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Mitigating Supply Chain Risk Through Resilience

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MIT Faculty Club
Cambridge, MA

James B. Rice, Jr.
Deputy Director – MIT CTL

Today's Message

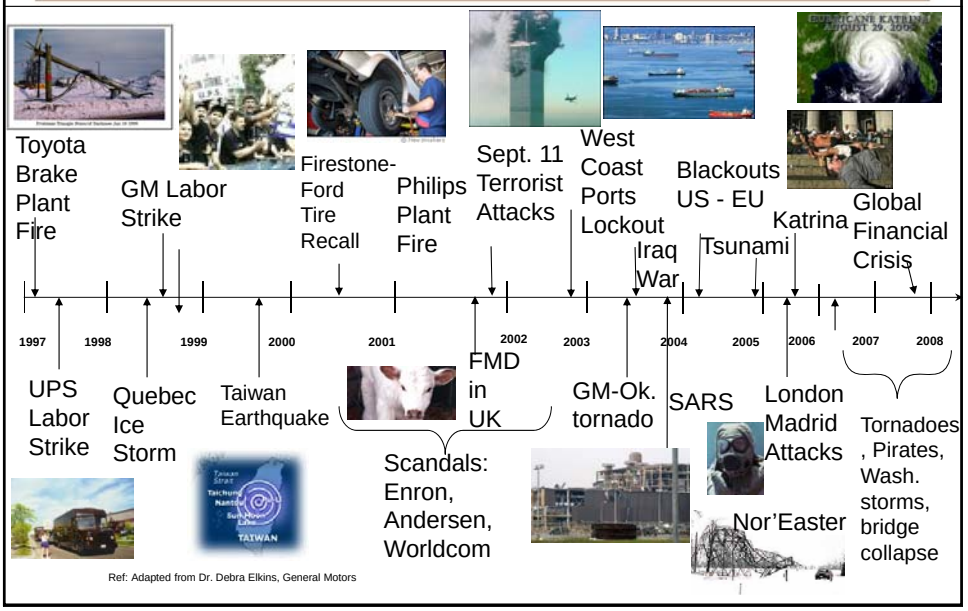
- Today's supply chains are at risk
- 5 Key Elements of Supply Chain Risk Management (SCRM) helps us deal with the risk
- Key principles reducing the risk: Resilience
- Case review: Sendai Disaster

Supply Chains & Risk Today

Supply Chains Today

- Global sources of supply & customer destinations
  - Increasing distances
  - Many transborder imports & exports
  - Added security constrains flow, raises costs (C-TPAT, AEO)
- Complexity! More parties in the supply chain
  - More outsourcing
  - More dependence on others in supply network
- Lean supply chains
  - Reduced inventories
  - Fragile supply chains
- Result is high vulnerability
  - Our vulnerability is a function of the supply network
  - Ex. Pan Am over Lockerbie; Williams Pipeline

High Consequence-Low Probability Disruptions



Ref: Adapted from Dr. Debra Elkins, General Motors

And more recent disruptions….

Eurozone Financial Crisis 2012
Thai Floods 2011
New Zealand 7.9 Earthquake 2011
Japan Earthquake/Tsunami 2011
Japan Nuclear Meltdown 2011
Midwest US Floods Spring 2011
New Zealand Earthquake 2011
Haiti Earthquake 2010
Gulf Oil Spill 2010
Australian Floods 2010
Iceland Volcano 2010
Landslide in Peru 2010
Chile Earthquake & Tsunami 2010
Russian Wildfires 2010
Hurricane Earl 2010
Pakistan Floods 2010
Hungary Toxic Spill 2010
Haiti Cholera Outbreak 2010
Indonesia Volcano & Tsunami 2010
Guatemala Sinkhole 2010
US East Coast Blizzard 2010
Beijing Olympics Summer 2008

What disruptions have affected you?

7

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

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….

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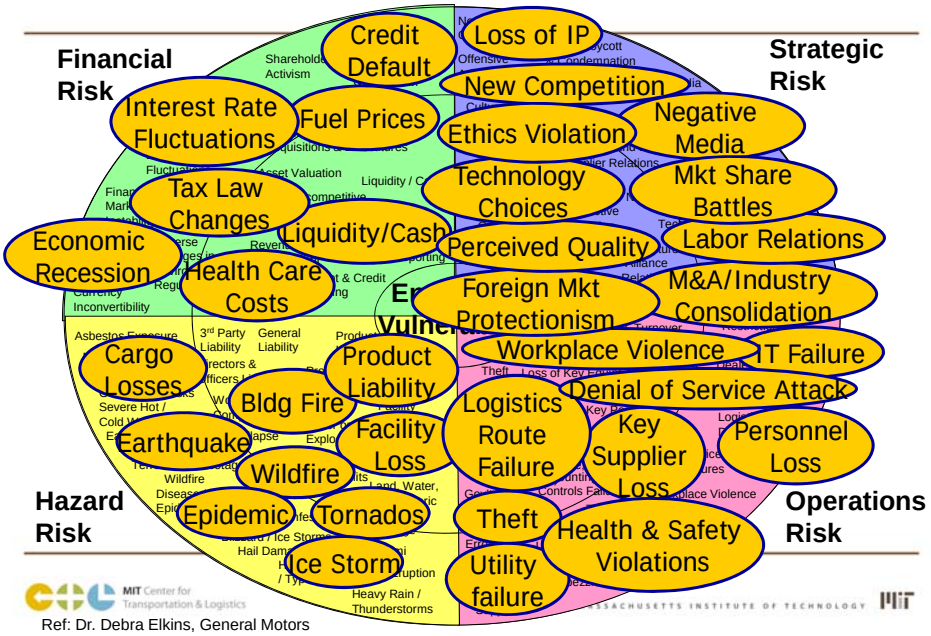
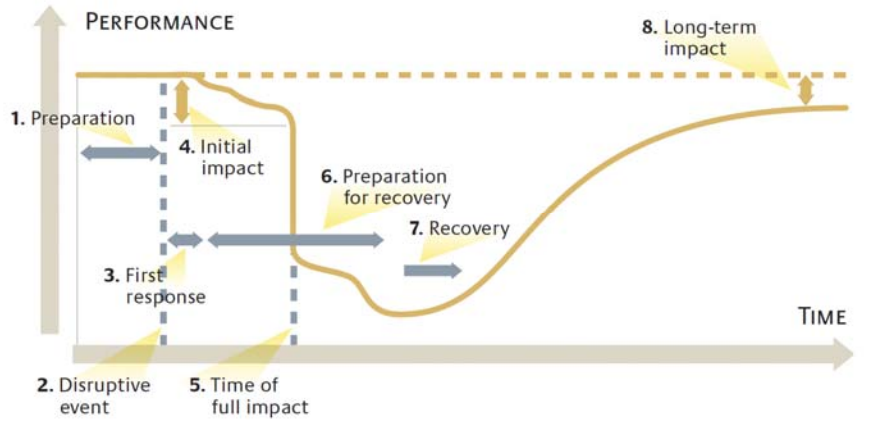
Known Risks – Enterprise Vulnerability



Ref: Dr. Debra Elkins, General Motors

Life Cycle / Profile of a Disruption



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Ref. – Sheffi, Rice, Supply Chain View of the Resilient Enterprise, SCMR 2005

Supply Chain Risk Management

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http://ctl.mit.edu
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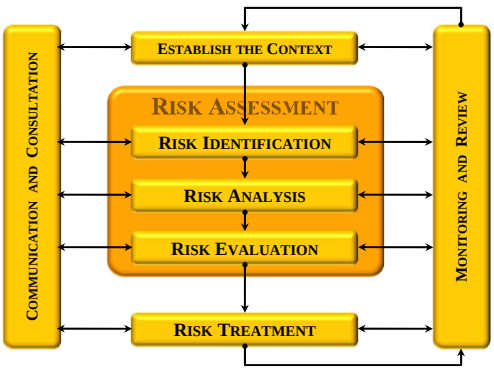
Supply Chain Risk Leadership Council

Risk Management Framework & ISO 31000

ISO 31000:2009
RISK MANAGEMENT – PRINCIPLES AND GUIDELINES



1. Vulnerability assessment
2. Mitigation planning & implementation
3. Ongoing Monitoring & Measurement
4. Crisis Management
5. Emergency Response

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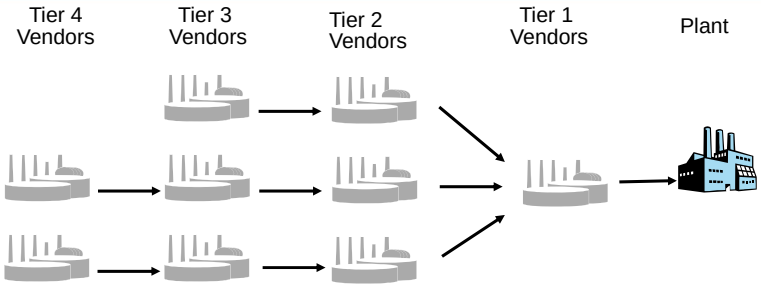
1. Vulnerability Assessment

- Map your supply network
  - Upstream Tier 1, 2, 3, & downstream to customer
  - Do you know the locations for your Tier 1 supply? Tier 2?
- Analyze source of risk
  - Natural disasters: predictable by region / season
  - Terrorism: threat adjusts to prevention
  - Labor unrest: threat often adjusts to preventive actions
  - Supplier failure: requires close monitoring
  - Many more……
- Risk analytics: quantitative and qualitative
  - Assess probabilities of disruption
  - Assess consequences of disruption
  - But data not always available to forecast and assess

Multi-tier Manufacturer Supply Chain



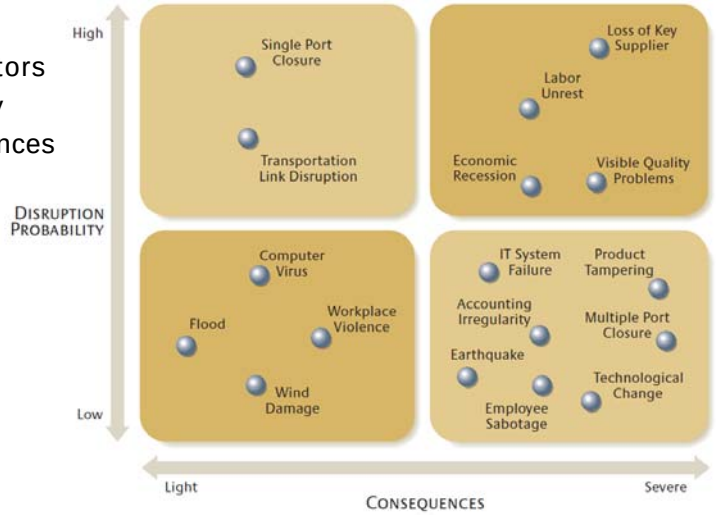
	Sheet metal	Formed metal boxes		
Silicon	Chips	Electronics	Exhaust System	Car maker
Kitty litter	Ceramics	Emissions System		

Qualitative Assessment: Staple Yourself to a Shipment

Ref: Permission to use photo by S. Lund

Vulnerability Maps: probability and consequence

Key risk factors
- Probability
- Consequences



Ref. – Sheffi, Rice, Supply Chain View of the Resilient Enterprise, SMR 2005

2. Mitigation Planning & Implementation

- Identify options for reducing probabilities & consequences
  - Identify company risk profile
  - Choose right mix of each for the business
  - Prevention or Response? How much of each?
- Reduce Probability→ Security and Prevention
- Reduce Consequences→ Response and Resilience

3. Ongoing Monitoring

- Design and install monitoring systems
  - Global event monitoring: geographic, political, weather
  - Supplier operational and financial health
  - Monitor entire network, find your sources
- Install measurement systems
  - Time to Recover (TTR): the number of weeks required to restore 100% operational output following a supply chain disruption (ref. Cisco)
  - Set targets and use flexibility and redundancy to hit target
- Software emerging that can help
  - Mapping upstream supply chain
  - Maintaining supplier data bases
  - Improved responses to Thai floods and Sendai disaster

4. & 5. Crisis Management & Emergency Response

- Develop response playbooks
- Impact analysis
  - On customers, facilities, products
- Create, train Corporate Emergency Response Teams (CERT)
  - Representatives from each function: Sales, marketing, logistics/supply chain, security, safety, legal, finance
  - Identify the roles for each function → practice
- Create protocols for communication
  - Methods, tools, frequency, responsibilities
  - Response roles identified and practiced
  - Public relations critical
- Beware of psychology of risk
  - Human brain bypasses cortex when dealing with risk, triggers emotional – not rational – response!

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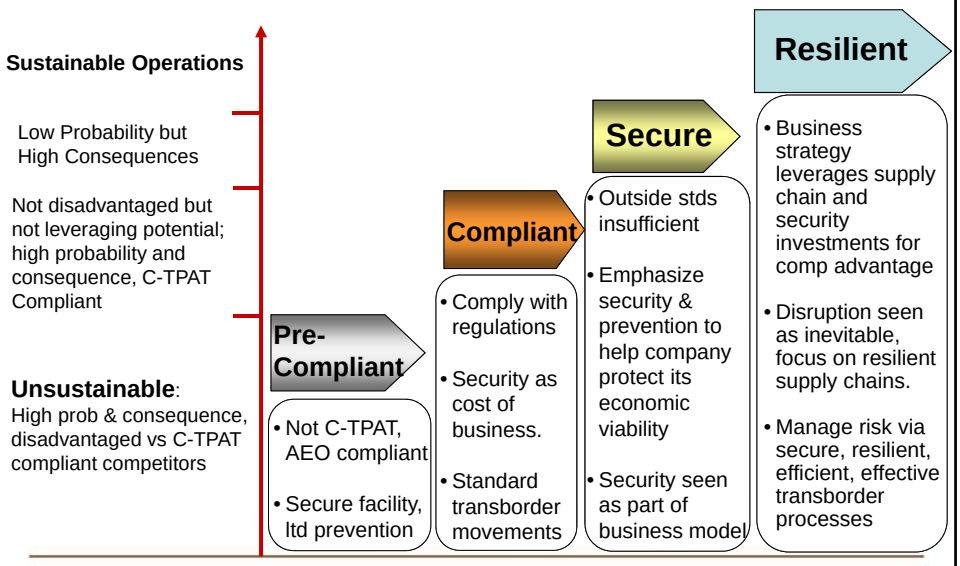
SC Risk Management Maturity Levels



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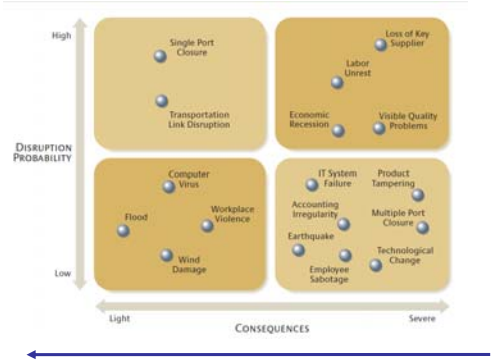
Ref:"How Risk Management Can Secure Your Business Future", *Supply Chain Strategy*, June/July 2007 by James B. Rice, Jr. (MIT) & William Tenney (Target)

Creating Supply Chain Resilience

Reduce Vulnerability to Disruption

1. Reduce probability of disruption: increase security, prevention



2. Reduce consequences of disruption: increase resilience

Ref. – Sheffi, Rice & SC Response Project

Supply Chain Resilience

- Supply Chain Resilience:
  - In material science, resilience is the physical property of a material that can return to its original shape or position after a deformation that does not exceed its elastic limit.
  - In today's business environment, resilience is widely used to characterize an organization's ability to react to an unexpected disruption, such as one caused by a terrorist attack or natural disaster, and restore normal operations.
  - It's the ability to recreate supply chain capabilities, to 'bounce back' from variations and disruptions
- Examples of supply chain resilience?

Source: "Building a Secure and Resilient Supply Network" by J. Rice, F. Caniato, SCMR Sept-Oct 2003

SC Resilience Principles

- Failure Mode Analysis – predictable outcomes
  - Plan for recovery from failure modes, not on risk source
  - Design to 'fail smartly' – plan to fail with limited impact
  - 'Options' thinking and planning
- Business Continuity Planning (BCP) for outcomes
  - Identify action plans to maintain & recreate business operations after disruption
    - Focus on responding to Failure Modes – outcomes
    - Prepare organization to response and recover
    - Choose mix of flexibility & redundancy
  - Design supply chain network for resilience
    - From upstream suppliers, internal operations and downstream to customer, plan for backup

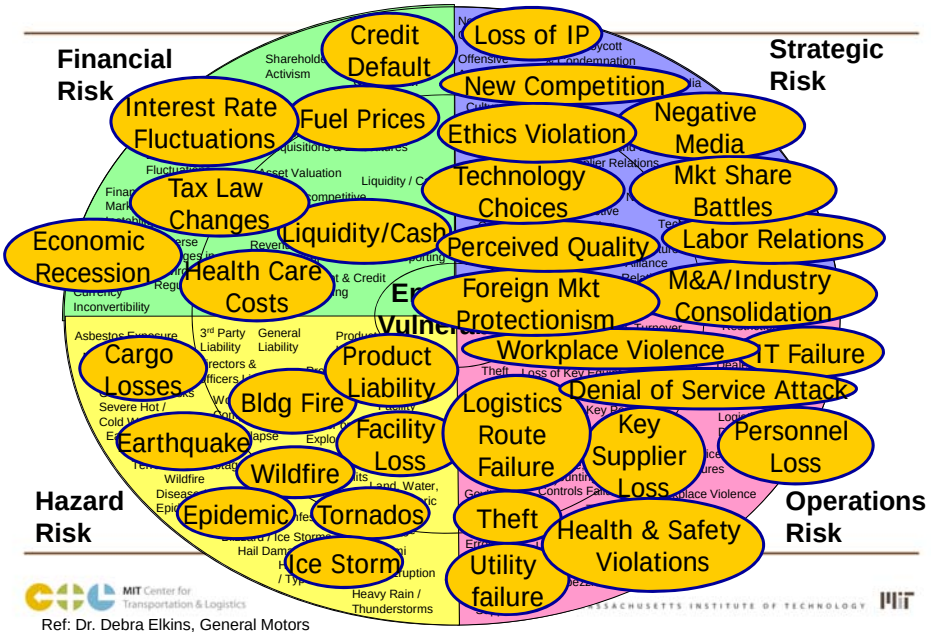
Sources: "SC Response Project Interim Report" by J. Rice, F. Caniato, Aug 8, 2003; Draft of SC Response Book project, Oct. 2004

Supply Chain Failure Modes

All disruptions result in a loss of one or more of these capacities:

- Capacity to acquire materials (supply)
- Capacity to ship/transport
- Capacity to communicate
- Capacity to convert (internal operations)
- Human resources (personnel)
- Financial flows

Known Risks – Enterprise Vulnerability



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Response Options by Failure Mode

Failure Mode	Resilience Action	Advantages	Disadvantages
Loss of supply / materials	Use multiple location & local sources	Spread risk across firms, locations	Higher cost to qualify suppliers, lower volume leverage
	Use single source	Known supplier	Vulnerable to disruption w/o multi-site back ups
	Modify product to use standard parts	Reduces part invty cost, complexity	Costly to modify existing materials standards

Response Options by Failure Mode

Failure Mode	Resilience Action	Advantages	Disadvantages
Loss of transport	Plan & use multiple modes	Pre-disruption relationship ensures support in crisis	Requires committing volume to alt supplier
	Spot market for capacity	Efficient transaction with no commitment	Unknown carrier means added risk, higher cost in crisis
	Use 3PLs to source transportation	3PLs have greater leverage	Requires committed volume and relationship

Response Options by Failure Mode

Failure Mode	Resilience Action	Advantages	Disadvantages
Loss of internal operations	Multiple sites handle multiple products	Able to move production	Must use std ops, need addl capital/facilities
	Modify inventory levels & policy	'Right' invty, risk pooling reduces invty costs	Requires periodic analysis, new network design
	Modify products to use standard processes	Use common capabilities for cost/availability	Costly to modify product and processes
	Contract for backup facilities	Committed back up assured	Cost for contract

"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
- UPS
  - Standardized processes enable work force flexibility
- 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, restarted 9-12-01
  - Redundancy added after '93 attack on World Trade Center
- USPS: Anthrax
  - Used excess capacity to shift processing to other sites
- Boston Scientific
  - Financial analysis indicated cash flow crunch
  - Set up redundant production facility, staff – ready & 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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Resilience via Flexibility & Redundancy

- Flexibility: prior investments in capabilities & options
  - Workforce trained to perform multiple tasks
  - Products designed to be easily reconfigured based on material and supplier selection
  - Production assets designed to be reconfigured to accommodate variability in demand
  - Provides benefit dealing with daily variations
- Redundancy: prior investments in assets
  - Inventory maintained throughout the supply chain, at suppliers, internally, finished goods inventory
  - Additional production capacity maintained beyond needs to serve known customer needs
  - Only provides benefit when assets are used

Sources: "SC Response Project Interim Report" by J. Rice, F. Caniato, Aug 8, 2003; Draft of SC Response Book project, Oct. 2004

Many Paths to Flexibility Through…

- Interchangeability
- Postponement
- Supply
- Distribution
- Flexibility culture

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

Many Paths to Flexibility Through…

- Interchangeability
  - Use standardized facilities
    - Intel 'Copy Exact' – same orientation to the sun….
  - Use standard parts
    - Common parts and platforms used at tech companies (Dell, Lucent), Lucent reduced platforms from 85→10
    - Single interface used by Southwest for pilots
  - Use standard processes
    - Helix Technologies reduced production process into many small steps that can be taught and performed quickly
    - Standard processes enable rapid response to disasters (UPS)
- Postponement
  - Delay customization of product
    - Benetton make greige sweaters, batch colors the final product
    - H-P makes standard printer & tailors for EU markets once demand surfaces

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

Many Paths to Flexibility Through…

- Supply
  - Contract with suppliers for different response rates (Jabil, Lucent)
  - Favorable relationship supports supplier collaboration in response to disaster (Toyota – Aisin fire)
- Distribution
  - Use distribution system to provide broad access to parts across entire network (Caterpillar)
  - Use make-to-order and direct distribution system to enable tailoring product sales to materials on hand (Dell)
- Flexibility culture
  - Make employees aware of risks & tradeoffs in decisions
  - Install early warning systems (Nokia)
  - Educate for awareness & train for response (Intel)
  - Distribute decision-making, open communications

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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

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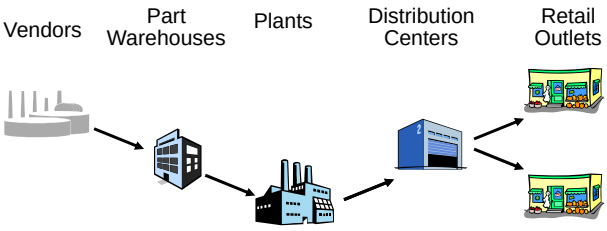
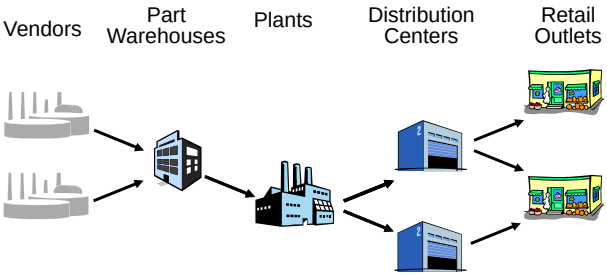
Adding Resilience to a Supply Chain



How would you add resilience to this supply chain?

Adding Resilience to a Supply Chain



Options include…..
- Adding back up supplier
- Adding additional inventory
- Add additional facility
- Choices on response time
- Buying options for additional capacity in your network….

The Japan Disaster and Supply Chain Impacts

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	Hitachi	Hitachi Automotive Systems	GM Engine Plant	General Motors
Product	**Sensor**	**Mass airflow sensor units**	Engines	Trucks & Cars
Location	Japan	Sawa/Ibaraki, Japan	Sawa/Ibaraki, Japan	Shreveport LA
	⇧ Factory damaged	⇧ Factory damaged	⇧ Part shortage; plant closed	⇧ Engine shortage; lines down

Hitachi airflow sensors affect Nissan, Ford, VW, Renault, GM.

Hitachi makes 60% of global supply of airflow sensors

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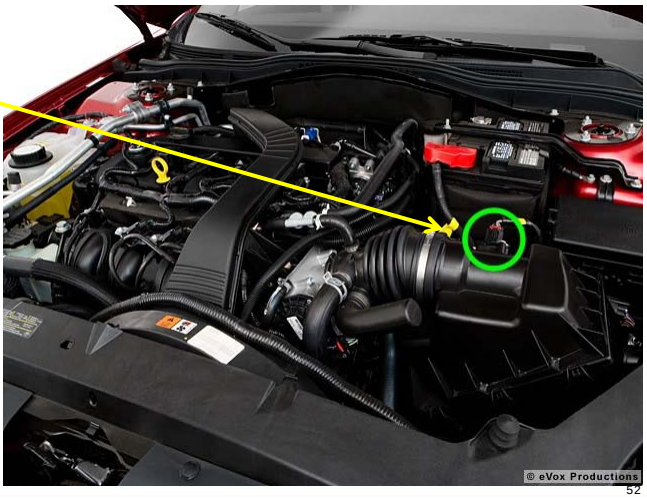
Hitachi airflow sensor in Mazda D23

$2 sensor in $90 airflow unit



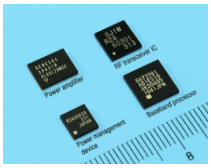
Tier 1-2-3 suppliers put GM (& others) at risk

Company	Renesas Electronics	Various	Auto OEMs
Product	**Microchip controllers**	Drive train	Trucks & cars
Location	Naka/Ibaraki, Japan	Various	Global assembly

Factory damaged

Part shortages

Assembly shortage; lines & plants down

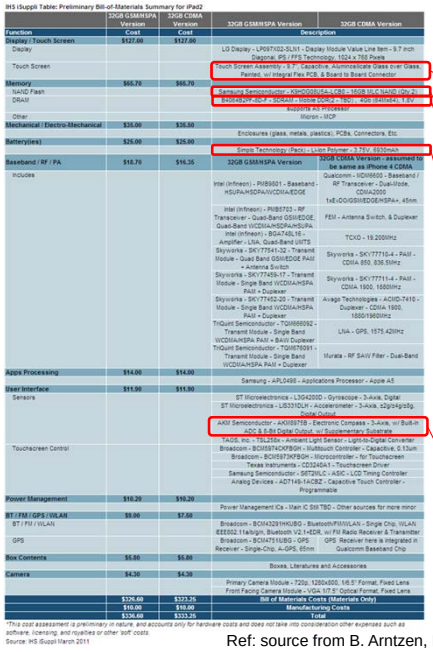


Renesas Electronics SP2531

Renesas makes 30% of global supply of microcontrollers, largest supplier

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

iPad2 Bill of Materials



IHS iSuppli Table: Preliminary Bill-of-Materials Summary for iPad2

Function	32GB GSM/HSPA Version Cost	32GB CDMA Version Cost	32GB GSM/HSPA Version	32GB CDMA Version
			Description	
Display / Touch Screen	$127.00	$127.00		
Display			LG Display - LP097X02-SLN1 - Display Module Value Line item - 9.7 inch Diagonal, IPS / FFS Technology, 1024 x 768 Pixels	
Touch Screen			Touch Screen Assembly - 9.7", Capacitive, Aluminosilicate Glass over Glass, Painted, w/ integral Flex PCB, & Board to Board Connector	
Memory	$65.70	$65.70		
NAND Flash			Samsung Semiconductor - KLMD2G5UFA-LCB0 - 16GB MLC NAND (Qty 2)	
DRAM			K4X4G82PF-BGCF - SDRAM - Mobile DDR2 - 78b0 - 4Gb (64Mx64) 1.8V	
Other			Supports A5 Processor Marvell - MCP	
Mechanical / Electro-Mechanical	$35.00	$35.50		
			Enclosures (glass, metals, plastics), PCBs, Connectors, Etc.	
Battery(ies)	$25.00	$25.00		
			Sanyo Technology -(Pack) - Li-ion Polymer - 3.7V - 6930mAh	
Baseband / RF / PA	$10.70	$16.35	32GB GSM/HSPA Version	32GB CDMA Version - assumed to be same as iPhone 4 CDMA
Includes			Intel (Infineon) - PMB9801 - Baseband - HSUPA/HSDPA/WCDMA/EDGE	Qualcomm - MDM9600 - Baseband / RF Transceiver - Dual-Mode, CDMA2000 1xEvDO/GSM/EDGE/HSDPA+, 45nm
			Intel (Infineon) - PMB5703 - RF Transceiver - Quad-Band GSM/EDGE Quad-Band WCDMA/HSDPA/HSUPA	FEM - Antenna Switch, & Duplexer
			Intel (Infineon) - BGA748L16 - Amplifier - LNA, Quad-Band UMTS	TCXO - 19.200MHz
			Skyworks - SKY77541-32 - Transmit Module - Quad Band GSM/EDGE PAM + Antenna Switch	Skyworks - SKY77710-4 - PAM - CDMA 850, 836.5MHz
			Skyworks - SKY77435-17 - Transmit Module - Single Band WCDMA/HSPA PAM + Duplexer	Skyworks - SKY77711-4 - PAM - CDMA 1900, 1880MHz
			Skyworks - SKY77452-20 - Transmit Module - Single Band WCDMA/HSPA PAM + Duplexer	Avago Technologies - ACMD-7410 - Duplexer - CDMA 1900, 1880/1960MHz
			TriQuint Semiconductor - TQM666092 - Transmit Module - Single Band WCDMA/HSPA PAM + Band Duplexer	LNA - GPS, 1575.42MHz
			TriQuint Semiconductor - TQM676091 - Transmit Module - Single Band WCDMA/HSPA PAM + Duplexer	Murata - RF SAW Filter - Dual-Band
Apps Processing	$14.00	$14.00		
			Samsung - APL0498 - Applications Processor - Apple A5	
User Interface	$11.90	$11.90		
Sensors			ST Microelectronics - L3G4200D - Gyroscope - 3-Axis, Digital ST Microelectronics - LIS331DLH - Accelerometer - 3-Axis, ±2g/±4g/±8g, Digital Output	
			AKM Semiconductor - AKI09791B - Electronic Compass - 3-Axis, w/ Built-in ADC & 8-Bit Digital Output, w/ Supplementary Substrate	
Touchscreen Control			TAOS, Inc. - TSL2581x - Ambient Light Sensor - Light-to-Digital Converter Broadcom - BCM59774KFBGH - Multitouch Controller - Capacitive, 0.13um Broadcom - BCM5973KFBGH - Microcontroller - for Touchscreen Texas Instruments - CD3240A1 - Touchscreen Driver Samsung Semiconductor - S6T2WLC - ASIC - LCD Timing Controller Analog Devices - ADT149-1ACBZ - Capacitive Touch Controller - Programmable	
Power Management	$10.20	$10.20		
			Power Management ICs - Main IC Still TBD - Other sources for more minor	
BT / FM / GPS / WLAN	$9.00	$7.60		
BT / FM / WLAN			Broadcom - BCM43291HKUBG - Bluetooth/FM/WLAN - Single Chip, WLAN IEEE802.11a/b/g/n, Bluetooth V2.1+EDR, w/ FM Radio Receiver & Transmitter	
GPS			Broadcom - BCM4751UBG - GPS Receiver - Single-Chip, A-GPS, 65nm	GPS Receiver here is integrated in Qualcomm Baseband Chip
Box Contents	$5.80	$5.80		
			Boxes, Literatures and Accessories	
Camera	$4.30	$4.30		
			Primary Camera Module - 720p, 1280x300, 1/6.5" Format, Fixed Lens Front Facing Camera Module - VGA 1/7.5" Optical Format, Fixed Lens	
	$326.60	$323.25	Bill of Materials Costs (Materials Only)	
	$10.00	$10.00	Manufacturing Costs	
	$336.60	$333.25	Total	

*This cost assessment is preliminary in nature, and accounts only for hardware costs and does not take into consideration other expenses such as software, licensing, and royalties or other 'soft' costs.
Source: IHS iSuppli March 2011

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)**

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

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

Electrotechno (Fukushima) makes ~50% of global BT resin

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

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

Kureha in Iwaki makes 70% of global supply of PVDF

New Awareness of Supplier Location & Share Risk

- Hitachi makes 60% of global supply of airflow sensors used by Nissan, Ford, VW, GM, etc. in Sawa/Ibaraki, Japan.
- Renesas makes 30% of global supply of microcontrollers for major auto OEMS, factory in Naka/Ibaraki, Japan
- Kureha makes 70% of global supply of PVDF used in iPad2, factory in Iwaki, Japan
- Electrotechno makes 50% of global supply of BT resin used in iPad2, factory in Fukushima, Japan
- These were known risks but not many were aware of exposure
  - Were companies aware of risk associated with concentrated supplier hubs? In Japan?
  - Were companies aware of the risk of high concentration of supply capacity in one to two suppliers? In Japan?

Considering the Japan disasters…

- What is new from this disruption?
  - 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

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What's going on here?

- Supply Chains are experiencing disruptions from known risks
  - We know about the risks now…..
  - For example, we are aware of the risks of tsunamis near nuclear power plants and the risks of supplier hubs
- There are many risks we are not aware of quite yet
  - But the risks are not fully evident….. Yet

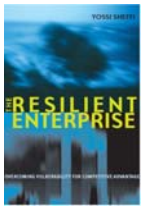
Emerging Trends & Risks that may impact SCs

- Concern over climate change, new environmental regulations
- Energy supply-demand mismatch
  - Fuel price volatility
- Supply constraints (rare earth & conflict minerals; regulation, market domination)
- Demographic shifts
  - Changing workforce in China, dissatisfaction growing
  - Population concentration in MegaCities
  - Aging population, worker shortage
- Emerging markets – new markets and supply sources
- Expanded use and vulnerability of electronic networks
  - Role of social media not known
- Global supply chain talent shortage
- Ongoing financial crises: EuroZone 2012, Greece, Spain, etc.

Learnings…..

- Companies proven to be more resilient than expected
- Supply Chain Risk Management program helps prepare
  - Assess sources of risk, identify Emerging Risks
- Apply Supply Chain Resilience principles to reduce impact
  - Prepare for outcomes (failure modes)
  - Business continuity planning
  - Design end-to-end network for resilience
- 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”

References & Thank you



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

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Learnings…..

- Companies proven to be more resilient than expected
- Supply Chain Risk Management program helps prepare
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Learnings…..

- Companies proven to be more resilient than expected
- Supply Chain Risk Management program helps prepare
  - Assess sources of risk, identify Emerging Risks
- Apply Supply Chain Resilience principles to reduce impact
  - Failure mode analysis & BCP preparing for outcomes
  - Design end-to-end network for resilience
- 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"

References & Thank you

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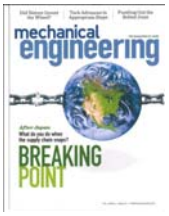

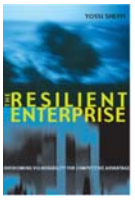

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