Looking Beyond the Compliance Checklist:

Functionally Verifying PCI Express® Compliance and SOC Functionality

Erez Kovshi
Cadence Design Systems

Agenda

- Compliance Checklist Review
- Checklist Implementation
  - ✓ Basic vs. Advanced approach
- Verification needs beyond the checklist
- Summary

PCI Express Compliance Checklist

- What the Checklist IS
  - ✓ Full and detailed issue list (~1,300 items)
  - ✓ Standardized set of checks
  - ✓ Based on the specification
- What the Checklist is NOT
  - ✓ Not a verification implementation
  - ✓ Does not provide completeness criteria for each check
  - ✓ Does not provide a reporting mechanism

You'll need help!

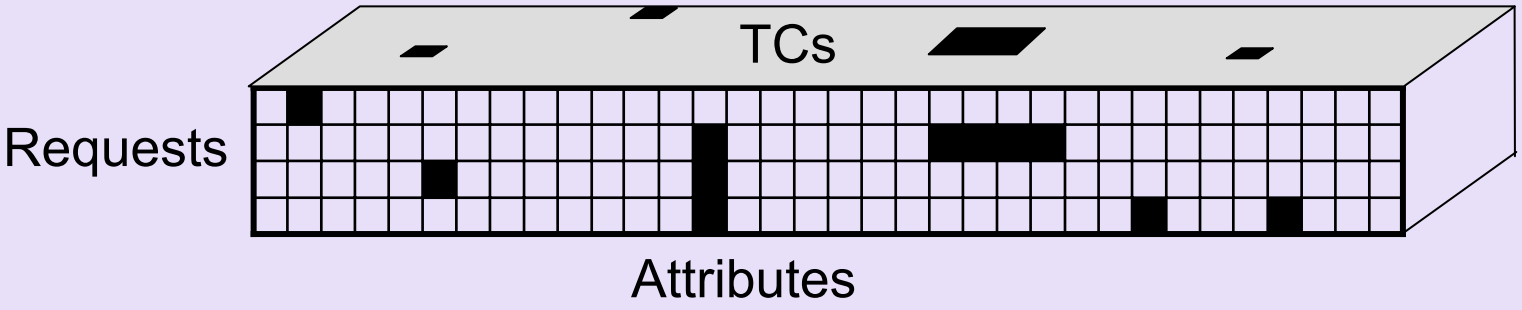
Checklist Shortcomings Example

TXN.2.21#19 - "Completions headers must supply the same values for the Requester ID, Tag, Attribute and Traffic Class as were supplied in the header of the corresponding request"

- The check does NOT:
  - ✓ Implement completion handling logic that the check depends on
    - – You'll need to implement a TXN.2.21#19 check
      - • "Check all completions fields with the corresponding requests"
  - ✓ Define which completions need to be check compliant
    - – You'll need to define the TXN.2.21#19 completeness criteria
      - • "Check should be done for ALL the requests kind"
  - ✓ Report which completions were and which were not checked
    - – You'll need to implement status measurement and reporting

Completeness Example

- TXN.2.21#19 - “Completions headers must supply the same values for the Requester ID, Tag, Attribute and Traffic Class as were supplied in the header of the corresponding request”
- 52 valid combinations out of 256 possibilities



Implementing Checks Using Basic Approach

- Based on directed testing
  - ✓ Write a test for each check
  - ✓ Run all tests with no failures

Example:

TXN.2.21#19 - "Completions headers must supply the same values for the Requester ID, Tag, Attribute and Traffic Class as were supplied in the header of the corresponding request"

- ✓ Test_2.21#19:
  - "Inject CFG READ request"
- ✓ Check:
  - "Completion fields are the same as the CFG READ request"
- ✓ Run Test_2.21#19
  - If it passes, the device is "2.21#19 compliant". ***Is it really??***

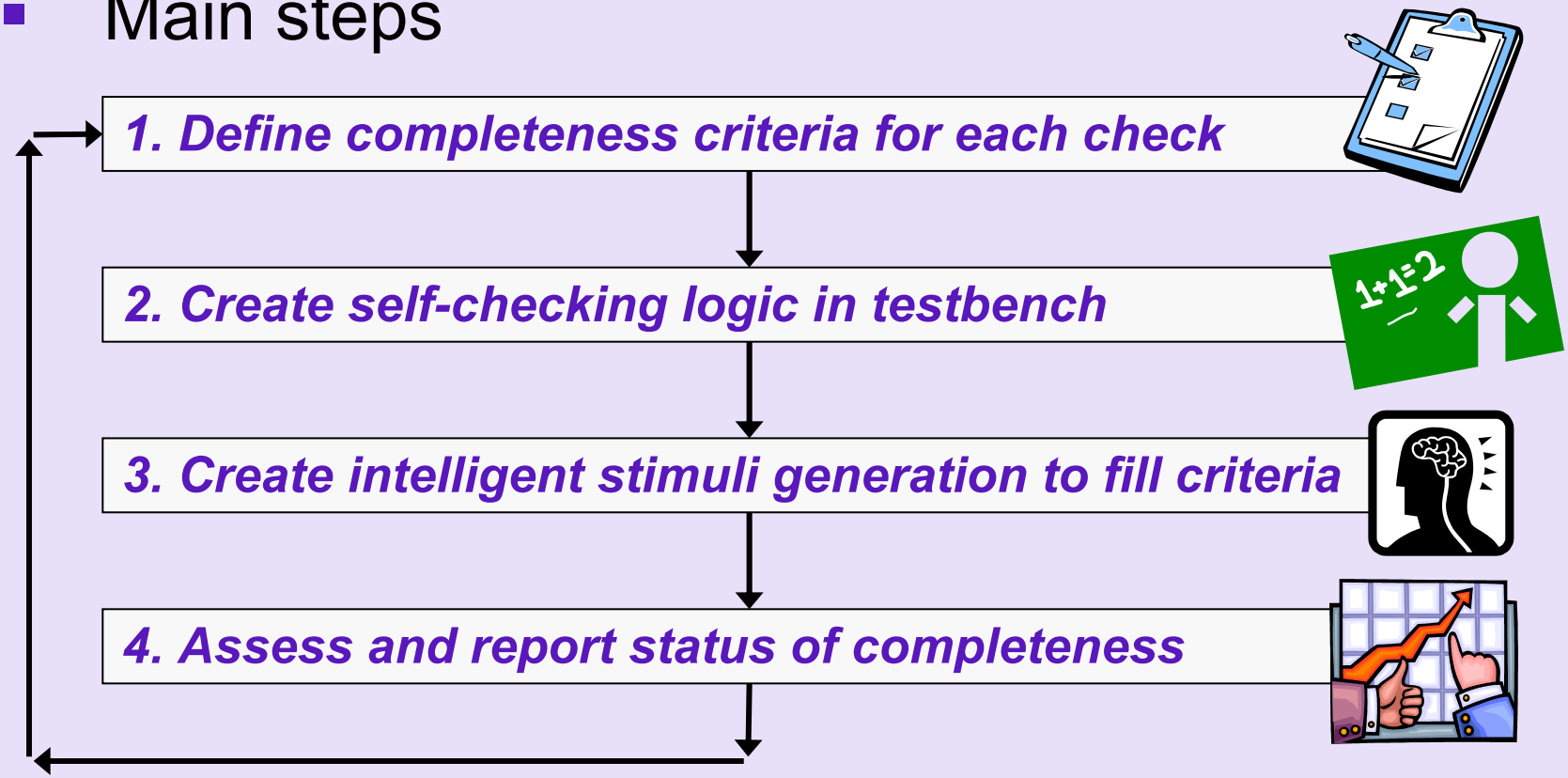
Basic Approach Summary

- Pros
  - ✓ “Easy” to write
  - ✓ “Easy” to get running results
- Cons
  - ✓ Maintenance is a major challenge
    - – Many (hundreds!) of tests to be written and maintained
    - – Many IP configurations—many verification environments
  - ✓ Each test covers only a single scenario of a check
    - – Test_2.21#19 test only completion for a CFG READ request
    - – What about CFG WRITE request?
  - ✓ Tests do not find new corner cases
  - ✓ Status reporting is not objective enough
    - – “233 of 949 tests completed” – what does that really mean??
    - – No way to determine which functionality contains greatest risk

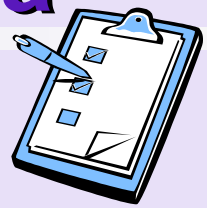
This approach is error prone and manual labor intensive

Checks Implementation The Advanced Approach

- Based on advanced verification approach
  - ✓ Typically applied to complex devices/systems
- Main steps



1. Define Completeness Criteria

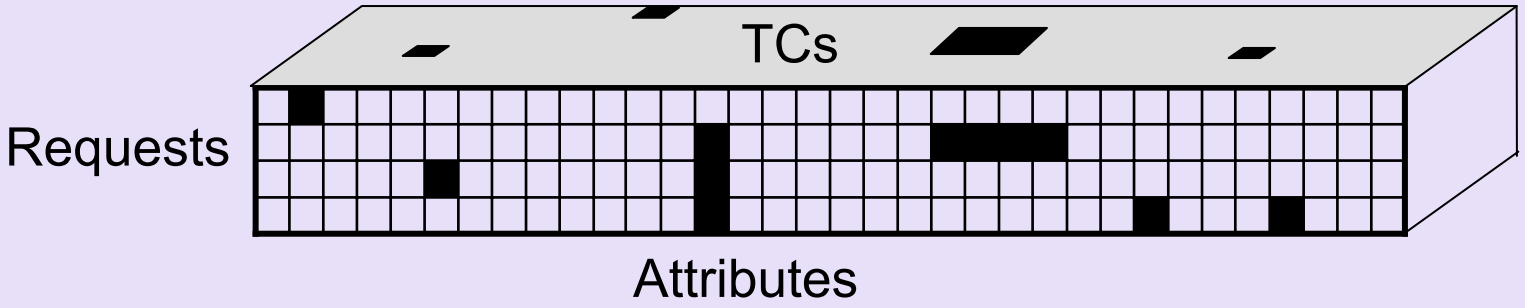


- For each compliance check X
  - ✓ Read the check definition
  - ✓ Define the possible scenarios
  - ✓ Define when your device is “X compliant”

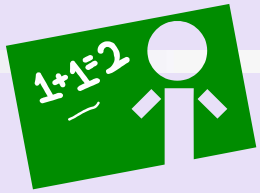
Example:

TXN.2.21#19 - “Completions headers must supply the same values for the Requester ID, Tag, Attribute and Traffic Class as were supplied in the header of the corresponding request”

- ✓ Identify ALL possible and legal scenarios
  - – Completions for the different types of requests
  - – Completions for TCs
  - – Completions for Attributes



2. Create Self-Checking Logic in Testbench



- For each compliance check
  - ✓ Implement an automatic check for all possible scenarios
  - ✓ Check should be as generic as possible
  - ✓ Check should be tested well to eliminate false alarms

Example:

TXN.2.21#19 - "Completions headers must supply the same values for the Requester ID, Tag, Attribute and Traffic Class as were supplied in the header of the corresponding request"

For each completion:

```
check that completion.id == request.id
   else dut_error();
```

3. Create Intelligent Stimuli Generation To Fill Criteria

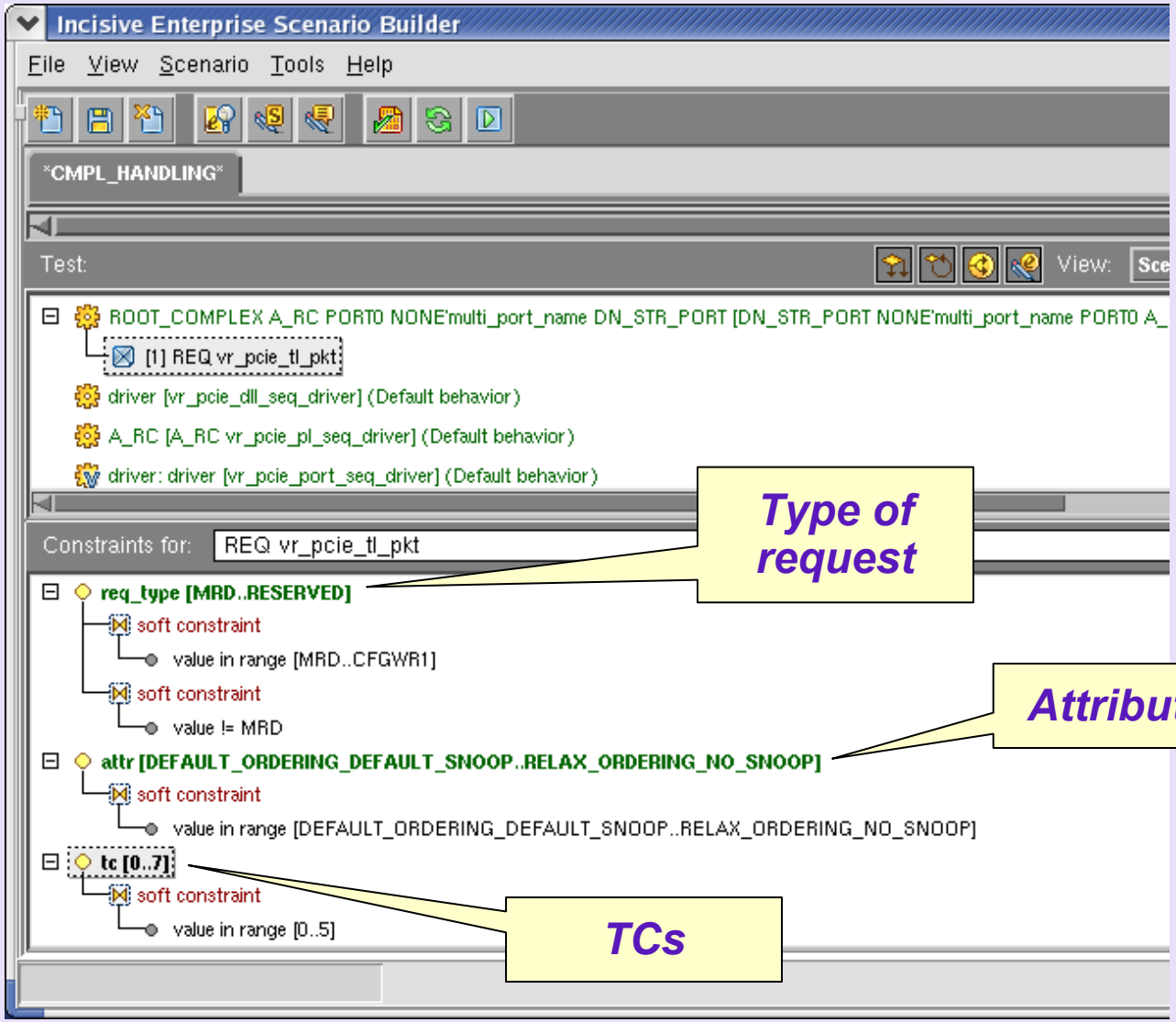
- For any given functionality and its corresponding checks:
  - ✓ Environment must create massive stimuli (randomly)
  - ✓ Environment must also generate directed stimuli (precisely)

Example:

TXN.2.21#19 - "Completions headers must supply the same values for the Requester ID, Tag, Attribute and Traffic Class as were supplied in the header of the corresponding request"

- ✓ Generate random requests to reach high percentage of coverage
  - Random types of requests
  - Random Attributes and TCs
- ✓ Control generation to address non-generated scenarios

Constrained Random Generation



Screen Capture From cadence PCI Express VIP

4. Assess and Report on Completeness

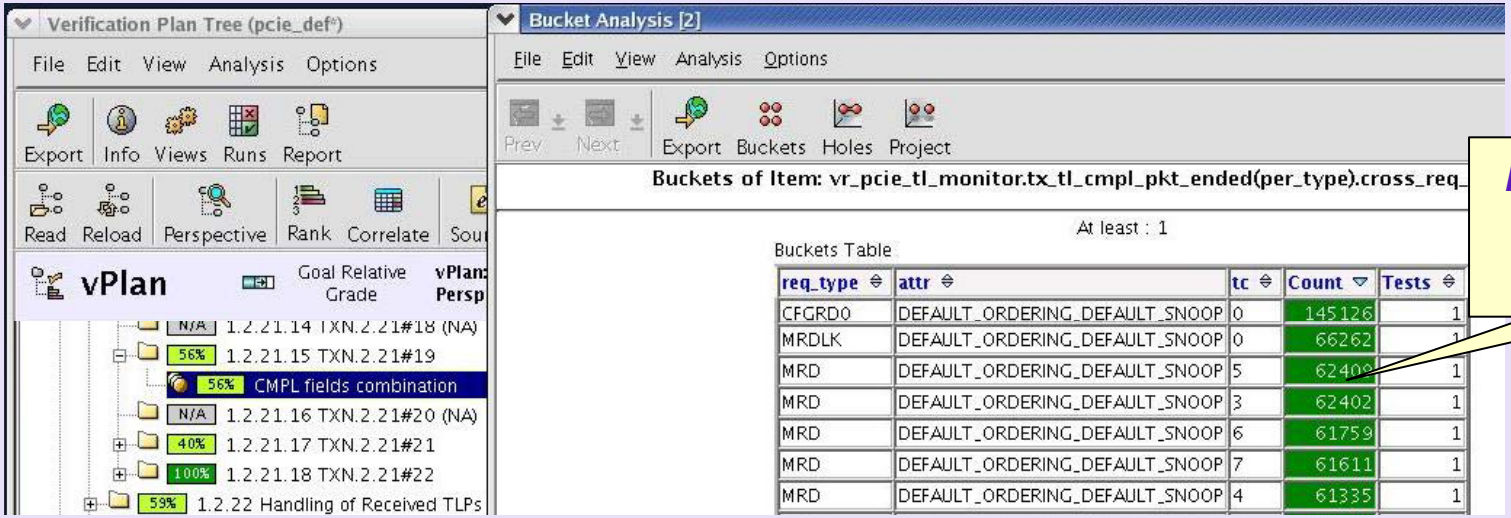
- Run random tests
- Collect the errors
- Assess for each check
  - ✓ Were all the possible scenarios exercised?
  - ✓ What are the remaining scenarios?

Example:

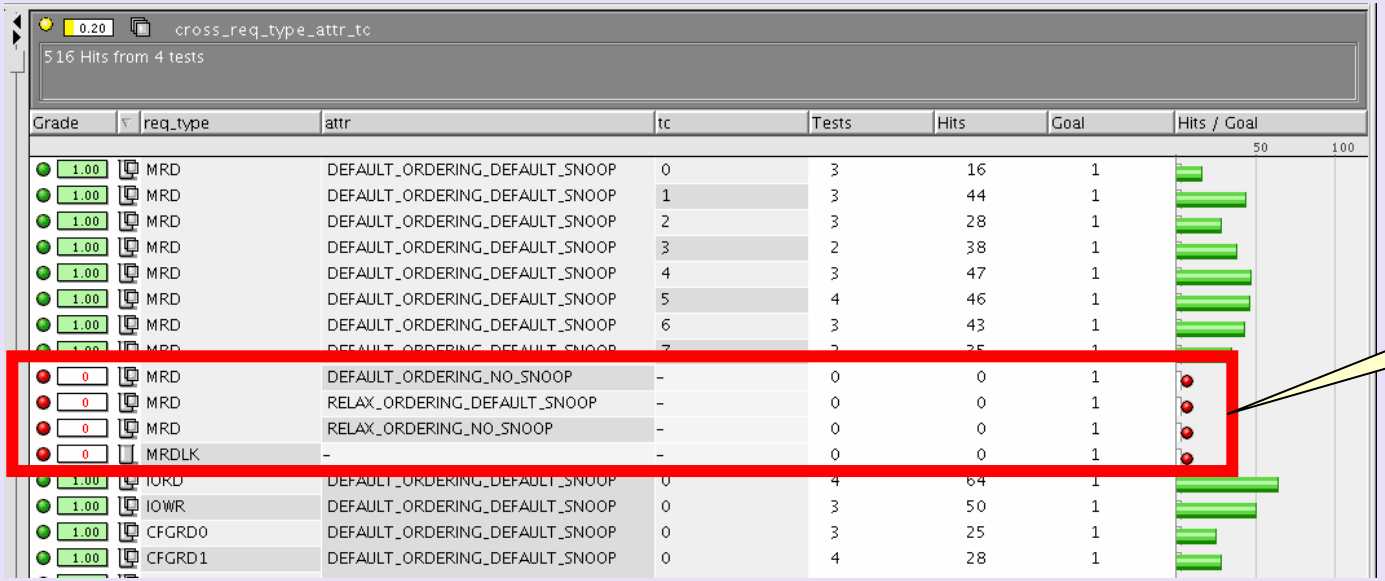
TXN.2.21#19 - "Completions headers must supply the same values for the Requester ID, Tag, Attribute and Traffic Class as were supplied in the header of the corresponding request"

- ✓ Which requests were NOT sent to your device?
- ✓ Where are the failures, and how can you reproduce the filed run?

Reporting Completeness Status Example



Functionality Checking IS Complete



Functionality Checking is NOT Complete

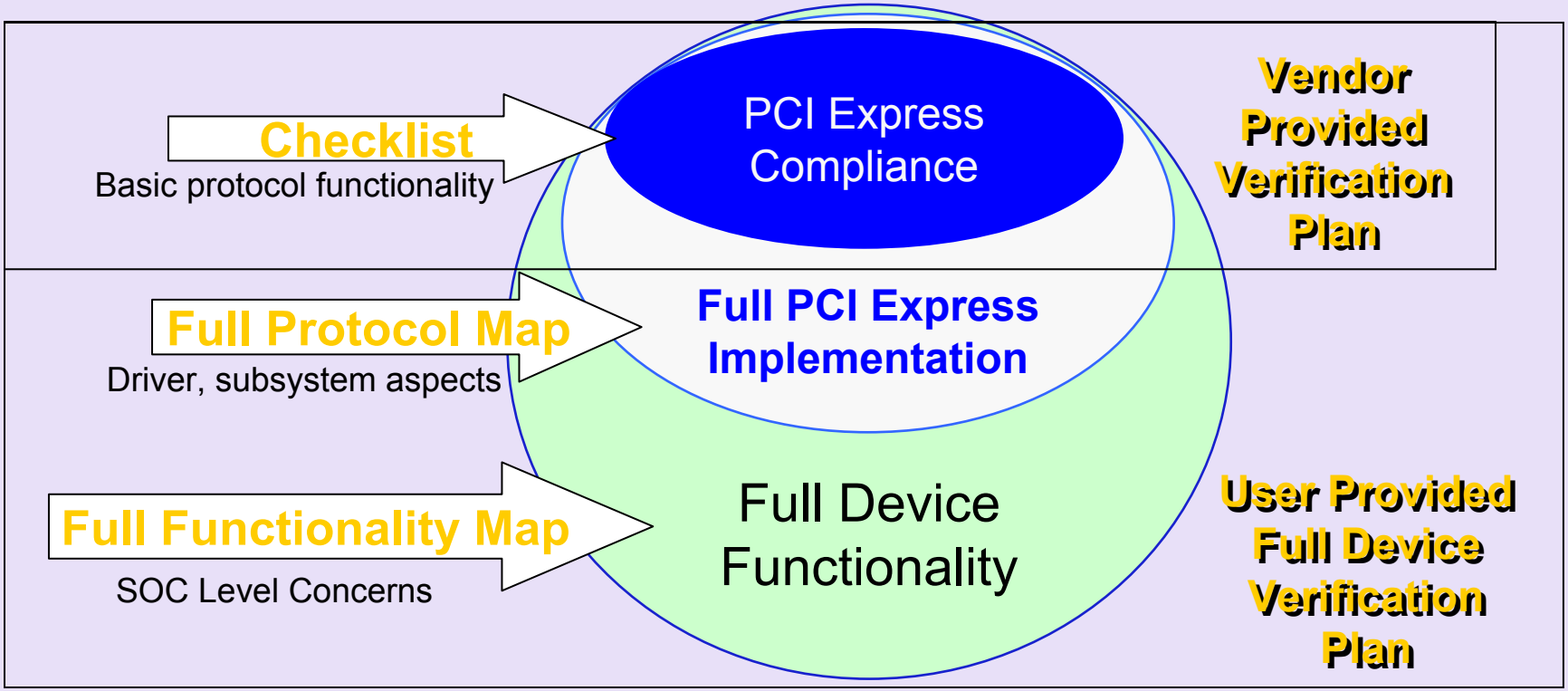
Screen Captures From cadence PCI Express VIP

Advanced Solution Summary

- The challenge
  - ✓ Implement advanced verification approach to exercise checks
  - ✓ Need to develop and maintain many (hundreds!) of checks
  - ✓ Many complicated scenarios to verify
- Pros
  - ✓ Provides clear goals for each check
  - ✓ Needs only a few random tests each covering many scenarios
  - ✓ Provides automatic means to measure and report progress
- Cons
  - ✓ Requires up front verification planning
  - ✓ Requires advanced verification expertise

Consider Using Commercial PCI Express Solution

Verification Beyond the Checklist

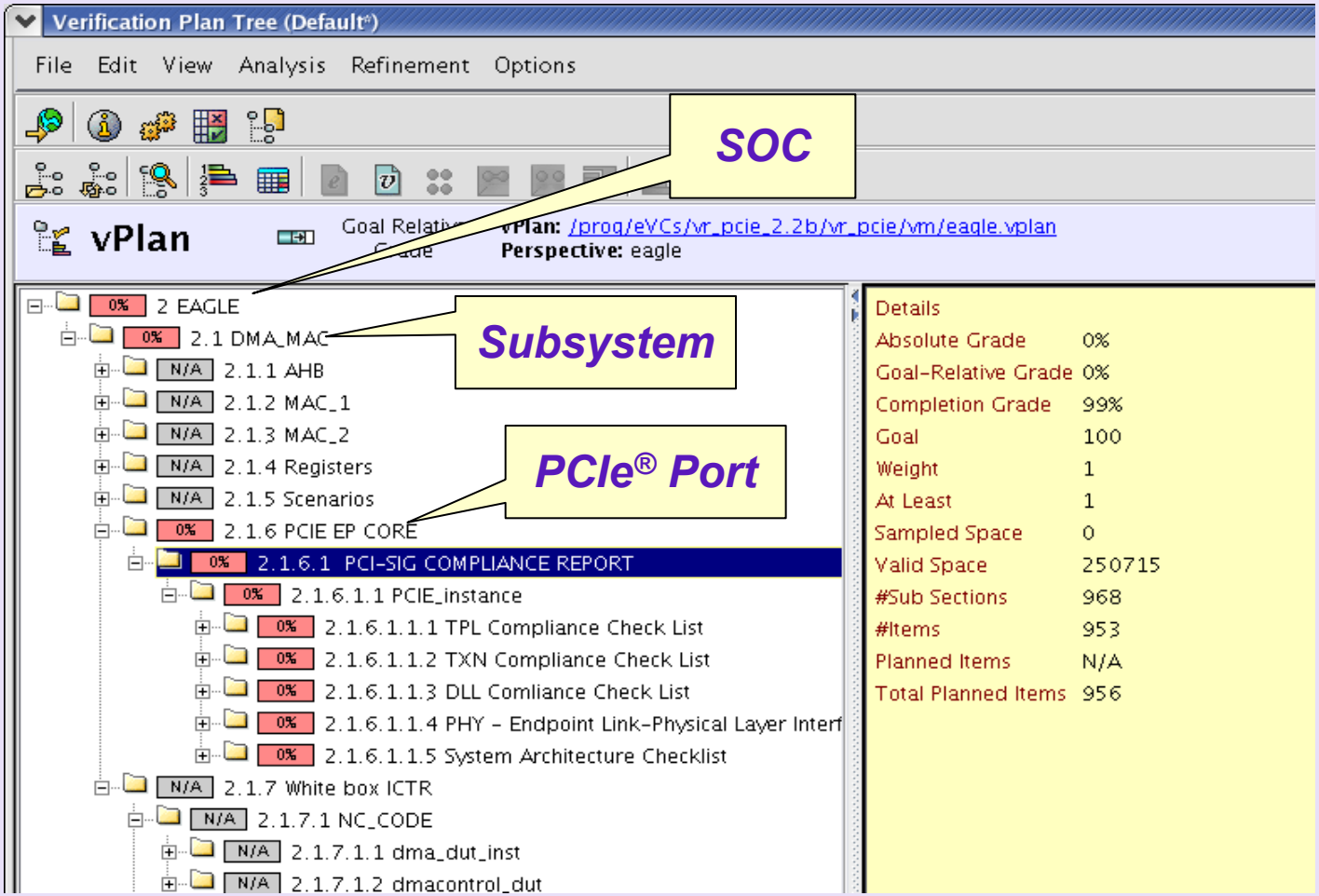


Compliance Is Necessary But Not Sufficient!

Full Device Verification

- With compliance solution in place you can focus on full device verification
- Need an easy way to gather and view compliance data together with (or separate from) full device coverage
- Need assurance for error-free integration
- SOC level aspects must be considered and verified
  - ✓ SW Initialization
  - ✓ System Deadlock conditions
  - ✓ End-to-end verification

Full Device Verification Plan



Screen Capture From

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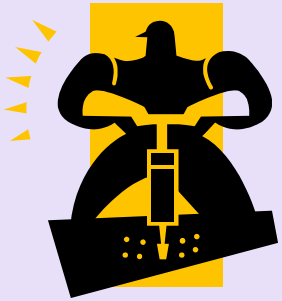
PCI Express VIP

Summary

- Checklist is necessary and valuable, but not sufficient
- Furthermore, checklist is only for compliance, not full device verification
  - ✓ Delivering quality products requires full device verification plan
- Using the compliance checks correctly provides an essential tool
- Not using the compliance checklist correctly gives a false sense of security



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