SCV/OEB/SF Chapter Electronics Packaging Society

Do You Know What's Hiding in Your Supply Chain?

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Agenda

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Objective

1. OEM/OSAT Characteristics
2. Foundry Characteristics
3. Supply Chain Models
4. Market Revenue
5. Impact of Disruptions on Supply Chain

Summary and Conclusions

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Introduction

The global environment for electronic packaging has changed dramatically in the last 10 years:

- Traditional E2E, all inclusive design, develop, assemble, test, qualify, and ship houses have been replaced by large OEMs, OSATS, and Foundries.
- Consumer-focused realm exists where compute has become pervasive

Regardless of facility type, OEM, OSAT, or foundry, each must define, develop and implement a Supply Chain methodology. Regardless of what choices are made, the interaction between each OEM, OSAT or Foundry supplier and their suppliers varies.

- There is multiple sourcing, single sourcing, and sole sourcing.
- When each entity works with their suppliers, and their suppliers work with their network of suppliers, the supply chain can become a very elongated, complex network that can be barrel-shaped, diamond shaped, or a hybrid of the different models.
- The simple traditional supply chains are few and far between.

It is easy to understand that Supply Chain disruptions can adversely impact supply chain dynamics.

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Electronic Packaging Supply Chain Landscape Today

The supply chain for electronic packaging has also changed significantly:

- 62% of companies have limited visibility of their supply chain and 15% only have visibility on production. Meanwhile, 6% report full visibility, and only 17% say they have extended supply chain visibility. (GEODIS, 2017)
- Supply chain visibility is among the top strategic priorities of companies worldwide. (GEODIS, 2017)
- “38.8% of US small businesses experienced supply chain delays due to Covid.”
- “Global supply chain market size value is $15.85 billion (2019).”
- “Global supply chain market is expected to experience a CAGR of 11.2% from 2020 to 2027. This results in an increase to $37.41 billion in 2027.” (ResearchAndMarkets 2021)
- “Only 22% of companies have a proactive supply chain. (Logistics Bureau, 2020)”
- 40.02% want to invest in real-time supply chain visibility. (Statista, 2021)
- 46% of small businesses use don’t track their inventory or don’t have an automated method to track it. (Wasp Barcode, 2018) “67.4% of supply chain mangers use Excel spreadsheets as a management tool.”
- “21% report that they don’t have inventory.”

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Objective

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To highlight through examples that it is not intuitively obvious what components are in your final products. Even with detailed Bill of Materials for a given assembly, or final product, you may be surprised by what you find. It is unfortunate that many ***SURPRISE(s)*** occur, or are exacerbated, when supply chain disruptions happen:

- OEM, OSAT, and Foundry Characterizations are reviewed
- Market revenue per above are discussed.
- Examples of supply chain issues, their impacts, and disruption run amuck.

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1.0 What is an OEM? → Characteristics

OEM*

E2E control of design, development, qualify, manufacture and production;
Strict quality and reliability requirements required for all selected suppliers
Direct supplier management at all levels and tiers enabling:

- Supply chain transparency;
- Flexibility and agility to change;

Demand driven;
Lower cost through long term contracts;
Multiple sourcing for non-critical content (covers about 80% of bill of materials);
Single source for critical components and or those considered core (IP protected);
Etc.,

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***OEM/Enterprises/Companies such as IBM, Intel, HP, etc.**

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1.0 What does an OSAT look like? → Characteristics

OSAT

- Less flexibility than OEM
- OEM part supplier relationship limited for OSAT owned content
- Lack of supply chain transparency (OSAT owned)
- Dependent on OSAT trust and communication
- OSAT cost reduction yr. to yr. expected; sometimes hard to achieve
- Acceptable risk versus control
- Consolidation (through mergers and acquisitions) with other OSATs to increase product offering differentiation;

Characteristics

- **Turn-key operation** for product/product content placed in their facility;
- **Supply Chain** (suppliers and subtier suppliers) **management;**
- **Accountable for all assembly and test, quality, service support, etc.;**
- **Own Production flow** (quality and yield) **management;**
- **Optimized cost** as a result of economies of scale for bill-of-material parts;
- Typically, **non-core competencies at a lower cost** than in-house;
- Specific set of packaging types offered (dependent on selected OSAT);
- **OSATs collaboration** with other OSATs when required for a given package;
- **Potential IP Sharing**
- **Limited dollars for R&D** of new package type, new technology, and/or new materials and process introduction;
- Competitive edge exists but **hard to maintain;**
- **20 to 25% cost margins** (usually indicative of a highly competitive market)

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1.0 Evolving OSAT Landscape Brings Challenges

1. Rising demands for chip packages and multiple package types from OSATs leading to shortages in manufacturing capacity and limited package type from a given supplier anticipated
2. ***IC packaging market driven by more than just mobile (think -- AI, IOT, automotive, high-performance computing (HPC), medical wearables, VR/AR (virtual reality/augmented reality), and cryptography for security)***
3. Number of OSATs decreasing as OSATs consolidate, merge or invest more dollars in other OSATs
   - Increased dollar investment in specialty OSATs Increased R&D investment dollars to introduce new technologies, new packages, materials, and processes;
   - Increased capital equipment expenditures to meet demand ***Technology gap widens between top tier OSATs and smaller OSATS***
   - Growing need for low-cost packaging alternatives
4. To maintain competitive edge OSATs need to introduce advanced package offerings
5. Non-traditional facilities required to meet demand, offer turn-key advance packages

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1.0 OSAT consolidation addresses most challenges while strengthening market share

China's largest OSAT → JCET (Jiangsu Changjiang Electronic Technology) acquired Singapore's STATS Chip PAC in 2015

- STATS ChipPAC offers innovative advanced package design and associated manufacturing processes with deep packaging knowledge
- JCET Group garnered a significant patent portfolio as a result of the acquisition

Amkor increased its ownership

- in Japan's largest OSAT → J-Devices and obtained their large package patent portfolio including their copper wire technology (2016)
- Amkor acquired Nanium, a world class provider of wafer-level fan-out (WLFO) semiconductor packaging solutions (2017)

ASE (the #1 OSAT in the IC packaging market today) merged with SPIL (Siliconware Precision Industries) in 2018

Consolidations and investment dollars addressed on previous page. As a result of consolidation there is a dramatic decrease in the OSAT base; Meeting the increasing demand with this smaller OSAT base is not a guarantee that all OEM demand in this market sector can be met.

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2.0 What does a Foundry look like? → Characteristics/Challenges of OSATs

Foundry

A traditional foundry is a semiconductor fabrication facility that is dedicated solely to the fabrication and delivery of a Customer's (OEM) IC design.

A non-typical foundry is a semiconductor design and fabrication facility that offers a full service OSAT type capability.

- They can develop and sell their package types to customers.

Foundries are competing with OSATs to fill void as a result of a reduced OSAT base.

TSMC, Samsung, Intel are large semiconductor companies that also have expansive dedicated foundries.

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2.0 What does a Non-Traditional Foundry look like

Foundry

Characteristics

A foundry develops and sells its own package types and may provide a turn-key operation for product or product content placed in their foundry.

- Full-service foundry
- Supply Chain (suppliers and subtier suppliers) management accountability;
- Dedicated foundry that can scale production better than OSAT facility
- Significant investment dollars available for R&D
- Ability to introduce new and/or advanced packaging technologies on a shorter development cycle than an OSAT
- Cost margins of 40 to 50% (a typical foundry) but must be willing to accept a lower cost margin from OEMs to compete with OSATs
- Foundry IP portfolio

Challenges

Less flexibility

Foundries mostly sole-sourced

Acceptance by foundry of lower cost margins typical of OSATs and not the higher cost margins that they are used to receiving

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3.0 OEM, OSAT, and Foundries all have supply chain choices →

What are these supply chain sourcing models?

Multi-Source: More than one supplier exists that can deliver a specific component or part (typically off-the-shelf). Because of this, a facility can source from more than one supplier for a given part. These sources are usually competitors so procurement can play one against another to get the lowest part cost. This provides some degree of comfort should one or another of the suppliers have shortage, part failures or manufacturing problems.

Single Source: Cost optimization obtained by companies when they engage in long-term strategic supplier agreements in which a single source is selected for a given part or sub-assembly. While other sources are available the company selects just one based on their needs and balanced on what they receive by doing so. higher qualified, supply chain transparency, long-term agreements, .. Etc.,

Sole Source: When there is only one source available for a given component, part or subassembly based on a supplier's intellectual property or trademarked technology there is inherent risk is there is supply disruption

In the latter 2 cases, if the supplier can't provide the single/sole source part the potential single point of fails (SPOFs) can result in supply chain disruption.

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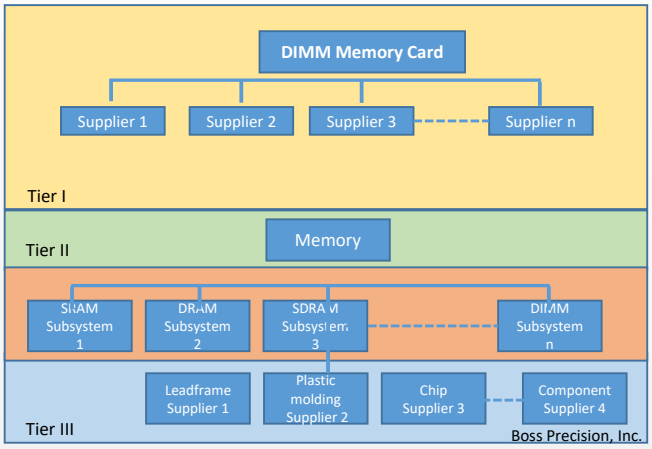
3.0 Traditional Tier Supplier Model

Sometimes this is referred to as a pyramid structure

A simple memory card assembly requires PCB, memory component and constituents of the memory component

Automobile assemblies, in the past, typically rely on a pyramid-shaped supply structure.

Memory card or automobile assemblers work closely with their Tier 1's and rely on the Tier 1's to do the same with their set of suppliers and subtier suppliers.



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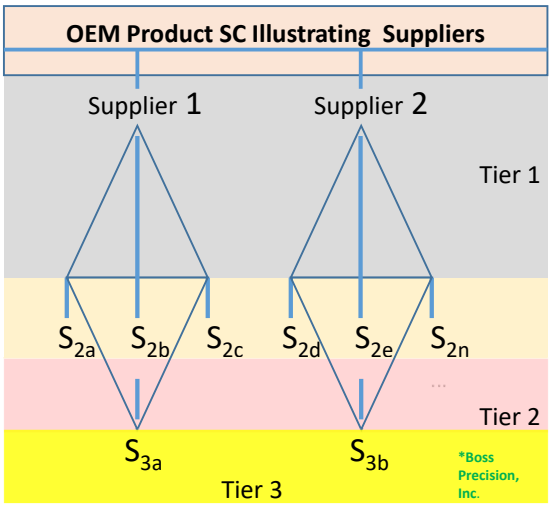
3.0 Diamond Shape Supply Chain



Supplier 1 and Supplier 2 are multi-sourced to 3 different Tier 2 suppliers. In a diamond shaped supply chain, these 3 Tier 2 suppliers use the same Tier 3 supplier for either the package, components in the package, or a key raw material in said package. If the Tier 3 supplier cannot supply, then it becomes the SPOF (single point of failure). Therefore, benefits of multi-sourcing (in this example) are lost.

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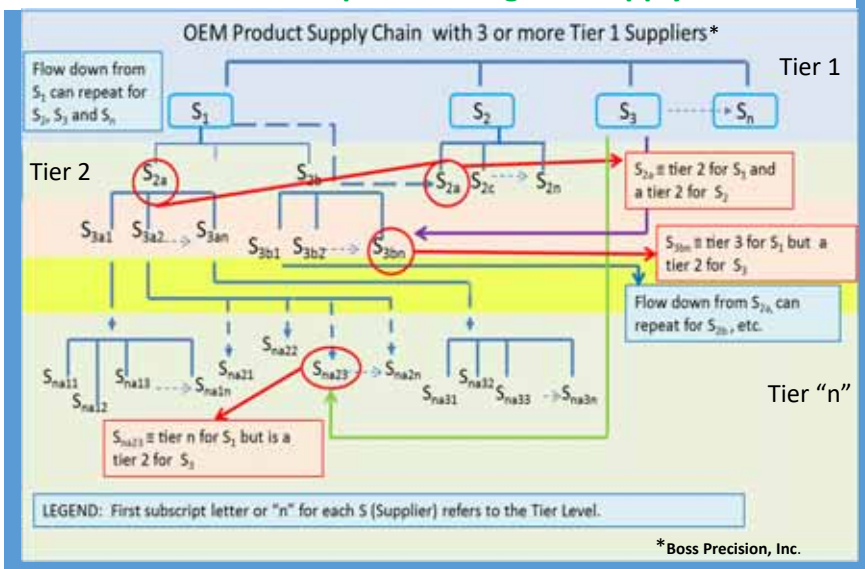
3.0 Barrel Shaped or Elongated Supply Chain



An elongated supply chain (SC) has the following characteristics:

- Extreme complexity due to multi-tiered, multi-channel
- No direct management of critical suppliers, esp. when sub-tier
- Lack of transparency/visibility to suppliers' sub-tiers
- Loss of control over the end-to-end manufacturing SC
- Non-resilient, hence unable to sense and respond.

A given"n" tier supplier can be the same part number but a different Tier for other supplier(s) in the same Assembly SC

- Focus 1st on S_{3bn}. This supplier is a 3rd tier supplier of Supplier 1, and at the same time it is a Tier 2 supplier of Supplier 3
- Focus 2nd on Supplier 2a. This 2nd tier supplier to Supplier 1 is also a Tier 2 Supplier for S2.
- Focus 3rd , further down the chain at Sna23. This is the 21st supplier of the nth tier of Supplier S2a. It is also a 2nd Tier supplier of Supplier 3.
- Continuing in this effort it is easy to see how this elongated SC model takes on the name "barrel shaped"

A shortage of one PN for a given supplier can cause havoc in another supplier's assembly

4.0 Global OSAT market segment overview

- OSAT total market revenue is valued at 34.4 B$ in 2020, and is projected to reach $52.93 billion by 2030 (Allied Market Research)
- ASE is the top ranked revenue contributor to the OSAT market and posted 1.86 B$ revenue with a 35% YoY growth (Trendsource)
- North America was the highest revenue contributor at 13.87 B$ or a little over 40% of the market share (Allied Market Research) in 2020
- Top 8 OSAT's revenue reached 5.88 B$ in 2020

Ranking *	OSAT	2019 M$	2020 M$	2021 M$	2019/2020 YOY	2020/2021 YoY
1	ASE	1160	1379	1863	18.9	35.1
2	Amkor	895	1173	1407	31.1	20
3	JCET	679	879	1099	29.5	25
4	SPIL	678	910	931	34.2	2.3
5	PTI	479	649	742	35.5	14.3
6	TFME	283	351	591	24	68.4
7	TSHT	312	284	467	9.7	64.4
8	KYEC	193	256	274	32.6	7
TOTAL M$		4679	5881	7374		

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Data from Trendsource

4.0 Global foundry market segment overview*

Foundry Name	2Q 2019 M$	2Q 2020 M$	2Q 2021 M$	2019/2020 % Growth	2020/2021 % Growth
TSMC	7,750	10,105	13,300	30.4	31.6
Samsung	3,180	3,678	4,334	15.7	17.8
Global Foundry	1,358	1,452	1,522	6.9	4.8
UMC	1,162	1,440	1,819	24.0	26.3
SMIC	791	941	1,344	19.0	42.8
Power Jazz	306	310	362	1.3	16.8
Power Chip	174	298	459	59.8	65.1
VIS	223	265	363	18.8	37.0
Hua Hong Semi	230	220	658		2.0
Dongbu HiTek	185	193	245	4.3	26.9
Top 10 Total	15,359	18,902	24,406		29.1

*Data from Trendsource

- While there currently are chip shortages and corresponding foundry capacity shortages, the top 10 foundries delivered 2Q 2021 revenue of $24.4 B with a YoY of 29%. UMC and Samsung are directly competing.
- TSMC by far is the number 1 ranked foundry. In 2Q 2021 it posted 13.3 B$ revenue and a 31.6 % YoY growth. This accounted for greater than 50% of the market
- TSMC, GlobalFoundries

*"Research included in the recently released 50-page *April Update* to the 2018 edition of IC Insights' *McClean Report* shows that in 2017, the top eight major foundry leaders (i.e., sales of ≥$1.0 billion) held 88% of the $62.3 billion worldwide foundry market" https://anysilicon.com/semiconductor-foundries-sales-ranking-2017/

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5.0 Regardless of supply chain model – supply chain disruptions are impactful

Manufacturing capacity (productive assembly lines, equipment maintenance, balanced product lines in assembly process, …)

Raw material shortages (Chip, substrates, …)

Design and Development Changes

Pandemic → COVID affecting SC logistics, tariffs, political – chip shortages

Counterfeit parts

Industry Standard Parts

Extreme weather such a hurricanes, typhoons, earthquake, flooding*

Political/ Personnel Unrest Disruptions
- Strikes
- Geo-political tensions

Accidents such as factory fires/explosions – Tiajin Port Explosion, other*

Mergers and acquisitions account for*

Business Sales*

*Resilinc, 2018

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5.0 Raw Material Shortages – ABF Demand Increased and Limited Mfg. Capability

ABF Suppliers

- Unimicron and Nan Ya PCB main suppliers
- Ibiden and Kinsus

What Happened to Raw Material Shortage ABF (Anjinomoto build-up film)→

- 2019 demand for ABF increased dramatically for HPC packages (CPU, GPU, FPGA and ASICs)
- Newer packages required higher layer counts, larger body sizes
- Small set of ABF suppliers and limited manufacturing capacity existed
- Costs of raw material drove more cost [2,3]

What was the impact →

- Investment dollars needed for more optimized process equipment , materials, and substrate mfg. companies
- Smaller companies (Ibiden and Kinsus) repurposed a few of their lower demand SLP lines to provide additional capacity to support companies (AI, 5G, IOT and consumer electronics
- Unimicron experienced 2 plant fires (Dec 2020 and Feb 2021) exacerbated lack of ABF supply
- Still capacity remains short of demand for processing new HPC chips solutions being rolled out [2,3]

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5.0 Covid 19 Supply Chain Disruptions – Evolving Chip Shortages

ABF Suppliers

Two key bottlenecks exist in resolving supply chain issues:

Fabless companies (Apple and Qualcom) are consuming the capacity of the two large foundries (TSMC and Samsung)

FACT: global semiconductor revenue was 555.9 billion USD in 2021, an increase of 26.2% (YoY). This is equivalent to 1.15 trillion semiconductor units shipped throughout the year. The sales are predicted to further increase by 8.8% and exceed 600 billion USD in 2022. Can we afford to not meet the demand? [4]

What Happened?

- Pandemic disrupted various industry sectors
- Highly significant to electronic packaging industry is the resultant "microchip" shortage; subsequently curbing automotive
- In 2020 Covid led to the shut down of automotive manufactures
- Shut-down was followed by cancelled orders with chip suppliers
- Chip suppliers then had excess mfg. capacity and sought other markets for their product (PCs, tablets,, and consumer electronics)
- Several automotive manufacturers in May 2021 reopen
- Poor inventory planning, the chip mfg. capacity was taken up by consumer electrons
- Drought in Taiwan made matters worse and has led to more severe chip shortages
- Now automotive sector is at the back of line in obtaining chips at this point

What was the impact →

- Chip demand not met
- No excess capacity
- Chip shortages improving but recovery time is slow
- Expected to continue in 2022 and even last until 2023 [3,4,5]

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"An ***estimated 15 percent*** of all spare and replacement electronic parts purchased by The Pentagon are counterfeit."[6,7]

***Counterfeit Electronic Parts: A Multibillion-Dollar Black Market** [6,7]
(Brett Daniel , July 27 2020)
Counterfeit Electronic Parts: A Multibillion-Dollar Black Market (trentonsystems.com)

5.0 What About Counterfeit Parts ..

Left over or surplus parts,
- most likely not a full reel of the parts
- components from multiple sources collected to complete the roll

Recycled parts
- Components removed from machines that are being recycled.

Old parts
- varied date codes
- Parts are past useful life but still functioning
- field roll parts returned to factory

Used parts that don't make it out the door
- Binned parts from assembly line (bent pins, non wets, damaged housing, didn't place right on board)

Mixed grade parts thrown in same bin (hi REL military grade parts versus industry standard) re-enter as new parts

Defective parts re-enter good bins because of mislabelling, mis sort

Quality Rejects –parts that are out of spec and not sorted, may still work and labelled correctly

Counterfeiters Cloned or Fake are the worst!!*
- Very sophisticated today, make their own components, boards, and systems from scratch and then package them into superficially similar products.
- Clones/fakes may be less reliable than the genuine product, having never undergone rigorous testing.
- May host unwanted or even malicious software, firmware, or hardware—and the buyer may not know the difference, or even know what to look for. [6,7]

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5.0 Counterfeit Hondata s300 plug in module for engine computer (2014)

Genuine s300 module

What was cloned→
- Mark Heera reversed engineered the Hondata s300, plug-in module for the computer engine unit that reads data from sensors in Honda cars. This controls the functions such as automatically adjusting air-fuel mixture, idle speed, and other functions. The clones looked the same, but the circuit boards used in the ECU were built in China to Mr Heera's designs and not to the original company specifications.
- Counterfeit S300s have been sold as new and used in the US, Canada, Europe and Australia.

What was the impact → Safety Issues
- Failure to upload or to datalog.
- Random rev limits.
- Failure to start.
- Corruption of ECU table data.

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5.0 Boeing 787 Grounded - Design and Subsequent Development of Follow-on Products

Boeing

…unable to respond quickly to the 2013 grounding of the Boeing 787 due to **increased outsourcing**, **novel** battery **design and** then again in 2020 for fuselage failures (ne**w** composite **materia**l). Both were due to the changing sourcing strategy from the preceding product, Boeing 737.

What Boeing Did →

- Had a multi-tiered, multi channel supply chain
- Increased outsourcing from 30 to 50% from that of the 737 with the intent to reduce costs and time to market.
- Entered strategic partnerships that when combined, with the increased outsourcing, the development/design and assembly removed suppliers from their direct purview.
- Introduced new raw composite material for the fuselage
- Designed a novel Li-ion electrical power distribution system using lithium-ion batteries
- Replaced the traditional supplier relationships with strategic partnerships (SP): SPs given non-typical, risk sharing contracts in which the supplier would not be paid until delivery of the 787 to the customer
- SPs own complete design, development and assembly of a given subsystem

What was the impact →

- New supply chain methodology established 50, *1st tier supplier partnerships* Boeing had no visibility to the Tier 1 suppliers or their suppliers.
- Hence, Boeing did not coordinate the suppliers' output and had no idea how all the subsystems (modules) went together since Boeing only had direct communications with their strategic partners.
- Boeing did, however, continue to retain direct contracts for Tier 2 suppliers of critical, high dollar parts. [8,9,10, 11, and 12]

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5.0 Industry Standard Parts – Takata Airbags

Takata

Takata Airbags were not the first Takata product that failed.

- Prior to this, **Takata seat belts** were failing at an unusual high rate
- Degradation and fracture of the seat belts' polymeric release buttons resulted in 3 failure modes
  - Belt fails to latch
  - Belt will latch but will not unlatch
  - Belt appears to be latched but is not

[13,14]

What Happened →

- Takata airbags considered industry standard parts
- Nearly entire automotive industry procured air bags from Takata
- Field failures of the airbags leading to many deaths around the world
- Failures occurring at a rampant pace and caught both Takata and end users by surprise
- **End customers had no visibility to Takata's suppliers nor access to their quality records**
- **Takata had inadequate quality control to NO quality control**

What was the impact →

- Significant safety issue leading to many deaths in the field
- Air bags ruptured prematurely because of unstable chemical (Ammonium Nitrate)
- **Design and manufacturing defects, and quality documents had been manipulated**
- Resulted in the largest safety recall ever in the US. [13, 14]

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5.0 Japan 2011 Tsunami and Toyota – Natural Disasters and Mfg. Capability

Toyota

…**assumed** number of **suppliers increased** with **each sub-tier** which would tend to **provide redundancy**, but this was not the case [13]

What Toyota Did →

- Had a multi-tier, tightly controlled supply chain
- Utilized "just in time" manufacturing practices.
- Reduced its supplier base
- Single sourced too many parts
- Small subset of the reduced supplier list was a direct supplier or Tier 1
- Directly managed its Tier 1 suppliers but not its critical sub-tie, hence not aware that Tier "n" supplier Tier 1, Tier 2, … Tier "n' could utilize one of their other Tier 1 as a Tier 2
- Reported a $1.2B revenue loss after the March 2011 Japan earthquake and tsunami.

What was the impact →

"Toyota had assumed that the number of suppliers increased with each sub-tier in a pyramid hierarchy which would tend to provide redundancy. However, many of their supply chain sub-tiers included unique factories that provide materials, parts or production processes (e.g., assembly) to many upstream suppliers." Instead, Toyota had a "barrel-shaped" supply chain. Toyota's lessons learned showed that they had about 60 to 70% sole sourced parts. Because of the extremely high number of single source parts a disruption of this magnitude hit Toyota hard.

Toyota increased transparency and reduced the number of single source parts. [13,14]

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6.0 Summary and Conclusions – Supply Chain Challenges Experienced

Companies are faced with significant challenges as they introduce their end-product to the marketplace. The impacts vary in degree based on the design, development, qualification, manufacturing ramp-up, and manufacturing model deployed.

- Supply chain complexity due to several multi-tiered, multi-channel
- Control over, or the lack thereof, of the end-to-end manufacturing supply chain
- Lack of supply chain transparency (what is really in our product?
- Management of critical suppliers, esp. when sub-tier (seldom done?)
- Quality monitoring/tracking (is it adequate if we don't know what the quality data looks like?)
- Control of upstream suppliers
- High degree of single source parts (no backup)
- Excessive outsourcing (absolutely no control)
- Just-in-time manufacturing not always a benefit (no backup, no inventory in times of need)
- Supply chain resilience with little to no flexibility (hence unable to sense and respond)
- New materials or technology used but not carefully monitored to ensure high quality or reliability (what are they, where do the come from, etc.,)
- Need strategic partnerships

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6.0 Conclusions

Supply chain visibility is essential for the global integrated supply chains that exist today and the supply chains that continue to optimize moving forward to 2025. Supply chain transparency must be enabled and optimized by utilizing state-of-the-art IT tools specifically selected to handle a unique enterprise's infrastructure at a given time. **CRITICAL TO KNOW WHAT IS IN YOUR SUPPLY CHAIN!!!**

1. Highly interconnected supply chains today need transparency, innovation, and investment in order to anticipate, predict, and hopefully prevent supply chain issues
2. Flexible and resilient supply chains are critical to handle fast changing demand in the market-place especially in times of disruption (such as Covid)
3. Visibility and analysis of information exchange and business processes within the company are essential". Gartner predicted that 30% of manufacturers will invest substantially to increase this, but "no companies would be/are able to provide this end-to-end supply chain visibility any time soon (2016)
4. Investing in their supply chain's visibility are just a few companies and these are limited by most, since they cannot see across their entire supply chain." (2020) In fact, "Greater than 50% of companies polled had no SC visibility at all. "

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Disruptions in Supply Chain -> Unknown Parts can Enter

Accidental Fires impacting manufacturing capacity and flexibility of global ABF materials, substrates

- Unimicron IC substrate plant in northern Taiwan (Oct 2020 and Feb 2021)
- Nittoba plant, Fukishima, Japan (July 2020) production

Global trade wars between the United States and the rest of the world will continue to impact many manufacturing supply chains, due to the imposition of U.S. tariffs and retaliatory tariffs that many countries have placed on a wide range of consumer products and components, impacting nearly all industries. (2019-2021)

Port Explosion at Beijing's Maritime Gateway (Aug 2015)

- Greatly impacted automobile industry
- Supply chain visibility and strong contingency planning critical in minimizing losses

Heavy Rains/Flooding over Chennai, South India (Nov 2015)

- No early detection available meant many organizations, car makers suffered tremendous losses; suppliers at standstill

Political/ Personnel Unrest Disruptions

- Strikes disrupted India's largest container port (Jan 2015)
- Mombasa Port Strike impact multiple industries across East Africa (July 2015)
- Chilean customs stoppages as a result of geo-political tensions

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Questions?

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