Imperial College London

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

*Prof. James B. Rice, Jr (MIT)*

Friday, 12 August 2011 - 16:00

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MIT Center for Transportation & Logistics

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

Imperial College
London, UK
August 12, 2011

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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

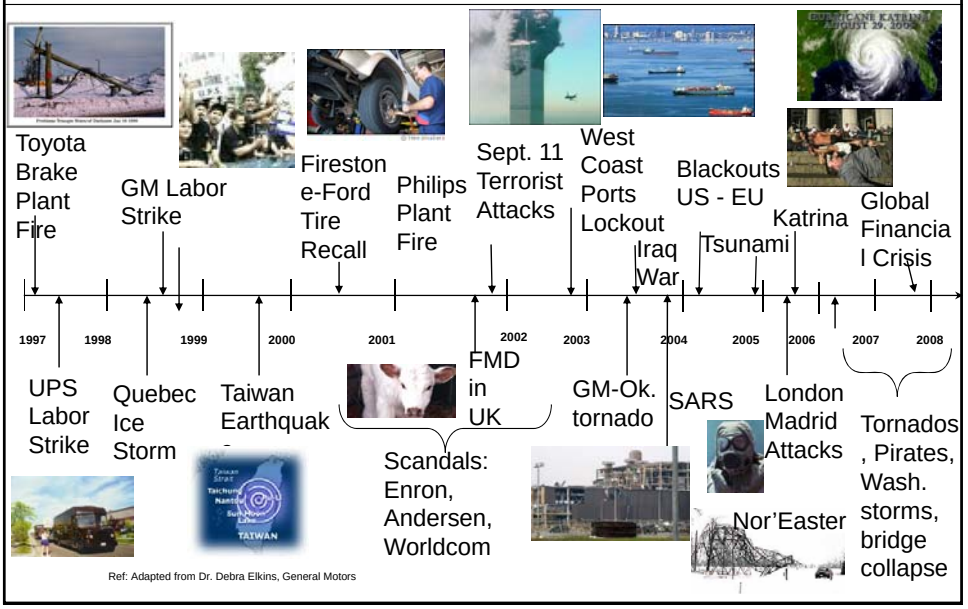
## What we've come to know about global SCs

- 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**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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

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## 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

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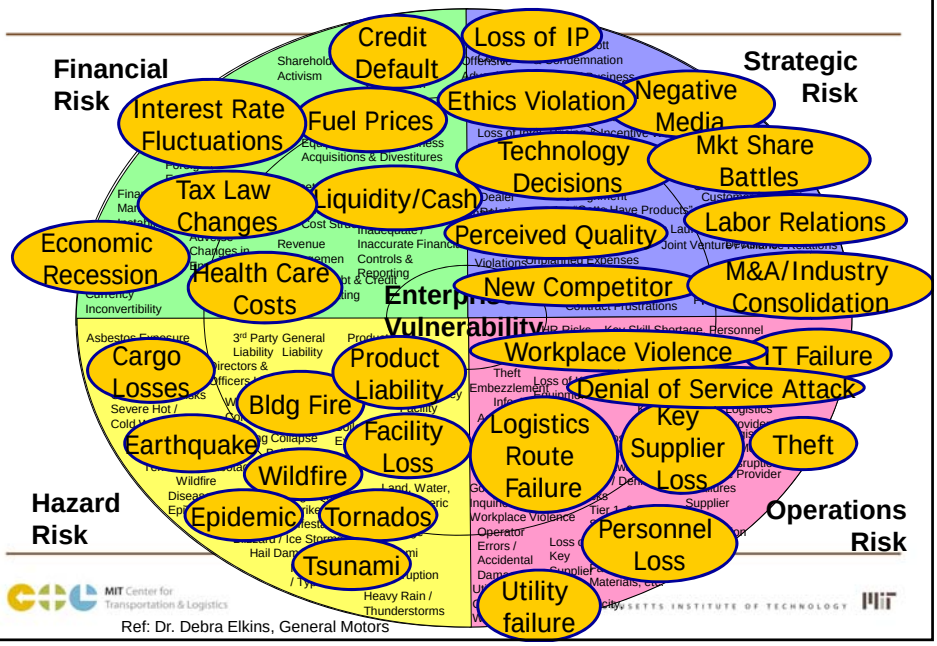
## Sources of Enterprise Vulnerability

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## 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….

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## 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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| Company | Product | Core Capacity Loss (Failure mode) | Brief Impact |
|---|---|---|---|
| Apple | iPad 2 | Expect loss of supply | Key component suppliers shutdown (NAND flash memory, touch screens, iPad batteries) |
| Freescale | Accelerometers, pressure sensors and other chips | Loss of internal capacity | Plant in Sendai shutdown, shifting production to other facilities |
| GM | Automobiles | Loss of supply | US plant closed because lack of supply of engine air flow sensors |
| Hitachi | Engine air flow sensor | Loss of internal capacity | Plant damaged |
| Honda | Finished vehicles, auto components | Loss of supply | Dependent on 10 suppliers located in radiation zone; Closed 3 comp & 2 assbly plants; expect to lose 16,500 units; lost contact with 44 of 113 suppliers |
| Mazda | Finished vehicles, auto components | Loss of supply | Plants closed, some to be closed until April |
| Nikon | SLR cameras | Loss of internal capacity | Plant closed; only plant making SLR cameras |
| Nissan | Finished vehicles, engines | Loss of internal capacity, loss of supply | Facility closed; lack water, electricity and gas to operate. Considering sending engines from Tennesee plant to Japan |
| ON Semiconductor | Semiconductors | Potential loss of internal operations | Temporary shutdown expected at several facilities |
| Powerchip Tech. | DRAM | Loss of supply | Redesigning product to use available supply |
| Renesas | Drive train microprocessor | Loss of internal capacity (clean room) | Facility closed; many auto companies dependent on this product |
| Shin-Etsu Chemical | Silicon wafers | Loss of internal capacity | Worlder's largest maker of silicon wafers disrupted; 57% of world's wafers come from Japan |
| Sony | Rechargeable batteries, DVD, Blu-ray discs, lasers | Loss of internal capacity | Closed 10 factories |
| Toyota | Finished vehicles; Yaris, Scion xB and Scion xD, Pruis V | Loss of supply parts, Loss of internal capacity | Shutdowns across all TMC plants. Expected loss of 140,000 units, Prius only made in Japan. |

## Impact on Ports


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

| **Company** | GM | GM Engine Plant | Hitachi Automotive Syst | Hitachi |
|---|---|---|---|---|
| **Product** | Trucks & Cars | Engines | Mass airflow sensor units | **Sensor** |
| **Location** | Shreveport LA | Buffalo, NY | Sawa/Ibaraki, Japan | Japan |
| | ⇧ Engine shortage; lines down | ⇧ Part shortage; plant closed | ⇧ Factory damaged | ⇧ Factory damaged |

Hitachi airflow sensors affecting Nissan, PSA, Ford, VW, Renault, GM. Hitachi makes 60% of global supply of airflow sensors

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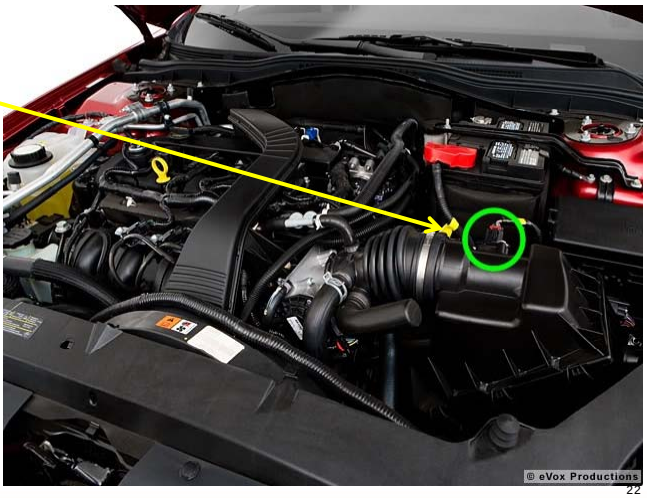
## Hitachi airflow sensor in Mazda D23

$2 sensor in $90 airflow unit

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

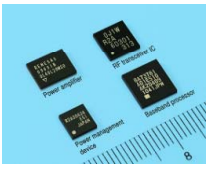
| **Company** | Auto OEMS | Various | Renesas Electronics |
|---|---|---|---|
| **Product** | Trucks & Cars | Drive train | **Microcontroller chip** |
| **Location** | Global assembly | Various | Naka/Ibaraki, Japan |

⇧ Assembly shortage; lines & plants down

⇧ Part shortages

⇧ Factory damaged

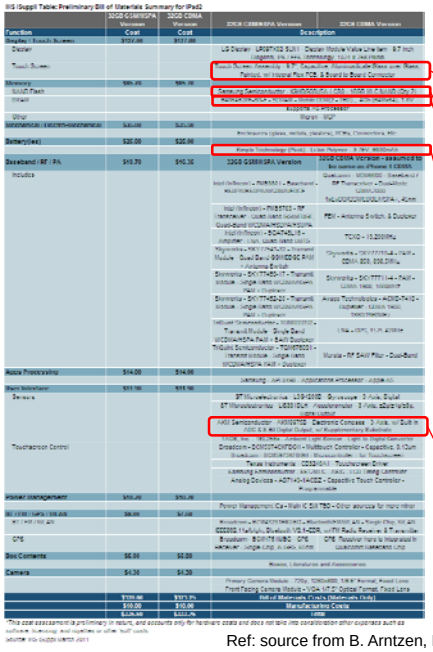
Renesas is world's largest maker of microcontrollers, 30% share



Renesas Electronics SP2531

Ref.: http://www.4wheelsnews.com/worlds-largest-maker-of-automotive-microcontrollers-affected-by-japan-earth/

## iPad2 Bill of Materials



Ref: source from B. Arntzen, MIT

## 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**

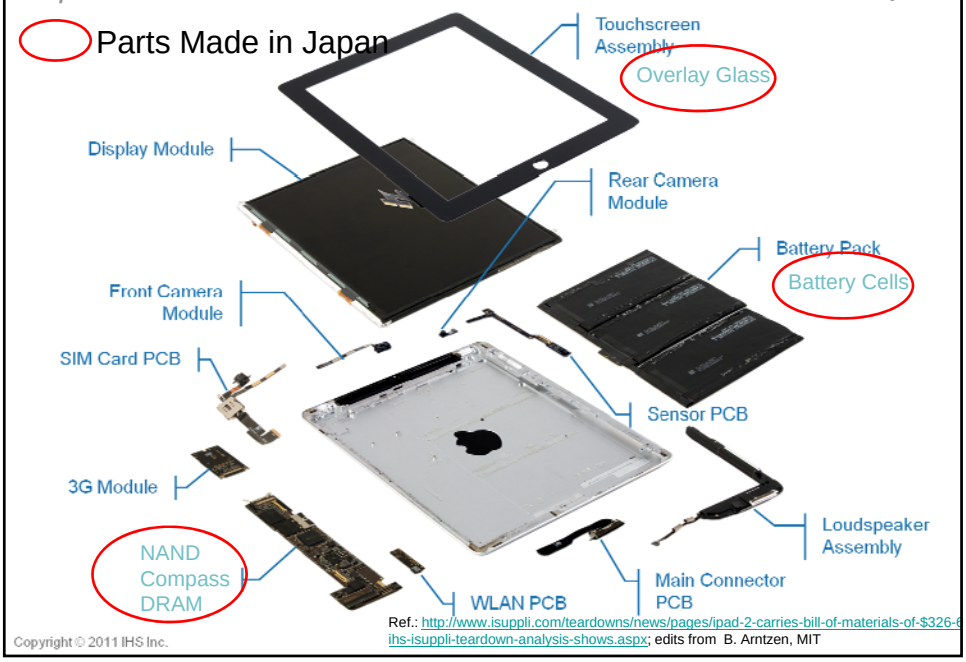
**Electronic Compass**
- **Produced by AKM in Japan**
- **Factory was not damaged**
- **Other sources available but not easy substitution (calibration reqts)**

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

*Exploded View*

*iSuppli*

*Teardown Analysis*

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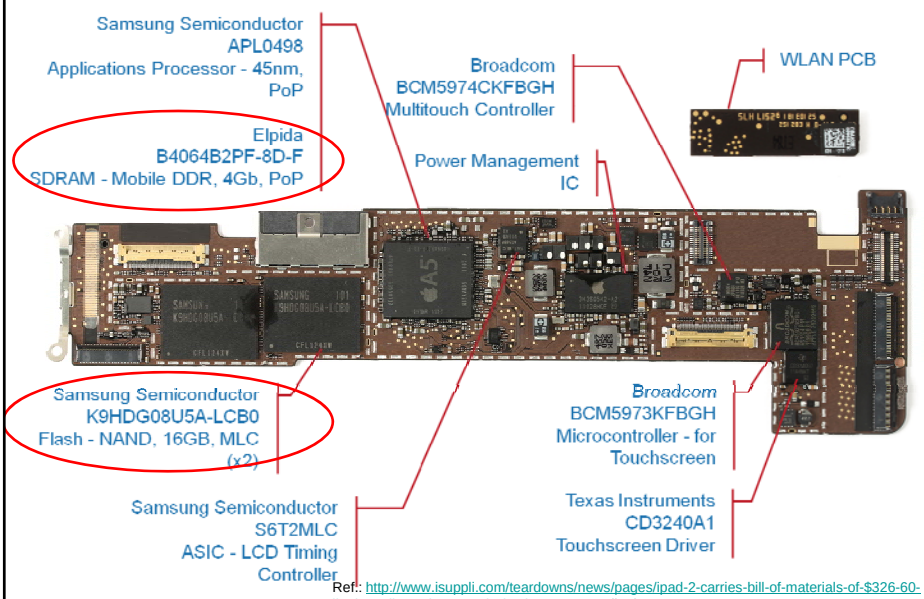
Ref.: http://www.isuppli.com/teardowns/news/pages/ipad-2-carries-bill-of-materials-of-$326-6-ihs-isuppli-teardown-analysis-shows.aspx; edits from B. Arntzen, MIT

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

*Disassembly – Main PCB, Bottom*

iSuppli Teardown Analysis

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Ref:: http://www.isuppli.com/teardowns/news/pages/ipad-2-carries-bill-of-materials-of-$326-60-ihs-isuppli-teardown-analysis-shows.aspx; edits from B. Arntzen, MIT

Battery Pack for iPad2

Ref.: http://www.isuppli.com/teardowns/news/pages/ipad-2-carries-bill-of-materials-of-$326-60-ihs-isuppli-teardown-analysis-shows.aspx; edits from B. Arntzen, MIT

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

| **Company** | Apple | FoxConn (Hon Hai) | ASE or SPIL | Kinsus or Unimicron | Electrotechno (Mitsubishi Gas Chemical sub) |
|---|---|---|---|---|---|
| **Product** | iPad2 | Assemble product | Chips (TSMC) to substr to PCB | Use BT to make IC substrate | Manufacture bismaleimide triazine **BT resin** |
| **Location** | Retail | China | Taiwan | Taiwan | Fukushima, Japan |

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



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

| **Company** | Apple | FoxConn (Hon Hai) | Apple Japan | Kureha |
|---|---|---|---|---|
| **Product** | iPad2 | Assemble product | Battery cells | **PVDF polymer resin** |
| **Location** | Retail | China | Japan | Iwaki, Japan |

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

Sources: "SC Response Project Interim Report" by J. Rice, F. Caniato, Aug 8, 2003; Draft of SC Response Book project, Oct. 2004, later pub as "The Resilient Enterprise by Y. Sheffi

## 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



## 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?

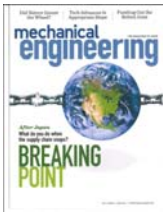
## Learnings….?

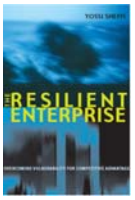
- Companies proven to be more resilient than expected
- Assess vulnerability and consider:
  - Source of risk AND
  - Predictable outcomes – Failure Modes
- Look deep within your supply chain. Tier 1 is not enough.
- ACT. We now have evidence…. But many continue to believe "it wont happen to us"
- Active 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
  - http://sloanreview.mit.edu/the-magazine/2005-fall/47110/a-supply-chain-view-of-the-resilient-enterprise/
  - Other references
  - http://ctl.mit.edu/research/supply_chain_reslience_publications




- Thank You
  - Jim Rice – jrice@mit.edu, 617.258.858

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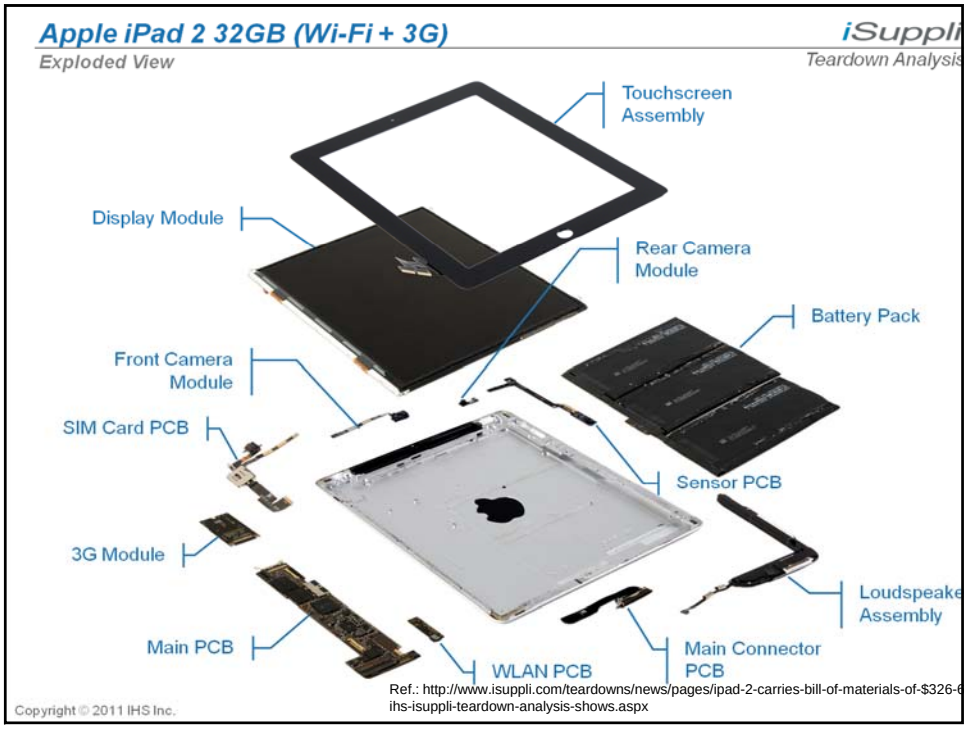


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