ESSENTIAL TOOLS TO COMBAT THE INGRESS OF COUNTERFEIT MATERIALS

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ABSTRACT

As the pace of innovation and globalization has increased dramatically over time, the tools to ensure that counterfeits are not inadvertently polluting any given supply chain have not kept pace with the changing needs. Complicating this dynamic is that counterfeiters are accumulating more resources and becoming more sophisticated to avoid detection. In addition to individuals and private groups participating in this practice, the risk increases that governments can leverage undetected back doors to further their own global ambitions. Limiting the number of suppliers can provide short term protections but does not fully protect the supply chain due to the indirect security practices that have been utilized. Limiting the number of suppliers also has the additional added cost of limiting innovation over time, as well as, the competitive advantage of any organization artificially limiting the number of their supply base. Because the impacts to an individual, company, industry, and country can potentially be very harmful along with the increased probability of counterfeits being injected insidiously into any given supply chain, it is imperative to proactively implement economically sustainable anticounterfeit tools that are scalable, create productivity gains, and are “future proof.” Fortunately, the available tools developed for a variety of other needs can be easily applied to counterfeit materials and driving significant productivity gains at the same time. This is true regardless of the industry or the economics.

Coupling IPC-1782, Blockchain, Cloud, existing SMT & identification tools, simple in situ risk decisions, Industry 4.0, IPC CFX (connected factory), Artificial Intelligence (AI), and Big Data Tools will proactively mitigate the risk of counterfeits, increase the trust & thus the speed of business, increase the productivity of businesses, and enable faster, easier, & better allocation of resources of every part of an organization. This approach will increase yields, quality, and reliability, as well as, provide the basis for more effective product innovation that matches customers needs better and enable the pushing of the envelope of design rules given the current tools. These tools can also be applied to software solutions, as well as, hardware solutions.

INTRODUCTION

Because Component Traceability has historically been a very manual End-To-End process with a high overhead cost that required a customized solution, Component Traceability has been perceived as either a specialty tool and/or too high of a burden to a typical commercial organization, as well as, innovation and it ultimately caused more problems than it solved due to the afore mentioned issues.

As the group developed IPC 1782, it took a much more modern, far less prescriptive, and more enabling approach, as well as, continually made certain that we pragmatically addressed the barriers that have historically kept Component Traceability from being utilized to its full potential. We also developed it utilizing an extendable and expandable structure that allows companies to move at the speed of business without having to wait for the standard to catch-up. This approach also enables information to be shared across different industries as appropriate. This paper will outline many of the reasonably foreseeable benefits to every industry on the planet and show how the concerns of the past have been addressed in a very economical and sustainable way.

Before getting into the specifics, it is useful to first define the tools at a high level.

Table one defines traceability from a technical and a business perspective.

Table 1. Traceability is an unbroken record of documentation of materials, parts, assemblies, processes and measurements.

Technical Point of View:	Business Point of View:
■ A build record of a product ■ Product information and flow data ■ Materials data ■ Process data ■ To varying degrees of precision ■ Product Innovation	■ Measurement of Resource Allocation ■ Measurement of Risk ■ Measurement of Supply Chain Issues and Efficiency ■ Measurement of Productivity ■ Measurement of Quality / Safety / Reliability ■ Measurement of Flexibility

Blockchain is a growing list of records, called *blocks*, which are linked using cryptography

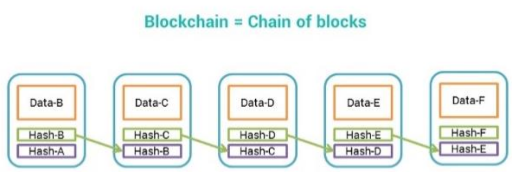

Figure 1. Shows how the blocks are immutably connected. The information contained in the blocks are incorporated into the hashing which joins the blocks together.

In a very simple way, Blockchain is somewhat analogous to rail cars on a train except that the order of the blocks and what goes into the blocks can not be modified or will leave a clear signature if either are modified.

Figure 2. Blockchain does not define what goes into each block. Like a rail car, it is method of holding the information.

Blockchain assumes no parties in a contract know or requires that they trust each other. No third party, in a traditional sense is therefore required, to complete the contract or exchange.

Cloud Computing:
The NIST Definition of Cloud Computing: Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models.

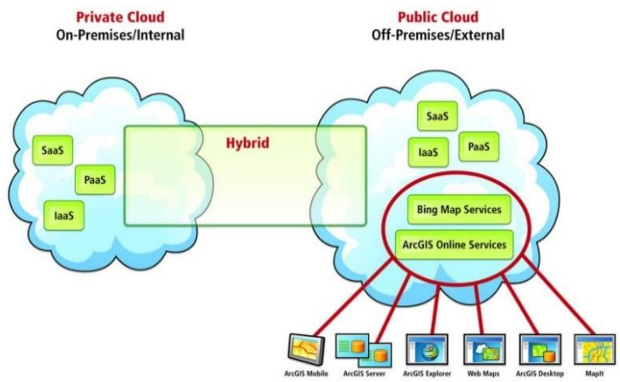

Figure 3. Example of a Hybrid Cloud

Existing SMT & identification tools:
Although there are opportunities to make commercially off the shelf SMT traceability solutions more robust and more mature, the currently available solutions provide the ability to have the ability to know exactly which part was used in which product. The typical cost to add this functionality to a new SMT line is around 10% or less.

Risk Assessment: Risk assessment is appropriate for individual manufacturing steps like recording information through business-critical decisions. Fundamentally, risk is the combination of the hypothetical severity if an event occurred coupled with the likelihood of that event occurring.

RISK ASSESSMENT MATRIX				
SEVERITY / PROBABILITY	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequent (A)	High	High	Serious	Medium
Probable (B)	High	High	Serious	Medium
Occasional (C)	High	Serious	Medium	Low
Remote (D)	Serious	Medium	Medium	Low
Improbable (E)	Medium	Medium	Medium	Low
Eliminated (F)	Eliminated			

Figure 4. Example from MIL-STD-882E

Industry 4.0

According to the website http://www.gtai.de/GTAI/Navigation/EN/Invest/Industries/Industrie-4-0/Industrie-4-0/industrie-4-0-what-is-it.html

Industry 4.0 is the name given to the German strategic initiative to establish Germany as a lead market and provider of advanced manufacturing solutions. However, due to the productivity gains from implementing this initiative, it has been adopted well outside of Germany's boarders.

Table 2: Summarizes each industrial revolution. Each step reduced variability and uncertainty.

Industry 1.0 (First Industrial Revolution):	Introduction of mechanically production with the help of water and steam.
Industry 2.0 (Second Industrial Revolution):	Division of labor, assembly line, and mass production with the help of electrical energy.
Industry 3.0 (Third Industrial Revolution):	Use of electronic and IT solutions that further automate production
Industry 4.0 (Fourth Industrial Revolution):	Use of Cyber Physical Solutions

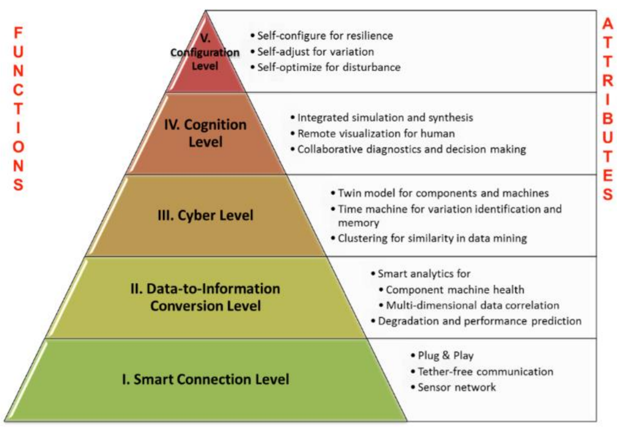

Figure 5: Highlights steps along the way to develop a more sophisticated solution.

IPC CFX (From IPC Website)

IPC-CFX (IPC-Connected Factory Exchange) is an electronics manufacturing industry developed standard forming the foundation/backbone of Industry 4.0 Applications. IPC-CFX simplifies and standardizes machine to machine communication while also facilitating machine to business/business to machine solutions.

IPC-CFX can simply be described as a standard providing a purpose, working components, benefits, with several applications and sustainability.

Purpose of IPC-CFX:

- World-wide Industrial IoT communication standard for assembly manufacturing
- The enabler of Industry 4.0, Smart Factory and Digital Factory solutions
- Working Components of IPC-CFX:
- Secure, omni-directional, AMQP v1.0 transportation protocol
- JSON data encoding
- Defined data content and structure of messages, across all manufacturing topics
- Benefits of IPC-CFX:
- Everyone has just one interface for complete visibility, reducing costs and complexity
- Machine vendors can further optimize machine operation based on wider knowledge
- IT solutions work in a "plug and play" environment
- Applications:
- Machine to machine communication
- Machine data to factory exchange
- Factory data to machine exchange
- Transactional events, such as logistics, work-orders etc.
- Sustainability:
- Enhanced business opportunity and cost saving for all parties
- Supports all Industry 4.0, Smart factory and digital factory applications
- Additional CFX specification can be added as required

Artificial Intelligence (AI):

Artificial Intelligence is the theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

After several promising attempts to develop AI, it has become a mainstay of technology companies.

Big Data Tools:

Big data is a moving target which finding patterns in structured and unstructured data sets beyond the ability of traditionally used software tools and hardware within a reasonable amount of time.

Implementation:

Up to this point in time, there have been many technological barriers to accumulating large volumes of data, converting that data into information, and then turning that information into knowledge. Much of the innovation that is occurring now is a result of applying multiple perspectives, tools, theories, and innovations from different fields & industries. It is a unique time in history.

Traditionally, people's perceptions have been driven primarily from a view of standards not being useful enough to justify the allocation of resources to develop them, standards are too rigid, and/or a perception that implementing a Component Traceability program was too difficult, too expensive, had poor ROI (Return On Investment) in general, was too rigid, and no easy or reasonable way of accumulating & accessing this information. Additionally, nearly all suppliers of raw material, components and/or PCB's almost never admit publicly that they have been counterfeited or had substituted materials or components enter their supply chains, as it would potentially indicate to the wider world that their respective supply chains have been compromised, thereby potentially having a knock-on to their commercial activities.

IPC-1782

To address these historical issues, IPC-1782's development team took a more modern approach to creating the standard. IPC 1782 is a far less prescriptive, and more enabling standard because it addresses component traceability from a very pragmatic approach.

IPC-1782's Material and Process levels can be sighted specifically in agreements between companies, implemented & budgeted for in a planned way, and expanded upstream & downstream to drive productivity gains. Each level in IPC-1782 has very specific data requirements that can be utilized in full or modified as necessary given the needs of the stakeholders.

Any organization implementing IPC-1782 will need to be mindful of the following items:

- Develop an End-To-End solution that anticipates or eliminates human error throughout the process and implements the tools, training, and appropriate resources to proactively find and manage problems.
- If you cannot measure it, you cannot manage it. Therefore, you will need to measure resources you will need to manage. This should be factored into your End-To-End Implementation Plan-Of-Action.
- Think in terms of completing a "Digital Build Record" to encapsulate a complete set of records which include exact history, exceptions, specific materials used, complete maintenance records along with supplies utilized, process events, key process parameters, equipment used, daily checks, specific personnel responsible for the processes for that specific build, measurements from every relevant test and inspection, as well as, include a formal report for any defect investigation, disposition, and/or repair history. This information is crucial because people's memories fade over time.
- Generating a flow diagram for each quantified work in progress will enable everyone to walk the process. This is a key part of any comprehensive Quality System. This would ideally be done automatically without human intervention utilizing the information already collected.
- Educate everyone in the organization about how to determine risk and make the appropriate risk versus reward decisions for your organization's culture and the industry in which you operate. This will empower line workers and make everyone in the organization better consumers of this information. This approach will enable the organization to function much more coherently as an organism.
- Set clear goals and expectations up front to ensure the entire organization works towards the same goal(s) from their various perspectives. This approach enables an organization to make the best use of diverse perspectives and make the organization the most productive possible. This negotiation & clarification step is also crucial to the entire global supply chain. If the entire supply chain follows the same approach and utilizes the same terminology, it makes it much easier to find and eliminate waste/problems much faster.
- Collection of and finding patterns in the data automatically enables machines to do what they do best and people to do what they do best. Thus automating the data collection and analysis by implementing known pattern recognition will help everyone be more productive, as well as, have fewer human errors.
- Utilizing a reporting tool that enables universally accessible information will make every stakeholder an advocate for the organization, the supply chain, and ultimately the customer. This leads to a win-win-win scenario. Coupling this approach with the automation scenario will not only allow for near real time analysis, it will facilitate predictive analytics to avoid problems rather than react to them after the damage is done.
- Uncertainty causes fear. Variability causes Quality and Safety problems. Quality over time is Reliability. IPC-1782 is a powerful tool to minimize the variability and uncertainty. If properly implemented and utilized, IPC-1782 can effectively create and maintain trust with all stakeholders by making any organization utilizing it much more in control of the inherent variability.
- IPC-1782 makes programs like ISO 9000 and other quality management systems work much better. IPC-1782 does not replace these other quality

management systems. It augments and supplements them if implemented properly.
- IPC-1782 will help to identify "one off" failures.
- IPC-1782 can be utilized as a strong Anti-Counterfeit tool. This is especially true if an organization is buying components, materials, or services from gray market suppliers due to End-Of-Life parts, Regulatory barriers to change, organizations unexpectedly going out of business or unexpectedly stopping production due to unforeseen events.

Blockchain
There are an increasing number of available Blockchain solutions.

From the October 31, 2015 edition of The Economist:
"Blockchains
The great chain of being sure about things
The technology behind bitcoin lets people who do not know or trust each other build a dependable ledger. This has implications far beyond cryptocurrency."

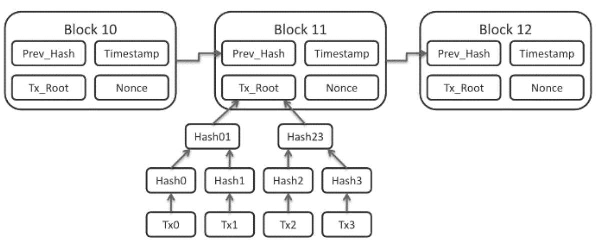

Figure 6: Example of a Bitcoin data block

From the October 31, 2015 edition of The Economist:
"Each transaction in the set that makes up a block is fed through a program that creates an encrypted code known as the hash value. Hash values are further combined in a system known as a Merkle Tree. The result of all this hashing goes into the block's header, along with a hash of the previous block's header and a timestamp. The header then becomes part of a cryptographic puzzle solved by manipulating a number called a nonce. Once a solution is found, the new block is added to the blockchain."

In the case being discussed by this paper, IPC-1782 would describe the Surface Mount Technology (SMT) data for the purposes of this paper. In principle, the information that would go into each block would be everything that would impact the quality, reliability, and product safety of the solution provided. This technique can be applied to hardware, software, or any series of events.

Cloud
Simply stated, Cloud computing is a scalable Internet based technology to share processing and data resources on demand. The solution can be entirely private, public, or a combination of public & private which is called Hybrid Cloud.

Combined Solution
By combining IPC-1782, Blockchain, Cloud, existing SMT & identification tools, simple in situ risk decisions, Industry 4.0, IPC CFX (connected factory), Artificial Intelligence (AI), and Big Data Tools, an organization will be able to quickly and easily capture all of the relevant data, based on risk, convert that into information, and then convert that information into knowledge that would be needed to manage the resources to meet or exceed their customers' expectations. This would also enable better decisions to be made regarding which features to supply to an organization's customers. This would be done by finding patterns in this data. Given the advancements in AI, this can enable machines to do what they do best and people to do what they do best.

Before you begin, you should consider the following:
- List up and map each production and transactional process involved
- Understand the data collection requirement from each:
  - ☐ Material data
  - ☐ Process data
  - ☐ Product & work-order data
  - ☐ Labelling Requirements
- What data could be collected automatically?
- What data needs to be collected manually?
- What sources of information need to be involved (roles, machines)
  - ☐ Quality
  - ☐ Reliability
  - ☐ Manufacturing
  - ☐ Supply Chain
  - ☐ Legal
  - ☐ IT
  - ☐ Big Data Team to mine patterns in data
  - ☐ Data format
  - ☐ Other Stakeholders
- Implementation Timeframe
- Budget
- Return On Investment
- Additional Benefits
  - ☐ Better Quality & Reliability
  - ☐ Better Resource Allocation
  - ☐ Increased Customer and Regulator Trust
  - ☐ More flexible business response
  - ☐ Tracking Exception Reports with Specific Products
  - ☐ Secure Supply Chain
  - ☐ More meaningful future product features
- Other Tools/Skill Sets
  - ☐ Big Data

- Connected Devices to capture real world use by the customer

CONCLUSION

IPC 1782 creates one clear traceability standard for the whole of the industry. By leveraging this standard, costs are reduced, negotiations are easier, and the risks of not meeting expectations are mitigated. Utilizing IPC-1782 with Blockchain and Big Data tools can drive productivity gains in every part of the organization, increase the trust, develop better brand image, develop more competitive products, and reduce the friction in the various processes of the business. Given all of the off the shelf tools, this is a unique time in history. This is an opportunity to develop the next generation of industrial revolution by reducing the uncertainty as much as interchangeable parts did earlier. Change is an opportunity to make things better. Combining these off the shelf tools will help us do more than make a faster horse. This opportunity will enable us to completely change how businesses operate.