

Establishing an End-To-End Methodology for Shield Reliability in Leading Tech Node PowerVIA Designs

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Abbreviation

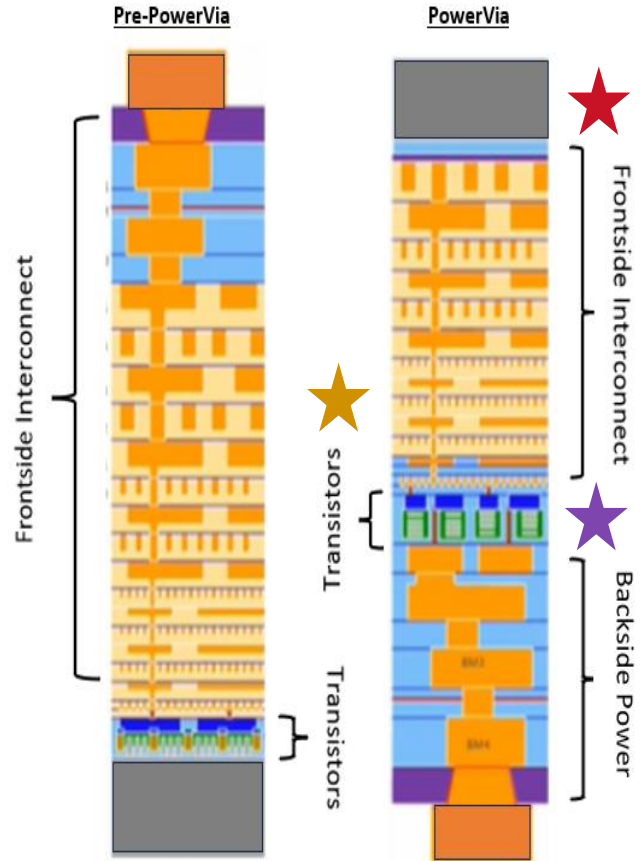
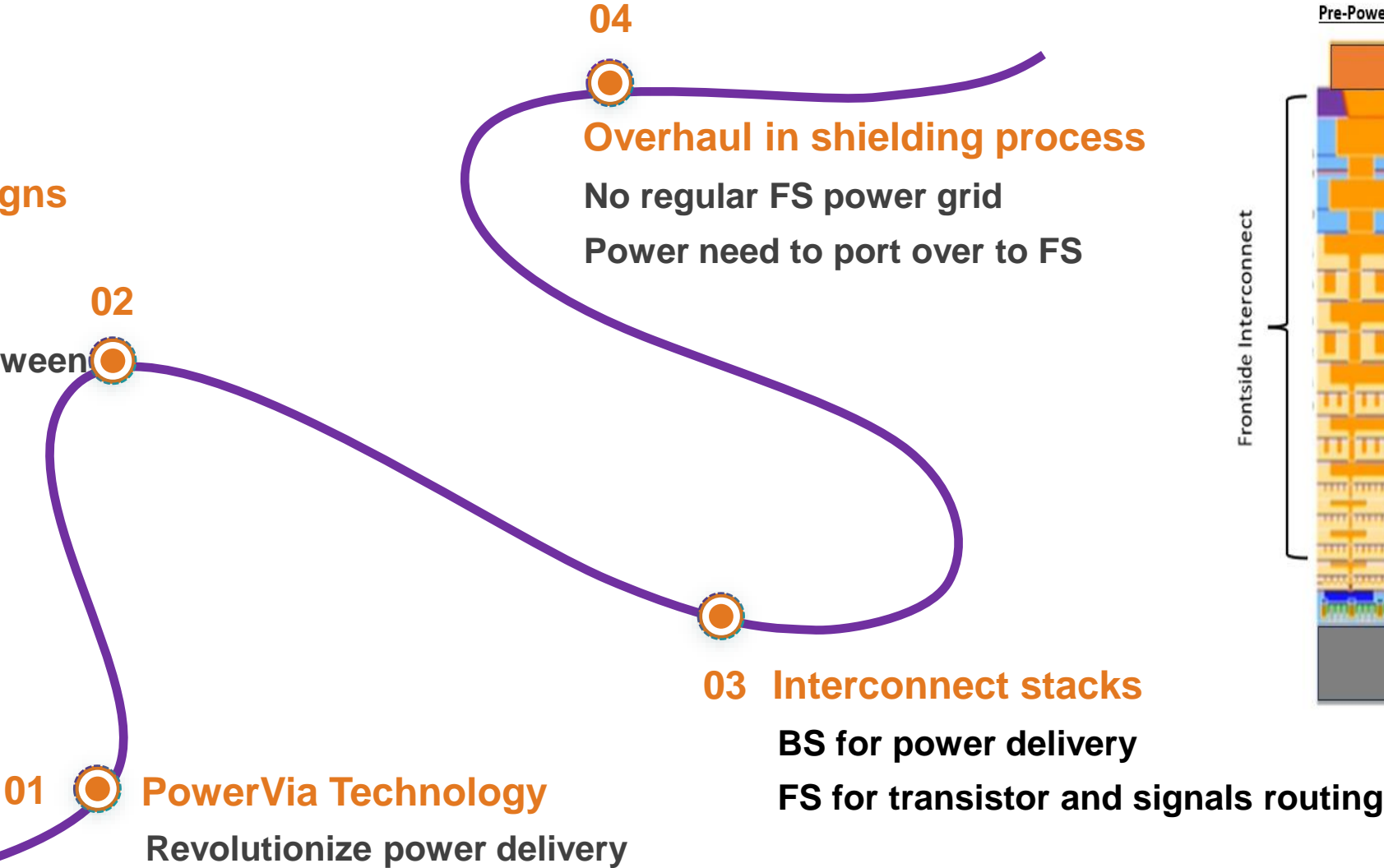
- FS – Front Side
- BS – Back Side
- PTAP – Power Tap
- VL – Via Ladder
- APR – Auto Place & Route
- ECO – Engineering Change Order
- EDA – Electronic Design Automation

Introduction

Power Grid Changes in PowerVia Designs

PowerVia Designs

- BS interconnect
- FS interconnect
- Transistor in between



Shielding Methodology in PowerVia Designs



Collaboration with EDA vendors in APR flow had enabled two types of Shielding Methodology

Strong shield

- Deterministic with interval distance of Power Taps (PTAPs) which will bring BS power to FS layer.

The diagram illustrates a strong shield methodology. A central vertical line is labeled 'clock'. It is flanked by two vertical lines labeled 'shield'. Horizontal lines represent power planes. Small circular components labeled 'PTAP cells' are connected to the shield lines. A double-headed arrow indicates a 'User configurable distance' between the shield lines.

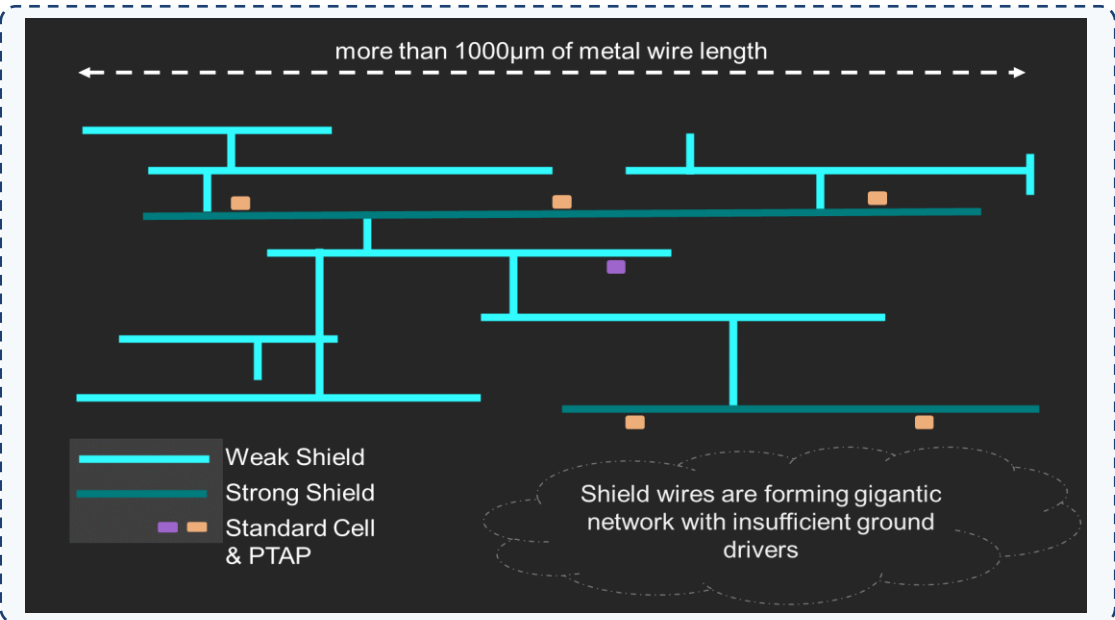
Weak shield

- Shield wires route automatically and connect to any nearby standard cells FS metal layer ground pin.

The diagram illustrates a weak shield methodology. A central horizontal line is labeled 'clock'. Below it, a horizontal line is labeled 'shield'. Several standard cells are shown, each with a 'vss' pin in the frontside metal layer. Shield wires (blue and red) are shown connecting the shield line to the vss pins of the standard cells.

Shield coverage check - how well a net is shielded

Late Design Discovery : Shield Reliability Concern

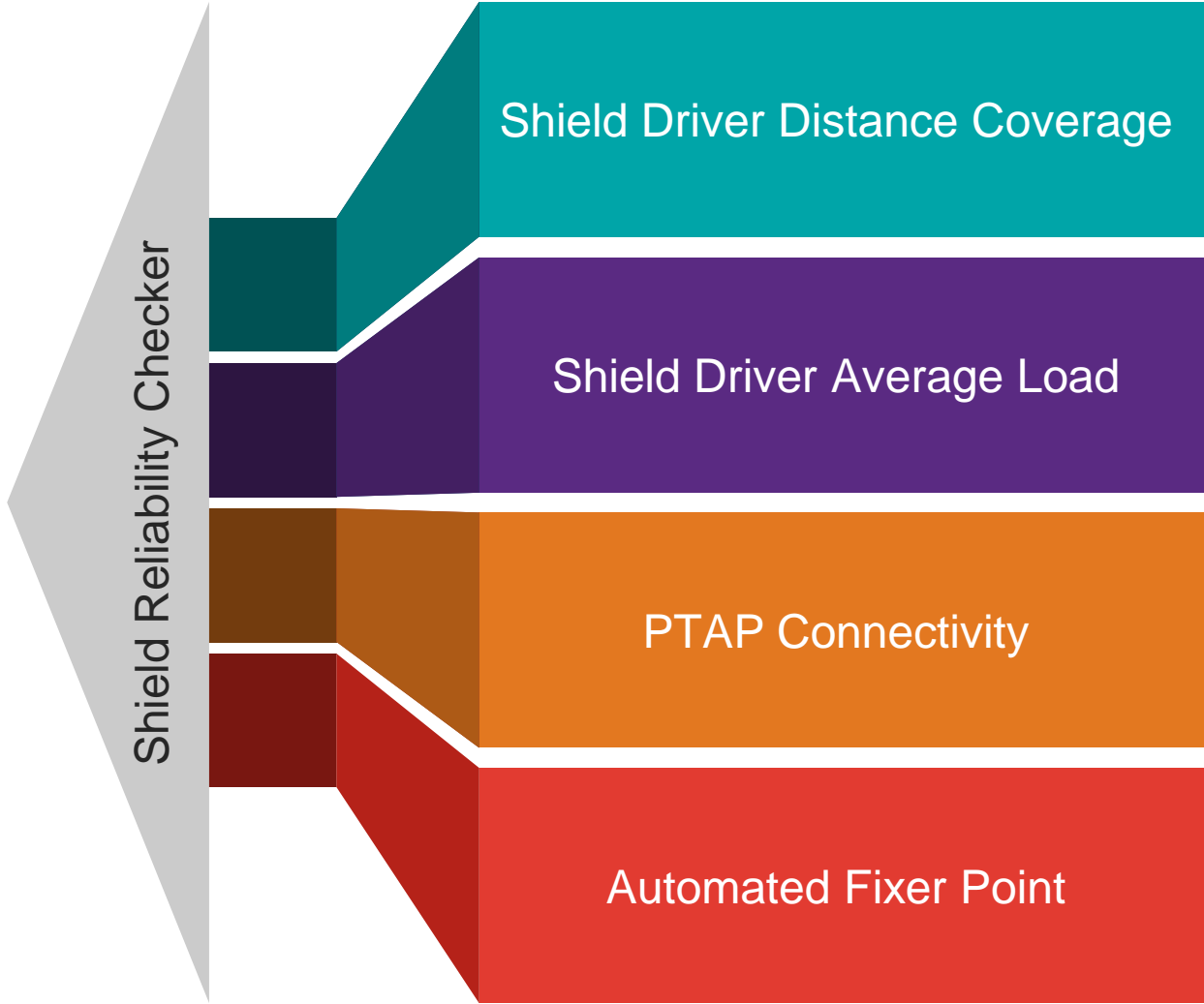


Shield Reliability

No signoff tools can tell whether shield-wire is sufficiently driven

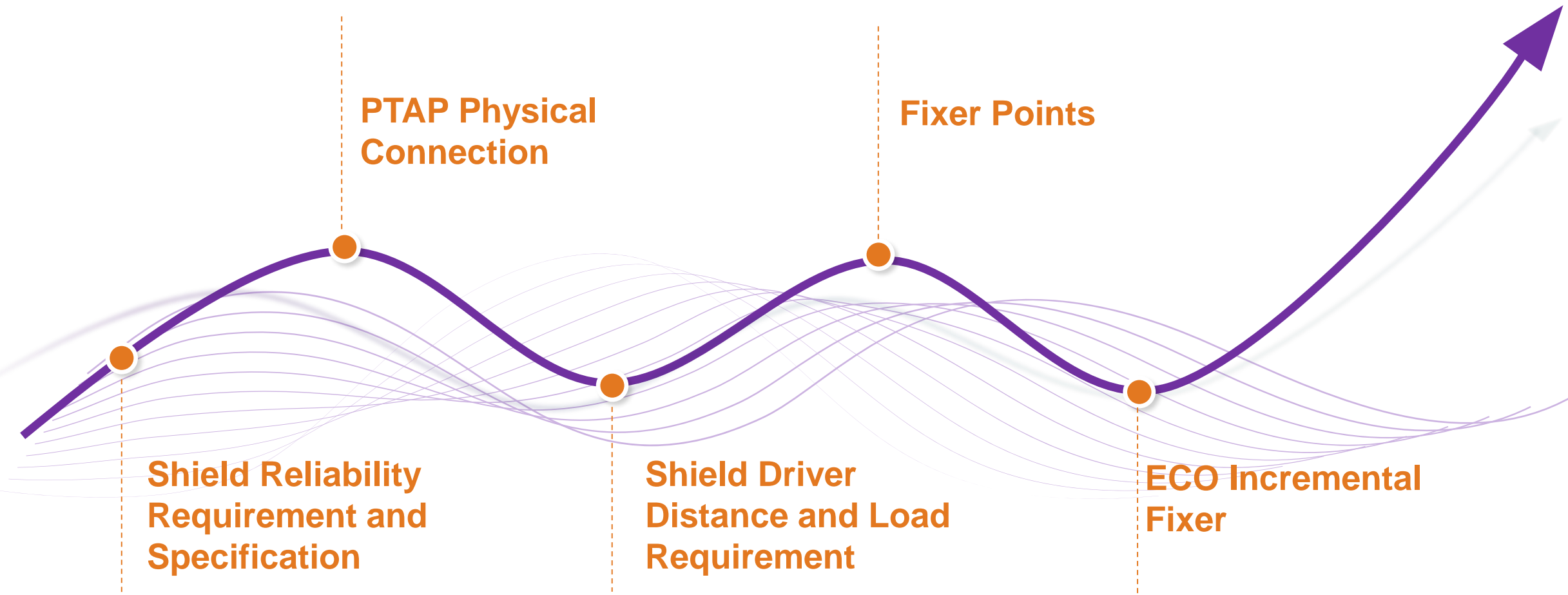
Costly Manual Effort

10 violations per day

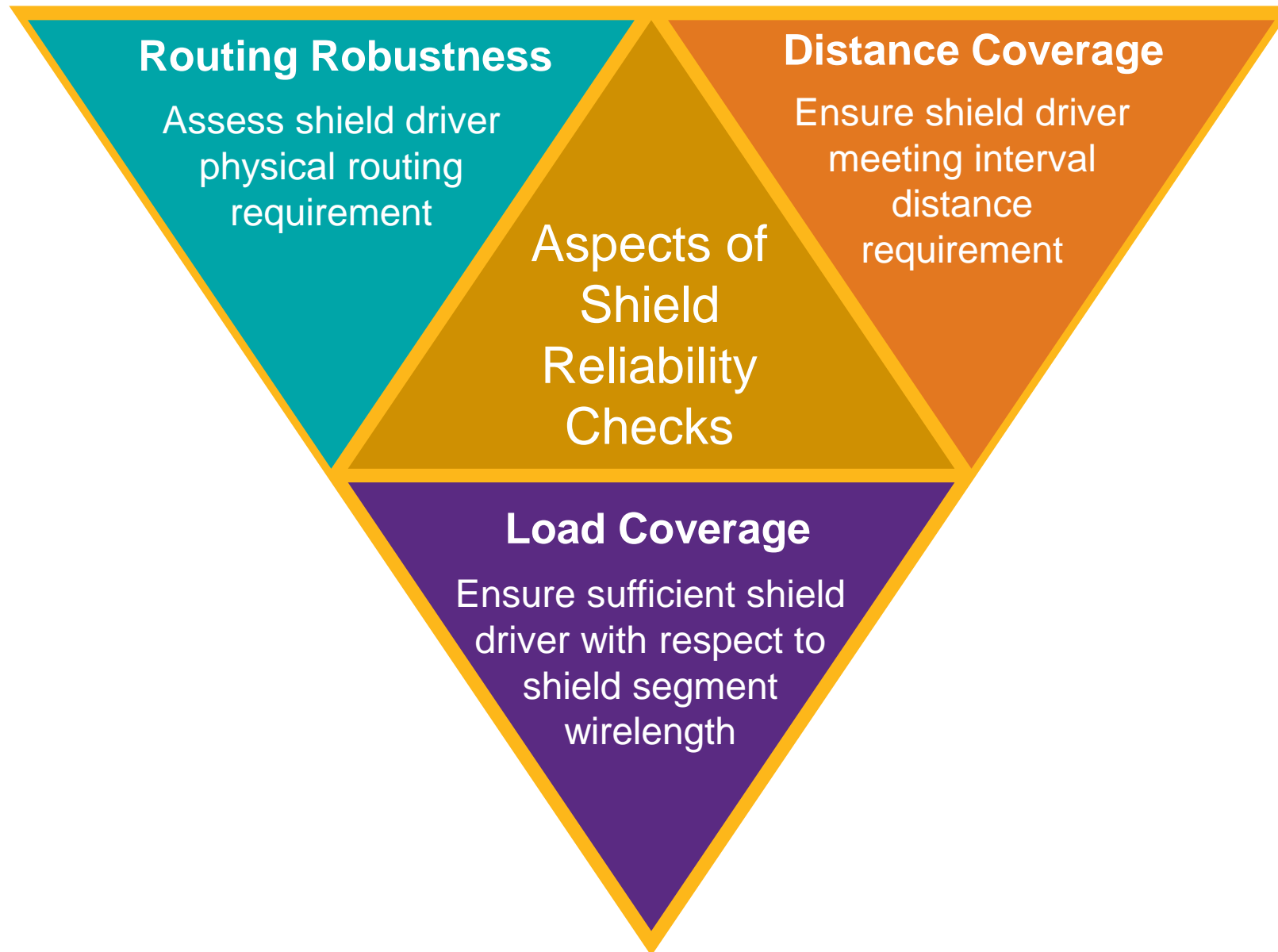


Shield Reliability Checker and Fixer Utility

Overview of Shield Reliability Checker and Utility Fixer



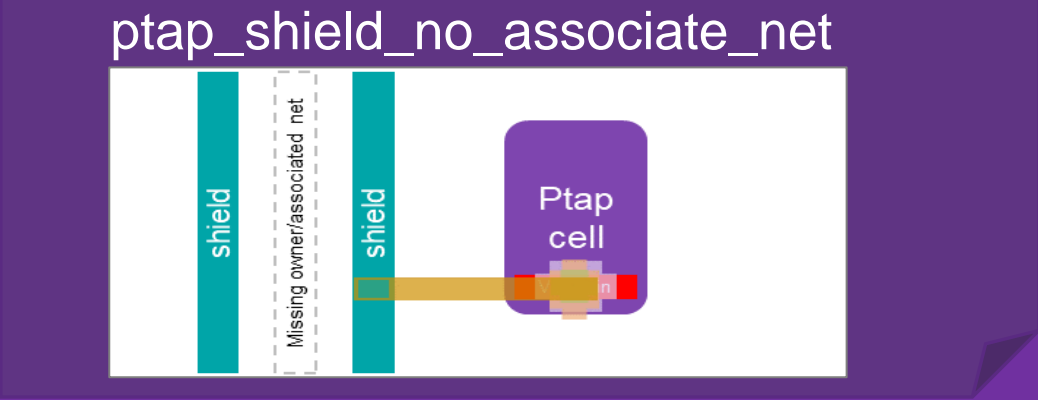
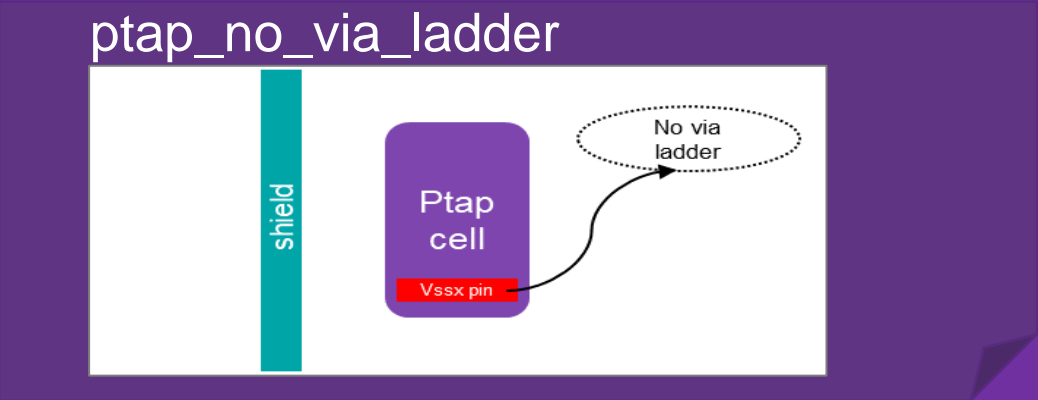
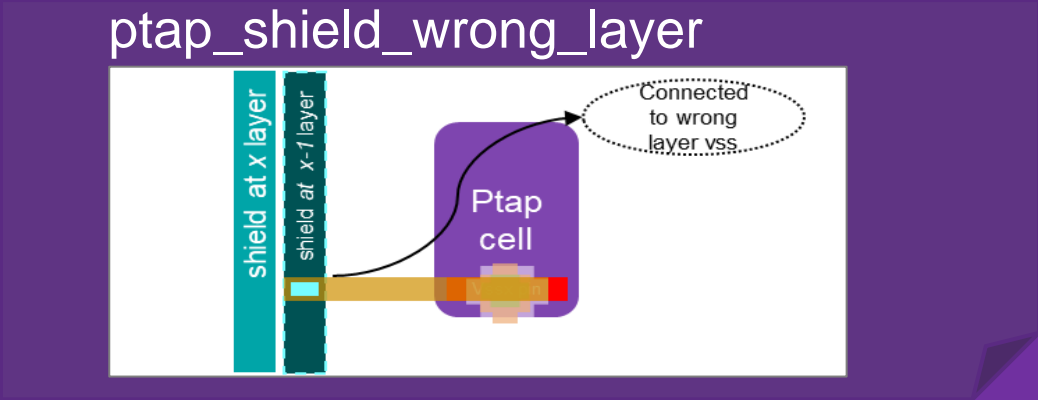
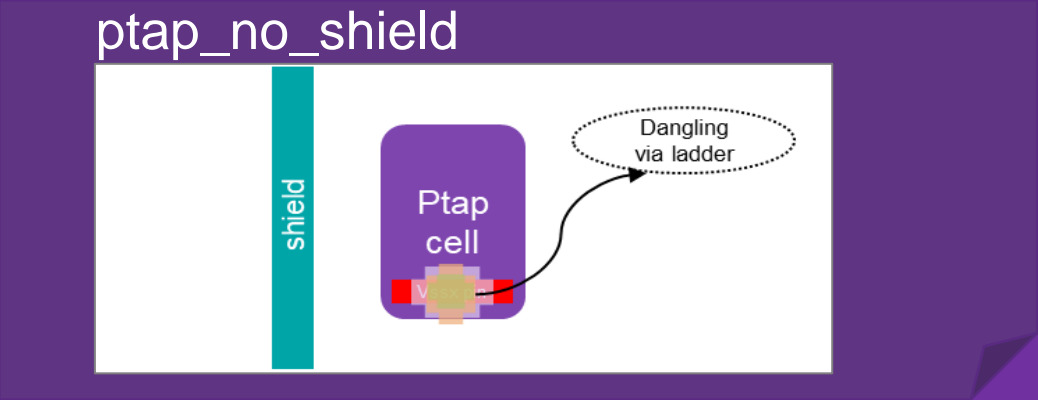
Shield Reliability Requirement



PTAP Physical Connection Checker



Ensure PTAP connectivity meeting requirement



Shield Segment Checker



Detect connected shield segment which are out of shield-driver coverage

- Connected shield segments should have shield-driver in every $X\text{-}\mu\text{m}$ diamond-shape coverage.
- Shield segments exceeding the coverage are labeled as cold-shield segments with potential of shield reliability risk.
- Checker will generate visual report for cold-shield segments.

| ErrorSet | Total |
|---------------------|-------|
| par | 614 |
| check_cold_shield | 614 |
| shield_cold_segment | 610 |
| | 1 |
| | 3 |
| | 8 |
| | 12 |

| ID | Type | Layer | Error File Name |
|-----|--------------------|-------|----------------------|
| 178 | shield_cold_seg... | | check_cold_shield... |
| 177 | shield_cold_seg... | | check_cold_shield... |
| 176 | shield_cold_seg... | | check_cold_shield... |
| 175 | shield_cold_seg... | | check_cold_shield... |
| 174 | shield_cold_seg... | | check_cold_shield... |
| 173 | shield_cold_seg... | | check_cold_shield... |
| 172 | shield_cold_seg... | | check_cold_shield... |
| 171 | shield_cold_seg... | | check_cold_shield... |
| 170 | shield_cold_seg... | | check_cold_shield... |
| 169 | shield_cold_seg... | | check_cold_shield... |

137: Layer: Type: shield_cold_segment
Cell type: Standard
Type Summary :
Obj Info : Shield cluster segment with no nearby driver based on
Shield cluster ID: 5450
Total wire length: 477.565
Longest wire: 54.56000
Longest cold segment: 56.03600
Total driver: 1
Average wire length per driver: 477.565

Error ID: 177 Status: Error
Bbox : (2568.39300 2783.22200) (2685.80000 2903.79200)

Shield Fixer Points Generation



Generate fixer-points to add ground drivers to the shield network.

Fixer point #1 (distance coverage):

- Iteratively add shield-driver fixer points on all cold-shield segments to ensure meeting coverage.

X by X μm coverage box

Ground source

Fixer points

```
1404: Layer: Type: ptap_fixer_points
Type Summary :
Obj Info : Fixer points for power tap insertion to cover cold segm
Average wire length per driver (driver_load) : 163.724
Post-Fixer(cold_shield) Average wire length per driver : 54.57
Post-Fixer(driver_load) Average wire length per driver : 54.57
Shield cluster ID: 793
Total wire length: 163.724
Total ground source: 3
Existing driver: 1
Fixer(cold_shield) : 2
Fixer(driver_load) : 0
NetShape1: PATH_54_79177
NetShape2: PATH_315_16105
Error ID: 135 Status: Error
Bbox : (2679.82000 3016.51600) (2824.69650 3116.51600)
```

Fixer point #2 (load coverage):

- Perform load balancing on all shield segments to prevent web-like wire where total wirelength is significantly more but within diamond-shape coverage.
- Iteratively add fixer points until the ratio $\frac{\sum \text{shield network wire length}}{(\sum \text{existing drivers} + \sum \text{Newfixer points})}$ is less than X- μm .

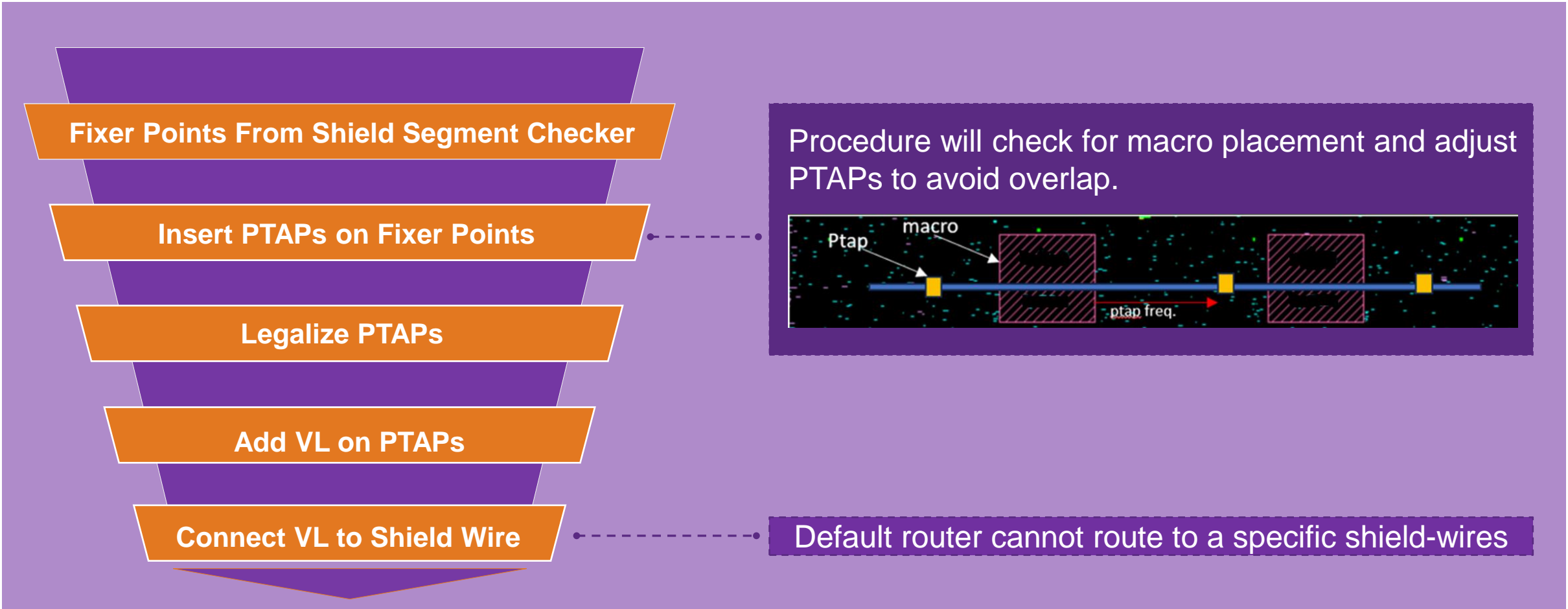
Fixer points

```
13: Layer: Type: ptap_fixer_points
Type Summary :
Obj Info : Fixer points for power tap insertion to cover cold segments.
Average wire length per driver (driver_load) : 475.194
Post-Fixer(cold_shield) Average wire length per driver : 475.194
Post-Fixer(driver_load) Average wire length per driver : 67.8848571429
Shield cluster ID: 3308
Total wire length: 475.194
Total ground source: 7
Existing driver: 1
Fixer(cold_shield) : 0
Fixer(driver_load) : 6
NetShape1: PATH_62_48208
NetShape2: PATH_46_105951
NetShape3: PATH_54_91707
NetShape4: PATH_54_89458
NetShape5: PATH_54_89596
NetShape6: PATH_46_109610
Error ID: 532 Status: Error
Bbox : (2695.35000 2778.91600) (2795.35000 2878.91600)
```

Incremental Fixer for Shield Reliability



Customized ECO command with via-ladder routing scheme to shield segment



Results and Summary

Results and Future Use



Fully converged design flow with 80x effort savings

Summary and Learnings

EDA Vendor Collaboration



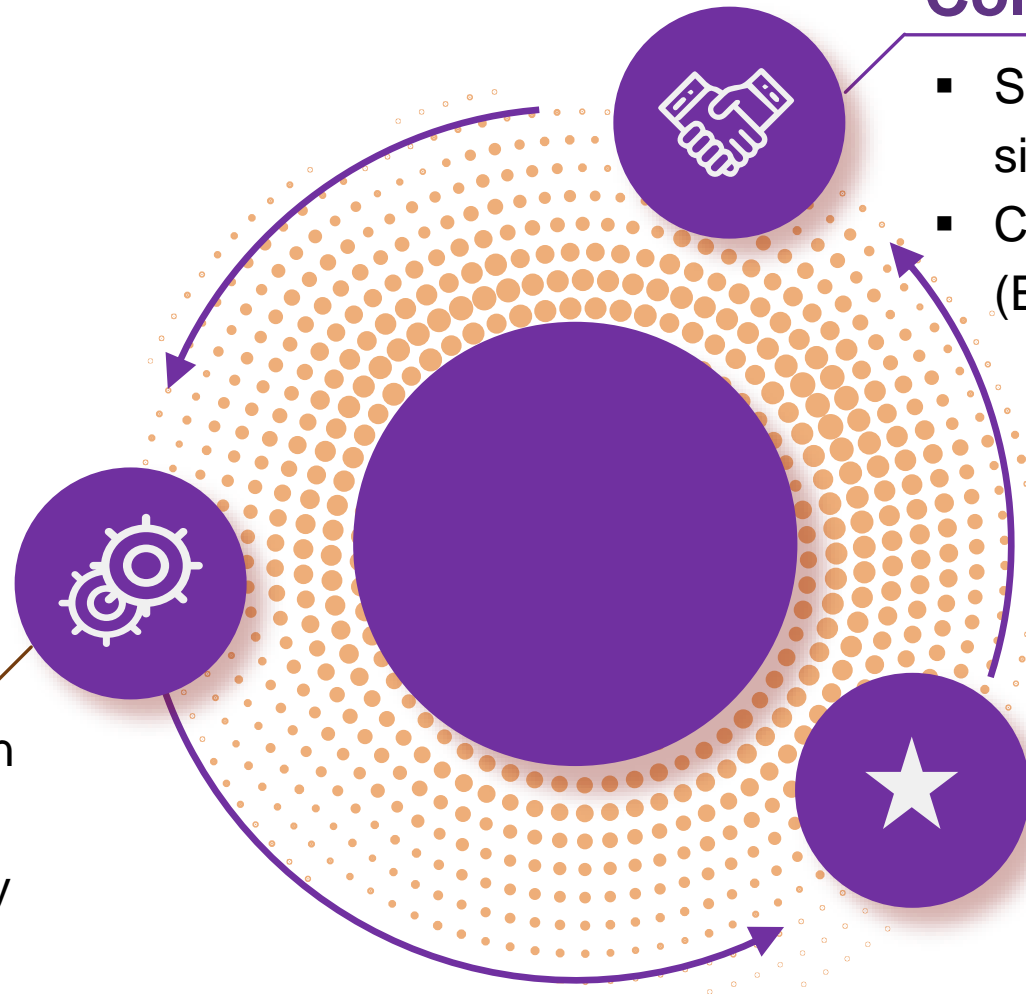
- Shield reliability modelling in signoff tools
- Construction tools enhancement (Ex :checker, router)

PowerVia Designs

- Revolutionary technology in power delivery
- New shielding methodology

Shield Reliability

- New design checks
- Checker and fixer in ECO mode



THANK YOU

Our
Technology,
Your
Innovation™