The Japan Disaster: What Lessons Learned for the Supply Chain?

Prof. James B. Rice, Jr (MIT)

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The Japan Disaster: What Lessons Learned for the Supply Chain?

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Agenda

- What we’ve come to know about global SCs
- The Japan Disaster and SC Impacts
- Learnings from The Japan Disaster
  - Applying Failure Modes to Japan
What we’ve come to know about global SCs

• Supply chains today – global, complex, vulnerable – with 10s to 100s of parties in each
• Low Probability disruptions ..... are not low probability

High Consequence-Low Probability Disruptions

Ref: Adapted from Dr. Debra Elkins, General Motors
And more recent disruptions....

New Zealand 7.9 Earthquake June 2011  
Japan Earthquake/Tsunami Mar 2011  
Japan Nuclear Meltdown Mar+ 2011  
Midwest US Floods Spring 2011  
New Zealand Earthquake Feb 2011  
Haiti Earthquake Jan 2010  
Gulf Oil Spill Summer 2010  
Australian Floods Dec 2010  
**iceland Volcano Mar-Apr 2010**  
Landslide in Peru Jan 2010

Chile Earthquake & Tsunami Feb 2010  
Russian Wildfires Jul 2010  
Hurricane Earl Aug 2010  
Pakistan Floods July 2010  
Hungary Toxic Spill Oct 2010  
Haiti Cholera Outbreak Oct 2010  
Indonesia Volcano & Tsunami Oct 2010  
Guatemala Sinkhole May 2010  
US East Coast Blizzard Feb 2010  
**Beijing Olympics Summer 2008**

Ref: Source material from "The Japan Disaster: Rebuilding Supply Chains" webinar for Journal of Commerce, by B. Artnzen and J. Rice, March 24, 2011; and presentation by Chris Caplice, Future Freight Flows, MIT NCHRP Project Workshop

What we’ve come to know about global SCs

- Supply chains today – global, complex, vulnerable – with 10s to 100s of parties in each
- Low Probability disruptions ..... are not low probability
- Traditional risk management focuses on addressing source of risk: but the risks are numerous
What we’ve come to know about global SCs

- Supply chains today – global, complex, vulnerable – with 10s to 100s of parties in each
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- Traditional risk management focuses on addressing source of risk: but the risks are numerous
- Cost of disruptions is high....
Impact of Supply Chain Failures High

- Japan Earthquake/Tsunami/Nuclear Meltdown 2011: $Bs+
- Philips Fire 2000–Nokia vs Ericsson, Ericsson loses $400m
- West Coast Lockout 2002, $~20B economic loss
- Boeing 787 Outsourced SC 2007-8, 2-yr delay, $2B charges
- Mattel Product Quality Recall, 2007, 50% stock price drop
- Hershey Halloween Miss (IT), 1999, $150M loss, -30% stock
- Nike IT system failure, $100M revenue drop, -20% stock
- Plus many other incidents and disasters
  - P&G Folgers (Hurricane Katrina),
  - GM (tornado at Oklahoma City),
  - Land Rover/UPF Thompson frame supplier bankruptcy,
  - Toyota (Aisin) brake plant fire 1997,
  - Hurricane Rita, London-Madrid-Bombay terrorist attacks, labor actions/strikes, SARS, H1NI, HiN5, Somali pirates….

What we’ve come to know about global SCs

- Supply chains today – global, complex, vulnerable – with 10s to 100s of parties in each
- Low Probability disruptions ….. are not low probability
- Traditional risk management focuses on addressing source of risk: but the risks are numerous
- Cost of disruptions is high....
- No SC is an island
  - And therefore you cannot isolate your SC to protect it from every disruption. Instead, expect disruptions and be prepared for them
  - SC Resilience Principles
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What happened: business impacts?

• Primary impacts – local operations damaged, personnel lost, communications lost
  • Automotive finished vehicles & parts; High tech: semiconductors, technology; Pharmaceuticals

• Secondary impacts – downstream customers suffered loss of supply from primary impacts causing shutdowns
  • Retailers and downstream customers working off inventories, slowdowns
  • Factories in Japan shuttered to conserve power
  • Unreliable utilities (power, water) continue to impact operations

• Discovery of critical dependence
  • Niche suppliers in lower tiers (Hitachi engine airflow sensors, Renesas drive train microprocessors, Mitsubishi Gas BT resin)
What else happened...

- **The clock started on a race**
  - To identify impact to the business: core operations, suppliers, customers
  - To execute business continuity plans (if in place)
  - To identify sources and secure remaining capacity

- **A challenge to JIT/Lean Concepts**
  - A knee-jerk reaction has been to challenge the wisdom of JIT/Lean

- **Experience dealing with bio-hazard impact**
  - A dry run for bio-terrorist attack
  - Learn from the response – process for responding [e.g. assessing impact, communicating guidelines (even as they change)] and preparation for potential impact [e.g. readiness for inventory conditioning, radiation-detection equipment]

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<table>
<thead>
<tr>
<th>Company</th>
<th>Product</th>
<th>Core Capacity Loss (Failure mode)</th>
<th>Brief Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>iPad 2</td>
<td>Expect loss of supply</td>
<td>Key component suppliers shutdown (NAND flash memory, touch screens, iPad batteries)</td>
</tr>
<tr>
<td>Freescale</td>
<td>Accelerometers, pressure sensors and other chips</td>
<td>Loss of internal capacity</td>
<td>Plant in Sendai shutdown, shifting production to other facilities</td>
</tr>
<tr>
<td>GM</td>
<td>Automotives</td>
<td>Loss of supply</td>
<td>US plant closed because lack of supply of engine air flow sensors</td>
</tr>
<tr>
<td>Hitachi</td>
<td>Engine air flow sensor components</td>
<td>Loss of internal capacity</td>
<td>Plant damaged</td>
</tr>
<tr>
<td>Honda</td>
<td>Finished vehicles, auto components</td>
<td>Loss of supply</td>
<td>Dependent on 10 suppliers located in radiation zone; Closed 3 comp &amp; 2 assembly plants; expect to lose 6,500 units; lost contact with 44 of 113 suppliers</td>
</tr>
<tr>
<td>Mazda</td>
<td>Finished vehicles, auto components</td>
<td>Loss of supply</td>
<td>Plants closed, some to be closed until April</td>
</tr>
<tr>
<td>Nikon</td>
<td>SLR cameras</td>
<td>Loss of internal capacity</td>
<td>Plant closed; only plant making SLR cameras</td>
</tr>
<tr>
<td>Nissan</td>
<td>Finished vehicles, engines</td>
<td>Loss of internal capacity</td>
<td>Facility closed, lack water, electricity and gas to operate. Considering sending engines from Tennessee plant to Japan</td>
</tr>
<tr>
<td>ON Semiconductor</td>
<td>Semiconductors</td>
<td>Potential loss of internal operations</td>
<td>Temporary shutdown expected at several facilities</td>
</tr>
<tr>
<td>Powerchip Tech.</td>
<td>DRAM</td>
<td>Loss of supply</td>
<td>Redesigning product to use available supply</td>
</tr>
<tr>
<td>Renesas</td>
<td>Drive train microprocessor</td>
<td>Loss of internal capacity (clean room)</td>
<td>Facility closed, many auto companies dependent on this product</td>
</tr>
<tr>
<td>Shin-Etsu Chemical</td>
<td>Silicon wafers</td>
<td>Loss of internal capacity</td>
<td>World's largest maker of silicon wafers disrupted; 57% of world's wafers come from Japan</td>
</tr>
<tr>
<td>Sony</td>
<td>Rechargeable batteries, DVD, Blu-ray discs, lasers</td>
<td>Loss of internal capacity</td>
<td>Closed 10 factories</td>
</tr>
<tr>
<td>Toyota</td>
<td>Finished vehicles, Yaris, Scion xB and Scion xD, Prius V</td>
<td>Loss of supply parts, Loss of internal capacity</td>
<td>Shutdowns across all TMC plants. Expected loss of 140,000 units, Prius only made in Japan.</td>
</tr>
</tbody>
</table>
Impact on Ports

Port of Sendai
Port of Hitachinaka
Port of Kamaishi
Port of Onahana

Tier 1-2-3 suppliers put GM (& others) at risk

<table>
<thead>
<tr>
<th>Company</th>
<th>GM</th>
<th>GM Engine Plant</th>
<th>Hitachi Automotive Syst</th>
<th>Hitachi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td></td>
<td></td>
<td>Mass airflow sensor units</td>
<td>Sensor</td>
</tr>
<tr>
<td>Location</td>
<td>Shreveport LA</td>
<td>Buffalo, NY</td>
<td>Sawa/Ibaraki, Japan</td>
<td>Japan</td>
</tr>
</tbody>
</table>

- Engine shortage; lines down
- Part shortage; plant closed
- Factory damaged

Hitachi airflow sensors affecting Nissan, PSA, Ford, VW, Renault, GM. Hitachi makes 60% of global supply of airflow sensors.
**Hitachi airflow sensor in Mazda D23**

$2 sensor in $90 airflow unit

**Tier 1-2-3 suppliers put GM (& others) at risk**

<table>
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<tr>
<th>Company</th>
<th>Auto OEMS</th>
<th>Various</th>
<th>Renesas Electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
<td>Trucks &amp; Cars</td>
<td>Drive train</td>
<td>Microcontroller chip</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Global assembly</td>
<td>Various</td>
<td>Naka/Ibaraki, Japan</td>
</tr>
</tbody>
</table>

Assembly shortage; lines & plants down  
Part shortages  
Factory damaged

Renesas is world's largest maker of microcontrollers, 30% share

### iPad2 Bill of Materials

#### Parts Made in Japan:

**Overlay Glass** – very special glass, very flexible and durable,
- Only source believed to be Asahi Glass
- AGC Kashima Plant damaged
- AGC Koriyama Plant damaged
- AGC Yonezawa Plant – access restricted due to fire at Cosmo Oil Co. nearby

**NAND Flash Memory**
- Can also be sourced - Samsung in Korea & Micron Technology in US

**DRAM Memory**
- Can also be sourced – Samsung/Korea

**Lithium-Ion Battery**
- Battery cells made by Apple Japan
- Polyvinylidene Fluoride (PVDF) polymer resin used in Li-ion batteries
- 70% of global supply of PVDF comes from Kureha Co in Iwaki, Japan

**Electronic Compass**
- Produced by AKM in Japan
- Factory was not damaged
- Other sources available but not easy substitution (calibration reqts)

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**Apple iPad 2 32GB (Wi-Fi + 3G)**

**Exploded View**

**Parts Made in Japan**

- Overlay Glass
- Display Module
- Rear Camera Module
- Battery Pack
- Battery Cells
- Front Camera Module
- SIM Card PCB
- 3G Module
- NAND Compass DRAM
- WLAN PCB
- Loudspeaker Assembly
- Touchscreen Assembly

*Ref: source from B. Arntzen, MIT*
### Tier 3 & 4 suppliers put Apple (& others) at risk

<table>
<thead>
<tr>
<th>Company</th>
<th>Apple</th>
<th>FoxConn (Hon Hai)</th>
<th>ASE or SPIL</th>
<th>Kinsus or Unimicron</th>
<th>Electrotechno (Mitsubishi Gas Chemical sub)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
<td>iPad2</td>
<td>Assemble product</td>
<td>Chips (TSMC) to substrate PCB</td>
<td>Use BT to make IC substrate</td>
<td>Manufacture bismaleimide triazine BT resin</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Retail</td>
<td>China</td>
<td>Taiwan</td>
<td>Taiwan</td>
<td>Fukushima, Japan</td>
</tr>
</tbody>
</table>

Electrotechno in Fukushima produces ~50% of global BT resin supply.

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### Tier 3 & 4 suppliers put Apple (& others) at risk

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<tr>
<th>Company</th>
<th>Apple</th>
<th>Apple Japan</th>
<th>Kureha</th>
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</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
<td>iPad2</td>
<td>Battery cells</td>
<td>PVDF polymer resin</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Retail</td>
<td>China</td>
<td>Japan</td>
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Kureha in Iwaki makes 70% of global supply of PVDF.
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SC Risk Management & Resilience Principles

- Failure Mode Analysis
  - Plan for recovery from failure modes, not on risk source
  - Business Continuity Planning (BCP) for outcomes
  - Design to ‘fail smartly’ – plan to fail with limited impact
  - ‘Options’ thinking and planning
- Design for Supply Network Resilience
  - Ability of system to sustain & recreate itself after disruption
  - Achieve through Flexibility and Redundancy
- Flexibility
  - Actions entail prior investments in infrastructure, capabilities
- Redundancy
  - Actions entail prior investments in capital, capacity that may not be used

Supply Chain Failure Modes/Core Capacities

All disruptions result in one or more of these capacity losses for a period of time:

- Capacity to acquire materials (supply)
- Capacity to ship/transport
- Capacity to communicate
- Capacity to convert (internal operations)
- Availability of human resources (personnel)
- Financial flows (e.g. demand)

“Fail Smartly”* via Flexibility

- Auto part supplier: Fire burned facilities, data
  - Standard production process, suppliers provide ‘lost’ info
- Cantor Fitzgerald: Lost traders, customer info
  - Recaptured 50% of trades using CRM for info
- Intel
  - Interchangeable plants via “Copy Exact!”, E’quakes BCP
- Lucent Technologies
  - Interchangeable parts, standard models, concurrent SC
- Reebok
  - Postpone customization of NFL jerseys
- Helix Technology
  - Simplified production so supplier produces in emergency
- Jabil Circuits
  - Builds flexibility into standard contracts, 100% in 4 weeks

* “Fail smartly” was introduced in the article “Homeland Insecurity” by Charles Mann, The Atlantic, September 2002.
“Fail Smartly”* via Redundancy

- Morgan Stanley
  - Redundant IT system, back up 9-12-01 (learned from ‘93 attack)
- USPS: Anthrax
  - Used massive excess capacity to shift processing to other sites
- Boston Scientific
  - Financial analysis indicated cash flow crunch
  - Set up redundant production facility, staff…. Waiting!
- US Government & J&J
  - Maintain stock of medical supplies, rolling inventory

* “Fail smartly” was introduced in the article “Homeland Insecurity” by Charles Mann, The Atlantic, September 2002

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Considering the Japan disasters...

- Do the resilience principles still hold?
  - Yes!
- What is new?
  - Awareness of supplier hub vulnerabilities
  - Dependence on niche suppliers in distant tiers
  - Triple disruption – quake, tsunami, nuclear plant failure but ONE OUTCOME – loss of capacity
    - Multiple disruptions are not new – Katrina and levee break
    - Scope is the same (global), scale of impact is greater
    - This really wasn’t different than any other disruption aside from the number of companies affected
- What can we learn from the Japan case?
Learnings....?

- Companies proven to be more resilient than expected
- Assess vulnerability and consider:
  - Source of risk AND
  - Predictable outcomes – Failure Modes
- Look deep within your supply chain. Tier 1 is not enough.
- ACT. We now have evidence.... But many continue to believe “it wont happen to us”
- Active Supply Chain Risk Management
  - Tradeoff efficiency, operating cost, security/prevention & resilience

References & Thank you

- SC Resilience Publications
  - Mechanical Engineering Magazine “Beyond the Breaking Point” article, June 2011
  - Sloan Management Review "A Supply Chain View of the Resilient Enterprise“ article
  - Other references
    - http://ctl.mit.edu/research/supply_chain_resilience_publications
- Thank You
  - Jim Rice – jrice@mit.edu, 617.258.858