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Ten things that may be costing you

Electronic and mechanical designers face the challenge of collaborating on PCBs

“Fifty-nine percent of complex products require at least two additional design iterations to address electromechanical issues and 68 percent of corporations cite electronics, mechanical and simulation design synchronization as a significant product design challenge.”

Source: Aberdeen Group, “Today’s PCB Excellence: On Time, On Budget, and Strategically On-Point,” November 2019.

Executive summary

Electronics companies in all industries are facing dramatic changes:

- Customized and personal products are on the rise. It is clear 5G will run at 10 times the speed with 100 times the traffic capacity and one-tenth latency. It is estimated that by 2024, 25 percent of all traffic will be carried by 5G networks
- According to IOT Analytics, devices are getting smaller and there is a disruptive pull of electronics in mature industries. Twenty-two billion Internet of Things (IOT) devices will be connected by 2025
- Customer experience is essential to growth. According to TechValidate, the data center infrastructure market will grow to \$90 billion by 2024 with annual global internet protocol (IP) traffic increasing 127-fold from 2005 to 2021

Abstract

Executive focus on lowering costs while maintaining and growing short-term productivity drives many of their high-level initiatives. Digital transformation is central to many research and development (R&D) efficiency initiatives to target speed, agility, quality and increased new product introduction (NPI) success with lower risk. It is important not to limit the discussion to one group or area of the business. Consider the value of integrated systems across the many domains supporting entire businesses (mechanical design, electronic design, engineering analysis, manufacturing, data management, product lifecycle management, enterprise resource planning, etc.).

Design and manufacturing leaders face the challenge of comparing tools and systems to understand the real value of change. Balancing competing systems can be complex. It is human nature to fear change, however, experts agree that a 10 percent improvement is not significant enough to disrupt their current process. We must identify a transformation that can overhaul our current methodologies to improve our productivity. Companies successfully changing systems often look for significant productivity improvements together with equivalent NPI efficiency impact. Consider the entire process and multi-domain workflow and look at challenges you may see where tools are not aligned, meaning that capabilities in one tool cannot be leveraged because of lack of that capability in other parts of the workflow. Large projects come with significant budgets. The impact of design issues can be seen in project budgets that assume re-spins with weeks of delay. These could be eliminated with the right tools.

This white paper looks at 10 areas where electronic and mechanical designers working with printed circuit boards (PCBs) face the dysfunctional nature of their collaborative tools. This is not intended to be a complete review.

1. External and Internal copper and solder mask/silkscreen data
2. True 3D model exchange and synchronization (pin 1 verification)
3. Full 3D Interference checking
4. Rigid-flex objects (multiple thickness boards, stiffeners, etc.)
5. High density interconnects and miniaturization
6. Variant exchange
7. Design intent collaboration (ownership, frozen groups)
8. Workflow synchronization
9. Simulation-driven design
10. Manufacturing preparation

1. External and internal copper and solder mask/silkscreen data

Without a full digital twin capability, mechanical computer-aided design (MCAD) users lack an accurate data representation of the PCB.

Copper, solder mask and silkscreen data has historically belonged in the electronic domain. This information is typically not understood and does not have a place in the MCAD domain. Teams often use 2D (DXF) items to do tedious manual checks, resulting in shorts, interferences and other manufacturing issues.

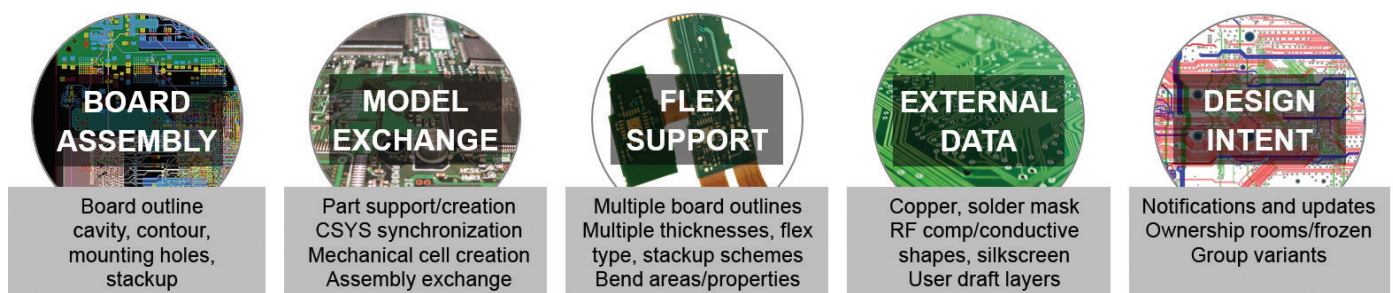


Figure 1. Design teams may consider five key areas of the PCB process. When looking for business impact it is important to not forget the disciplines that interact throughout the product lifecycle.



Enabling the mechanical team to collaborate on all copper, solder mask and silkscreen information is an important step in providing the mechanical engineer full visibility into the electronics design. Coordinated and rapid interference checks will also dramatically improve responsiveness between the two disciplinary groups.

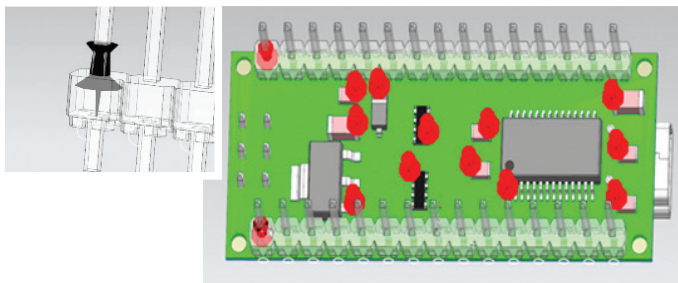
There are three simple examples. First, when a PCB design requires a shield around a high speed or radio frequency (RF) circuit to isolate the circuit, the mechanical shield may be close to a high powered net causing an electronic short.

Second, if a shield is placed on the board for good grounding and the solder mask definition runs under one edge then the shield can may be lifted, making the screening ineffective.

Finally, the complexity of designs in electronic and mechanical domains increases. PCB designs with very small one-inch micron air gaps between the electronics and the mechanical enclosures are becoming more typical. Design work becomes an order of magnitude more difficult without the ability to share the right content between teams.

2. True 3D model exchange and synchronization (pin 1 verification)

Low fidelity component representations limit the design team’s ability to confirm placement and check tolerances. Component placement errors that make it to manufacturing can end careers.



In the electronic domain, PCB components follow the IPC7351-C standard for orientation and definition. The mechanical domain libraries often do not follow a standard. This means that multiple reviews are required throughout the design process to identify if components in both domains are in the same location. This is often complicated by “aliasing” (or mapping) the electronic and mechanical libraries with a text file that is manually updated and manged.

For a large electronics original equipment manufacturer (OEM), discovering that connector orientations are different in electronic and MCAD domains cause major manufacturing issues. When product assemblies fail the best case is the team can make simple cabling changes. Often when the connector pin 1 is misaligned, a redesign of a portion of the PCB can be required to satisfy mating issues between components and connectors.

If the problem lies with a board-to-board connector and it is rotated 180 degrees off then it’s a complete bust and it can only be fixed using software.

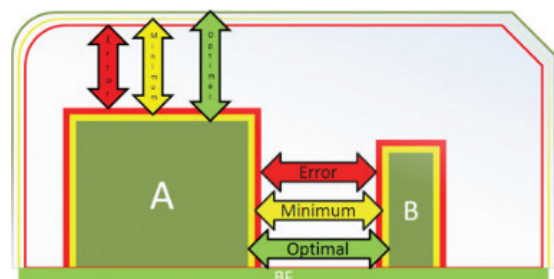
Collaboration between electronic and mechanical systems need to be automated so that orientation errors are eliminated and the correct model is selected.

True 3D model representations combined with automatic alignment and rotation prevents re-spins and can save hundreds of hours removing manual checks and errors during collaboration.

3. Full 3D interference checking

Limitations in many mechanical/electronic systems often lead to limited manual validation and checking on incomplete data. This can be the source of many of the re-spins and resulting [additional] design iterations referred to by industry researchers.

MCAD and electronic systems often lack the required information from the other domain to provide a comprehensive validation to ensure the design requirements have been met. Not only is the information limited, but these checks are manual and are up to the designer’s judgment if a violation has occurred.



If the mechanical team receives monolithic files representing all components then reviewing changes and checking the design against corporate design rules can take hours to complete. The checks can be limited by 2.5D component representations and small features of the component like leads can interfere with the casing.

Mechanical design rule checks that are predefined to align with company standards can save hundreds of hours validating the electromechanical design and prevent multiple design re-spins due to incomplete data.

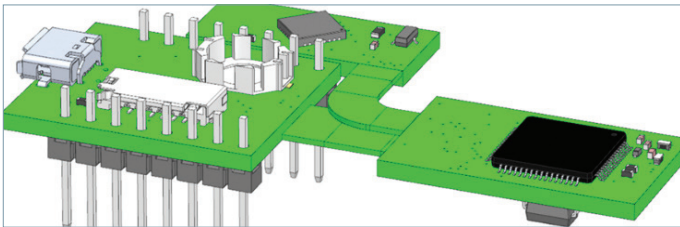
Do not forget the electronics team also wants to “left shift” interference checks. By sharing mechanical data like enclosure geometry, they can also identify and work to avoid violations in their tools. Common data and design checking capabilities will prevent issues that will cause re-spins and improve the overall design. For example, potentially reducing the board real estate and therefore significantly reducing the cost of the design.

A common dedicated PCB-aware tool that uses full 3D representations of components and stores company design rules and can dynamically and automatically check the design can identify violations using native data earlier to improve design quality.

4. Rigid-flex objects (multiple thickness boards, stiffeners, etc.)

Advanced PCB projects require advanced tools, especially in electronics miniaturization where new form factors are required. This includes a true representation of a PCB that provides accurate data for 3D design rule checking

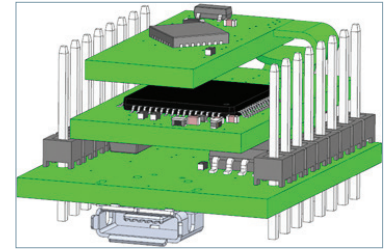
Mechanical systems have historically not interpreted complex electronic PCB structures. Rigid-flex is a key example in which designers are required to make multiple manual modifications to align the databases to capture the design intent.



An industry-first mechanical design capability exists to enable an electromechanical solution to support true rigid/flex collaboration including: multi-thickness, unique stackups, bend line and properties, coverlay,

stiffeners and adhesives.

Companies without this capability typically use workarounds like sheet metal functions to create the design as a single thickness and then modify to represent the design. The implied limitations are costly, daily design life is harder and more prone to risk.



Designers need to:

- Check component clearance in folded and flat states, trial-and-error scenarios in manufacture
- Represent the true copper layer stackup
- Realize the design in the folded and flat states within the same model
- Make manufacturing fit form and function checks

The ability to create, modify and collaborate true 3D multi-thickness designs within a fraction of the design time is a technical breakthrough. Designers can address the above issues and also iterate associatively between electronic and MCAD for the folded and flatten states. Management should investigate available savings of up to 80 percent per unique PCB throughout the design lifecycle.

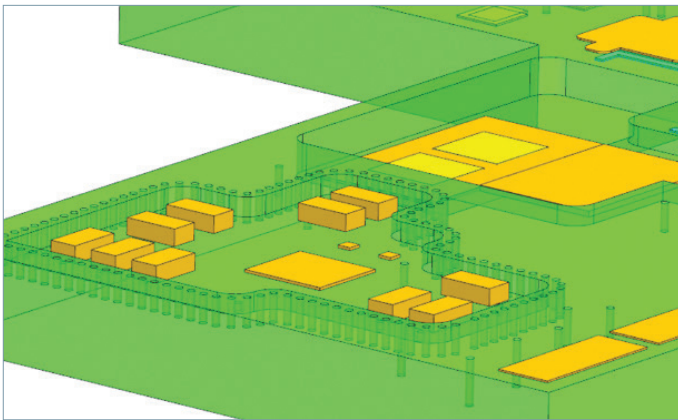
5. High-density interconnects and miniaturization

In addition to new form factors, electronics miniaturization can be achieved by decreasing PCB features (smaller components and interconnects) and increasing the density on the board.

High-density interconnects (HDI) boards are printed circuit boards with a higher density of tracks and pads when compared to a normal PCB. They often include blind, buried and micro vias. Everything is smaller on these boards, traces, spacing, capture pads, etc. HDI boards have the advantage of reduced size and weight, and yet they can still boost the electrical performance of the device. High-density designs allow a larger number of active components in a device. That means designers can add more powerful and compact devices in the same space of the product, leading to a high-density design with an enhanced performance.

When the PCB assembly height needs to be minimized, components can be placed within cavities. Similar to rigid-flex, cavities in rigid boards provide a similar challenge for 3D collaboration. Components can appear to

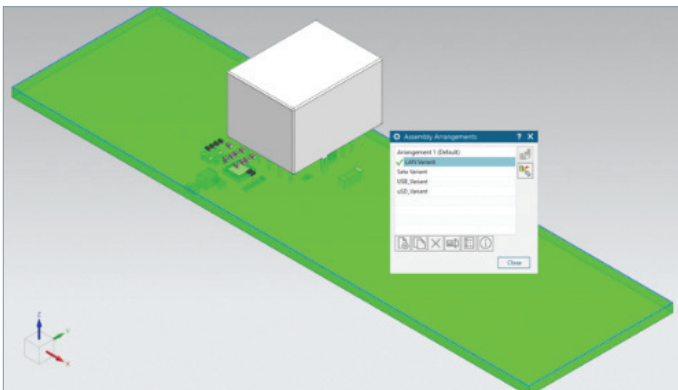
“float” above the PCB rather than sit in the cavity. A solution that accurately represents components in cavities positioning the component model at the correct Z position relative to the cavity is therefore needed. A saving of at least one manufacturing re-spin and hundreds of hours removing manual checks and errors during collaboration could be realized.



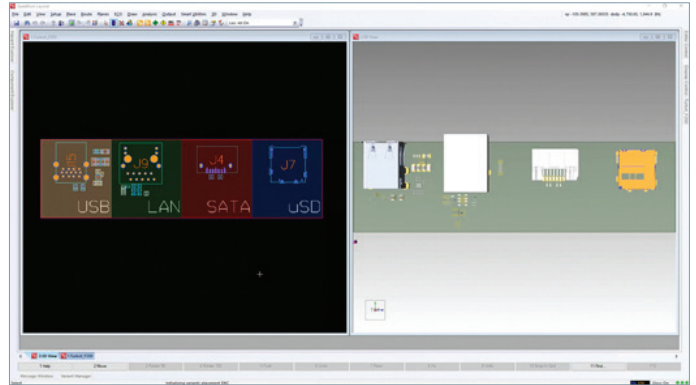
6. Variant exchange

This is another area where an electronic designer will tell you that [most] mechanical design tools do not properly support design intent. The ability to extract and support PCB variant information from the electronic design layout simplifies updates and collaboration on families of boards designed to support different market requirements.

Designs including multiple variants are common in the electronics world. Designers typically generate the design for the complete assembly with all possible options (for example, multiple connector options).



The mechanical designer often makes individual copies for each of the variants. Working with complete assemblies is possible, with everything from all variants placed via postprocessing (typically involving Excel spreadsheet software) to get the representation that is needed.



Communication is disjointed and change is non-associative. This often leaves the mechanical designer without the variant knowledge (unless communicated by other manual means like email, paper, etc.). They are left to work with the complete assembly on the mechanical side, which means leaving unnecessary space for non-existent components. No MCAD system provides the ability to switch between variants.

Mechanical design teams managing variants purely by bill-of-materials (BOM) often have repeated issues where they can't differentiate the multiple variants in the electronic and mechanical BOMs.

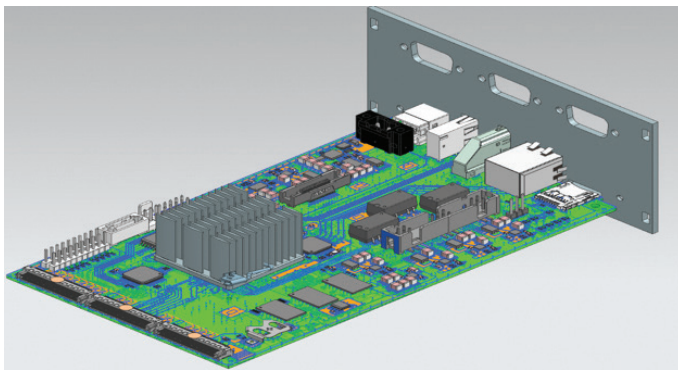
When variant PCB information is managed manually, design teams find when each variant is able to exist in multiple projects, managing development and ensuring that updates are consistently applied becomes complicated and hence costly.

The solution is for the electronic system to be used to define and manage variants of a board assembly within a single project. This information should be directly transferred to the mechanical system in a way that allows designers to see the native master design and each individual variant within the design. With the addition of variant information, the mechanical designer can be aware of the electronic domain data and can collaborate to find a single digital truth. This can lead to typical savings of dozens of hours of manual editing per design variant throughout the design lifecycle.

7. Design intent collaboration

Understanding design intent is known to dramatically improve efficiency and productiveness, yet in many electronic and mechanical systems, the mechanisms to pass design intent do not exist.

In electromechanical designs it is typical that components or objects are owned by one domain. For example, mechanical owns placement of connectors. If this information, or ownership, is not automatically transferred to the other domain, multiple wasted iterations can ensue as items are incorrectly moved, causing design violations.



Component changes are often missed if the users are exchanging monolithic step files. Inadvertent modification of components causes unnecessary cycles with both domains modifying the same components.

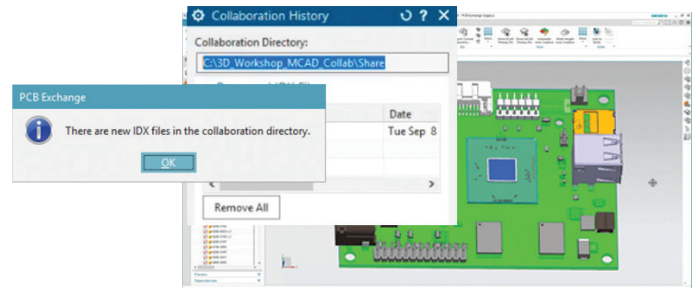
Not only is the ownership of components to prevent accidental movement required, but so is the ability to transfer knowledge of that intent. Managed blocks and re-usable circuits like RF circuits or power stages should mimic the movement in the electronic system when moved in by the mechanical designer. Failure to do so will impact the characteristics of the electronic design and may badly impact the design. With the bonded constraint, users can move these so-called frozen groups to prevent breaking the electronic rules.

Conveying the design intent in both domains when collaborating on electromechanical designs saves hours of reinvention and the frustration of wasted design cycles.

8. Workflow synchronization

With teams spread across the world, how do designers highlight collaboration status and pending data that needs to be processed? Can designers be confident they have updated the other domain on what has been accepted or rejected?

Teams can have a loose view of collaboration. Often when data is sent the databases are not synchronized. Changes occur without the knowledge of other domains, which breaks their design requirements.

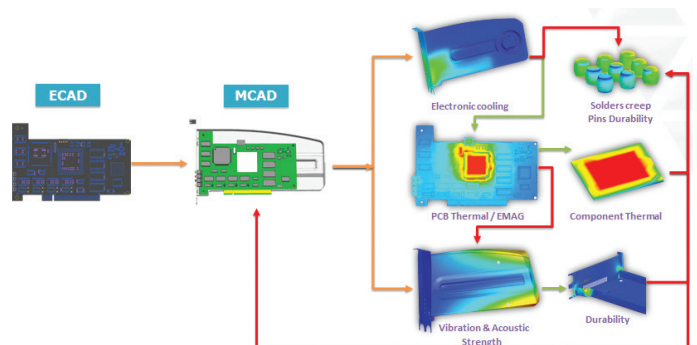


Cases in which the electronic design has been published and the MCAD domain is not aware of it can cause many hours of lost time, either waiting for changes that have already been done, or making changes that no longer work with the new design.

It is important to close the loop with a response to synchronize the two domains and ensure both parties understand what elements need to be accepted or rejected. In-tool notifications ensure the users know of unprocessed files that need to be reviewed and can save days of attempting to synchronize design data between domains and prevents design re-spins due to out-of-date data.

9. Simulation-driven design

Miniaturization of modern electronics and ever-increasing complexity requires multi-physics simulation to improve reliability and maximize electrical performance. Combined with a faster development cycle, earlier and more frequent simulation results are required to drive design decisions to avoid costly prototypes or re-spins. A simulation-driven design approach requires efficient collaboration across the multi-disciplinary team and sufficient integration across the design tools for passing design information.



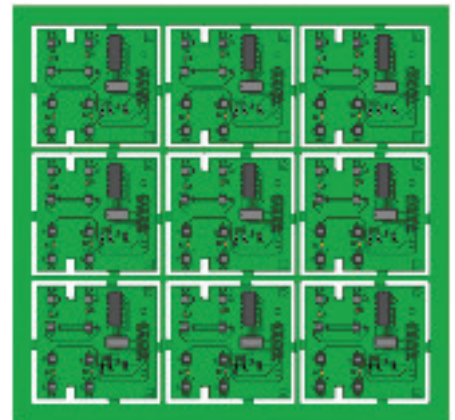
To get accurate results, board geometry, component geometries and positions as well as the PCB, stackup layers are required to construct a realistic model on which different physics may need to be considered: for example, thermal management due to more heat in smaller areas and structural analysis for small pitch ball grid arrays (BGAs). Based on the environmental conditions surrounding the PCB, constraints or boundary conditions are applied to the model before solving the model solution. Although all three representations (electronic computer-aided design, MCAD and computer-aided engineering) must be accurate, it is common to make additional simplifications to the geometry for the simulation, like filtering passive components that have little impact on the simulation result and significantly reduces the processing time.

During this collaboration across multiple stakeholders, data synchronization is also important in the simulation domain. If changes are made to the component placement or copper connections in the layout, the modifications must propagate to the 3D assembly model. The same changes must also propagate to the simulation model to match. If the layout changes are well identified, an update to the simulation model may be required. In a worse-case scenario, the changes are not well understood or too important, and it requires the recreation of the simulation model. This effort is time-consuming and error-prone, considering multiple iterations can happen during the design cycle. Streamlined and automated workflows, consistent interfaces and efficient processes that reduce engineering are what matters. This in turn allows engineers to spend their time on the design task.

10. Manufacturing preparation

PCB-array designs may dramatically impact, either positively or negatively, the assembly process. Also called panelization, the various considerations are complex and will be affected by PCB geometry or the machine capabilities of countless PCB assembly service suppliers. PCB costs can also be significantly affected by the array design.

The panelization process also requires collaboration. NPI engineers need to consider the input from mechanical (tooling), manufacturing (assembly requirements) and electrical engineers (test). Enabling the mechanical team to visualize the panel with an accurate 3D realistic representation facilitates the review and collaboration and improves their ability to design additional manufacturing tools, such as a PCB carrier for the component assembly, a test fixture, assembly drawings, etc. At the end of the collaboration, the PCB layout that best meets manufacturing constraints will have been defined.



Conclusion

Electronics designers and manufacturers face a large challenge to find systems that provide a significant advantage. With the mechanical design power of NX and the innovative PCB design solutions in Xpedition, product designers and engineers have the tools to revolutionize their workflow. The cohesive solutions

found within NX and Xpedition provide efficiency, cost savings and productivity gains that extend across organizations.

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