AI-Powered PCB Engineering Forum

From Experts to Everyone

AI-Augmented Approach to PCB Design Verification

"The Wright brothers' first flight lasted just 12 seconds."

Build, write, and evolve DRC rules from a single line of natural language – bringing verification capability from a handful of experts to every engineer

Hyunjae Kim
Sr. Application Engineer

JK ED&C
www.ednc.com

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Remember? Three Years Ago, in This Same Room

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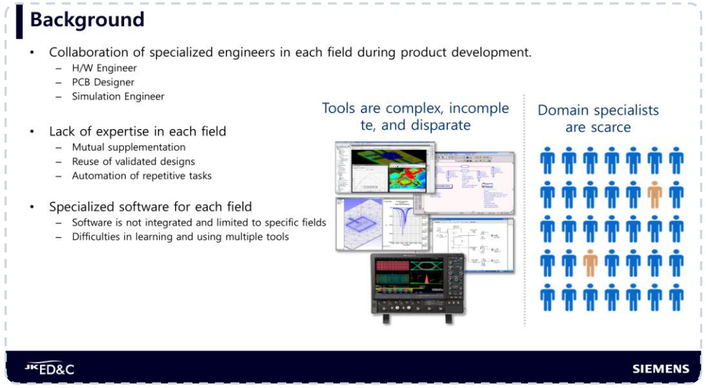
2023 → 2026

Back in 2023, at this very forum, I proposed: **"Let's solve the expert bottleneck with verification automation."**

2023 — The Proposal·Verification Automation

2026 · Today — Maturation·Operational Adoption

The Next 3 Years — Starting Today, Together



What was a trend three years ago has become today's standard practice.

The trend for 2026 begins – here, today, in this room.

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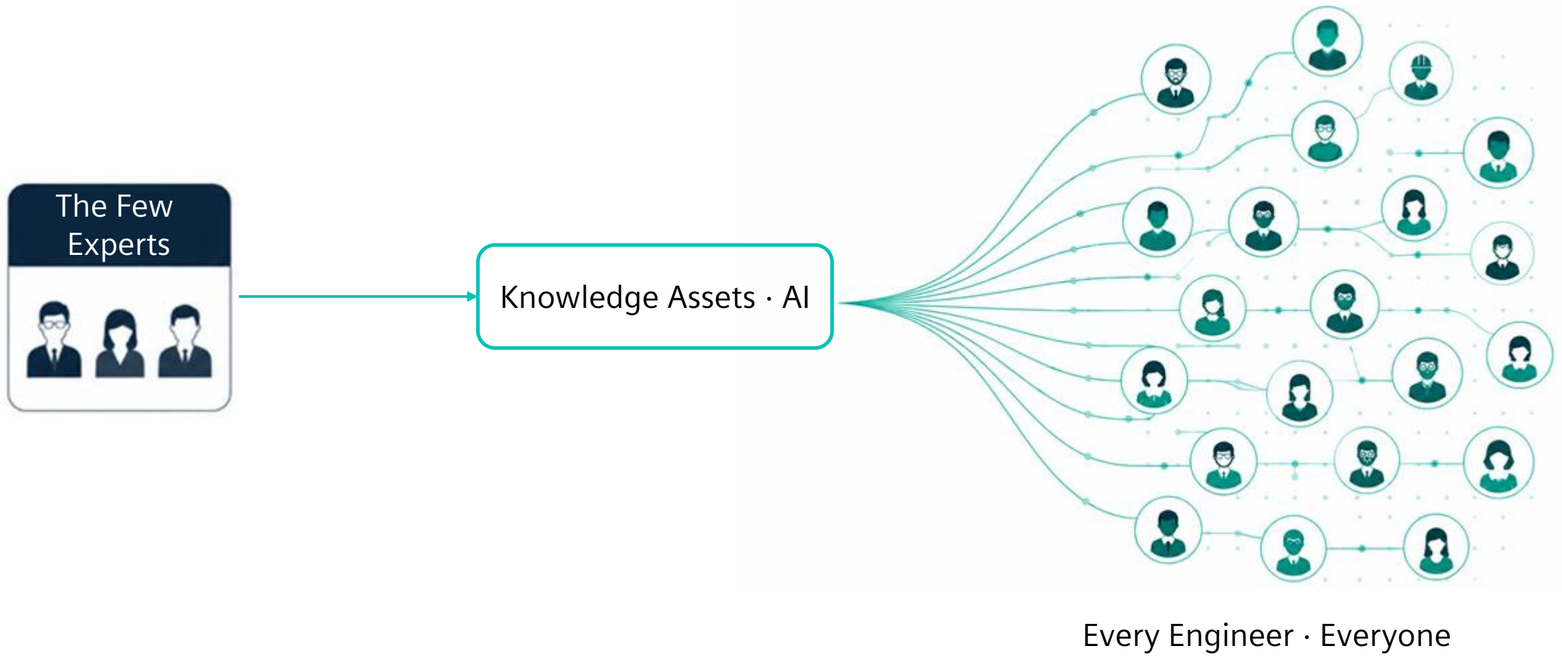
DRC Authoring, No Longer Experts-Only

THE SHIFT



The key is that the structure of ***"who creates it"*** changes — from the few to everyone.

Today, I'll show you how that structure actually works in practice.

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What We'll Cover Today

AGENDA

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01 **The Problem**

Traditional DRC rule development and the expert bottleneck

02 **Phase1 · Knowledge Assetization**

Structuring knowledge — API index· patterns · knowledge

03 **Phase2 · AI**

Natural language → generation · testing · explanation · reporting

04 **Field Cases** — our deepest dive

Crop · Same-Net Cross · onboarding existing rules

05 **Evolution & Future**

Evolution by industry & business unit, and redefining the expert

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The Traditional DRC Rule Development Flow

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PROBLEM 01

Every time a new requirement comes up, an expert has to dig through the COM API and hand-assemble the rule.

106

COM Automation objects

1,742

API members (properties·methods)

Barrier to Entry

Mastering the object model and safely assembling it in Python isn't something just anyone can do

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So Where Does It Hurt?

PROBLEM 02

A

Schedule Bottleneck

Every new rule means waiting in line for an expert’s availability.

B

Locked-In Roles

Engineers are stuck at “execute&review.” They can’t create.

C

Quality Variance

Edge-case and exception handling swings wildly depending on who wrote it.

“How do we share this capability with everyone?”

First, Turn the Expert's Mind into a Structured Asset

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STAGE 1 · Assetization

01

AOM Local Index

106 API objects · 1,742 members, turned into a searchable index. No more humans digging through docs.

02

Pattern Library

Dimensions · traces · spacing · vias · BGA · components... verification scripts by category.

03

Knowledge Base

Gotchas · errors · patterns, accumulated on a per-object basis..

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STAGE 1 · Assetization

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AOM Local Index

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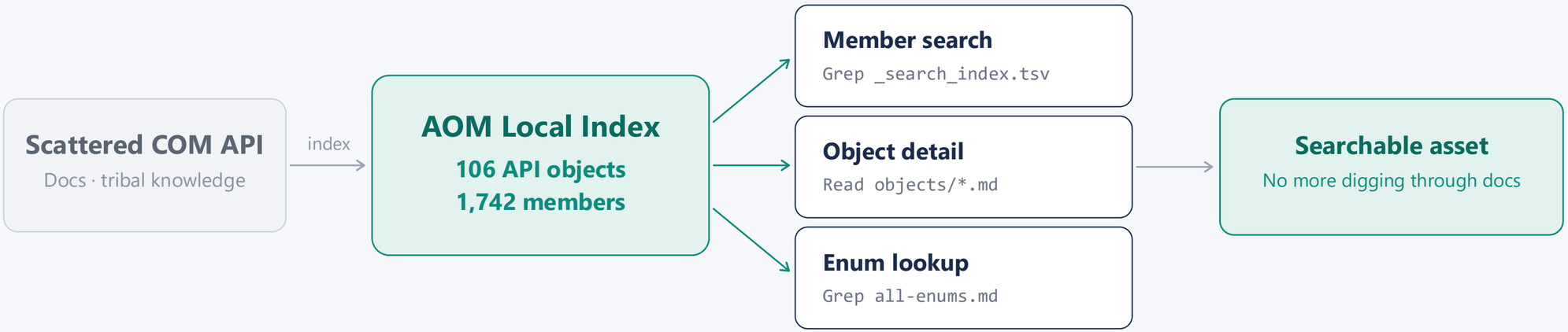

First, Turn the Expert's Mind into a Structured Asset

STAGE 1 · Assetization

02

Pattern Library

Dimensions · traces · spacing · vias · BGA · components... verification scripts by category.

ID scheme

G-NNN	Gotcha
E-NNN	Error
P-NNN	Pattern

Entry schema

- **AOM** · Related object
- **Severity** · critical / important / basic
- **Context** · Problem · Solution
- **Example** · python snippet
- **Title** · date (YYYY-MM-DD)

register

`pattern.md` — Summary table

→ `by-aom/{Cat}.md` — Detailed patterns

→ `_aom_index.tsv` — Grep lookup

`Grep "^{AOM}\t" _aom_index.tsv` — find patterns instantly by object name

First, Turn the Expert's Mind into a Structured Asset

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STAGE 1 · Assetization

03

Knowledge Base

Gotchas · errors · patterns, accumulated on a per-object basis..

knowledge/

_aom_index.tsv
Grep-optimized search index

gotchas / errors / patterns .md
Summary tables

by-AOM/{Category}.md
Core · Geometry · ViolationRule · NetTrace
ComponentPin · BoardLayer · Via · Collection ...

scripts/rebuild_index.py
by-AOM/*.md → _aom_index.tsv

Organized per AOM object

READ · before using an AOM

```
Grep "^{Object}\t" _aom_index.tsv
→ Read by-AOM/{Category}.md
```

WRITE · after a fix or finding

1. Add detail → by-AOM/{Category}.md
2. Add row → summary table
3. Run rebuild_index.py

Step 3 regenerates the search index — the loop that keeps knowledge queryable

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First, Turn the Expert's Mind into a Structured Asset

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STAGE 1 · Assetization

01 AOM Local Index

02 Pattern Library

03 Knowledge Base

...but up to here, a **human still has to assemble it**. One more step to go.

Natural Language Goes In, a Verification Rule Comes Out

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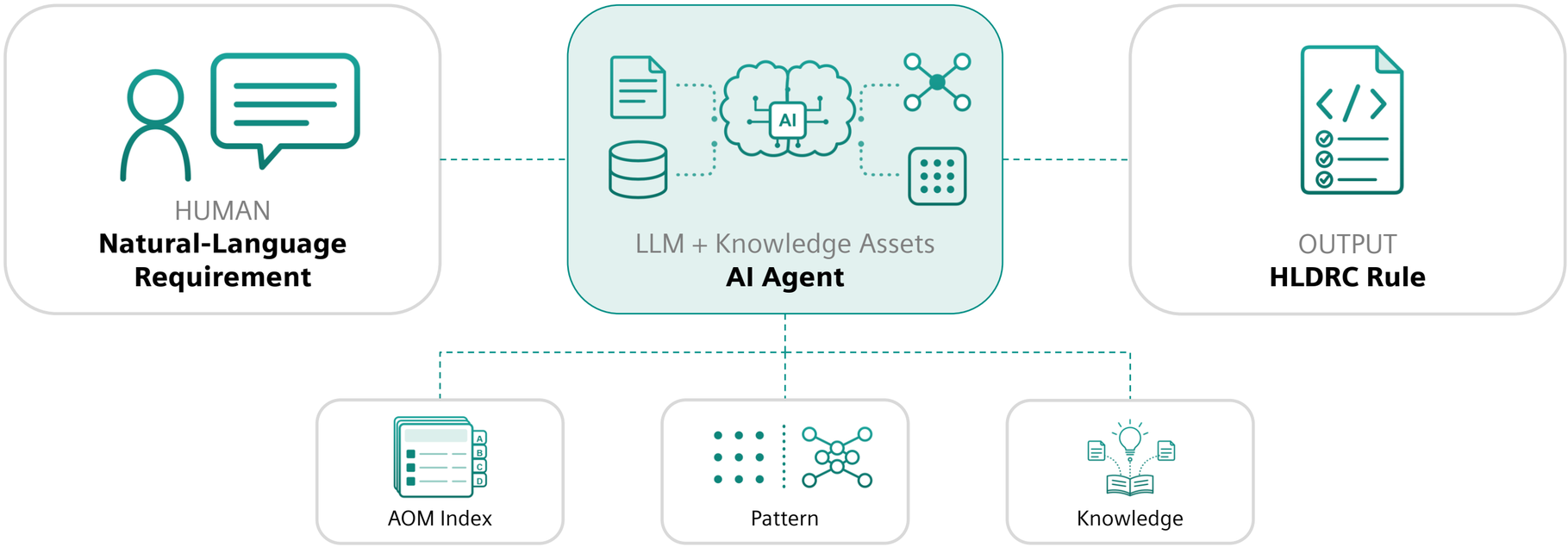
STAGE 2 · AI



Expected Benefits — 4 of them, demonstrated in real-world cases

- Faster Turnaround
- No Expert Bottleneck
- Barrier Removed
- Rule Quality & Accuracy

It doesn't stop at generation — **testing · explanation · debugging · reporting** all flow as one continuous process.

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One Workflow, Six Skills

STAGE 2 · Tools

/hldrc-rule

Natural Language →

Rule generation · editing · review

/hldrc-api-lookup

AOM index-based API lookup

/hldrc-test-rule

Live COM execution · auto-fix · report

/hldrc-debug

Error diagnosis · debugging (knowledge)

/hldrc-explain

Analyze existing rules · Mermaid flowchart

/hldrc-pattern

Pattern library search · recommendation

Generate → Run → Self-Correct → Report

STAGE 2 · END-TO-END

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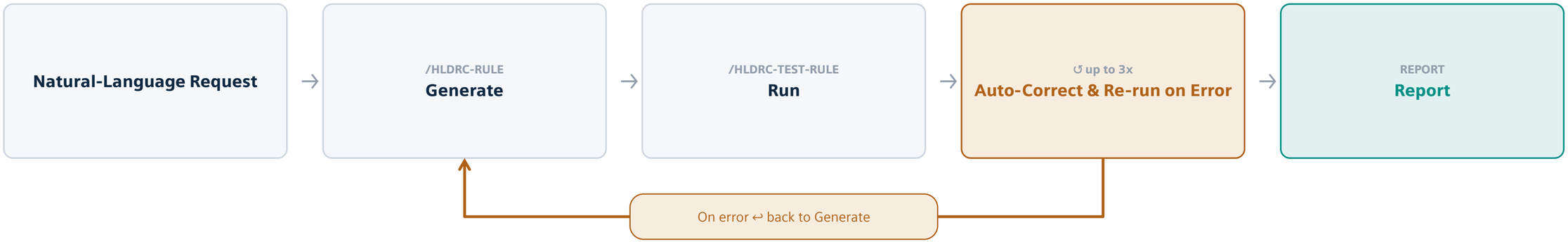

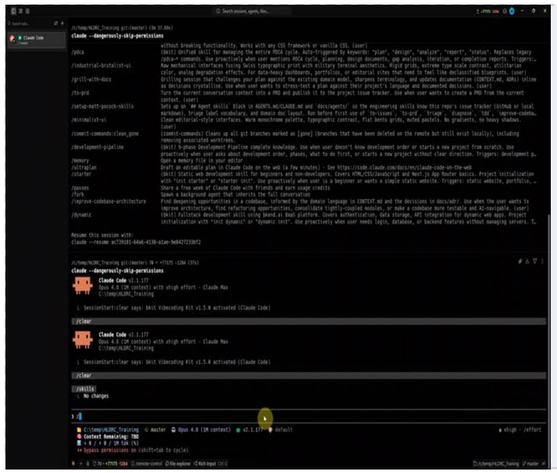

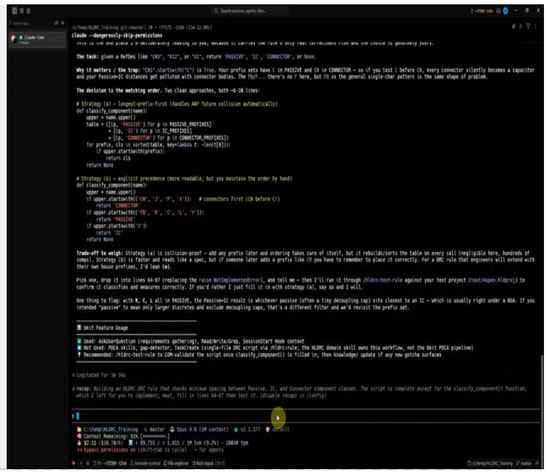

Why It Matters:

- Not “build and done” – **validated by running on a real design**
- Even on failure, it **fixes itself** using knowledge
- Results remain as a **shareable report**
- The **expert sign-off gate** before deployment stays in place

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Three Real-World Cases

REAL CASES

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04

How the system solves the exact points where engineers actually **got stuck.**

All real cases, real deliverables – work that **even experts had to dig through the API for, every time,** now compressed into natural language.

UC1 · Large-Scale Design Crop

UC2 · Same-Net Cross

UC3 · Explaining Existing Rules

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Large-Scale Design — Crop / Rule Area Selection

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No Expert Bottleneck

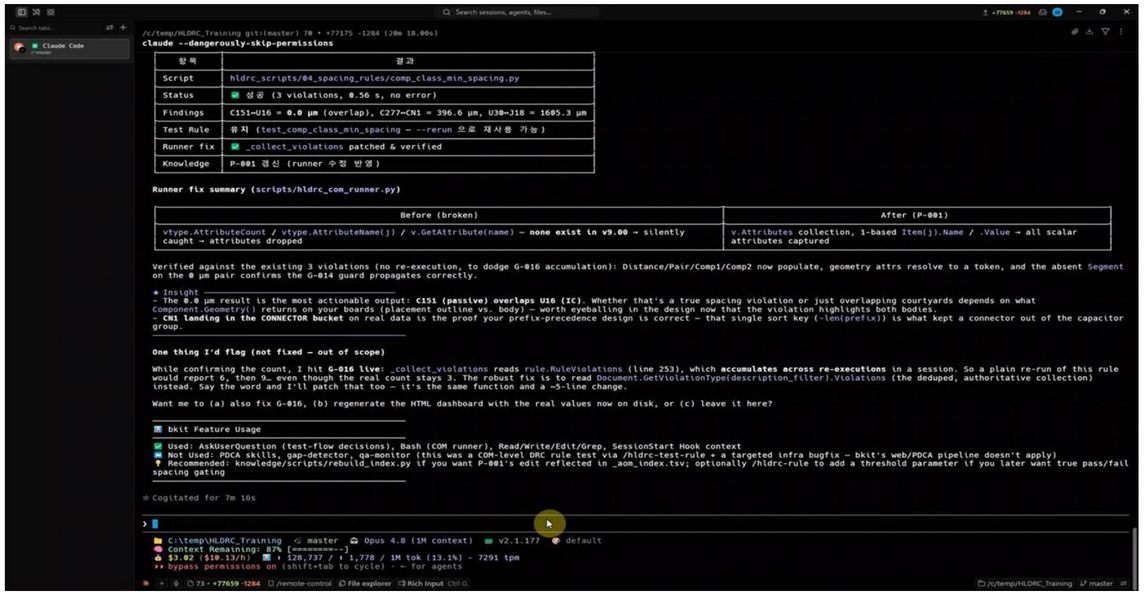
Entry Barrier Removed

The Sticking Point

"I want to crop just part of a huge design, or define a Rule Area to verify – but I don't know how to handle it"

Here's How AI Does It

- Expand selected objects by a **Margin**
- Auto-generate the **boundary**
- Save just the cropped region with **SaveAreaCrop**



~13MB

Cropped output design (.hldproj) – only the verification scope, separated out

One Shot

Fully automated from selection to crop-save

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Large-Scale Design — Crop / Rule Area Selection

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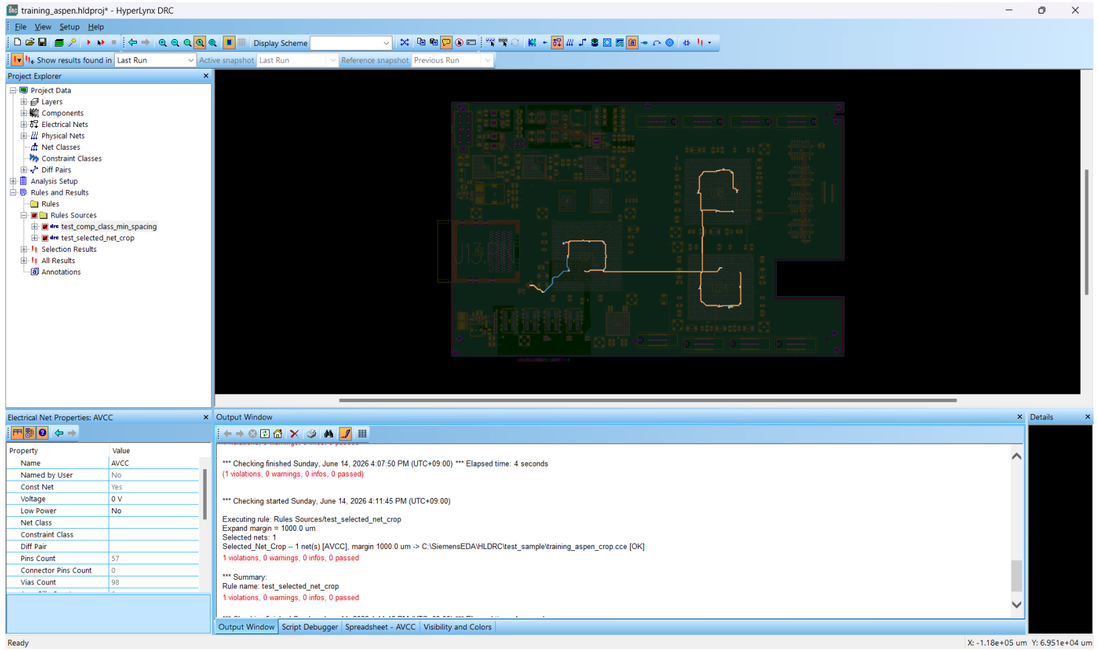
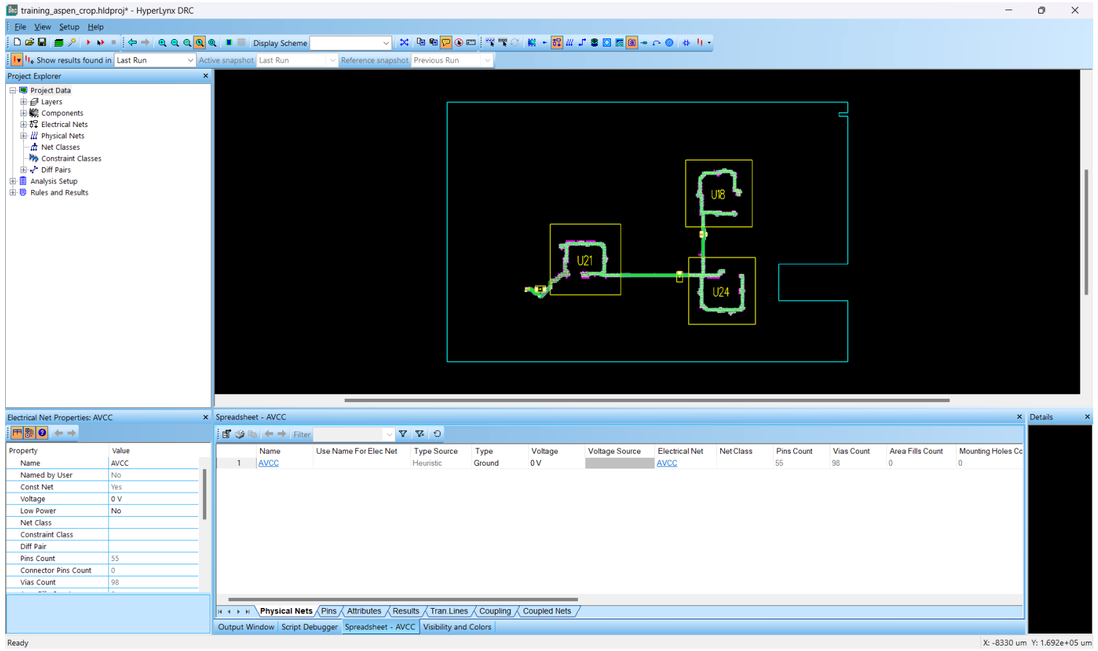
No Expert Bottleneck

Entry Barrier Removed





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Same-Net Clearance — Cross Method

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Fater Turnaround

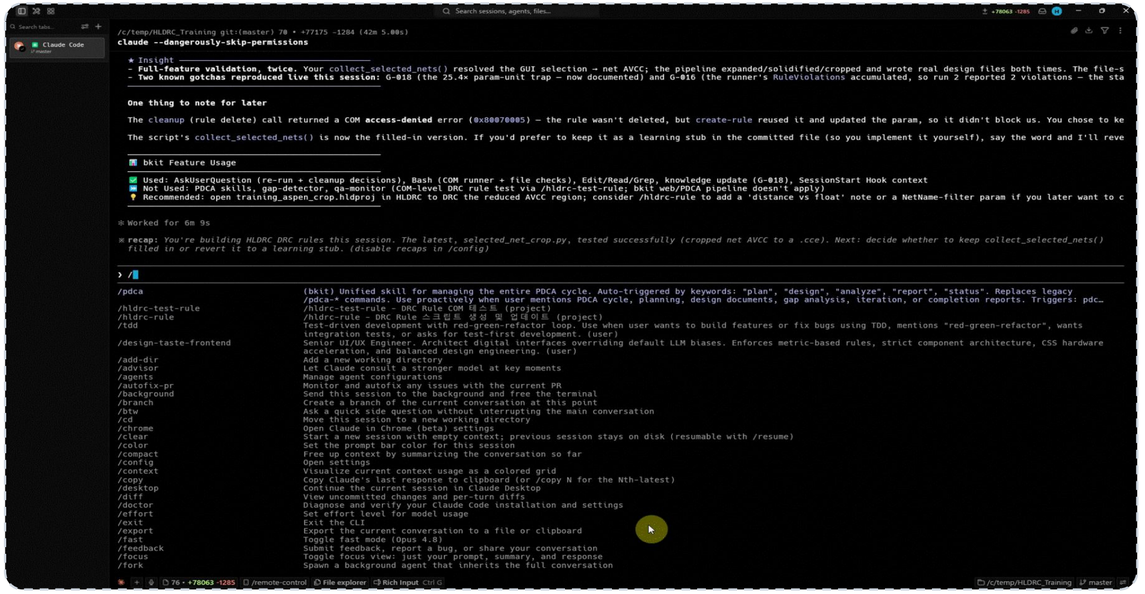
Rule Quality & Accuracy

The Sticking Point

"The Cross method seems useful for Same-Net Clearance checks, but I don't know how to use it."

Here's How AI Does It

- Compute the intersection region with **GeomEngine.Cross()**
- Branch on intersection count + Net.Name comparison
- Auto-handle the empty-collection **None+Count doule-check gotcha**



Cross()

The core geometry operation

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Written with zero expert consultation

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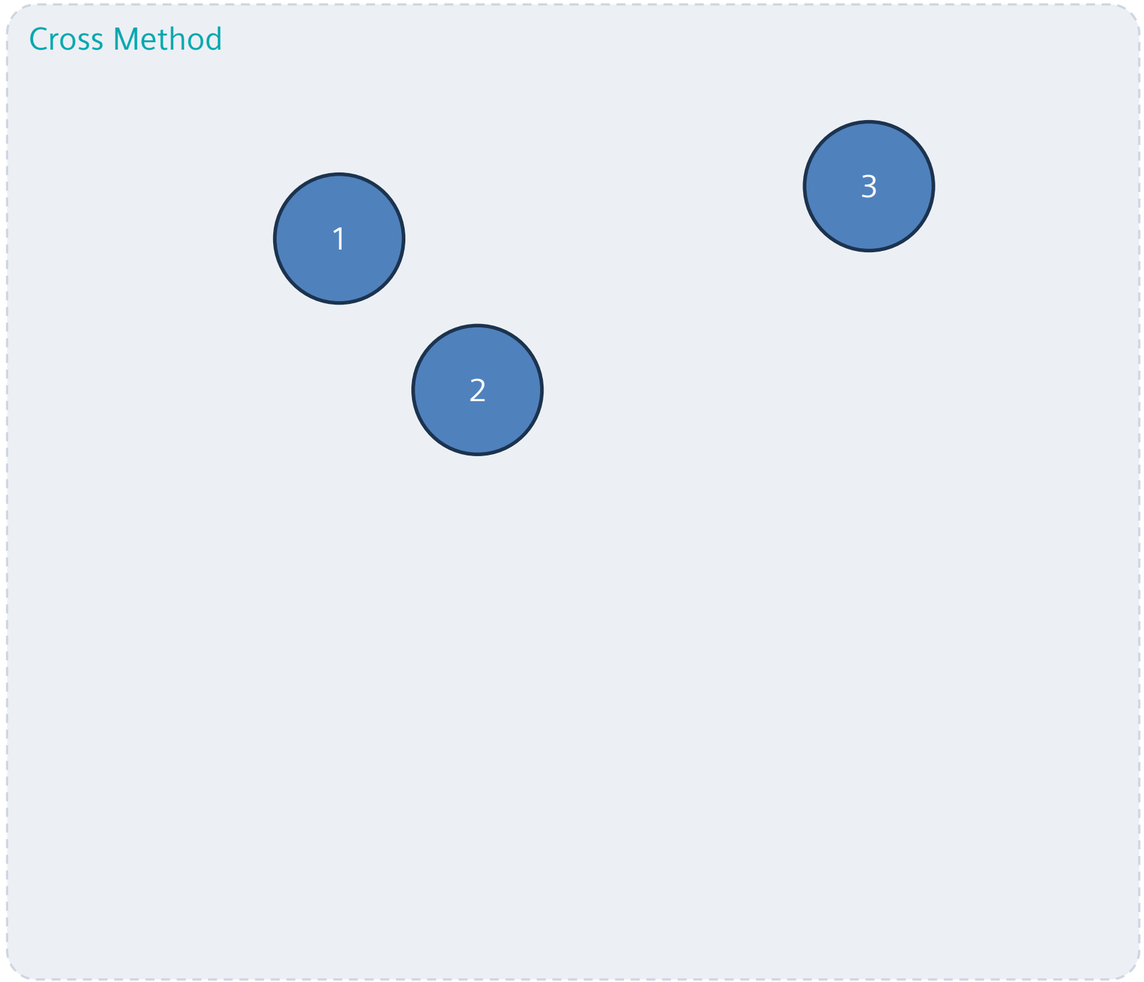

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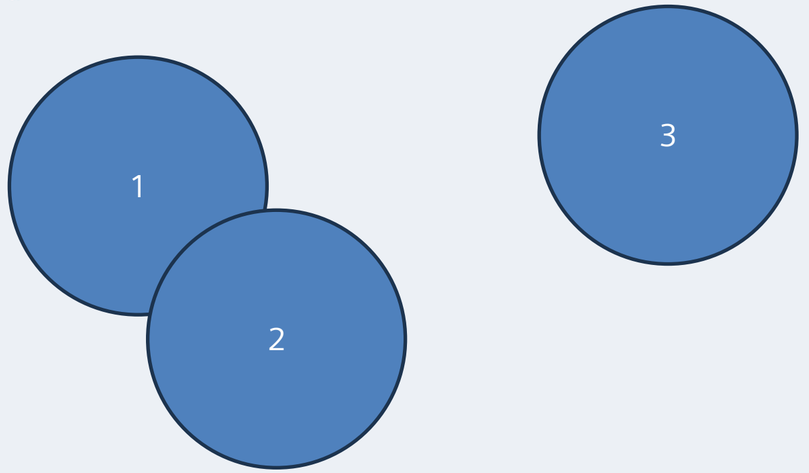

Expanded Via Geometries

Via Geometries

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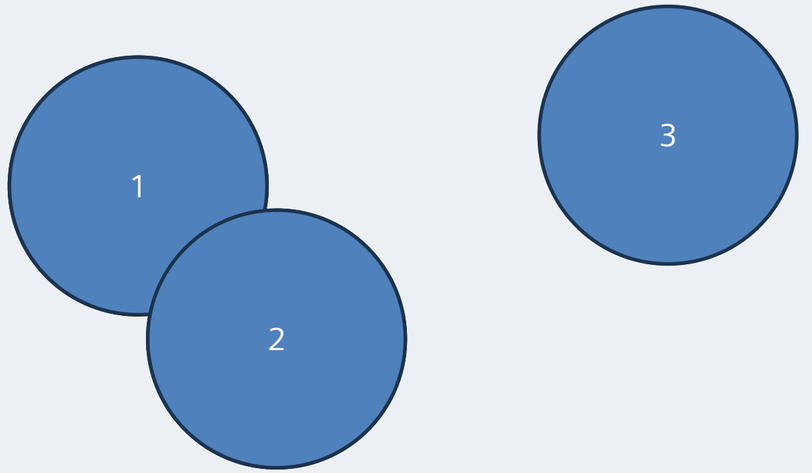

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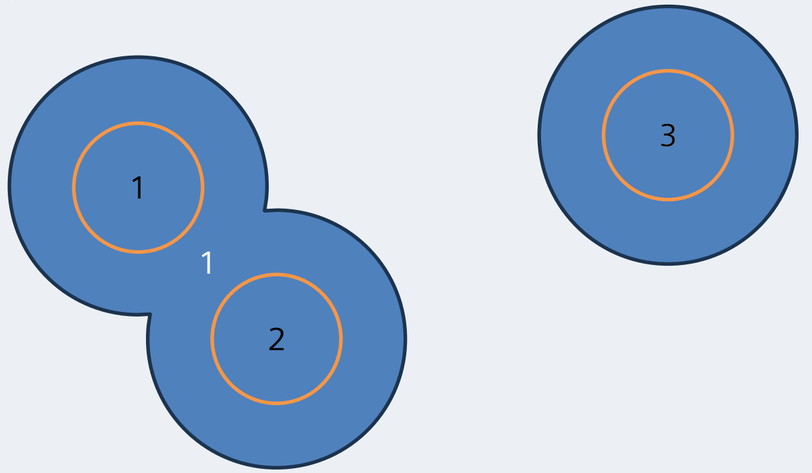

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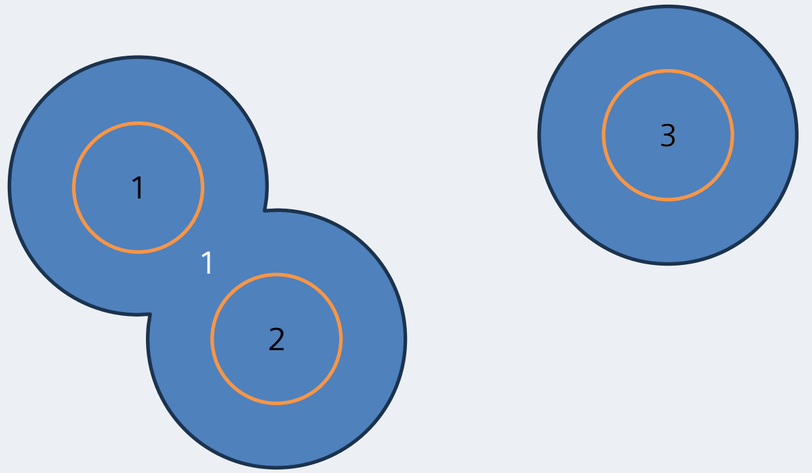

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Index of collection expanded via geometries	1	1	2
Index of collection via geometries	1	2	3

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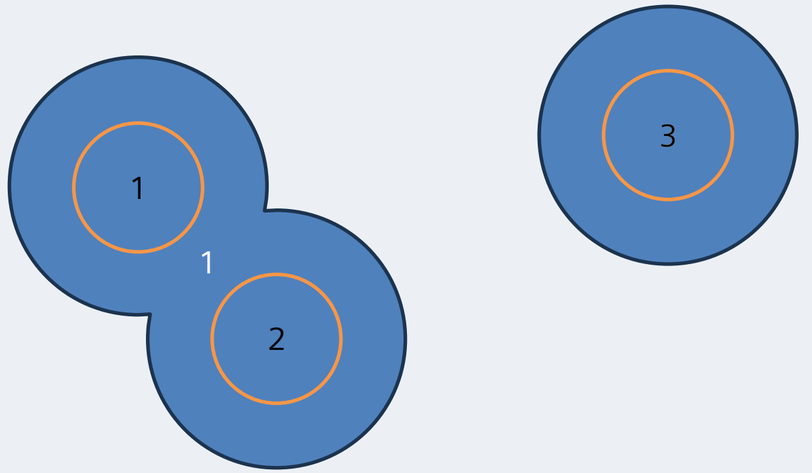

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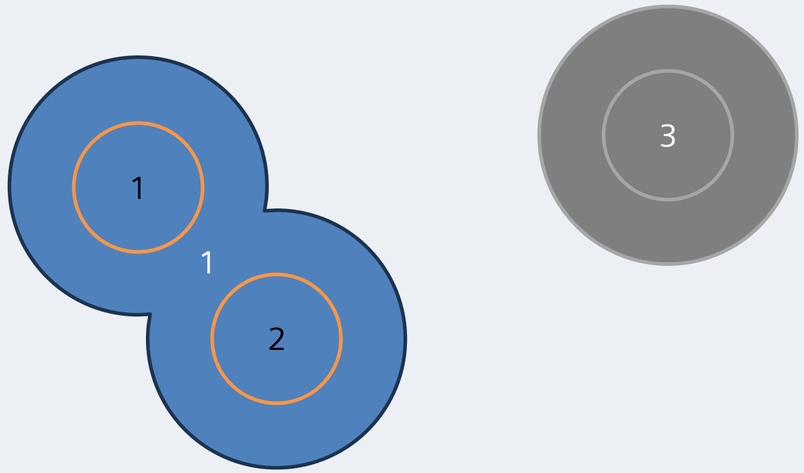

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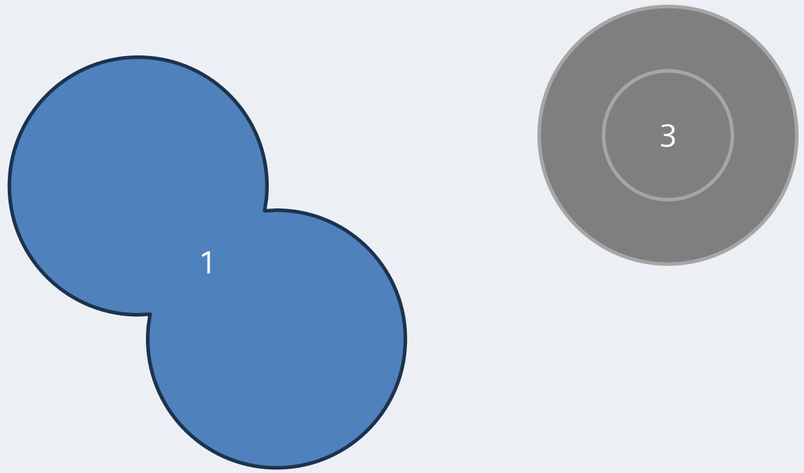

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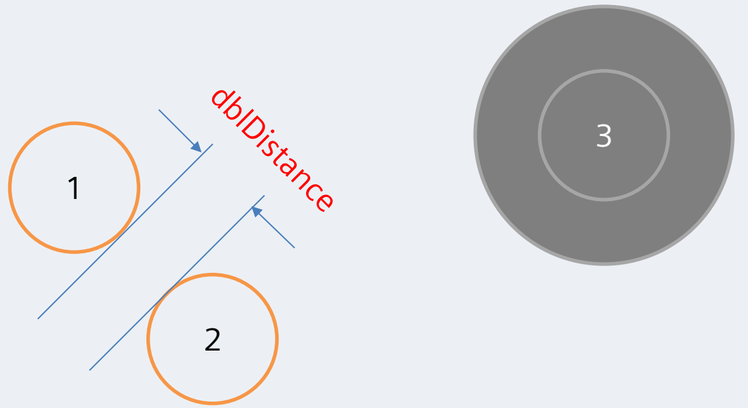

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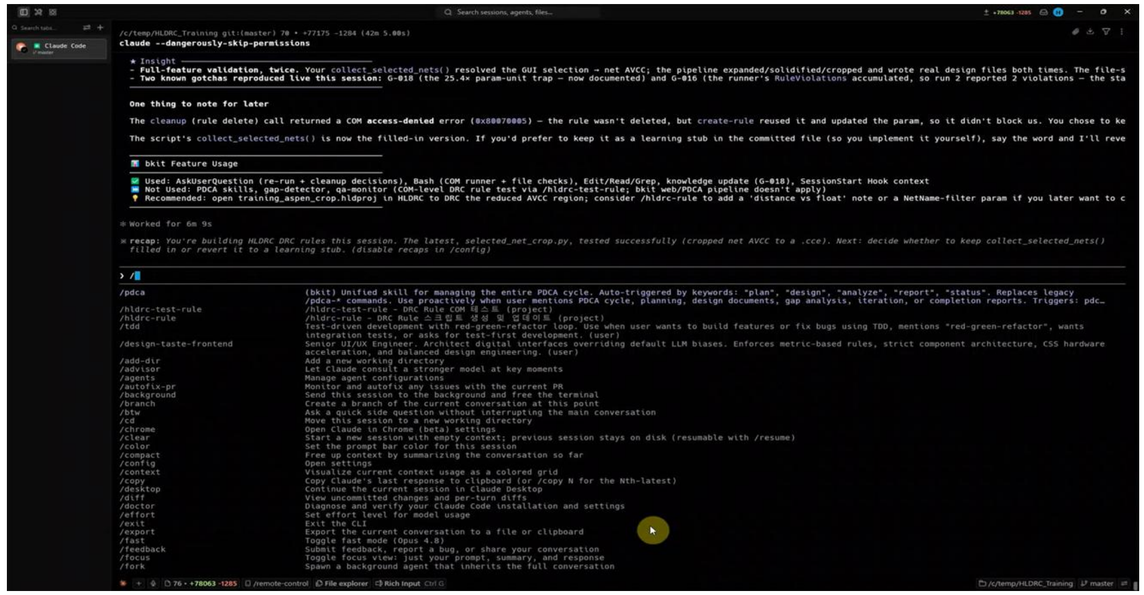

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Instantly Understand Existing Rules — Onboarding & Handover

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Anyone Can Do It

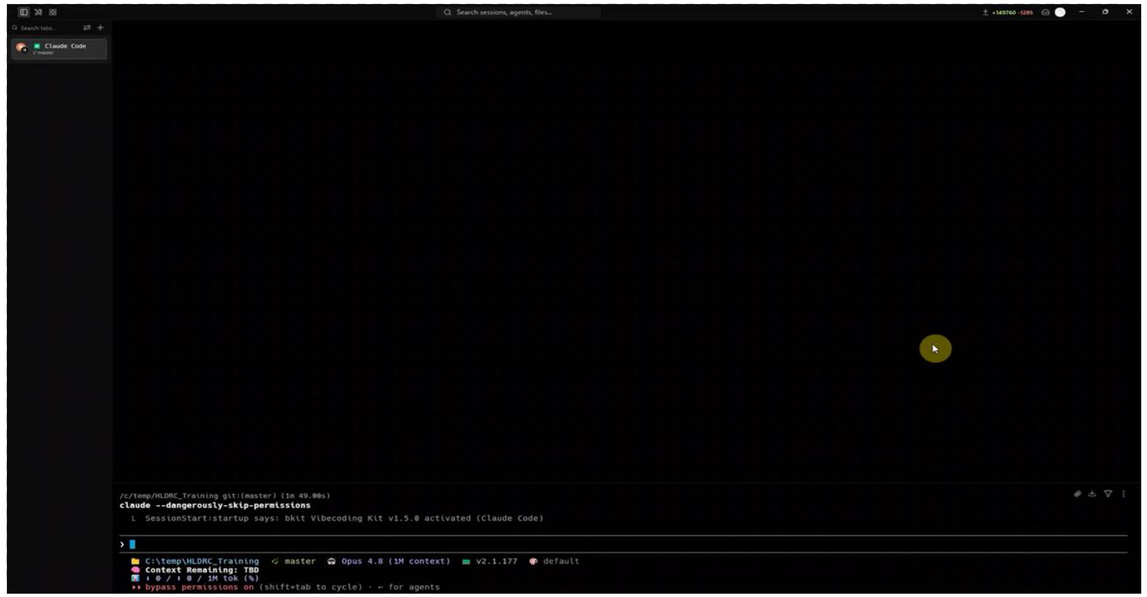
No Expert Bottleneck

The Sticking Point

"I inherited someone else's complex rule, but I have no idea what or why it's checking – so I can't touch it."

Here's How AI Does It

- One-line summary + code-section breakdown via **/hldrc-explain**
- Trace & explain **every COM API used**, through the AOM index
- Auto-generate a **Mermaid flowchart** – the logic at a glance



1,742

Member API index for automatic tracing & explanation

Minutes

Grasp even a rule you've never seen – no expert handoff

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Four Things Move at Once

IMPACT

Faster Turnaround

API exploration and trial-and-error disappear – the entire write-verify cycle gets shorter.

No Expert Bottleneck

Decoupled from the expert's schedule, which used to be the bottleneck. Build it the moment you need it.

Entry Barrier Removed

Author in natural language with no API knowledge – the role expands from "execute & review" to "create."

Rule Quality & Accuracy

Avoids knowledge gotchas + verified by running on real designs – author-to-author variance shrinks.

The four things promised in Phase 2 – **confirmed, exactly as stated, across all three cases.**

Deployment Isn’t the End – It’s the Beginning

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EVOLVING

Knowledge doesn’t stop at customer deployment. It keeps accumulating and evolving.

By Industry	Case 1	Case 2	Case 3	Case 4	+ New Domains
By Business Unit / Model	Business Unit 1	Business Unit 2	Model Type X	Model Type Y	+ Always Growing
Knowledge Accumulation	Gotchas	Errors	Patterns	Quality ↑ Virtuous Cycle	

The more gotchas and patterns accumulate, the higher the **AI generation quality** climbs → a system that gets smarter the more you use it.

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Experts Don’t Disappear – Their Role Changes

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REDEFINITION

BEFORE — Rule Author

- Hand-codes every request
- The cause of the schedule bottleneck
- Knowledge trapped in individuals

AFTER — Curator · Validator · Direction-Setter

- **Curates** knowledge assets & patterns
- **Validates & approves** AI deliverables
- **Sets the direction** on hard problems & standards

Every engineer’s verification quality **expands**, and the expert becomes **leverage.**

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This Is Just the Beginning

WHAT'S NEXT

01 **Enterprise System Integration**

Connect with PLM · constraint DBs · design standards

02 **Platform Integration**

Embed rule automation into verification pipelines / CI

03 **The Full Verification Flow**

Expand beyond DRC to the entire PCB verification process

> "The age of aviation began with 12 seconds. For PCB verification, that 12 seconds is **now** — and we've **already taken off**."

From Experts to Everyone

THANK YOU

Three Takeaways

- Natural language → rule, end-to-end, **actually works**
- The **three field challenges** that used to block you are solved
- Knowledge **keeps evolving**

Want to Learn More?

If you're curious about this approach (AI-assisted DRC verification), feel free to reach out by email – I'd be glad to help you one-on-one.

Hyunjae.kim@siemens.com

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