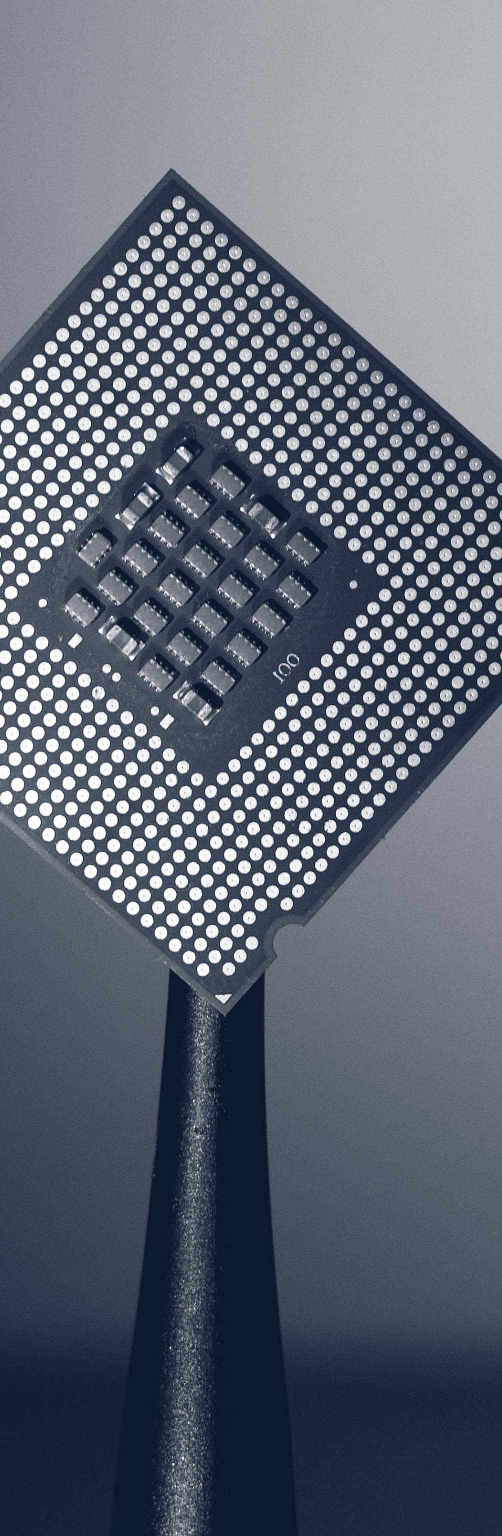

Mastering the Semiconductor Product Requirements Document:

A Comprehensive Guide and Checklist

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INTRODUCTION

The status quo of requirements specification in non-dedicated authoring tools is no longer an option due to increased complexity/cost of post-silicon validation, increasingly stringent standards compliance, and specification quality issues due to reuse and best practice negligence. Fortunately, there are now requirements authoring tools that solve all of these issues by emphasizing authoring requirements right the first time by leveraging automated compliance, best practice, and consistency checks.

THE STATE OF REQUIREMENTS ENGINEERING FOR SEMICONDUCTOR PROJECTS

The semiconductor product requirements document has become so complicated that requirements management 101 is becoming more sophisticated by the day. Engineers understand that and are keeping up with the increasing levels of complexity, but it gets harder and more challenging to keep the executive decision-makers up to speed, so they implement marketing strategies that make sense for growth and innovation. The challenge arises because of the modern development environment of 5G communications and the ever-growing Internet of Things (IoT) markets.

The status quo of semiconductor requirements specification in non-dedicated authoring tools is no longer an option due to increased complexity/cost of post-silicon validation, increasingly stringent standards compliance, and specification quality issues due to reuse and best practice negligence. If we look closely at the use case for developing requirements involving Marketing Requirements Documents (MRD), Product Requirements Documents (PRD), and technical specifications that run into the hundreds of pages, as well as the cross-functional deliverables that they apply to such as ecosystems of die, software, and firmware, we see that all of these complicated factors combined with the challenges of advanced reasoning algorithms, demands on semiconductor memory, and emerging sensor technologies, companies executives and stakeholders are in over their heads in delivering what their customers demand at an expected time-to-market.

USE CASE FOR *SEMICONDUCTOR REQUIREMENTS* DEVELOPMENT

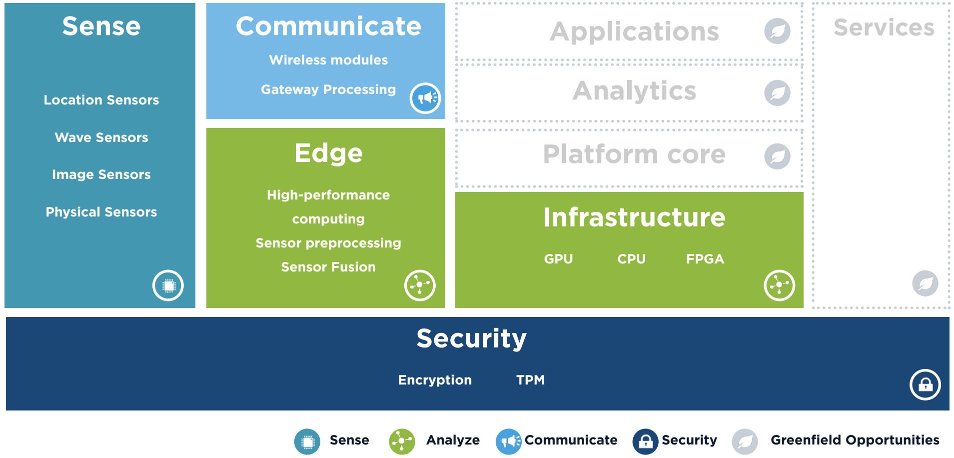
Deloitte, in their July 2018 paper, IoT Opportunity in the World of Semiconductor Companies, developed an approach on how to deal with these massive levels of requirements complexity in a system of systems engineering view of the challenge.

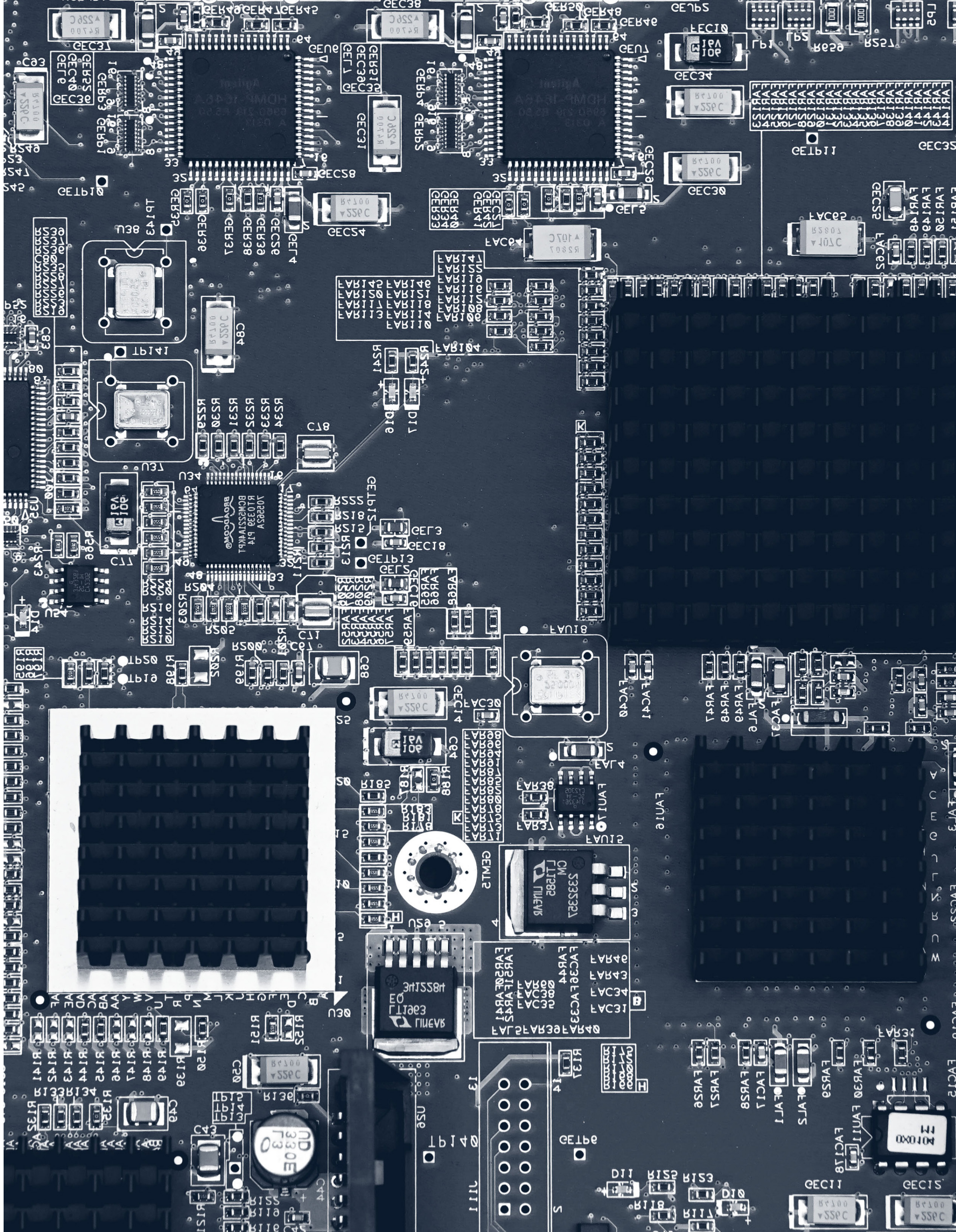
The first thing to do is to recognize the constraints on your requirements development environment. We've subtly hinted at the issue, but let's say it out loud. The situation in which you are doing your semiconductor project initiation work is not static. It's a dynamic, constantly changing system. It would be best if you embraced those changes and champion a change requirements atmosphere within the project team. The best thing to do is understand what is forcing the changes and change your tack accordingly. Let's look at four changing features of semiconductor design.

- Increasing the performance of the semiconductor device no longer holds the power it once did. Moore's Law has reached a level of constraint. Semiconductor product performance has peaked. The density of transistors on a chip is maxed out. New materials and new innovative methods must assume the challenge, and that's a more difficult proposition. Traditional physics must give way to quantum physics with more RDT&E investments headed in that direction. However, the maturity of that technology is still years in the future.
- The semiconductor device market is a commodity market now with competitive equality among the players. There are many companies, large and small in the mix. The profit margins are razor-thin. As noted above,

RDT&E efforts will focus on emerging tech, where growth and innovation has a better ROI. That includes shifting elite technical talent to new endeavours so that companies can retain their valuable employees. Smaller companies are taking on the job of innovation, given that their growth strategies are better suited to these new limited semiconductor capability improvements.

- Larger companies are now forced to seek partnerships with smaller companies to maintain their profit margins if we carry forward the logic and reasoning from the previous two points. The RDT&E burden will then be a shared effort with larger companies providing seed money to their smaller partners. Thus, the risk is shared, and the inevitable failures of semiconductor projects based on misdirected requirements will be offset with other semiconductor projects that succeed and fuel the growth of both the large company and its orbit of smaller partners.
- What we have introduced is an innovative process disruption in the technology value chain. The smaller companies will pursue more automation and integration initiatives in building a real system of systems concept to deliver Industry 4.0 actions of developing faster-to-market and cheaper semiconductor technology through more accessible, smooth and efficient open-source API's and dynamic architectures. In other words, bury the technical complexity under automation and open-source development.





TIPS FOR DEVELOPING REQUIREMENTS FOR SEMICONDUCTOR PROJECTS

The Deloitte use case points out some trending issues that impact developing requirements for semiconductor projects. Let's start building a list as a guide as you go about creating a work plan in the initiation phase of your project. It should serve well in eventually developing a checklist tailored directly to the objective of the work you'll be doing.

1. DO NOT BLINDLY COPY PAST REQUIREMENTS DOCUMENTS

Given the dynamic nature of the changes to the semiconductor ecosystem, one should not copy forward all of the requirements that were developed for a project constructed earlier in time. Sift through a previous list of requirements carefully to exclude those that are no longer a best practice.

2. USE SYSTEMS THINKING APPROACHES TO DEVELOP YOUR REQUIREMENTS

Consider the entire IoT or Industrial IoT (IIoT) tech stack by constructing a system-level signal flow diagram to focus your effort. Create an end-to-end solution that realizes your final market solution. It will make your requirements list flow with the logic and reasoning necessary to prevent requirements from slipping through the cracks. Security and encryption requirements for data, in particular, come to mind in that regard to protect the data and predictive analytics being performed within the system.

3. DEVELOP YOUR REQUIREMENTS USING A STRONG TEAM, PROCESS-BASED FOUNDATION

Make sure you develop your requirements using a strong team, process-based foundation that features the four basics of requirements management:

1. **Planning** – what are we building?
2. **Collaboration** – Do we have full team visibility?
3. **Traceability and Version Control** – Are we using a structured requirements authoring tool? Does everyone have access to it? Is it accessible from anywhere, any time? Is the content protected from unauthorized changes?
4. **Verification** – Who is responsible for managing the tool and information to verify the applicability of each requirement, i.e., source authority, format, and description?

4. MAKE AN INFORMED DECISION REGARDING REQUIREMENTS MANAGEMENT TOOLS

Make an informed and smart business decision regarding which requirements management tool you use to document your choices for requirements. The complexity of a semiconductor design process demands it. If that hasn't been emphasized enough by now, please take note of it here. Your tool must be able to capture cross-functional system requirements in a system of systems environment so that everything is cross-referenced in a single, web-based location that cleared and entitled users can access it integrated with the other tools users understand.

5. CONNECT YOUR REQUIREMENTS ACROSS THE PRODUCT LIFECYCLE.

Consider all of your target markets and develop a tailored list of requirements for each vertical. Document expectations, preferences, standards, regulations, and governance, risk, and compliance measures from the diverse sources each product demands.

6. MAKE QUANTIFIABLE CONSTRAINTS

All semiconductor designs have constraints that must be accounted for in the way of a requirement. It must be quantifiable in terms of cost, delivery schedule, and the ability of the design to meet performance, ergonomics, safety, usability, reliability, maintainability, and any other compliance metrics that apply.

7. TRACE THE RELATED DESIGN CRITERIA AND CONSTRAINTS AS THE PRODUCT EVOLVES

The relationship between requirements and constraints is critical to the success of your semiconductor design. During the project, as each stage of the product, lifecycle completes, it would be best if you traced the related design criteria and constraints together as the product evolves. The complexity of the requirements stack drives the need to do this.

8. DEVELOP CLOSED-LOOP PROCESSES

You need to develop closed-loop processes that automatically feed information to the responsible developer as new requirements are added related to that part of the semiconductor design or when a constraint may be compromised.

9. PAY ATTENTION TO COMMERCIAL STANDARDS

To strengthen the systems engineering rigour of your requirements engineering approach, you must pay attention to these three commercial standards when drafting your requirements:

- IEEE 1220 – 2005 – the IEEE standard for the application and management of the system engineering process
- EIA 632 – another standard from a different industry group general process descriptions for engineering a system
- ISO 15288 – system lifecycle processes. Other standards referred to in 15288 are the ISO/IEC 19760.

10. RESPECT THE 4-SIGMA CONSTRAINT

Your design for testability and manufacturability needs to respect the 4-Sigma constraint – the point at which the cost of making quality improvements exceeds the benefit gained.

These ten tips are general in nature and apply across the board to most any semiconductor design project. They are, however, slanted toward the technological disruptions being imposed upon the semiconductor industry by the initiatives of the fourth industrial revolution or Industry 4.0. So, let's talk about that in a bit more depth and put some perspective directly on those issues. It's important because this is where the semiconductor industry can still make a decent profit. The industrial sector growth number for semiconductor devices is expected to grow at a CAGR of 9.8% from $39B in 2015 to $49B in 2020. That's twice the growth anticipated from traditional sources for semiconductors.

INDUSTRY 4.0 RELATIONSHIPS TO SEMICONDUCTOR REQUIREMENTS ENGINEERING

Data gathering from embedded sensors and more robust communication networks (5G) inside and outside the semiconductor factories are at the root of the issues. We must learn to adjust to the new technology paradigms to process data in real-time and develop valuable insights to lower the cost of manufacturing and increase the capabilities of the systems pending the advent of quantum computing which will open a whole new world of the power of artificial intelligence and machine learning. This is the concept of IoT applied to industrial manufacturing or IIoT. This is where the opportunities for the semiconductor industry to shine exist.

- Asset performance management from deriving machine performance from the embedded sensor data (semiconductor applications) we collect is directed at reducing unplanned production line downtime. Using the data insights to develop predictive maintenance processes allows the factory to minimize wear and tear on the machinery, which will increase uptime and reduce operational costs.
- Developing predictive maintenance processes is a two-value effort. First, institutional operations can be optimized, giving the machines greater reliability and availability. Second, engineering design parameters can be adjusted to develop the next generation production machines to operate more efficiently right from activation, which introduces cost reduction benefits. We will be generating new requirements for production machines from evaluating the performance of the old requirements. That's automated process improvement in action using a closed-loop cycle, a systems engineering mandate. Imagine being able to generate a new set of ISO TS-16949 Customer Specific Requirements that are already pre-verified with a body of data collected using the old requirements. It beats sitting a bunch of subject matter experts from industry down around a table for ten years arguing over the adapting a new standard.

Let's look a bit deeper into a specific industry that the semiconductor industry serves in a big way, automotive engineering.

FUTURE AUTOMOTIVE REQUIREMENTS FOR SEMICONDUCTORS

The amount of electronics being put on automobiles is increasing at astonishing rates. That means the semiconductor industry will be busy for the next ten or twenty years meeting the semiconductor demands of that industry. The opportunity growth is at a CAGR of 9.2%, which represents about a $20B increase in business. Electronics is no longer just for the premium models. The customers have made it clear that they want all levels of models outfitted with more electronics.

The capabilities for more self-driving features, alerts for when the car is not performing up to the expected level will be pinging the driver more often. You can imagine the TV commercials now exploding with the same kind of ads similar to the tire pressure light and check engine light. The service stations will be flooding the airwaves with offers to "check it for free." The repair, of course, will not be free, but that's another story for another time.

What capabilities will be using semiconductor devices?

- Autonomous driving features beyond the automatic parking and cruise control will increase dramatically. We can already see the new widgets going into the dashboard. Every model will have a Wi-Fi standard to reduce the FOMO paranoia. Do you think distracted driving might be on the rise?
- The monitoring of automobile performance will be endless. You may not see it while driving or hear any bells and whistles, but your vehicle will be collecting and sending gigabytes of data every second to edge computers in the sky. Right now, the average number of sensors per vehicle is about 25. Look for that number to skyrocket. I haven't even mentioned the sophistication of the computer that's under the hood controlling and automatically adjusting car performance to be optimal, all the time.
- Entertainment systems will go over the top. Via Wi-Fi, you have access to streaming music and entertainment services you haven't even thought of yet because those industries have just started to see the opportunities.

The engineering requirements package for a new vehicle will have to be stored in the cloud because the paper documentation would need a room of its own for each model.

CONCLUSION – MANAGING CONTINUED GROWTH IN THE SEMICONDUCTOR INDUSTRY

The best advice based on what this paper has described in its journey to this point is to embrace the connected world if you want your semiconductor business to take advantage of the opportunities coming in 2020 and beyond.

The automotive use case was cited for a reason. Vehicles are evolving as an extension to the always-connected world that people have a never-ending thirst for more and better ways to be in touch anywhere and anytime to being entertained with connectivity just as robust as what they have at home. These vehicles will be electric and autonomous as they transport the family around the world as new developments lead to vehicles that can fly be powered by solar energy. People will want something to do while being transported and arrive safely at their destination. It will take computers and lots of semiconductor engineering to make that happen.

What are the near term technologies to watch? We've answered that question, but to summarize:

- The Internet and Industrial Internet of Things (IoT/IIoT) as all cities become smart cities, homes become digitally connected to everything.
- Artificial Intelligence and machine learning to increase the ever-growing need for computational power, storage, and accessibility anywhere, any time.
- Quantum computing stands as the next level of technology that will one day run the world, but it won't be able to do it without semiconductor driven devices to complement the physics of making it all work.
- The communication infrastructure with 5G leading the way to the future today

Capitalizing on these opportunities will not only involve an incredibly complex supply chain, and a level of customer engagement yet to be realized, but also proper planning and consideration for requirements engineering. Use this guide and checklist to ensure your requirements are clear, concise, and compliant and you'll end up with a product requirements document that is a dream to work with.

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Semiconductor Requirements Checklist

- ☐ 1. Do not blindly copy past requirements documents
- ☐ 2. Use systems thinking approaches to develop your requirements
- ☐ 3. Develop your requirements using a strong team, process-based foundation
- ☐ 4. Make an informed decision regarding requirements management tools
- ☐ 5. Connect your requirements across the product lifecycle.
- ☐ 6. Make quantifiable constraints
- ☐ 7. Trace the related design criteria and constraints as the product evolves
- ☐ 8. Develop closed-loop processes
- ☐ 9. Pay attention to commercial standards
- ☐ 10. Respect the 4-Sigma constraint

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