PCB Sourcing Using PCQR^2

Al Block, Naji Norder and Chris Joran

National Instruments
Austin, Texas

Abstract
In a global market, it is often difficult to determine the best PCB suppliers for your technology needs, while also achieving the lowest costs for your products. Considering each PCB supplier has their own niche in terms of equipment, process, and performance, uniform test data from the IPC-9151D Process Capability, Quality, and Relative Reliability (PCQR^2) Benchmark Test Standard can help find the right source for the board based on its specific technology requirements. By using a data-based approach to vendor selection, this can remove the subjective nature of sourcing, reduce the need for PCB process experts to map suppliers into technologies, and eliminate irrational sourcing decisions.

By incorporating the standard results into our corporate quote model, our company has significantly lowered costs, both by helping to get each board to the right supplier and by reducing failure rates during development, in production, and in the field. Using PCQR^2, the company screens for suppliers that can deliver consistent quality utilizing statistical process control (SPC) to monitor and control their process variables, filtering out those that rely on specific employees for temporary success.

In addition, the company is able to track PCQR^2 performance trends from submission to submission, allowing for the observation and correlation of capability advancement with improving equipment and processes. Using this data, the company can then push our supply base by challenging them to build higher-technology PCQR^2 samples when ready, which, in turn, moves them higher in the quote model and leads to more quoting opportunities and higher revenue.

Introduction
Our company provides products and systems for a wide variety of applications. This requires a supply chain that can support and thrive in a high-mix, low-volume environment. With over one thousand unique PCB designs, one of our challenges is sourcing boards to the "right" shop, with the best mix of technology, capacity, and cost. Compounding this challenge, PCB sourcing is decentralized, so each R&D team has the ultimate decision on which shop is awarded the business. A data-based approach to supplier qualification using the IPC-9151D Process Capability, Quality, and Relative Reliability (PCQR^2) Benchmark Test Standard, built into a company Quote Model, guides each request for quotes to the correct subset of suppliers based on the board's technical requirements and allows R&D teams to focus on price and delivery when making the final vendor selection.

Background
Prior to PCQR^2, the PCB quoting environment was haphazard. Many sourcing decisions were of a subjective nature, based on individual R&D teams' past experience with a given vendor regardless of PCB technology requirements. Quote requests were sent in various formats (spreadsheets, documents, handwritten email, etc.), sometimes lacking data pertinent to the PCB cost. Every supplier received every quote request, so some shops were being asked to quote, and in some cases build, boards for which they were not qualified. When this resulted in failures during prototype validation, R&D was set back and the product release delayed. In other cases, the experience of employees at the suppliers, working above and beyond the capabilities of their processes and equipment, could deliver boards of sufficient quality for validation and production. Such a production methodology – where key workers produce "art" instead of following a process to yield a product – represented a risk to supply continuity that presented itself as a challenge to our PCB Commodity Team.

Quote Model

To solve this challenge, the team needed a dynamic, automated solution, one that would scale with and adapt to changes in the supply base, technology, and market. The solution chosen was to develop a company Quote Model. A standard quote form, filled out by the PCB designer with the board specifications, expected volume, contacts, etc., captured data in a uniform format and ensured completeness. The PCB specifications could then be fed into the Quote Model database to determine qualified suppliers. Initially, suppliers were stratified into low, medium, and high technical capability, and only those suppliers deemed qualified to build a board, given its technology, would receive a request for quote. The R&D team could be assured that each and every received quote was valid, and they could evaluate based on a simpler subset of criteria: prototype or production costs and lead times.

How, then, should we determine the proficiency of each supplier at each facility? Most vendors state their process capabilities on their web sites. These are useful to determine rough competence, but they are also never 100% accurate or reliable. Onsite audits were and continue to be helpful, but these are still somewhat subjective, and using them exclusively to qualify suppliers could require us to retain or hire content experts above and beyond those required for any other commodity. A custom qualification board would allow shops to demonstrate their capabilities on the specific technologies required for the next few generations of company products, but this would require the commodity team to develop test vehicles and manage the evaluation of each sample, and it would be limited to only those suppliers who had received the test vehicle and built it. A better option was to use a third-party test vehicle, and the PCB commodity team chose the IPC-9151D test standard.

PCQR^2

The Printed Board Process Capability, Quality, and Relative Reliability Benchmark Test Standard and Database, IPC-9151D, defines available test coupons and the tests to be performed on them. These coupons can be arranged onto a variety of test panels, currently eleven different options primarily differing in layer count, via structures, and trace geometries. Ideally, vendors would each produce the panel that best showed the transition from successful to unsuccessful production, establishing the boundaries of their production capabilities. To facilitate comparison of results between shops, we chose to focus on three panel types – 10R, 18R, and 24VH – roughly corresponding with low, medium, and high technical capabilities. Vendors self-select the panel types they wish to attempt, though vendors who easily accomplish their chosen panel are encouraged to attempt a more difficult one on a future test cycle.

Figure 1 shows the dielectric and copper specifications, and through and blind via structures of the 10R-E panel intended as an entry point for the company's lowest-technology, lowest-cost suppliers. If a low technology vendor does not have equipment for microvia processing, they can choose not to build any or all of the V2 structures without impacting test of the rest of the panel.

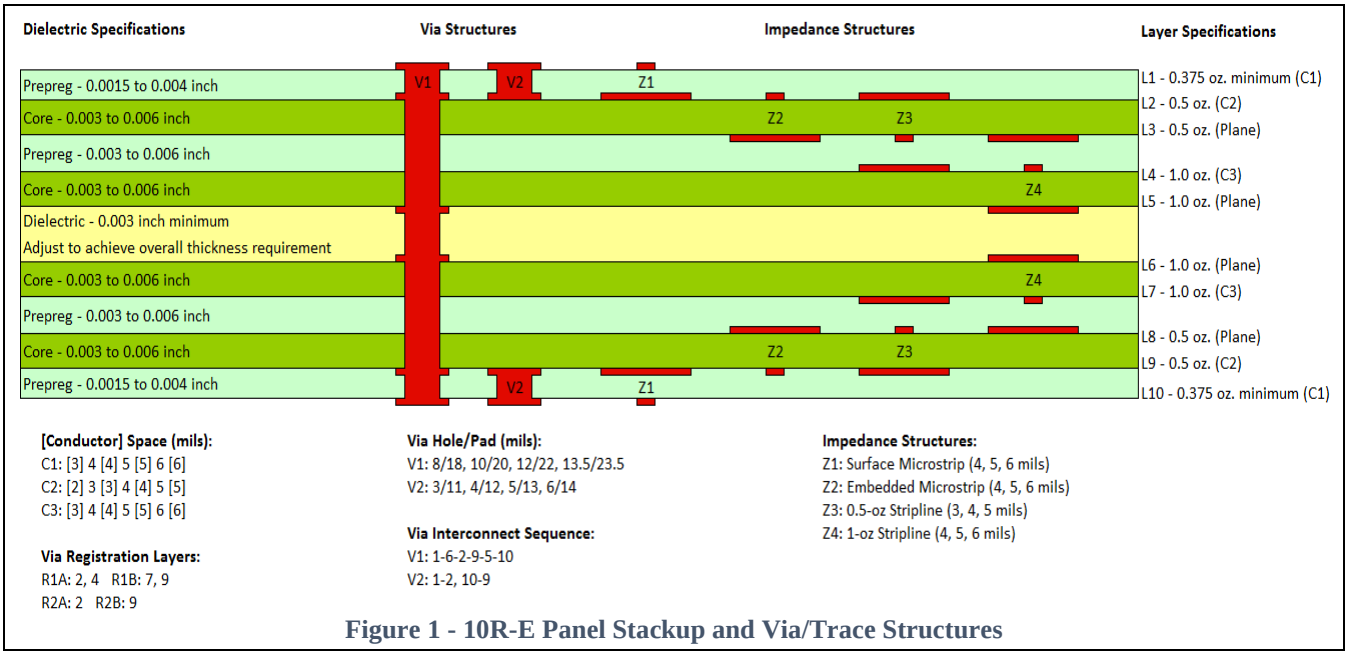


Figure 1 - 10R-E Panel Stackup and Via/Trace Structures

As a supplier's technology increases, they can advance to a medium complexity panel, such as the 18R-E as shown in ***Figure 2***. This board focuses on a higher level of technology with a reduced via size, highlighting a supplier's copper plating reliability and registration capability.

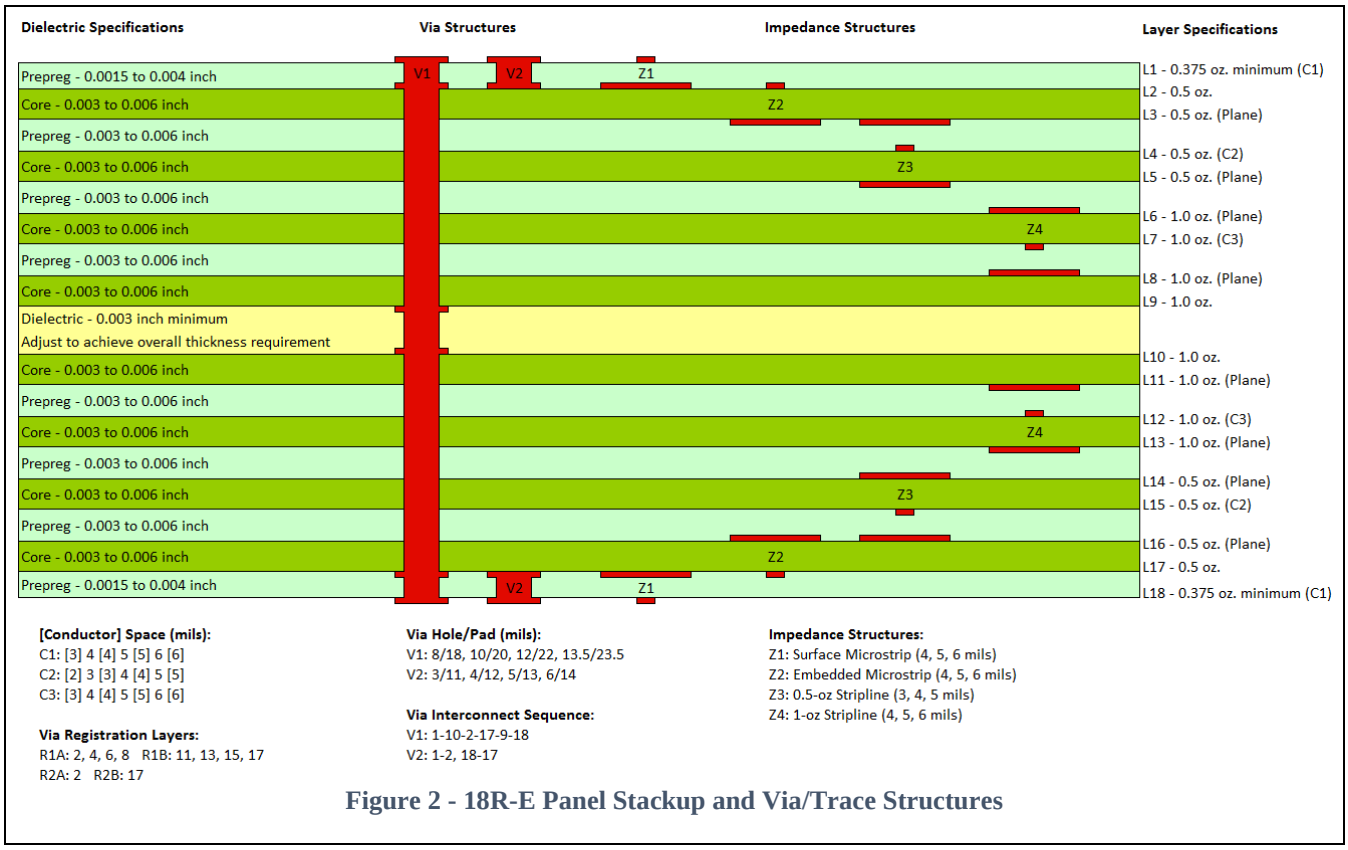


Figure 2 - 18R-E Panel Stackup and Via/Trace Structures

A more complex panel, such as the 24VH-E panel illustrated in ***Figure 3***, allows higher-technology vendors to demonstrate more advanced via structures such as buried vias, skip microvias, and backdrilling, as well as the complex registration requirements of a higher layer count board.

To better evaluate suppliers' ability to maintain process controls over time, a test submission is built in three groups of three panels each, with the jobs spread out over several weeks. All panels are sent, untested, to a third party for evaluation of parameters such as conductor and space yield, via registration and reliability, soldermask registration, and impedance control. Results are typically available in an online report or downloadable for processing. We compare the raw test data against an internal grading criteria to establish pass/marginal/fail limits based on company-specific needs.

As the Quote Model concept evolved, the original low/medium/high stratifications were supplemented with more than a dozen parameters related to specific board features. The smallest feature geometry on which a supplier can consistently meet the internal criteria drives that supplier's rating for that feature. By making PCQR^2 submission an annual requirement, vendors regularly demonstrate their ability to maintain their processes and the tangible results of their capital expenditures and process improvements.

Using PCQR^2 Results

These results can be quickly and objectively applied to our Quote Model. ***Figure 4*** shows example Quote Model database logic. Boolean criteria are based on specific features the suppliers did or did not implement on their chosen submission, as well as other parameters such as ITAR capability and those established by audit. Minimum/maximum values are objectively established by PCQR^2 performance for each feature.

For example, consider the internal conductors of the 24VH-E panel. That test vehicle has internal conductors of widths 0.05, 0.075, 0.1, and 0.125 mm (2, 3, 4, and 5 mils). Most vendors are unsuccessful with 2 mil traces when compared against our grading criteria, while some succeed with 3 mil traces, more with 4 mil traces, and all with 5 mils. A shop that does not meet criteria at 4 mils but passes at 5 mils would be rated for a minimum of 5, while one that fails at 3 mils but is marginal at 4 and passes at 5 might be rated better (such as 4.5 mils) depending on the marginal performance. A flexible, customizable quote model can support other exceptions, such as that shown for Supplier 5 in ***Figure 4*** where sequential lamination capability requires consultation with the PCB commodity team.

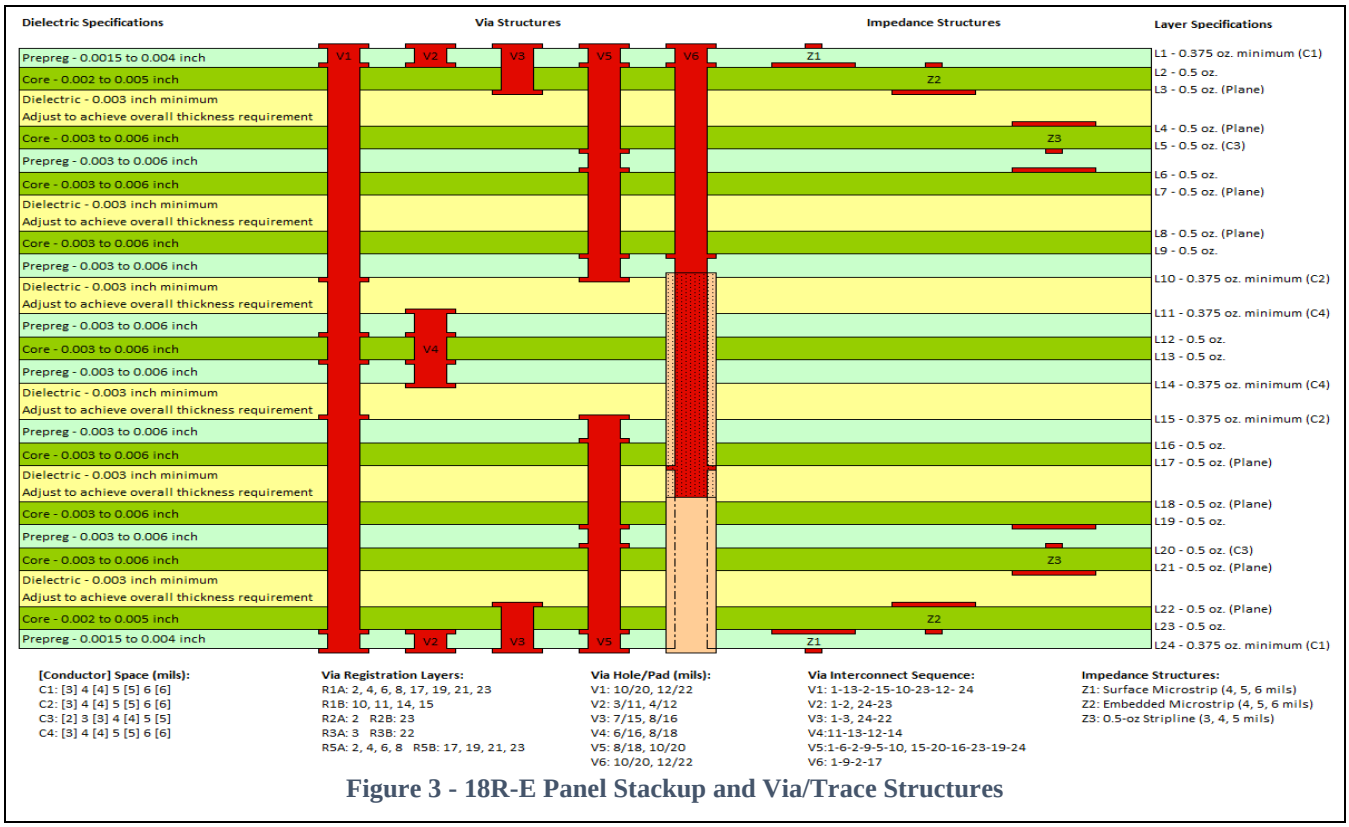


Figure 3 - 18R-E Panel Stackup and Via/Trace Structures

Collating the results of multiple submissions enables trend analysis. Data from four different PCQR[2] submissions are shown in ***Figure 5***. The data in this example could be used in a trend analysis over time at Supplier #1 Site A, or between Supplier #1 Sites A and B, or between Suppliers #1 and #2. The results of such a trend analysis then help establish agenda priorities during on-site audits and can be correlated with production issues, or most importantly used to predict a production issue and resolve it before it occurs.

Benefits to the PCB Buyer / PCB Assembly Manufacturer

We see numerous benefits from sponsoring and sharing the test results of a third-party test vehicle such as PCQR[2].

Control Mechanism for ITAR | Various Yes/No Criteria based on Results and Analysis | Various Min/Max values based on Results and Analysis

Tech	PCB Supplier	ITAR OK?	HPFR4?	VP?	BD?	GF?	BB?	uVia?	SG?	SL?	Max Layer	Contr Imp	Thru Hole	Via in Pad	MinLine SL	MinSpc SL	MinLine Ext	MinSpc Ext	MinLine Int	MinSpc Int
H	Supplier 1 - Site 1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	28	5	0.01	0.02	0.006	0.004	0.003	0.004	0.003	0.003
H	Supplier 2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	28	5	0.01	0.02	0.004	0.006	0.003	0.004	0.003	0.003
H	Supplier 3 - Site 1	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	28	7.5	0.01	0.02	0.005	0.004	0.006	0.004	0.003	0.003
H	Supplier 4	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	28	10	0.01	0.02	0.006	0.004	0.004	0.004	0.003	0.003
M	Supplier 5	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	*	18	10	0.01	0.02	*	*	0.004	0.004	0.003	0.004
M	Supplier 1 - Site 2	Yes	Yes	Yes	No	Yes	No	No	Yes	No	18	7.5	0.01	0.02	N/A	N/A	0.0045	0.0045	0.004	0.004
M	Supplier 6	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	18	10	0.01	0.02	N/A	N/A	0.004	0.004	0.003	0.003
M	Supplier 7	No	No	No	No	No	Yes	Yes	No	No	18	10	0.01	0.02	N/A	N/A	0.005	0.005	0.004	0.004
M	Supplier 3 - Site 2	No	Yes	Yes	Yes	No	Yes	Yes	No	No	18	10	0.01	0.02	N/A	N/A	0.004	0.004	0.003	0.003
L	Supplier 1 - Site 3	Yes	Yes	Yes	No	Yes	No	No	Yes	No	10	10	0.01	0.02	N/A	N/A	0.0045	0.005	0.004	0.004
L	Supplier 8	Yes	No	No	No	Yes	No	No	No	No	10	10	0.01	0.02	N/A	N/A	0.005	0.005	0.004	0.004
L	Supplier 9	No	No	Yes	No	No	No	No	No	No	6	10	0.01	0.02	N/A	N/A	0.0045	0.005	0.004	0.004

HPFR4?	Is approved for high-performance FR4
VP?	Is approved for Via Plugging
BD?	Is approved for Back Drill
GF?	Is approved for Gold Fingers

BB?	Is approved for Blind/Buried Vias
uVIA?	Is approved for Micro Vias
SG?	Is approved for Selective Gold
SL?	Is approved for Sequestional
*	Conditional - Ask Al Block or Naji

Figure 4 - Example Quote Model Database

Supplier Info				Conductor and Space 1.5 ounce (Outer Layer)														4mil 1 Deep Blind Via		
				Trace								Space								
				3	3	4	4	5	5	6	6	4	4	5	5	6	6			
Supplier	Locations	Date	Stack up	CV 6<10	DPMI 150<500	CV 6<10	DPMI 150<500	CV 6<10	DPMI 150<500	CV 6<10	DPMI 150<500	CV 6<10	DPMI 150<500	CV 6<10	DPMI 150<500	CV 6<10	DPMI 150<500	Via Capability	Min Cycles to 10%	Min Cycles to Open
																		CV 6<10	250 >500	250 >500
Supplier #1	Site A	02/01/11	24 VHE	11.86	0	7.59	46	9.03	0	4.85	0	5.01	92	4.11	46	3.55	0	6.13	345.00	350.00
Supplier #1	Site A	03/05/12	24 VHE	13.09	433	7.97	238	11.03	95	4.64	142	4.08	1403	3.43	608	2.96	704	20.37	500.00	500.00
Supplier #1	Site B	08/01/11	24 VHE	10.86	327	7.27	0	6.03	0	4.52	94	4.83	1258	4.04	371	3.42	421	8.30	220.00	245.00
Supplier #2	Site A	10/12/12	24 VHE	0.00	0	0.00	0	6.03	0	0.00	0	0.00	0	0.00	0	0.00	0	7.10	275.00	285.00

Figure 5 - Example Trend Analysis

- **Removes subjective sourcing.** Technical capabilities are established and advanced through objective metrics customized to our products' needs.
- **Helps weed out suppliers who do not support SPC/CIP in their corporate culture.** The test panels are designed to show the limits of a vendor's production capabilities and processes. Vendors that do not use statistical process control (SPC) cannot maintain consistency from lot to lot and submission to submission, and those without capital investment stagnate or fall backward in their test results. These objective measurements supplement audit results when decided to address or disengage from a struggling supplier.
- **Drives supplier quality.** ***Figure 6*** shows PCB PPM reject trending down as the technical capability of our suppliers (represented by the average layer count of PCQR[2] submissions) increases.
- **Reduces R&D time to market.** Any vendor that quotes a board has already demonstrated their ability to repeatedly and consistently build that type of board.

- **Right source / right price.** If technical capability is not an underlying concern, R&D purchase managers can focus on price as a deciding factor, helping drive business to lower-cost suppliers where the technology fits.
- **Drives supplier competitiveness.** We share generic results with all our suppliers so they know where they stand relative to their peers.
- **Drives supplier technology and process improvements.** Quality issues can be correlated with weaknesses or slips in test results. Likewise, the benefits of suppliers' capital and process improvements can be tangibly demonstrated in their improved performance.
- **Increases customer satisfaction.** More products built through reliable and demonstrated processes means fewer failures and fewer escapes, leading to fewer field failures and customer returns.
- **Keeps manufacturing costs down.** Reliable products have fewer manufacturing issues and require less NCMR processing and out of sequence work. Moreover, using a third-party test vehicle is less expensive than developing an internal one.
- **Helps find new suppliers.** The test results are typically shared between all test sponsors, so we can see the results of all test submissions, not just those we sponsored.

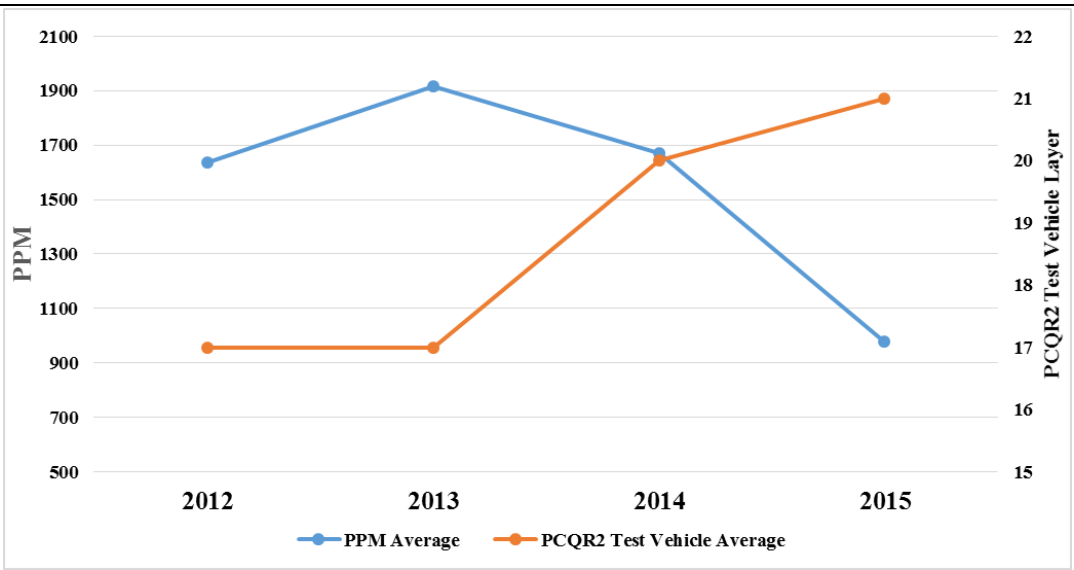


Figure 6 - Quality Improvement with PCQR

Benefits to the PCB Vendor

Suppliers who embrace continuous improvement and regular performance assessment also see benefits from using the test standard.

- **Results are a marketing tool.** For their existing customers, PCQR^2 improvements provide tangible proof of the benefits of their capital expenditures and process improvements, and should lead to higher qualifications and more market share potential. In addition, because results are available to all subscribers (not just the one that sponsored the submission), good performance can lead to new customers.
- **Drives technology and process improvements.** Initially, suppliers were somewhat reluctant to use data sponsored by and shared with their customers to drive their internal process improvements and equipment upgrades. Now, however, suppliers eagerly anticipate their annual test standard submission as an opportunity to demonstrate, to both their customers and their management, the results of their capital investments.
- **Increases customer satisfaction.** Fewer field failures mean fewer unhappy buyers.
- **Keeps costs down.** Test vehicles let suppliers identify and correct manufacturing issues before they affect production yields or delay quick-turn and prototype jobs, saving scrap and the costs of defective product returns. Submission and testing costs are paid by a customer.

Conclusion

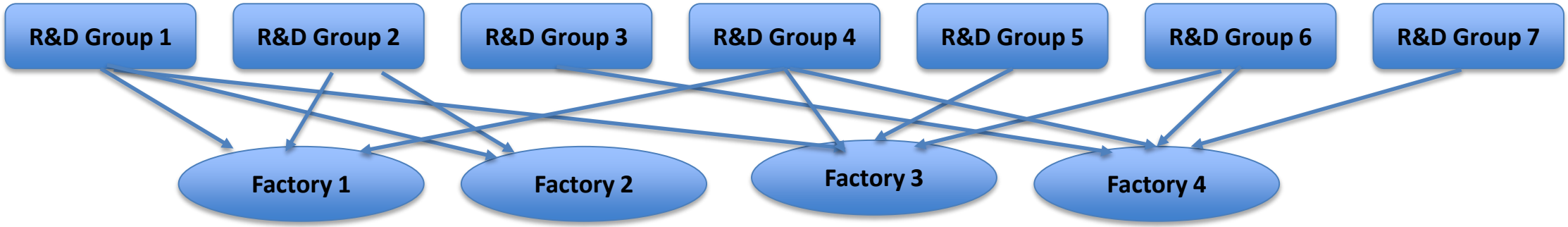
In choosing to utilize the IPC-9151D PCQR^2 database, PCB sourcing at our company has been streamlined by removing subjectivity and ensuring that awarded PCB technology aligns with each supplier's capability. Moreover, the process was implemented without investing in and maintaining company-specific test vehicles. This change has resulted in an increase in quality, higher customer satisfaction, and dramatic cost savings to both the company and our PCB supply base.

PCB Sourcing Using PCQR2

Al Block, Naji Norder and Chris Joran
National Instruments

Our Challenge for PCB Sourcing

- Providing a test and measurement solution in a high mix/low volume environment posed many challenges
- With over 20 R&D teams controlling their own PCB sourcing, decisions were decentralized



- The environment was one of haphazard PCB sourcing and many sourcing decisions were of a subjective nature
- Sourcing to the right shop with the right technology was critical for success

We Needed a Dynamic Automated Solution to Solve this Challenge

What was Developed, was the Corporate Quote Model!

Designing the Quote Model

What Elements did we need to Incorporate into the Quote Model?

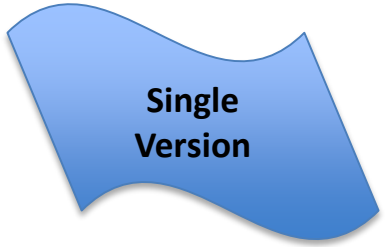
1) A Standard Quote Form

- The form should be one format, that could be filled out with the PCB specifications and other relevant data
- The form should ensure completeness so all information can be conveyed
- We would develop this within the Quote Model database

Pre Quote Model

- **Manually Created**
- **Various Formats (Spreadsheets, Documents, Email, etc…)**
- **Various Levels of Completeness**
- **No Logic as to Who Would Receive the Quote**

Post Quote Model



- **Auto-Generated**
- **Single Format**
- **Completeness Assured**
- **Only Qualified PCB Shops would Receive**

How Would We Determine Qualified PCB Shops?

Designing the Quote Model

What Elements did we need to Incorporate into the Quote Model?

2) An Official Qualification Process

- To enable logic within the new Quote Model
- To reduce quality issues related to technology
  - **Why not simply use the stated capabilities per the PCB Supplier's website?**
  - **Why not simply use the results of on-site audits?**
  - **Why not develop a specific qualification board?**

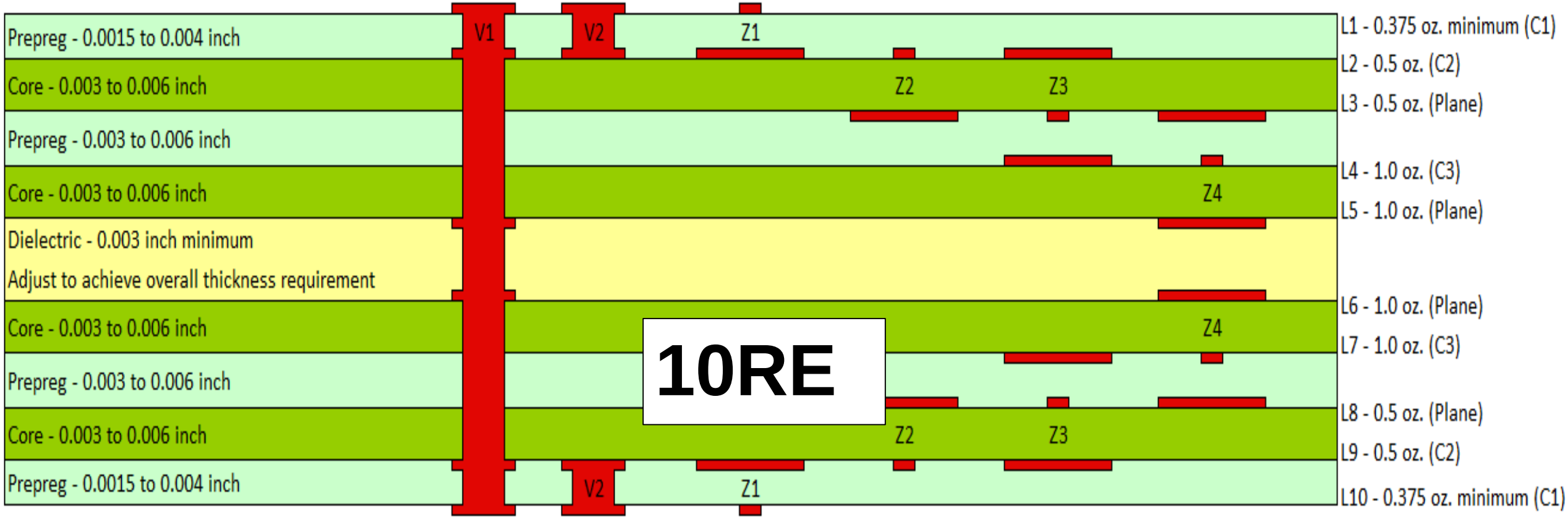
What we concluded, was the need for a third party test vehicle…

We Decided to use IPC PCQR2 as our Qualification Criteria

What is the IPC PCQR2 Test Board?

- PCQR2 stands for Process Control Quality and Relative Reliability
- Benchmarks PCB Supplier's Capabilities
- 11 Different Test Vehicles
  - Our Company Primarily uses 10RE,18RE, and 24VHE

Dielectric Specifications | **Via Structures** | **Impedance Structures** | **Layer Specifications**



[Conductor] Space (mils):

C1: [3] 4 [4] 5 [5] 6 [6]
C2: [2] 3 [3] 4 [4] 5 [5]
C3: [3] 4 [4] 5 [5] 6 [6]

Via Registration Layers:

R1A: 2, 4 R1B: 7, 9
R2A: 2 R2B: 9

Via Hole/Pad (mils):

V1: 8/18, 10/20, 12/22, 13.5/23.5
V2: 3/11, 4/12, 5/13, 6/14

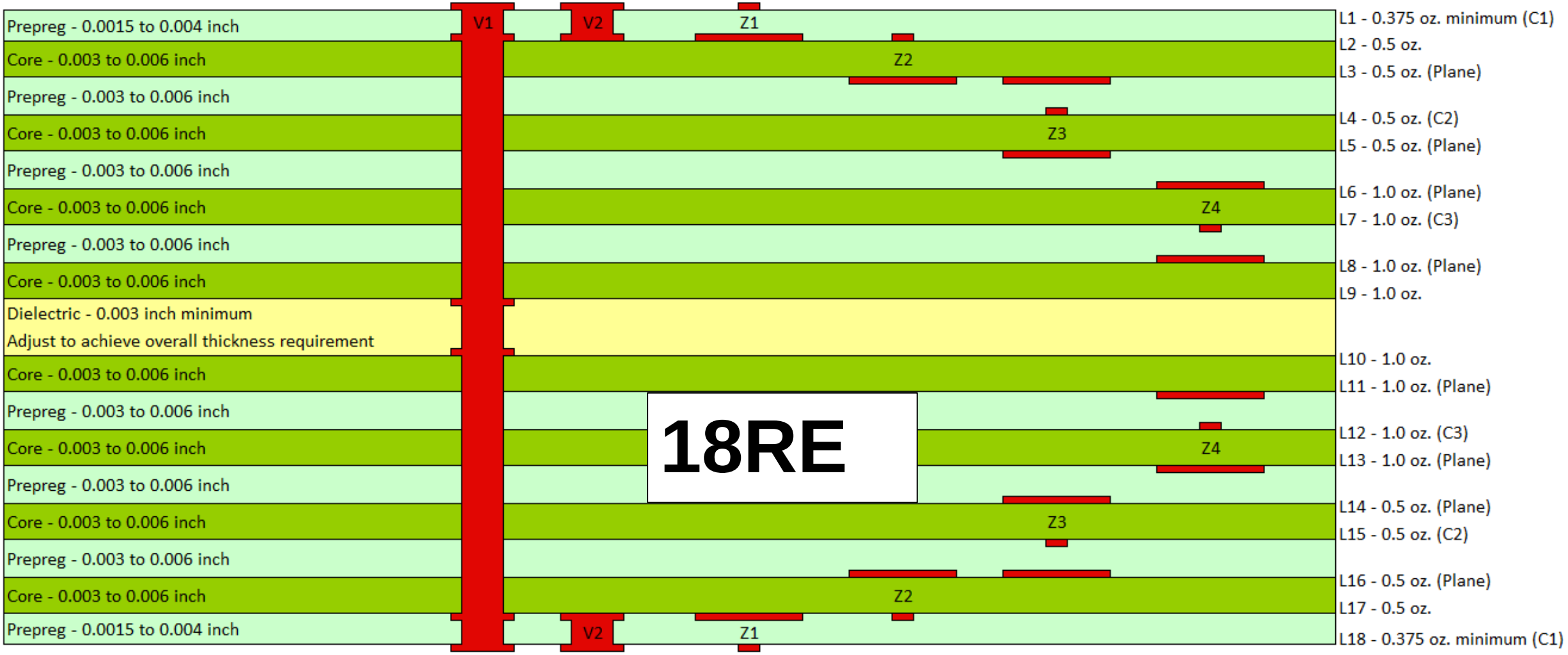
Via Interconnect Sequence:

V1: 1-6-2-9-5-10
V2: 1-2, 10-9

Impedance Structures:

Z1: Surface Microstrip (4, 5, 6 mils)
Z2: Embedded Microstrip (4, 5, 6 mils)
Z3: 0.5-oz Stripline (3, 4, 5 mils)
Z4: 1-oz Stripline (4, 5, 6 mils)

Dielectric Specifications | **Via Structures** | **Impedance Structures** | **Layer Specifications**



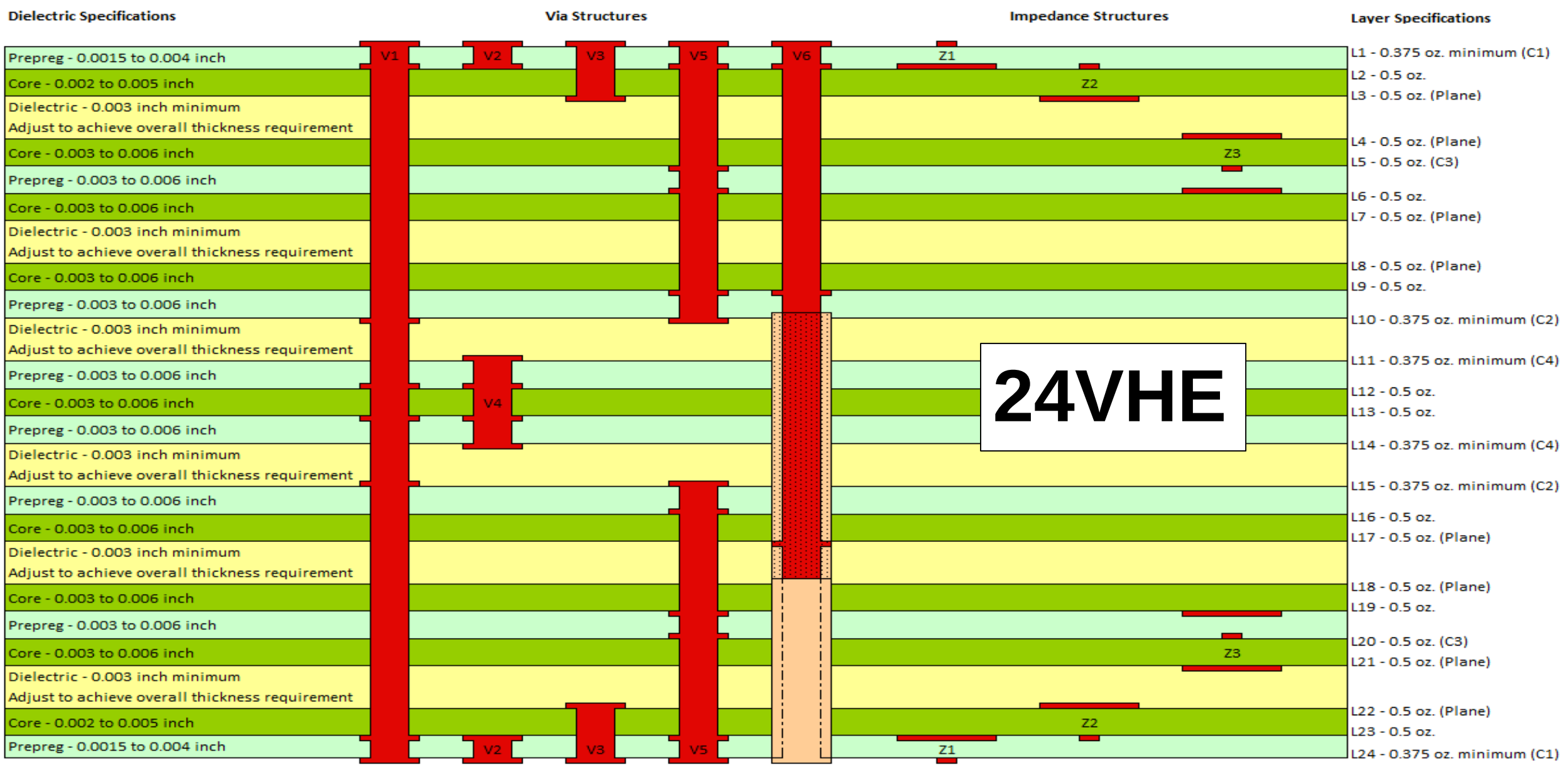
[Conductor] Space (mils):
C1: [3] 4 [4] 5 [5] 6 [6]
C2: [2] 3 [3] 4 [4] 5 [5]
C3: [3] 4 [4] 5 [5] 6 [6]

Via Registration Layers:
R1A: 2, 4, 6, 8 R1B: 11, 13, 15, 17
R2A: 2 R2B: 17

Via Hole/Pad (mils):
V1: 8/18, 10/20, 12/22, 13.5/23.5
V2: 3/11, 4/12, 5/13, 6/14

Via Interconnect Sequence:
V1: 1-10-2-17-9-18
V2: 1-2, 18-17

Impedance Structures:
Z1: Surface Microstrip (4, 5, 6 mils)
Z2: Embedded Microstrip (4, 5, 6 mils)
Z3: 0.5-oz Stripline (3, 4, 5 mils)
Z4: 1-oz Stripline (4, 5, 6 mils)



[Conductor] Space (mils):
C1: [3] 4 [4] 5 [5] 6 [6]
C2: [3] 4 [4] 5 [5] 6 [6]
C3: [2] 3 [3] 4 [4] 5 [5]
C4: [3] 4 [4] 5 [5] 6 [6]

Via Registration Layers:
R1A: 2, 4, 6, 8, 17, 19, 21, 23
R1B: 10, 11, 14, 15
R2A: 2 R2B: 23
R3A: 3 R3B: 22
R5A: 2, 4, 6, 8 R5B: 17, 19, 21, 23

Via Hole/Pad (mils):
V1: 10/20, 12/22
V2: 3/11, 4/12
V3: 7/15, 8/16
V4: 6/16, 8/18
V5: 8/18, 10/20
V6: 10/20, 12/22

Via Interconnect Sequence:
V1: 1-13-2-15-10-23-12- 24
V2: 1-2, 24-23
V3: 1-3, 24-22
V4:11-13-12-14
V5:1-6-2-9-5-10, 15-20-16-23-19-24
V6: 1-9-2-17

Impedance Structures:
Z1: Surface Microstrip (4, 5, 6 mils)
Z2: Embedded Microstrip (4, 5, 6 mils)
Z3: 0.5-oz Stripline (3, 4, 5 mils)

What is the IPC PCQR2 Test Board?

- PCQR2 stands for Process Control Quality and Relative Reliability
- Benchmarks PCB Supplier's Capabilities
- 11 Different Test Vehicles
  - Our Company Primarily uses 10RE,18RE, and 24VHE
  - Our Company has an Annual Requirement to stay Approved in our Quote Model
    - Drives Cap-Ex and Process Improvements
- PCQR2 Database Output
  - The subscriber is able use the graphical analysis tool w/in the Database
  - Company downloads the results in txt format to use in our Quote Model

We Have Unique Grading Criteria due to our Sensitivities

What We do with the PCQR2 Results

1) Download into our Quote Model

Control Mechanism for ITAR

Various Yes/No Criteria based on Results and Analysis

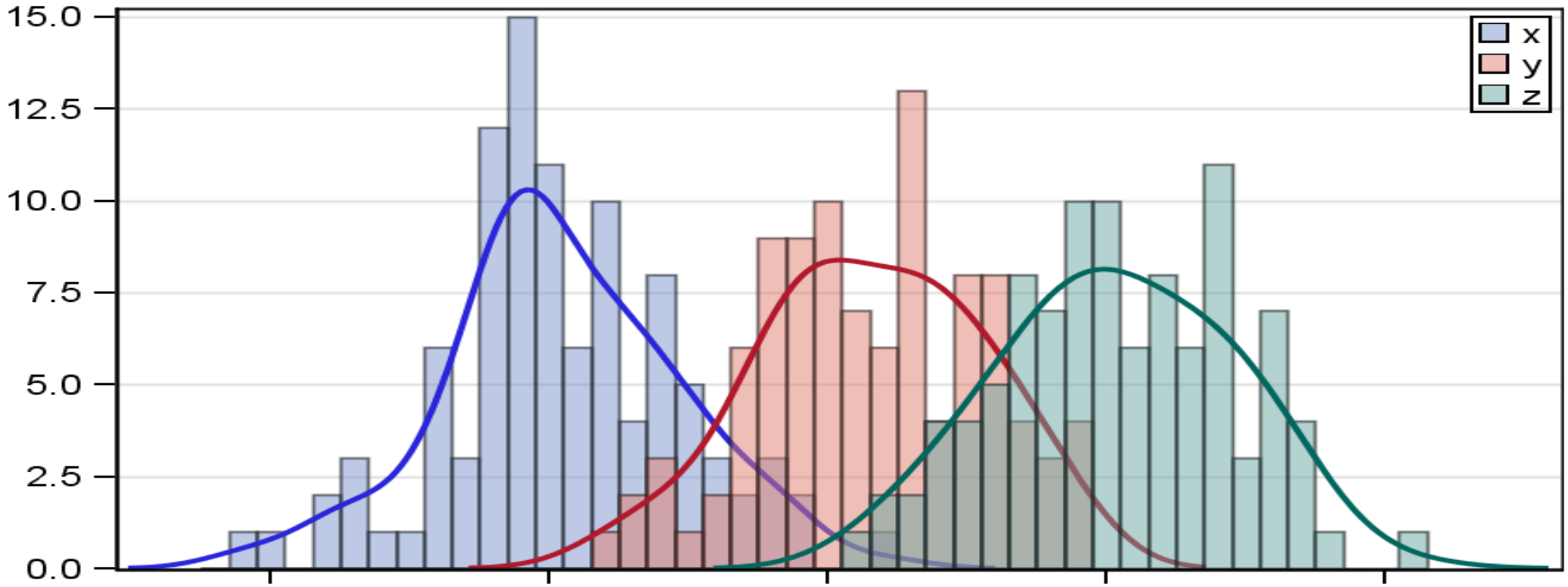
Various Min/Max values based on Results and Analysis

Tech	PCB Supplier	ITAR OK?	VP?	BD?	GF?	BB?	uVia?	SG?	SL?	Max Layer	Contr Imp	Thru Hole	Via in Pad	MinLine SL	MinSpc SL	MinLine Ext	MinSpc Ext	MinLine Int	MinSpc Int
H	Supplier 1 - Site A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	28	5	0	0	0.006	0.004	0.003	0.004	0.003	0.003
H	Supplier 2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	28	5	0	0	0.004	0.006	0.003	0.004	0.003	0.003
H	Supplier 3 - Site A	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	28	7.5	0	0	0.005	0.004	0.006	0.004	0.003	0.003
H	Supplier 1 - Site B	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	28	10	0	0	0.006	0.004	0.004	0.004	0.003	0.003
M	Supplier 4	No	Yes	Yes	Yes	Yes	Yes	Yes	*	18	10	0	0	*	*	0.004	0.004	0.003	0.004
M	Supplier 3 - Site B	Yes	Yes	No	Yes	No	No	Yes	No	18	7.5	0	0	N/A	N/A	0.0045	0.0045	0.004	0.004
M	Supplier 5	No	Yes	No	Yes	Yes	Yes	Yes	No	18	10	0	0	N/A	N/A	0.004	0.004	0.003	0.003
M	Supplier 1 - Site C	No	No	No	No	Yes	Yes	No	No	18	10	0	0	N/A	N/A	0.005	0.005	0.004	0.004
L	Supplier 6	Yes	Yes	No	Yes	No	No	Yes	No	10	10	0	0	N/A	N/A	0.0045	0.005	0.004	0.004
L	Supplier 7	Yes	No	No	Yes	No	No	No	No	10	10	0	0	N/A	N/A	0.005	0.005	0.004	0.004

VP?	Is approved for Via Plugging
BD?	Is approved for Back Drill
GF?	Is approved for Gold Fingers
BB?	Is approved for Blind/Buried

uVIA?	Is approved for Micro Vias
SG?	Is approved for Selective Gld
SL?	Is approved for Sql. Lam.
*	Conditional - Ask Al or Naji

Comparative Histogram



- **This is an Example of How a Supplier can be Consistent Within a Lot, but Not Lot to Lot**

What We do with the PCQR2 Results

2) Trending and Analysis

- **Site Trends**
  - Same Company/Same Site (Supplier 1, Site A, 2011 vs 2012)
  - Same Company/Different Site (Supplier 1, Site A vs Site B)
  - Different Company/Different Site (Supplier 1 vs Supplier 2)

Supplier Info				Conductor and Space 1.5 ounce (Outer Layer)														4mil 1 Deep Blind Via		
				Trace								Space								
				3	3	4	4	5	5	6	6	4	4	5	5	6	6	Via Capability	Min Cycles to 10%	Min Cycles to Open
Supplier	Locations	Date	Stack up	CV 6<10	DPMI 150<500	CV 6<10	DPMI 150<500	CV 6<10	DPMI 150<500	CV 6<10	DPMI 150<500	CV 6<10	DPMI 150<500	CV 6<10	DPMI 150<500	CV 6<10	DPMI 150<500	CV 6<10	250 >500	250 >500
Supplier #1	Site A	02/01/11	24 VHE	11.86	0	7.59	46	9.03	0	4.85	0	5.01	92	4.11	46	3.55	0	6.13	345.00	350.00
Supplier #1	Site A	03/05/12	24 VHE	13.09	433	7.97	238	11.03	95	4.64	142	4.08	1403	3.43	608	2.96	704	20.37	500.00	500.00
Supplier #1	Site B	08/01/11	24 VHE	10.86	327	7.27	0	6.03	0	4.52	94	4.83	1258	4.04	371	3.42	421	8.30	220.00	245.00
Supplier #2	Site A	10/12/12	24 VHE	0.00	0	0.00	0	6.03	0	0.00	0	0.00	0	0.00	0	0.00	0	7.10	275.00	285.00

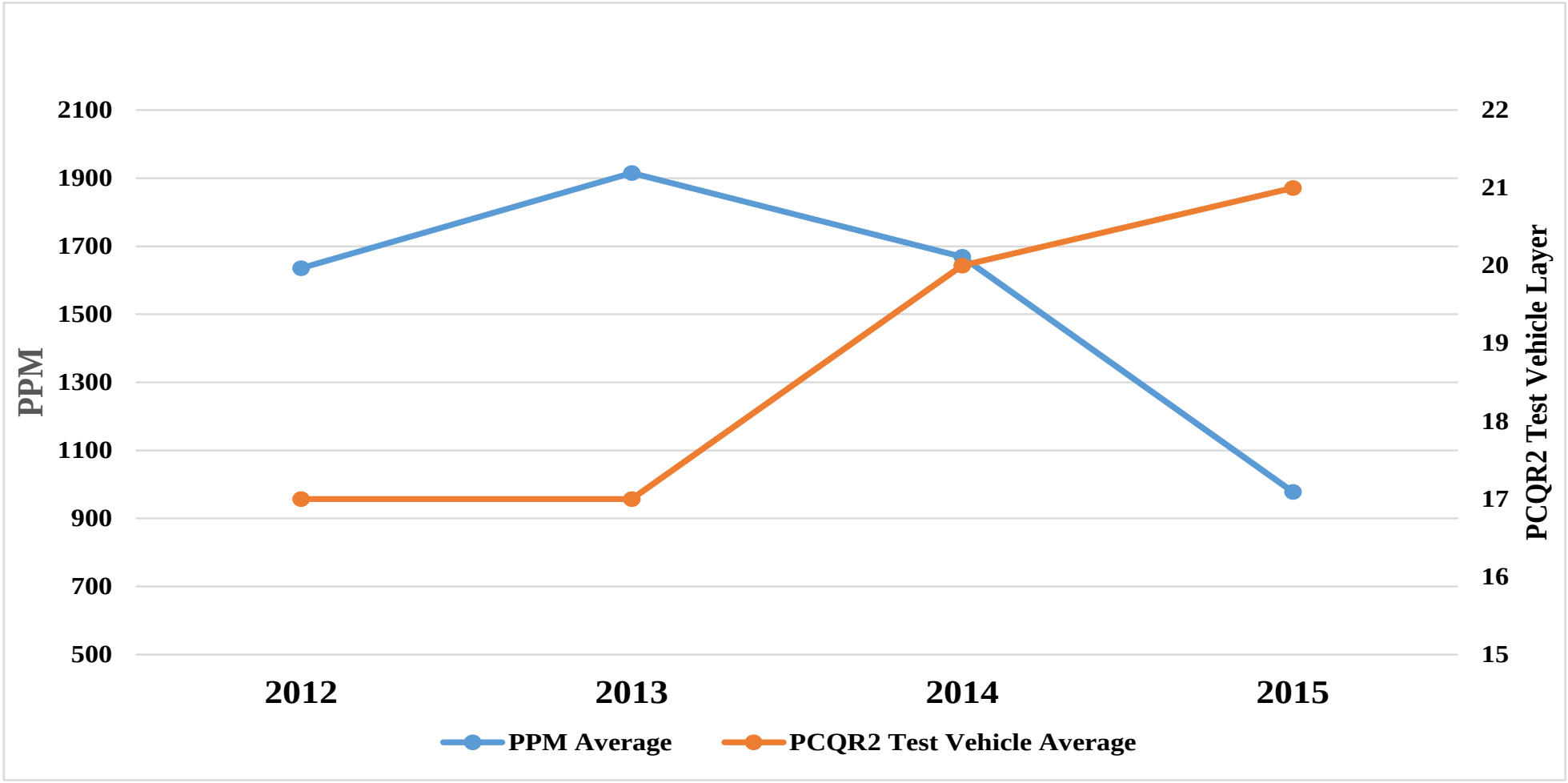
- **Supplier Audit Support**

- **Validates Our Requests for Improvements**

Benefits to Our Company for Using PCQR2

- **Reduces Quality Issues (Increased Customer Satisfaction)**

PPM and PCQR2 Trend



As our PCB Supply Base Matured in PCQR2 Technology, our Average PPM has Trended Favorably

Benefits to Our Company for using PCQR2

- Reduces Quality Issues (Increased Customer Satisfaction)
- Removes Subjective Sourcing
- Eliminates Suppliers who do not Support SPC/CIP in their Corporate Culture
- Reduces R&D Time to Market
- Drives Supplier Competitiveness
- Drives Supplier Technology and Processes
- Right Source/Right Price
- Keeps Our Costs Down
- Supplier Research

Subscribers can see all Submissions, not just those they Sponsored

Supply Base Benefits of Utilizing PCQR2

- Reduces Quality Issues (Increased Customer Satisfaction)
- Marketing Tool Based on Results
- Drives Supplier Technology and Process Improvements
- Keeps Costs Down

Good Scoring Helps in Marketing and Validates Claimed Capability

In Summary…

- The IPC PCQR2 Test Board Provides Logic to the Corporate Quote Model and also…
  - **Removes Subjectivity for PCB Sourcing**
  - **Ensures the PCB Technology Aligns with the PCB Supplier Capability**
  - **Removes the Need for a Company Unique Test Board**
  - **Increases Quality and Customer Satisfaction**
  - **Helps Control Costs for the PCBA Manufacturer**
  - **Provides Cost Savings for the PCB Supplier**

Thank You!