with authorized evaluation and collaboration teams.

5 Test Environment and Methodology

5.1 Common Methodology

Both result sets were evaluated using the following workflow:

1. Run the golden reference flow on the selected design.
2. Run LVR on the same design, using equivalent geometry, boundary, unit, and rule inputs.
3. Parse the golden and LVR result databases.
4. Normalize rectangles and rule associations.
5. Perform one-to-one exact coordinate matching.
6. Perform geometric overlap matching for non-exact but spatially corresponding markers.
7. Compute golden misses, LVR extras, recall, precision, and per-rule statistics.
8. Review capped rules and rules not exercised by the selected design separately.

5.2 Interpretation of Capped Golden Results

In the non-density dataset, seven golden rules reached a maximum-violations reporting ceiling of 1,000 markers. For those rules:

- every retained golden marker was reproduced by LVR;
- golden results beyond the reporting ceiling are unknown;
- additional LVR markers beyond the retained golden set cannot be classified reliably as false positives;
- those additional markers were therefore treated as *unverifiable*, not incorrect.

This treatment is conservative and prevents a truncated golden result file from being interpreted as proof that additional LVR geometry is false.

6 Result Set A: Cell Design Non-Density DRC

6.1 Scope

This dataset covers non-density DRC behavior on a commercial-process cell design. Density rules were excluded so that conventional geometric DRC behavior could be assessed independently.

6.2 Aggregate Results

6.3 Interpretation

The non-density result is the strongest evidence in the present dataset.

Table 2: Cell-design non-density correlation summary

Metric	Result
Golden rectangles	7,511
LVR rectangles used in scored comparison	7,667
Exact matches	7,506
Golden markers overlapped by LVR	7,510
Golden misses	1
LVR markers overlapping golden	7,555
LVR extras without golden overlap	112
Golden-marker overlap recall	**99.9867%**
Exact golden-marker recall	**99.9334%**
LVR precision	**98.5392%**

- LVR recovered **7,510 of 7,511** golden markers by overlap.
- Only **one** golden marker was not reproduced.
- **7,506** golden markers were reproduced with exact coordinates.
- The overlap recall of **99.9867%** indicates essentially complete recovery of golden violations.
- The exact recall of **99.9334%** demonstrates close agreement not only in detection, but also in marker geometry.
- Seven capped rule groups reproduced every golden marker retained in the golden database.

The small difference between overlap and exact recall is expected in cases where one reference polygon is not an axis-aligned rectangle or where marker-box construction differs slightly while still identifying the same physical violation.

6.4 Representative Rule-Level Results

Table 3: Representative non-density rule correlation using anonymized rule identifiers

Rule	Golden	LVR	Exact	Recall	Observation
Rule 1	1,000	3,523	1,000	100%	Golden capped; all retained markers reproduced
Rule 2	1,000	3,523	1,000	100%	Golden capped; all retained markers reproduced
Rule 3	1,000	3,523	1,000	100%	Golden capped; all retained markers reproduced
Rule 4	1,000	3,109	1,000	100%	Golden capped; all retained markers reproduced

Rule	Golden	LVR	Exact	Recall	Observation
Rule 5	441	441	441	100%	Exact result-set agreement
Rule 6	1,000	3,277	1,000	100%	Golden capped; all retained markers reproduced
Rule 7	1,000	3,523	1,000	100%	Golden capped; all retained markers reproduced
Rule 8	63	63	63	100%	Exact result-set agreement
Rule 9	1,000	1,496	1,000	100%	Golden capped; all retained markers reproduced
Rule 10	1	16	0	100%	Same violation overlapped; marker representation differs
Rule 11	1	1	1	100%	Exact result-set agreement
Rule 12	1	16	0	100%	Same violation overlapped; expanded marker representation
Rule 13	1	1	0	100%	Inexact coordinate match with valid overlap
Rule 14	1	1	1	100%	Exact result-set agreement
Rule 15	1	16	0	100%	Same physical violation represented by multiple LVR rectangles

6.5 Rule-Level Engineering Assessment

The rule-level results support the following technical conclusions:

- **Rules 1–4, 6, 7, and 9** reached the golden reporting cap. LVR reproduced every retained golden marker for each of these checks. Additional LVR markers on these rules remain unclassifiable until an uncapped or higher-cap golden run is available.
- **Rule 5**, **Rule 8**, **Rule 11**, and **Rule 14** show exact result-set agreement for the retained testcase output.
- **Rule 10**, **Rule 12**, and **Rule 15** identify the same golden violation locations, but LVR decomposes the reported geometry into multiple rectangles. These are marker-representation differences rather than missed physical violations.
- **Rule 13** overlaps the golden marker but is not coordinate-exact, indicating a localized marker-boundary construction difference.

- **Rule 16** is the only golden rule result not reproduced in the present non-density run and is the principal functional discrepancy requiring closure.

6.6 Outstanding Non-Density Items

The principal follow-up items are limited and identifiable:

- investigation of the single missed golden marker;
- review of small LVR-only marker groups;
- consolidation of cases where one golden marker is represented by multiple LVR rectangles;
- validation of generated-rule output collisions in which structurally different checks produce identical rectangle sets;
- uncapped golden reruns for a conclusive precision measurement on capped rules.

These items do not alter the central result: golden-marker recovery is effectively complete for the tested non-density cell-design workload.

7 Result Set B: Density Correlation

7.1 Scope

The second dataset evaluates density verification on a representative design. This result is reported separately because density rules depend heavily on derived-layer scope, density-window construction, boundary handling, and testcase-specific layer availability.

7.2 Aggregate Results

Table 4: Density correlation summary

Metric	Result
Golden density rules	15
Golden rectangles	2,632
Comparable LVR rectangles	1,174
Coordinate-exact matches	1,174
Golden markers overlapped	1,529
Golden misses	1,103
LVR false positives	0
Exact recall	44.6%
Overlap recall	58.1%
Exact precision	**100.0%**
Overlap precision	**100.0%**
Rules not exercised by the golden dataset	63
LVR markers in not-exercised rules	461

7.3 Interpretation

The density result should be interpreted as an intermediate engineering milestone rather than a completed correlation result.

The strongest result is precision:

- every LVR marker in the comparable rule set was supported by the golden result;
- there were **zero false positives**;
- exact and overlap precision were both **100%**;
- several implemented rules achieved complete golden overlap despite producing a subset of the golden window set.

The reduced recall is concentrated in a limited group of missing or incomplete rule outputs. Five rules produced no LVR markers in this run, accounting for 1,077 golden rectangles. These rows are being treated as a **pending layer-scoping item**, not as evidence of random geometric disagreement.

7.4 Pending Layer-Scoping Work

The current density gaps are associated with one or more of the following:

- derived layers not yet included in the active density scope;
- incomplete mapping of layer variants used by selected density checks;
- missing inclusion of certain process-layer combinations in the current design configuration;
- testcase boundary or window-scope differences;
- remaining rule-specific density-window implementation work.

The important distinction is that implemented outputs are clean: LVR is not generating unsupported density violations. The next engineering step is therefore to expand scope and recover the remaining golden rows, not to correct broad false-positive behavior.

7.5 Per-Rule Density Results

Table 5: Density rule correlation

Rule	Golden	LVR	Exact	Ovlp. Recall	Precision	Status
Rule 17	119	91	91	100%	100%	Implemented subset; all golden regions overlapped
Rule 18	2	1	1	100%	100%	Implemented subset
Rule 19	120	92	92	100%	100%	Implemented subset
Rule 20	120	0	0	0%	—	Pending layer scoping
Rule 21	339	0	0	0%	—	Pending layer scoping
Rule 22	497	0	0	0%	—	Pending layer scoping
Rule 23	409	348	348	100%	100%	Implemented subset
Rule 24	235	175	175	100%	100%	Implemented subset

Rule	Golden	LVR	Exact	Ovlp. Recall	Precision	Status
Rule 25	120	92	92	100%	100%	Implemented subset
Rule 26	120	0	0	0%	—	Pending layer scoping
Rule 27	92	64	64	100%	100%	Implemented subset
Rule 28	36	22	22	100%	100%	Implemented subset
Rule 29	120	92	92	100%	100%	Implemented subset
Rule 30	302	197	197	91.4%	100%	Mostly correlated; 26 golden regions pending review
Rule 31	1	0	0	0%	—	Pending layer scoping

7.6 Density Rule-Level Engineering Assessment

The density correlation is concentrated into two clearly distinguishable categories:

- **Implemented and correlated checks: Rule 17**, **Rule 18**, **Rule 19**, **Rule 23**, **Rule 24**, **Rule 25**, **Rule 27**, **Rule 28**, and **Rule 29** achieve 100% overlap recall and 100% precision for the produced LVR windows.
- **Partially correlated check: Rule 30** achieves 91.4% golden overlap recall and 100% precision, leaving 26 golden windows for focused review.
- **Pending layer-scope checks: Rule 20**, **Rule 21**, **Rule 22**, **Rule 26**, and **Rule 31** produced no LVR markers in the current configuration. Together they account for 1,077 golden markers and define the primary remaining density work package.

This distribution is technically encouraging because the active LVR density outputs contain no unsupported markers. The remaining work is therefore dominated by completeness of layer derivation and scope rather than by false-positive suppression.

7.7 Density Engineering Plan

1. Complete scoping for the five silent density rules.
2. Confirm all required base and derived layers are available in the testcase environment.
3. Align density-window generation and clipping behavior with the golden configuration.
4. Re-run the full 15-rule comparable set.
5. Investigate the 26 remaining golden markers in **Rule 30**.
6. Expand correlation to additional designs after closure of the current layer-scope items.

8 Why LVR Is Suitable for Pre-Signoff Deployment

The correlation results support a practical pre-signoff deployment model. LVR can be inserted before the final signoff stage and used repeatedly during implementation. This allows design teams to run verification more frequently without changing the established tapeout methodology.

8.1 Engineering Value

- **Earlier issue discovery:** implementation errors are detected during active design closure rather than at the end of the flow.
- **Reduced signoff iterations:** high-correlation pre-checks decrease the number of avoidable violations reaching final signoff.
- **Faster ECO turnaround:** engineers can verify localized changes without waiting for scarce signoff resources.
- **Wider tool availability:** additional pre-signoff capacity can be deployed across larger design teams.
- **Transparent correlation:** rule-level and marker-level comparison provides measurable confidence rather than relying only on aggregate pass/fail summaries.

8.2 Commercial Value

- reduced dependence on premium signoff licenses for intermediate runs;
- improved utilization of implementation engineering teams;
- shorter design-closure cycles;
- differentiated verification capability for design service providers;
- scalable licensing for projects requiring many concurrent verification users.

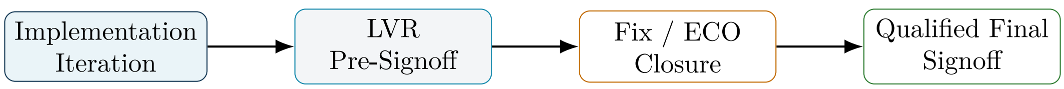
9 Value for Design Service Providers

Large design service organizations often support several semiconductor customers and multiple customer programs simultaneously. In this environment, pre-signoff verification capacity can become a direct productivity constraint.

LVR can be evaluated as a complementary platform for:

- customer design bring-up and initial rule-deck validation;
- daily implementation-stage DRC and density runs;
- ECO verification before formal signoff submission;
- regression testing across design partitions and customer programs;
- distributed execution across internal compute infrastructure;
- providing faster turnaround as part of a differentiated design service offering.

The intended workflow is straightforward:



10 Proposed Collaboration Program

Ramtera proposes a phased collaboration that allows technical evaluation before broader deployment.

10.1 Phase 1: Controlled Technical Evaluation

1. Select one representative customer design and an agreed set of non-density and density checks.
2. Establish the reference flow, result format, boundaries, units, top cell, and run-control configuration.
3. Execute the same workload using LVR.
4. Generate rule-level and marker-level correlation reports.
5. Review discrepancies jointly and classify them by root cause.

10.2 Phase 2: Pilot Deployment

1. Integrate LVR into an active implementation or regression flow.
2. Run LVR before formal signoff checkpoints.
3. Measure runtime, queue reduction, violation recovery, and engineering turnaround.
4. Track the number of signoff iterations avoided or simplified.

10.3 Phase 3: Production Expansion

1. Expand to additional designs, teams, and customer programs.
2. Add rule families and technology variants based on project demand.
3. Establish support, escalation, regression, and release-management procedures.
4. Define a production licensing and deployment model.

11 Suggested Pilot Success Criteria

A pilot should use measurable technical and operational criteria. Suggested criteria include:

Table 6: Illustrative pilot success criteria

Area	Evaluation Method	Suggested Target
Correlation	Golden-marker overlap and exact-coordinate comparison	Agreed per-rule thresholds
False positives	Review unsupported LVR markers in comparable uncapped rules	Low and explainable
Runtime	Compare wall time on representative workloads	Operationally useful for daily iterations
Stability	Execute repeated regression runs	Reproducible results
Integration	Invoke from existing scripts and environments	Minimal flow disruption
Support	Track issue triage and closure	Defined response process
Business impact	Measure reduced signoff usage and iteration time	Quantifiable engineering benefit

12 Ramtera Collaboration Commitments

Ramtera is prepared to:

- maintain strict confidentiality of customer and technology material;
- provide reproducible run instructions and machine-readable reports;
- support rule-level discrepancy review;
- maintain controlled regression suites for pilot designs;
- report limitations transparently;
- prioritize confirmed correlation gaps;
- provide engineering support during evaluation and integration;
- collaborate on performance, scalability, and deployment requirements.

13 Recommended Next Step

The recommended next step is a focused technical workshop followed by a controlled pilot on one representative customer design. The workshop should define:

- target design and verification scope;
- reference outputs and comparison methodology;
- compute environment and runtime expectations;
- confidentiality and data-handling requirements;
- success criteria and review checkpoints;
- ownership of discrepancies and expected closure process.

14 Conclusion

The current results demonstrate that LVR has reached a level of maturity suitable for broader industry evaluation as a pre-signoff physical verification engine.

For the cell-design non-density dataset, LVR achieved:

- **99.9867% overlap recall**;
- **99.9334% exact recall**;
- only **one missed golden marker** out of 7,511;
- complete recovery of every retained marker in seven capped golden rule groups.

For the representative density dataset, LVR achieved:

- **100% exact precision**;
- **100% overlap precision**;
- **zero false positives**;
- complete overlap on multiple implemented rule groups;

- a clearly bounded set of pending layer-scoping items.

These results provide a strong basis for joint evaluation with semiconductor companies and design service providers. LVR can complement established signoff tools by enabling faster, more frequent, and more economical physical verification throughout implementation.

Collaboration Proposal

Ramtera invites qualified partners to evaluate LVR on representative customer designs and jointly define a path toward production pre-signoff deployment.

A Appendix A: Metric Definitions

Golden marker A violation geometry reported by the golden reference flow.

LVR marker A violation geometry reported by LVR.

Exact match Golden and LVR marker coordinates are identical.

Overlap match Golden and LVR marker geometries intersect, even if their bounding boxes are not identical.

Golden miss A golden marker with no corresponding LVR overlap.

LVR false positive An LVR marker with no supporting golden overlap in a fully comparable, uncapped rule.

Capped rule A golden rule whose output is truncated at a configured maximum-violation count.

Not exercised An implemented LVR rule for which the selected golden testcase contains no corresponding result block.

Pending layer scoping A rule whose required base or derived layers are not yet fully included in the testcase execution scope.

B Appendix B: Suggested Evaluation Attachments

The following supporting material may be included in an authorized customer or partner evaluation package:

- sanitized screenshots of golden and LVR markers;
- per-rule correlation CSV files using anonymized rule identifiers;
- run logs showing software version and execution parameters;
- testcase boundary and unit summaries;
- regression-script overview;
- architecture diagram of the LVR rule-processing flow;
- issue-closure table for the single non-density miss and pending density rules.

C Appendix C: Contact Information

Company	Ramtera Inc.
Contact	Sameer P.
Role	Founder / CEO
Email	[sameer@ramtera.com]
Telephone	[+91-7259103580]
Website	[www.ramtera.com]

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