Supply Chain Management and Manufacturing Strategies for Supply Assurance

FTF-AUT-F0354

Michelle Marr, Ryan Dohse
Mr. Herbert Nebl - Daimler

APR. 2014
Introductions

• Freescale and Daimler have teamed up for a co-operative presentation focusing on automotive supply chain management disciplines from OEM and Semiconductor Supplier Perspective

• Today’s Presenters

<table>
<thead>
<tr>
<th>Daimler – Mercedes-Benz</th>
<th>Freescale Supply Chain Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbert Nebl</strong></td>
<td><strong>Michelle Marr</strong></td>
</tr>
<tr>
<td>Semiconductor Management - Procurement</td>
<td>Supply Chain Compliance Manager</td>
</tr>
<tr>
<td>and Supplier Quality</td>
<td></td>
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<tr>
<td></td>
<td><strong>Ryan Dohse</strong></td>
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<tr>
<td></td>
<td>Global Supply Chain Manager</td>
</tr>
</tbody>
</table>

• A Question and Answer session will follow each presentation
Agenda

• Introductions
• Daimler Semiconductor Management
• Q&A (Daimler Content)

• Freescale Supply Chain Management and Manufacturing Strategies for Supply Assurance
  - Manufacturing Network (Internal Facilities, External Partnerships)
  - Automotive Commitment (Technology Alignment and Dual Sourcing)
  - OEM / Tier 1 Support
  - Allocation Management (Supply Continuity and Risk Mitigation)

• Q&A (Freescale Content)
Agenda

• Introductions
• Daimler Semiconductor Management
• Q&A (Daimler Content)

• Freescale Supply Chain Management and Manufacturing Strategies for Supply Assurance
  - Manufacturing Network (Internal Facilities, External Partnerships)
  - Automotive Commitment (Technology Alignment and Dual Sourcing)
  - OEM / Tier 1 Support (Add something here)
  - Allocation Management (Supply Continuity and Risk Mitigation)

• Q&A (Freescale Content)
Daimler: Four Areas of Freescale Strategic Partnership

- **Manufacturing Network**
  - Internal Fab & Assay/Test
  - External Partnership, Foundry and Backend

- **OEM / Tier 1 Support**
  - Supply Continuity
  - Flex Sourcing

- **Allocation Management**
  - Disaster/Crisis
  - Industry Upside
  - Industry Constraint

- **Automotive Technology Commitment**
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- **Automotive Technology Commitment**
  - Supplier Continuity
  - Flex Sourcing
Freescale Manufacturing Facilities

- Freescale Chandler Fab – 8”
  Chandler, AZ

- Freescale Oak Hill Fab – 8”
  Austin, TX

- Freescale Austin Technology & Manufacturing Fab – 8”
  Austin, TX

- Freescale Tianjin Final Manufacturing
  Tianjin, China

- Freescale Kuala Lumpur Final Manufacturing
  Kuala Lumpur, Malaysia

Automotive Microcontroller
Manufacturing Partners – Automotive

Underline indicates new/expanded source
## Manufacturing Facilities

### Foundry Relationships

<table>
<thead>
<tr>
<th>External Foundries</th>
<th>Key Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSMC</td>
<td>Logic/MS CMOS, Native &amp; e-Flash</td>
</tr>
<tr>
<td>GLOBALFOUNDRIES</td>
<td>CMOS, Mixed Signal/Analog, e-Flash &amp; High Performance</td>
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<tr>
<td>UMC</td>
<td>Logic CMOS &amp; Mixed Signal Analog</td>
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<td>IBM</td>
<td>High Performance</td>
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<td>Sensors</td>
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<td>STMicroelectronics</td>
<td>MOS Capacitors</td>
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<td>NXP</td>
<td>GaAs</td>
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### Assembly & Test Manufacturing Partners

<table>
<thead>
<tr>
<th>External Foundries</th>
<th>Key Technologies</th>
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<tr>
<td>ASI GROUP</td>
<td>SOIC, MAPBGA, Sensors, FCPBGA, LQFP, QFN</td>
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<tr>
<td>Amkor</td>
<td>QFP, QFN, MAPBGA, TSSOP, SOIC</td>
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<td>STATSCHIPAC</td>
<td>MAPBGA, PBGA</td>
</tr>
<tr>
<td>Ardemtec</td>
<td>Wafer probe</td>
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<tr>
<td>Carsem</td>
<td>QFN</td>
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<tr>
<td>KES</td>
<td>Final Test and Burn-in</td>
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</tbody>
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**Automotive Microcontroller**
Daimler: Four Areas of Freescale Strategic Partnership

**Manufacturing Network**
- Internal Fab & Assay/Test
- External Partnership, Foundry and Backend

**OEM / Tier 1 Support**
- Supply Continuity
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**Allocation Management**
- Disaster/Crisis
- Industry Upside
- Industry Constraint

**Automotive Technology Commitment**
## Front-end Manufacturing Facilities & Supply Continuity

### Multiple Sources for Key Automotive MCU Technologies

<table>
<thead>
<tr>
<th>Automotive Technology</th>
<th>Primary Source</th>
<th>Secondary Source</th>
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</thead>
<tbody>
<tr>
<td>.25µ SGF</td>
<td>CHD/TSMC3</td>
<td>ATMC</td>
</tr>
<tr>
<td>.18µ SGF</td>
<td>TSMC11</td>
<td>ATMC/TSMC3</td>
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<tr>
<td>C130FG</td>
<td>ATMC</td>
<td>TSMC</td>
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<tr>
<td>C90 (i.Mx)</td>
<td>TSMC12</td>
<td>UMC12i</td>
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<tr>
<td>C90FG</td>
<td>ATMC</td>
<td>TSMC14</td>
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<tr>
<td>C65 (i.Mx)</td>
<td>TSMC12</td>
<td>TSMC14</td>
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<tr>
<td>C55FG</td>
<td>TSMC14</td>
<td>(TSMC12)</td>
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<tr>
<td>C40(i.Mx)</td>
<td>TSMC14</td>
<td>(TSMC12)</td>
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<td>28TFS</td>
<td>TSMC12</td>
<td>TSMC15</td>
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ATMC = Austin Technology and Manufacturing Center, CHD = Chandler Arizona
Both Freescale Internal.

### Dual Sourcing / Crisis Recovery Timing

![Dual Sourcing / Crisis Recovery Timing Diagram]

**Automotive Microcontroller**

- Automotive Intent Microcontroller
### Back-end Manufacturing Facilities & Supply Continuity

**Multiple Sources for All Key Automotive MCU Package Technology**

<table>
<thead>
<tr>
<th>Automotive Technology</th>
<th>Primary Source</th>
<th>Secondary Source</th>
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<tbody>
<tr>
<td>MAPBGA</td>
<td>TJN</td>
<td>ASE-CL</td>
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<tr>
<td>PBGA</td>
<td>KLM</td>
<td>ASE-KR</td>
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<td>LQFP</td>
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<tr>
<td>SOP</td>
<td>ATP</td>
<td>TJN</td>
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<tr>
<td>TeBGA</td>
<td>AMKOR-K4</td>
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<td>Flip BGA</td>
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#### Assembly Packaging

<table>
<thead>
<tr>
<th>Automotive Test Platform</th>
<th>Primary Source</th>
<th>Secondary Source</th>
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<tbody>
<tr>
<td>Ultra-flex</td>
<td>KLM</td>
<td>KES-M/KTM</td>
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<td>HP93K</td>
<td>KLM/TJN</td>
<td>ASE-KR</td>
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<tr>
<td>J750-1K</td>
<td>KLM</td>
<td>TJN</td>
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<td>J750-512K</td>
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<tr>
<td>J750-256K</td>
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#### Dual Sourcing / Crisis Recovery Timing

<table>
<thead>
<tr>
<th>Primary Site</th>
<th>Tech Qual'd</th>
<th>FSL Product Qual'd</th>
<th>Ctmr Product Qual'd</th>
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<td>1-12</td>
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</table>

Normal quoted leadtime applies.
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- **Automotive Technology Commitment**
Specify requirements for next generation car platform
- Technical Features for next. gen. ADAS, Cluster, Powertrain etc.
- Safety requirements -> ASIL Level C, B, D
- SW requirements -> Autosar 3.x, 4.x

Establish timing of product development, qualification milestones and ramp requirements
- NPI must fit with Car platform Schedule
- Technology roadmap align to manufacturability
- Autosar and dev. Tools should be available in Time
- Manufacturing capacity supports early launch, growth and sustaining volumes

Define approval acceptance criteria for our products
- Logistic -> Leadtime, Capacity, Buffers
- Quality -> Low PPM, ISO26262 etc
- Support -> Sales, FAE dedicated support

Proactively engage in supply chain continuity risk mitigation activities
- Dual sourcing / qualification
- Mid to Long Range Forecasting
- Consistent order coverage ≥ quoted leadtimes (26 weeks ideal)
Freescale Dual Sourcing Strategy

<table>
<thead>
<tr>
<th>FAB</th>
<th>A/T</th>
<th>Primary Site</th>
<th>Tech</th>
<th>FSL</th>
<th>Ctm</th>
<th>Product Qual’d</th>
<th>Product Qual’d</th>
<th>Months</th>
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NOTE: All leadtimes provided are general projections and may not include customer qualification timing

Scenario A: Freescale has a single site qualified and in use, no existing secondary source and no plans for secondary source (FAB: 12-18 Mths, A/T: 6-12 Mths)
Scenario B: Freescale has primary site qualified and has secondary site qualified on technology only (FAB: 3-12 Mths, A/T: 3-9 Mths)
Scenario C: Freescale has primary site qualified and has secondary site qualified on technology and product (FAB & A/T: 3-6 Mths)
Scenario D: Freescale has two sources qualified with FSL and Customer Product Qualified (FAB & A/T: Normal Leadtime 3-4 months)

A/T = Assembly and Test
Manufacturing Cycle Time vs. Order Lead Time

- Typical semiconductor cycle time from wafer start to finished good test out is 20-26 weeks*
- Die and Finished Goods buffers established based on forecasted run rates can help reduce customer order lead times to more manageable levels; typical automotive lead times in the 12-14 week range
- Forecasts and order coverage (actual orders placed ≥ LT) extremely important to help keep lead times lower; unexpected / un-forecasted increases can quickly diminish buffer levels, resulting in lead times extending to 16-20+ weeks

Typical Semiconductor Cycle Time = Manufacturing Cycle Time = 20 + weeks

* certain technologies have significant layer count which could result in CT exceeding 26 weeks

High Volume Avg. Order Lead Times = 12-14 wks
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Freescale Business Continuity Strategy

Each tier focuses on specific risk area
Manage major business interruptions
Assess potential risks to operations/supply

Standard procedures for each tier
Take actions to prevent high-risk incidents from occurring and prepare for high-risk incidents that cannot be prevented

Establish the known facts
Assess the impacts (consider worst case scenarios)
Identify key issues
Set priorities
Involve the appropriate people
Assign actions and deadlines
Communicate core messages internally and externally

Establish Command Center
Assure that crisis response plans are in place and have been tested
Freescale Business Continuity Strategy

FSL Corporate Crisis Management and Business Continuity

Site Crisis Management

Protection of Information

Product Supply

Procurement Supply

Assures rapid recovery of business operations and facilities from a business interruption

Safeguards our facilities infrastructure from a business interruption

Formal risk management assessments
Scenario planning
  Earthquakes, weather
Proactive planning
  CDC outbreaks
  Local rescue drills

Contracts with local temporary agencies
Work closely with local law enforcement
Regular drills with onsite EMT
Evacuation drills
Freescale conducts its business and operations in approximately 75 sites and in over 25 countries worldwide.
Freescale Business Continuity Strategy

Site Crisis Management

Assures product delivery to customers
- Decision Maker
  - Product allocation
  - Site infrastructure
  - Delivery status

Communication protocols
- Internal
- External (customers, suppliers)

Information repository for communication and event responses

Playbooks to ensure the continuous delivery of critical services and products

Work directly with the customer

FSL Corporate Crisis Management and Business Continuity

Protection of Information

Procurement Supply
Freescale Business Continuity Strategy

FSL Corporate Crisis Management and Business Continuity

- Site Crisis Management
  - Assures the delivery of raw materials to Freescale sites
  - Require subcons to comply with a detailed risk assessment to mitigate risk of facility, human, equipment or natural disaster business interruptions
- Protection of Information
- Product Supply
  - Dual source strategies
  - Manage self-assessment audits of suppliers
  - Raw material buffers
  - Proactive risk assessment for suppliers
  - Require service agreements for suppliers
- Procurement Supply
Procurement Supply

Supplier Management

- Proactive risk analysis
- Financial Health, Market Share Analysis and Capacity Availability, Geographic analysis based on proximity of 2\textsuperscript{nd} source
- Procurement Personnel located close proximity of suppliers

Assurance of Supply

- Fast track qualification process for raw materials
- Documented methods and expectations for issue escalations
- All critical suppliers must comply with a detailed risk assessment to mitigate risk of Utility, Human, Equipment or Natural Disaster business interruptions
Freescale Business Continuity Strategy

Addresses the recovery of Freescale data systems
Data backup strategies
Frequent system testing
Executing restoration procedures and operations
Hardware: mainframe, servers, network, end user
Software: applications, operating systems, utilities
Communications (network and telecommunications)
Site data recovery plans
Supply Risk Response Timeline

**Preparedness before Supply Risk**
- Preventive Risk Control
  - Identify & mitigate critical risks (earthquake, flood, utility, fire, IT, etc.)
  - Emergency Response Team Training/Drills
  - Effectiveness verification via scenario test
  - Dual sourcing
  - Buffer strategies

**Supply Risk**

**0-1 hr**
- Emergency Response
  - Life safety protection & contamination (first responders)
  - Protect employee safety via evacuation plan
  - Emergency Response Team activation

**1-48 hrs**
- Crisis Management
  - Compile detailed lists of affected factories/sites, resources, products, customers
  - Damage evaluation*
  - Stakeholder communication

**hrs to weeks**
- Business/Supply Continuity
  - Production recovery or Relocation
  - Facility recovery
  - Compile initial finished goods supply plan and initial customer supply plans based on allocation guidelines
  - Activate back-up plan for critical production process or service
  - Communicate

**Process after Supply Risk and BCP Team is Deployed**
Utilize appropriate roles to keep communication consistent, cohesive and in fastest timeframe possible.
Communication Flow - Product Supply Continuity (Delivery)

- Customer Supply Plans
- Gap Analysis & Closure
- Minimum Demand Rates
- Expedite Options

- Gathering of Drop Dead Req’ts
- Report to Factory (War room)
- Communication of Supply Tracker
- Allocation Decisions
- Executive Escalation

- WIP Positions
- Capacity Allocation Decisions
- Supply Tracker Update and Publish
- Manufacturing Execution

- Demand rates and required delivery dates
- Acceptable alternatives & exceptions

Typical Communication To/From
Conclusion

- Manufacturing Footprint
  - Combines and internal network of front end Fab/Probe operations and backend Assembly and Test with external foundry partners (front end) and A/T subcontractors
  - Enables primary and secondary sourcing for supply risk mitigation and continuity

- Freescale and OEM continuous collaboration is key for requirements specification, roadmap timing and approval/qualification acceptance

- Dual Sourcing Strategies in place to ensure supply continuity and risk mitigation

- Sufficient customer forecasts and order coverage (ordering ≥ quoted leadtime) enables Freescale to implement buffer strategies thus reducing order leadtimes

- Freescale deploys a continuous closed loop communication flow to gather requirements from customer and communicate to/from our manufacturing network and planning community
Backup Slides
## Semiconductor Manufacturing Cycle Time

### C90FG State of the Art Power Architecture™
- 32-bit MCU
- ~350 Wafer Fab Process Steps
- ~83 Million Transistors

### Manufacturing Process

<table>
<thead>
<tr>
<th>Process</th>
<th>Steps</th>
<th>Typical Duration (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wafer Fab Process</td>
<td>Diffusion – Photo – Etch – Implant – Metal/Film – CMP</td>
<td>18</td>
</tr>
<tr>
<td>Wafer Probe</td>
<td>Sorts plus Data Retention Bake</td>
<td>3</td>
</tr>
<tr>
<td>Package Assembly</td>
<td>Backgrind -&gt; Saw -&gt; Die Bond -&gt; Plasma Clean -&gt; Wire Bond -&gt; Mold -&gt; Mark -&gt; Plating / Ball Attach -&gt; Singulation -&gt; Scan</td>
<td>2</td>
</tr>
<tr>
<td>Final Test</td>
<td>Burn-in -&gt; Tri-temp Test Inserts</td>
<td>2</td>
</tr>
<tr>
<td>Ship</td>
<td>Pack: Bake -&gt; Scan -&gt; Tape &amp; Reel -&gt; Dry Pack -&gt; Label -&gt; Ship</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Total Cycle Time</strong></td>
<td><strong>26</strong></td>
</tr>
</tbody>
</table>
Wafer Processing Overview

- **Raw Silicon/Substrate**
- **Diffusion**
  Grows or deposits a layer of oxide, nitride, poly, or similar material.
- **Photo**
  Spins on photoresist, aligns reticle and exposes wafer with reticle pattern. Develop removes resist from exposed areas.
- **Etch**
  Removes film layer that was uncovered during develop. Strips resist.
- **Implant**
  Dopants are implanted for electrical characteristics.
- **Metals/Films**
  Connects devices electrically and isolates circuit pathways.
- **CMP**
  Polishing technique to keep surfaces flat so more layers can be added.
- **Probe/Test**
  Test Device Functions

- IC Manufacturing uses a recursive deposition and masking process to define patterns of doped areas, isolation films, and metal conductors to create solid state devices.
Assembly Package Process Flow

- Wafer Backgrind → Wafer Clean & Mount → Wafer Saw → Die Bonding → Die Attach Cure
- Lead Plating & Post Plating Bake → Post Mold Cure → Mold → Wire Bonding → Plasma Clean
- Solder Ball Attach → Flux Clean → Trim & Form or Pkg Singulation → Lead / Ball Integrity Scan → Final Visual Inspection
- Laser Mark
- QFP
- BGA
- BGA
- QFP
# Wafer Sourcing

<table>
<thead>
<tr>
<th>Fab Site</th>
<th>.25u SOI</th>
<th>.18u/15u</th>
<th>Q.12u HIF7 NVM/3SOI</th>
<th>C30 H1P8 NVM</th>
<th>C30 H1P8/LP/3SOI</th>
<th>HDTMOS I HDS /HD6</th>
<th>SMOS 5AP</th>
<th>SMOS9MV</th>
<th>SMOS9MV</th>
<th>LFET</th>
<th>CS5</th>
<th>C45SOI</th>
<th>C40</th>
<th>C20</th>
<th>LDMOS</th>
<th>Sensors / MEMS</th>
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<tr>
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<td>TSMC3</td>
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**Legend:**
- Grey: Current Sourcing
- Blue: Planned Sourcing
- AS: Analog Sensor
- MC: Auto MCU
- DN: Digital Networking
- RF: Radio Frequency
- IMC: Microcontroller
## Tester Sourcing

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*Grey: Current Sourcing*  
*Blue: Planned Sourcing*  
*Yellow: Planned Change*  
*AS: Analog/Sensor*  
*AM: Auto MCU*  
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*RF: Radio Frequency*  
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