50 Years of Smart City
Impact of Logistics Ecosystems
on social economical and environmental development

Keynote Abstract

Professor Elizabeth Chang

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1-3 Nov 2015
Outline

1. Smart City – Where we are at
2. The enablers of Smart City – Innovation IT
3. The iconic representation of Smart City – Logistics Ecosystems
4. World Wide Research Issues & Our Work
5. Smart City – Where we are going – Hot topic
6. Conclusion
Iconic Representation of Smart City - Logistics

- Logistics is one of the keys to distinguish RICH and POOR countries, the Logistics GAP continues; [World Bank 2013].
- Logistics is the 3rd largest industry sector in developed economies, contributing up to 15%+ of GDP. Germany, annual turn-over 210B Euros, US: US$1.4 T; Emerging economic countries, China, US$1.4 T; [German House, NY 2013];
- Logistics is THE KEY for economic competitiveness, growth and poverty reduction, [World Bank Trade Logistics Survey 2013].
- Logistics is THE enabler in Domestic and International Trade Flows [World Bank 2013].
- Logistics is the Chief driver for top performance.
- Countries that pursue progressive logistics reforms, continue to improve their economic performance.
- Developed countries continue to build the INFRASTRUCTURE and LOGISTICS and in Green logistics [World Bank 2013].
- How good your logistics is, determines how good your economy will be ➔ How Smart your city will be
1. 50-100 years of effort - Smart City

From civilisation to modernization

Where we are at
100 years effort – Smart City

Civilization -------- > Urbanization -------- > Modernization -------- > Personification


100 years effort – Smart City

Smart City
Smart Phones
Smart Devices
Smart Transport

Sustainable City
Smart Grid
Smart Homes
Renewable Energy
Green Environment

Eco-City
Connectivity
Information Highway
Globalization
E-Commerce

Garden City
Traffic Light
Trains
Automobile

Electrical
Telecommunication
Community
Society
Population Re-direction
Economics

Infrastructure
Planning
Transportation

Electronics
Innovation ICT
Digitization

Smart Citizen
Health care
Well being
Quality of Life
Robots city
U City

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Innovation ICT
Digitization
2. The enabler

Innovation ICT underpinning Smart City
Enabler – Communication Infrastructure

Civilization -------- > Urbanization ---------- > Modernization -------- > Personification


Garden City

Eco-City

Mainframes

Radio and Telephones

PCs

Intelligent Machines

Sustainable City

Mobile Devices

Smart things

Smart City

U City

5G 2020 (?)

4G (LTE) 2010

3G (UMTS)

1G

Time
Enabler – Information Network

Civilization -------- > Urbanization > Modernization -------- > Personification


Garden City
Radio and Telephones
Mainframes
Eco-City
Sustainable City
Intelligent Machines
Mobile Devices
Smart things
Smart City
U City

Computers
LAN
WAN
INTERNET
WIFI
IOT
CPS
Enabler – Embedded Systems

Modernization

1890
1920
1940
1960
1980
2000
2010
2020

Time, Speed, Space, Heterogeneity

CPU
Parallel
Transporter
GPU

1000s core
Enabler – Big Data Management

Mobility, Flexibility, Simplicity, Personalised & Cognitive UX

- Dynamic Data Ecosystems
- Data lakes, data farms
- Mobilised DS BI
- On-Demand DS BI
- Geo-Mobile enabled BI
- Augmented reality for BI
- Hybrid Clouds
- Open Source Ecosystems
- Smart Digital Enterprises
- Cyber and mobile security
- Cognitive UX
Iconic Representation of Smart City - Logistics
Smart City
The world since mid 2000s
Smart Grid

The No.1 successful evidence and RoI
Smart Transportation
The No.2 successful evidence and RoI

http://connectedcarexpo.com/smart-transportation-innovation-coalition-stic/

London Airport 2013
Smart Home
The world effort since early 2010s
Smart Manufacturing
The world effort since 1980s
Smart Medicare
The world effort Since 2000s

Robotic surgery and remote operation
Defence Modernization

5000 years of history, 2000BC vs 2000 AC, People and Technology
3. Logistics ecosystems
Ecosystem inspired Computing

Key features
- Self organization
- Self sustain
- Dynamic Architectures
- Temporary coalition
- Mutual benefit
Logistics

- Logistics is about movement of people, goods and services to the right place, at the right time, with the right people and material handling.
Trade Logistics=SC; Logistics Providers = Transport Logistics Operators = Supply Chain Services Specialist. Concepts differences. Logistics: horizontal; SC: Vertical. SC: inventory replenishment of goods; Logistics: transporting goods, & people & services. SC: 90% by volume are materials/semi-products, 10% are consumer goods; 40% Cargo Goods by Value are transported by Air. The more the trade, the more services, more jobs and better economy.

Time, JIT, QoS, Security, Safety, Heterogeneity, Optimisation, Efficiency, Productivity
Commercial vs Defence Logistics

Top 10 *Similarities*

Top 10 *Differences*
Commercial vs Defence Logistics

**Similarities**

**Commercial Logistics and Defence Logistics**

1. **Requirement** – place, time, space, cost, quality, quantity, handling, …definition
2. **Model** – Joint partnership, networked of operators and operations
3. **Intelligence** – Data & Information
4. **Tools** - Use of facilities, infrastructure, resources, technologies
5. **Services & Operations** – (WH, Distri…)
6. **Mode of Op** - air, sea, land, cyber, space
7. **Fuel** – lower the cost, sustainable
8. **Performance measures** - productivity, efficiency, optimisation, cost-benefit
9. **Environment** – complex, competitive, uncertainty, dynamic, un-predictable, crowded, connected, collective, constrained
10. **Attacks** – deny, corruption, interruption, disruption, security, safety, trust, risk
## Commercial vs Defence Logistics

### Differences

<table>
<thead>
<tr>
<th><strong>Commercial Logistics</strong></th>
<th><strong>Defence Logistics</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Purpose</strong>-business growth, cut the cost, increase revenue</td>
<td><strong>1. Purpose</strong>-enable capability, agility, sustainment</td>
</tr>
<tr>
<td><strong>2. Objectives</strong> – bottom-line, customers</td>
<td><strong>2. Objectives</strong> - save lives, win the war</td>
</tr>
<tr>
<td><strong>4. Focus</strong> - manufacturers and trade, supply chain</td>
<td><strong>4. Focus</strong> - maintenance, sustainment, wind-up operations</td>
</tr>
<tr>
<td><strong>5. Supply Chain</strong> - value Chain</td>
<td><strong>5. Supply Chain</strong> – chain of supply</td>
</tr>
<tr>
<td><strong>6. Asset</strong> - someone else asset, standards and automation</td>
<td><strong>6. Asset</strong> –its own asset, safety, reliability, availability</td>
</tr>
<tr>
<td><strong>7. Stock</strong> – minimum</td>
<td><strong>7. Stock</strong> – maximum</td>
</tr>
<tr>
<td><strong>9. Providers</strong> – partners, alliances, consortium</td>
<td><strong>9. Providers</strong> - Coalitions forces, integrated services, Defence + civilian contracts</td>
</tr>
<tr>
<td><strong>10. Situation</strong> - harmless</td>
<td><strong>10. Situation</strong> – dangerous, violent, lethal</td>
</tr>
</tbody>
</table>
## Difference between the three types of Logistics

<table>
<thead>
<tr>
<th></th>
<th>Business</th>
<th>Humanitarian</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal</strong></td>
<td>Customer, cost (profit) and time</td>
<td>Alleviate the suffering of vulnerable people and minimize the deprivation costs</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td>Customer demand</td>
<td>Vulnerability needs</td>
</tr>
<tr>
<td><strong>Pattern of occurrence</strong></td>
<td>Repetitive – less uncertainty</td>
<td>Unpredictable – high uncertainty</td>
</tr>
<tr>
<td><strong>Demand for resources</strong></td>
<td>Less fluctuations</td>
<td>High fluctuations</td>
</tr>
<tr>
<td><strong>Competition</strong></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>What is at stake?</strong></td>
<td>Profits, reputation, business</td>
<td>Life, reputation, suffering</td>
</tr>
</tbody>
</table>

4. World wide research
   Issues and our work
World Needs Logistics
Economies, Humanity, Society

Defence
Medicare
Agriculture
Manufacture
Dairy
Emergency
Humanitarian Support
Jobs
Food
Empty
USA Trade Logistics Will Triple in 20 yrs
Example USA - the Economic Superpower

Shipping containers and the growth of global trade will double in the next decade [worldpress May 30, 2013 by Marty Lariviere]

[Graph showing increased container traffic and revenue growth from 1999 to 2030]

[Map showing over 70% of imports passing through other markets and ports handling one third of all container traffic in U.S. and nearly two-thirds of containers from Asia]

Average Wage & Salary for Typical Blue Collar Sectors in Southern California, 2003

Blue Ribbon Panel of Transportation Experts Steve Adams, City of Riverside, CA Thursday, August 15, 2013
World Trade Logistics Will Triple in 20 yrs
Developed and Emerging Countries

Germany’s foreign trade 2012: export +3.4%; import +0.7%

In 2012 Germany exported goods worth 1,097.3 billion euro and imported goods worth 969.1 billion euro. That means that Germany’s exports increased by 3.4% and its imports by 0.7% in 2012 compared with 2011.

In 2012 the foreign trade balance closed with a surplus of 188.3 billion euro. In 2011 the foreign trade balance surplus amounted to +158.7 billion euro.

Imports and exports of e-bikes, 2012

Number of bicycles

Imports
People’s Rep. of China: 19,300
Hungary: 29,900
Japan: 29,300

Exports
Netherlands: 59,600
Austria: 18,600
Switzerland: 7,500

China’s trade surplus (2002-2011)

Unit: US$100 million

Balance of Trade of China (billion USD)

Exports Imports

China’s growing share of U.S. trade deficit, 2000 - May 2009 (non-oil goods)

Trade surplus Imports & Exports

Australia Trade Logistics Will Triple in 20 yrs
Source: Port Handbooks 2011
Global Issues

1. Homeland Security
2. Congestion (Roads & Ports)
3. Collaborative Logistics
4. Carbon Footprint
5. Big Data Management
Global Issue 1 – Homeland Security

Two key Areas

Regulations: Homeland security; National security measures; different countries, different priority; my way is the best way, mutual recognition; Information sharing between Governments; between Logistics and SC providers;

Technologies: X-Ray, Sniffer, CT-Scan facilities, Goods Tracking, Container tracking; Material tracking; RFID; Sensors; Facility scattered, no way to screen all; no methods to track beyond borders, information and data interoperability.
Research into Transport Security

Our Work

1. **Ambient Security**, Logistics Network and Inter-modal; ARC LP0349100, 2003-2006; PATREC, 2003-2007; StatOilHydro 2009

2. **Trust** - ARC LP 0560346, 2005-2008


Outcomes

- 5 grants obtained
- 5 preliminary patents filed
- 5 Post-Docs supervised
- 6 Keynotes delivered
- 12 PhD theses completion
- 3 Books Co-Aauthored
- 30+ Tier 1 Journal Papers
- over 200 Scientific Papers
Inter-modal Security

Security help identify and measure the Logistics operation security and vulnerability, monitoring and control of malicious activities, through IT. It also detects the attacks, fraud, and intrusion etc.

Technology underpinning the above are:

- RFID tamper detection
- Logistics Network Security
- Supply Chain Security
- Barcode Watermarking
- Information Security
Logistics Network Attack is described as operations to disrupt, deny, degrade or destroy logistics communication data within nodes, hub and networks. Logistics Network is widely shared, it is easier and vulnerable against attack such as Eavesdropping and Traffic Analysis etc.
Trust

Trust is defined as the belief the trusting agent has in the trusted agent’s willingness and capability to deliver a mutually agreed service in a given context and in a given time slot.

- Trust
- Definitions of Trust
- Trustworthiness
- Reputation
- Definition of Reputation
- Ontology and Trust
- Trust Relationships
- Reputation Relationships
- Recommendation Relationships
- Third Party Relationship
- Reputation Query Relationships
- Reputation for Trustworthiness Prediction
- Business Intelligence
**Risk**

- **Risk** evaluation involves the determination the probability of failure and the consequences of failure.

- The possible Risk is a combination of:
  - The probability of failure of the business activity
  - The consequences of failure, and
  - The financial, human or resources loss probability.

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**Determining Risks in an Interaction**

- The expected behavior (ProCom) is determined by:

  \[
  \text{ProCom}_{\text{Interaction}} = \sum_{i=1}^{n} (1 \times \text{Accu}_{\text{Criterion}} \times \text{Sig}_{\text{Criterion}})
  \]

  where the value of 1 represents the degree of fulfillment of the criterion according to the expected behavior.

- The level of un-commitment in the interaction (Failure) is found by

  \[
  \text{Failure}_{\text{Interaction}} = \frac{\text{Pr}_{\text{oCom}} - \text{Assess}_{\text{oCom}}}{\text{Pr}_{\text{oCom}}} \times 100
  \]

- The level of un-commitment can then be mapped to the Failure scale to determine the actual Failure Level (Actual Failure Level):
Future Work

• Real Time Information Mining and Sharing for Ambient Security
• Building and maintaining the trust; and predicting trustworthiness of Partners; Trust relationship mining,
• Cascading failures arising from dependencies, Value at Risk models,
• Adoption in governments, extended enterprises and consortium logistics.
• Adoption in Defence Force. If we have logistics failure, it could result in high casualties, and high consequences.
Global Issue 2 – Congestion on Road

California, the petrol wasted in congestion/week could allow UA to circle the world 10 trips/week.

Creating more lanes?, UCB PATH
Congestion is a Logistics Issue

It is NOT the infrastructure itself or who built it, who use it, who planned it, who paid for it. Civil Engineers, Businesses, Governments or General public are not accountable or responsible for the congestion. The lack of Logistics professionals, their participation in planning and design of the logistics infrastructure are the key to the problem.

2 key Areas

• **Existing infrastructure**: Optimising of Infrastructure and Resources; **Our aim is to build Virtual Logistics Infrastructure for better use of physical infrastructure through** Internet Communication, WSN, Google Traffic, iApp, GPS, etc.. Traffic conditions prediction, routings and routes recommendations.

• **New infrastructure**: solve the problem, not just shift the problem, or not solve the problem. Based on demand, purpose of transportation: for work, business, to where, ... requirement for the roads, ports, distribution, trade demand, population growth, budget; urban planning and regulations .... through **Complex System Modelling and Simulation**(Not 4 vars, but 20-100 vars, simulations )
Optimising Existing infrastructure through Virtual Infrastructure for better use of physical infrastructure
Our work – Traffic Prediction and Management

ARC LP 0990610, 2009-2012 Main Road WA

Real Time Traffic Prediction using Wireless Sensor Networks & Data Mining

Aims:
- Traffic flow Prediction in motorways and arterial roads
- Traffic Congestion Forecasting and Management through Real-time data mining

Challenges:
- Smart system to predict traffic on existing infrastructure
- Traffic prediction models on arterial roads
- Manage congestion in real-time

Outcome:
- Traffic prediction and simulation System based on historical data and real time sampled data
- Develop new prediction algorithms
- Enable management congestion in real-time
The amount of input patterns captured by the on-road sensors is large, not all input patterns are useful to predict the future traffic flow. The inclusion of useless input will mislead the neural network model prediction.

Taguchi method, a robust and systematic optimization approach for designing reliable and high-quality models, Case Study, develop a short-term traffic flow predictor based on past traffic flow data captured by on-road sensors located on a Western Australia freeway.
Hybrid exponential smoothing and Neural Network algorithm for short-term traffic flow forecasting

The mean relative absolute error obtained by the neural network (with exponential smoothing) is 4.5648% and the accuracy is 95.4351%.
Real-Time Traffic Flow Visualisation
Contribution of Research

• Compare with Google Traffic Systems


Optimising Existing infrastructure through Virtual Infrastructure for better use of physical infrastructure

Port
Global Issue 2 – Congestion in Ports

- truck queuing and bottlenecks in & out
- poor productivity,
- poor interoperability
- no shared responsibility
- no collaborative workflow
Port Congestion
The Australian, 7 Jan 2011

• “.bottlenecks at Australian ports increased the cost of doing business and reduce the competitiveness of Australian Businesses.” Stephen Cartwright, Chief Executive, NSW Business Chamber.

• “Rail and Road lines to ports were too often incapable of servicing the resources boom”. Anthony Albanese, Minister of Infrastructure.

• “Australia’s ports would not be able to handle growing demand without a national coordinated approach”. Paddy Crumlin, Maritime Australia

• “.Drivers are spending an average of 22 hours a week unpaid waiting in line to load and unload containers in the port”. Tony Sheldon, National secretary, Transport workers. The Australian

• Queues, either by ships at sea or trucks and rail on the landside can have significant impact on the national economy”. Paddy Crumlin, Maritime Australia
(1) The VBS is at the centre of all the recorded complaints

From Stevedore’s view, too many carriers using VBS; From Transporters’ view, it is VBS.

(2) 95% of SMEs,
(3) Road carriers have no control of time, and it costs them money, with extra journey, or waiting time, fines for lateness
(4) DP World (Stevedore) lost $1million in Federal court 2010
(5) Jayde Logistics loss $260,000 in fines to stevedores in one year
Existing and Future Work on Smart Port

Through virtual infrastructure to support port, rail and road carriers communication, seamless integration with the cyber-physical infrastructure to permit real-time congestion management.

Information Integration
VBS, TCS, EPBS

- VBS and TCS Integration, scheduling & reporting
- VBS and pre-gate operation and workflow
- VBS and Marshalling area, RFID, tagging and pre-gate operation.
- For Stevedores, Road carriers, and Port Authorities

Automated Marshalling Area Pre-gate Operations

- Co-ordinate stevedore, warehouse, empty container part, trucks,
- Provide expected waiting time,
- Wired-Wireless technology,
- GPRS, Broadcast, Mobile, LCDs
- Hybrid technologies.

Container on-demand Booking

Container on-demand Booking System, integrated with Road Transport Portal, VBS and TCS
Our Work on Complex System Simulation

“..Infrastructure planning has been developed and implemented in isolation, resulting in different approaches in each state, neither sensible nor efficient”. Anthony Albanese, The Australia Jan 2011.

“.. each operate under its own board of directors, required by local law to operate trade with care to the environment”. “..Led to layers of red tape and regulatory overlap, and ad-hoc management” (Hon Troy Buswell MLA, Minister for Transport, WA, Ports Handbooks WA 2010);

“The processes have become more complex, more expensive and more capricious in their administration”. David Anderson, Chief Executive, Port Australia, The Australian, 7 Jan 2011.

We simulate heterogeneous policy changes, its impact on the congestion; we simulate heterogeneous partners cooperation and how that impact on productivity, congestion, ... We simulate business and population or throughput growth, how that impact on congestion....
Our Work on Complex System Modelling

- Self-regulating networks
  - Agent-oriented Self-regulating systems
  - Dynamic graph Single/Multiple level deep dynamics approaches
    - Multi-level supply chain dynamics
    - Game Theory and group dynamics
    - Swarm intelligence
    - Spatial Temporal model
- Performance analysis
  - Chaos theory,
  - dynamic optimisation,
- fuzzy-analysis,
- Perturbation theory
- Uncertainty
- Dynamic theory
- Probability
- The TLC Model (Patent filed)
Future Work – Next Generation of Congestion Management

- Harmonising urban and regional logistics infrastructure development for long term transit and congestion management; embarking consortium logistics and heterogeneous partnerships to work together to develop plans, strategies, regulations, and technical standards for strong economic development, the national Agenda.
- **Bridge across different standards**, national and international;
- **Bridge across different state policies**, jurisdictions, red tape;
- **Bridge across silo based operations** (Gov, Industry & R&D); to foster Inter-disciplinary Infrastructure development;
- **Bridge across multi-disciplinary R&D**, Engineering, Business and Social Science.

- **Logistics Professionals are the key for solving the problem of Congestion.**
Gartner Report - the introduction of collaborative logistic systems can achieve a 500% return on investment [Gartner 2002]

Australian Logistics Council (ALC) estimates that every 1% increase in efficiency will save Australia around $1.5 billion [2011].

Transport operators could save 10% to 30% through optimisation of road networks and fleet resources including automated routes. (Andrew Verden, Intelligent Fleet Logistics 2011)

- Heterogeneous and distributed Partners or consortium logistics, geography, ownership and operation;
- MNC (10% -) vs SMEs (90%)
- Operation beyond its own region operation
- Inter-modal transportation, domestics trade logistics 4-6 inter-change; International 6-20+
- Shared responsibility and accountability
- Segment Pricing

Productivity addressed within company and between companies.

Logistics Performance strongly influences between company productivity.
Seamless integration between heterogeneous partners, consortium logistics and operations.

 Permit good Goods Track n Trace around the world through the logistics network, does not matter who handling the goods, who's company the customer belongs to, ...

 Tracking of operations, document, RFID and Bar Code Tracking, QoS, performance...

 Truck Security, Trust, Risk, Security, SLA
Contribution

• Seamless Real-time information sharing; cooperation management of SME Logistics Providers through e-Hub (a Virtual Logistics Hub);
• track and trace of vehicles, goods and services across regions and beyond borders; enabling technologies from service-oriented approach, data exchange XML to real-time data analytics and data mining.
• delivered 11 keynote papers; supervised 10 PhD theses to completion, 6 Masters, 2 Post-docs: and produced over 100 publications.
Future Work – Ad-Hoc Virtual Collaborative Logistics Hub for Defence Logistics, Emergency and Humanitarian Response

- Quickly assemble logistics network, provide intelligent environment, resource and local support information for Defence; emergency recovery and humanitarian relief; it also can provides Security, Trust of Logistics and Supply Chain providers; and Risk.

- Enabling Technology: capability for intelligent use of Infrastructure, environment and resources. Real time data and text mining. Enabled information sharing, transparency, control and intelligence.
Australia’s net Greenhouse emissions totaled 576 million tones of carbon dioxide equivalent.

Global Issue 4 – Carbon Emission

Emissions per Capita

Transport emissions per capita
(source: IEA 2009, including electricity)

<table>
<thead>
<tr>
<th>Country</th>
<th>Tonnage CO2e per capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luxembourg</td>
<td>13.5</td>
</tr>
<tr>
<td>Gibraltar</td>
<td>10.3</td>
</tr>
<tr>
<td>Qatar</td>
<td>7.0</td>
</tr>
<tr>
<td>Netherlands Antilles</td>
<td>6.7</td>
</tr>
<tr>
<td>United States</td>
<td>6.0</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>5.6</td>
</tr>
<tr>
<td>Canada</td>
<td>5.0</td>
</tr>
<tr>
<td>Australia</td>
<td>3.8</td>
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<tr>
<td>Saudi Arabia</td>
<td>3.7</td>
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<tr>
<td>Bahrain</td>
<td>3.7</td>
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<tr>
<td>Kuwait</td>
<td>3.6</td>
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<tr>
<td>New Zealand</td>
<td>3.5</td>
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<tr>
<td>Ireland</td>
<td>3.3</td>
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<td>Norway</td>
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<td>Iceland</td>
<td>3.0</td>
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<tr>
<td>Austria</td>
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<tr>
<td>Brunei Darussalam</td>
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<tr>
<td>Spain</td>
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<td>Finland</td>
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<td>Denmark</td>
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<td>Slovenia</td>
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<td>Netherlands</td>
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<td>Italy</td>
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<td>France</td>
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<td>Greece</td>
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<td>Czech Republic</td>
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<tr>
<td>Japan</td>
<td>1.9</td>
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<td>Germany</td>
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<td>Estonia</td>
<td>1.9</td>
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<tr>
<td>Korea</td>
<td>1.9</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>1.8</td>
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</tbody>
</table>

2 challenges:
1. Price on Carbon
2. Measure and Reduce
Electricity and Transportation are major causes for Emissions in Australia and working against Smart City.

- Australian target 300,037 metric tons, current levels 367,000 [2010]
- 30% penalty if emissions targets not achieved by 2020

<table>
<thead>
<tr>
<th></th>
<th>Public electricity</th>
<th>Other industries</th>
<th>Manufacturing industries</th>
<th>Transportation</th>
<th>Residential</th>
<th>Agri. sector</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>World</strong></td>
<td>37.2%</td>
<td>4.7%</td>
<td>16.8%</td>
<td>18.4%</td>
<td>7.8%</td>
<td>5.6%</td>
</tr>
<tr>
<td><strong>Developed countries</strong></td>
<td>41.0%</td>
<td>4.5%</td>
<td>15.0%</td>
<td>23.6 %</td>
<td>8.6%</td>
<td>6.1%</td>
</tr>
<tr>
<td><strong>Developing countries</strong></td>
<td>37.6%</td>
<td>6.6%</td>
<td>24.5%</td>
<td>16.4 %</td>
<td>7.4%</td>
<td>5.8%</td>
</tr>
<tr>
<td><strong>Australia</strong></td>
<td><strong>60.2%</strong></td>
<td><strong>5.1%</strong></td>
<td><strong>14.8%</strong></td>
<td><strong>21.2 %</strong></td>
<td><strong>2.0%</strong></td>
<td><strong>2.3%</strong></td>
</tr>
<tr>
<td><strong>Europe</strong></td>
<td>40.2%</td>
<td>4.2%</td>
<td>16.9%</td>
<td>19.2 %</td>
<td>12.1%</td>
<td>6.0%</td>
</tr>
</tbody>
</table>

Source: International Energy Agency (IEA)
Australia’s Transport CO2

76% road transport
12% air traffic
10% shipping
2% rail traffic

Australia's transport CO2-e emissions 2006

<table>
<thead>
<tr>
<th>Emissions (Mt CO2-e)</th>
<th>Per cent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil aviation</td>
<td>6.1</td>
</tr>
<tr>
<td>Road transportation</td>
<td>68.9</td>
</tr>
<tr>
<td>Railways</td>
<td>1.9</td>
</tr>
<tr>
<td>Navigation (domestic)</td>
<td>2.2</td>
</tr>
<tr>
<td>Other transportation</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>79.1</strong></td>
</tr>
</tbody>
</table>

Pollution increase, impact on health, environment and businesses
Price on Carbon, emission trading scheme, cost Logistics up

Costs of five health impacts attributed to smog pollution tops $521 million per year

Economic costs attributed to school absences, restricted activity days for adults, respiratory hospitalizations and asthma Emergency Room visits due to smog pollution. Other smog-related effects are not included in this tally.

Grams of CO2 per km per person

- Hummer H3: 270
- Ford Territory: 245
- Holden Commodore: 210
- Ford Falcon: 209
- Toyota Camry 4 cyl: 172
- Lexus hybrid: 152
- Toyota Corolla: 143
- Holden Astra: 141
- Proposed Hybrid Camry: 115
- Mini Cooper S: 114
- Fiat Punto: 110
- Toyota Prius: 87
- Tram: 52
- Diesel bus: 22
- Ethanol bus: 19
- Electric train: 14
- Diesel train (V/Line): 8
Alternative Fuel for Green Energy

Oil production forecast

IEA forecast of global all-oil production, million barrels per day

- Natural gas liquids
- Non-conventional oil
- Crude oil - additional enhanced oil recovery
- Crude oil - fields yet to be found
- Crude oil - fields yet to be developed
- Crude oil - currently producing fields

SOURCE: IEA
Our work

- **capture & measure** emissions in real time from different sources
- **analyse** emissions information
- **control & reduce** emissions

Underlying Technologies

1. Wireless Sensor Node development for measuring Emissions,
2. $\text{CO}_2$ sensor enabled wireless node, FPGA enabled processing,
3. GSM/GPRS enabled real time communication
4. Real Time Data Mining and Behaviour Mining

CO2 Sensors: CO2 transmitters targeting indoor air quality and energy conservation applications.

Air Test Technologies, Measures: 0-2,000 ppm CO2 (0-5000 ppm range also available)

Filter based design used to reduce the CO2 emissions

Carbo QC: Accurate and traceable CO2 measurement. Data memory for measurements

Air Quality Monitor: Measures carbon dioxide, temperature and humidity. It has 4-20mA analog output or optional digital display.
Smart Fleet Camp Project is funded by Fleetwood Int Corp and Australian Research Council. This project addresses the issues of high cost and high consumption of energy in mining Industries. We develop a world class unique wireless, infrared, sensor monitoring system. This system is going to save hundreds of thousand dollars per year from Industry and will help the world to cope with the energy shortages.
Future Work – Green Logistics

- Real time measures of Green Energy, Fuel performance and CO2 Emissions to provide evidence for Green Logistics, reduction in carbon footprint, reduce environmental pollutions, reduce cost; enabled by underlying technology of Real Time Data Sampling, Cyber-Physical Systems, Data mining and system interoperability.

- Infrastructures in Supply Chain for Domestic Usage, refuelling Stations, Cryogen Tanks Development, Storage Facilities, Engine Conversion enabled by joint effort of industry leaders in Logistics, Gas Technologies and Supply Chain.
Changing nature of logistics – powered by information!!!

- real time monitoring black box
- GPS vehicle tracking systems and location tracking
- sensors and WSN for tracking and monitor materials and containers
- video surveillance environmental monitoring and incident analysis
- driver fatigue monitoring and alerts

Challenges:

- No conjoint data management;
- no conjoint data mining.
- Interoperability, integration between Silo based systems.

Smart Information Use

- security, trust, risk,
- productivity,
- fuel performance,
- CO2 emission,
- vehicle performance;
- Material handling;
- weights

Example: 157 Tables in Container Material Tracking, only 10-15 are used, ~10% usage
Data Warehouses are out of date
Data Marts have no future
Interoperability should be forgotten

= Essential Core for BI before 2010
They did not contribute to BI Success
Simply

1. BA and BI is a Tool
2. It applies a set of algorithms or methods to a set of data of your choice; and
3. generate possible useful information, and
4. Require iterative processes to generate sound cases for any decision making.
Data for BI

Business Growing
Data Growing
Databases Growing
Extended Enterprises
Alliances, Partnerships etc..

The source of the data, information and knowledge are both internal organizationally collected as well as externally supplied by partners, customers or third parties as a result of their own choice.
Data Warehouses for BI

• Data Warehouses are constructed by experts,
• They followed the best practice and answer most business questions
• For middle and top end managers, who needed to answer the business questions
Data Warehouses and/or Data Mart for BI

• Original **Data Mart** is the access layer of the data warehouse environment that is used to get data out to the users.

• Data Marts could be a subset of the Data Warehouse (if DW is existing)

• Data Marts contains conformed dimensions or materialised views

• Data marts improve end-user response time
Data Warehouses and BI

**DW**
- Data are extracted from operational databases using ETL,
- Data are cleansed, transferred, sorted, organized, and
- Data are then loaded into a data warehouses and
- Some times in conjunction with Data marts
- made available to end users
**Data Warehouses and BI — Iterative process**

**BI is a Tool** that applies a set of algorithms or methods to a set of data of your choice and generate possible useful information and such iterative processes could generate sound cases for any decision making.

**DW is essential core for BI, but not the key to BI success!** Might be the key to BI failure?

E. Chang, Plenary Talk, (c) Business Analytics, Kuala Lumpur, 28-29 Jan 2008
DW, DM and Data Lake for BI

- **Data lakes** are data dumps
- Data stored in original native format, not formatting or merging or integration, until when you need them
- It is the end of data silos era
- Single source of truth
- Bring agility to the enterprise
- Major Hadoop vendors are still working on it
Today In-Memory DB (since 2010)

Multi-core processes, massive parallel 10x faster

Compression tech 9x

Logging and back up Persistent DB

High Speed, Real Time (Analytics, Application and platform), Structured and Unstructured Data, 100% ACID compliant, 1st release Nov 2010

http://go.sap.com
Today In-Memory DB

1TB RAM, support 5 TB uncompressed Data 2010
8 TB RAM, support 40 TB uncompressed Data 2011
100 TB RAM, support 500 TB uncompressed Data 2012

(Hardware/super computers, IBM, HP, Dell, NEC etc, ..)

Today most large public sectors: over 3000 employees…. With duplicate 20-50 TB
Today large private sector: over 10,000 employee 100TB-500TB …
DW is dead, DM has no future!
Interoperability should be forgotten!

1. Inflexible – build by Expert
2. Multiple Data Marts – no single source of truth
3. Require Expert to operate
4. Not for managers or end-users (of BI)
5. Expensive and low RoI
6. Vendor in control – Data and Data Warehouse
7. Security, privacy, trust
8. Data procurement is difficult
Issue 1: Inflexible – Build by Expert

- Expensive One-off service, build once, last once.
- Don’t adapt to the changes of business processes and policies.
- Requires DW and DM to change, when the business or processes are changed, but only Expert can do the job.
- Long lead time to get the change done
- Overtime, the one-off DW/DM only capture or use in-complete data, not the total data set
- hinder the org or enterprise development
Issue 2: Multiple Data Marts

— no single source of truth
**Issue 3: Require Expert to operate**

- BI expert, Data expert, DB expert

- **Real DW/BI Operations requires**
  
  \[
  \text{DW + Algorithms/BA + Business Expert + Data Expert} \]

  \[\Rightarrow \text{which data + which formulae + business knowledge + good report developers + Interpretation} \]

  \[\Rightarrow \text{leads to answer specific business question(s)} \]

- DW + BA/BI ≠ Decisions

- Require expert to interpret (missive tables, load of data, add mental load)

- Require expert to change

- Expert ≠ Domain Expert ≠ Decision making
Issue 4: Not for managers or end-users

- Plenty tables and graphs, no decisions, no decision support, no recommendations

- BI is part of every employee, and current systems are too complex for managers (low, middle, head or executives)
- Not for end users

- Expert ≠ Decision making
- What we have now ≠ what we should do now

- Require DSS as part of automated DW/BI
Issue 5: Expensive and low RoI

- Common best practice = one size fit all ≠ not fit for purpose or domain specific => cost for customization
- Separation of concerns : DW + BA/BI + Visualisation Tools = 3+ systems => More cost
- Expert Employees BI/Data/DB Experts => add cost
Issue 6: Vendor in control – Data and Data Warehouse

- My server, your data = Vendor in control
- Who owns my data = Who owns my money
- Vendors are not sharing between vendors systems = Vendors own the data they manage
- Vendor are in control of usages and real traffics, itemised clicks, application logs, web logs, interface logs, database logs
- Capture usages, capture the decision support process = > Organization knowledge/Asset
Issue 7: Security, privacy, trust

• My data, your data, who’s data, where is the data
• Single source of truth?
• Data manipulation => reports conflict/contradiction
• Pollution control, who’s job
• Trust and risks
• Enterprise Data/Secret Security => only apply to its employees, not apply to vendors => put org in risk
Issue 8: Data procurement is difficult

• Vendors are not sharing the data between Vendors or 3rd parties
• Vendors are software orientation, own agenda, not all in the interest of your org performance or cost
• Create data procurement issues, => lead to incomplete data set => more decisions => long lead time to aggregate the reports.
• Inefficiency in using the data, poor decision support, poor performance => poor org performance
DW & BI Adoption Challenges

1. Inflexible – build by Expert
2. Multiple Data Marts – no single source of truth
3. Require Expert to operate
4. Not for managers or end-users (of BI)
5. Expensive, low RoI
6. Vendor in control – Data and Data Warehouse
   Security, privacy, trust
7. Data procurement is difficult

Failure to address these issues in the next 10 years, Big Data Management will not be successful
Dynamic Data EcoSystems

– DES
Top 8 Challenges and Dynamic Data Mart

Top 8 Challenges
1. Inflexible – build by Expert
2. Multiple Data Marts – no single source of truth
3. Require Expert to operate
4. Not for managers or end-users (of BI)
5. Expensive and low RoI
6. Vendor in control – Data and Data Warehouse
7. Security, privacy, trust
8. Data procurement is difficult

Dynamic Data Mart solution
For existing Enterprises who has many structured DBs

Existing/old New enterprises-
stuck with existing systems

Guided Analytics

Self Service BI

Mobilised DS BI

New enterprises
Go to clouds
The heart of DES is

Data Supply – Decision Demand Chain

- Capability
- Acquisition
- Sustainment
- Disposal

- Priority
- Item
- Maintenance
- Users
- Inventory
- RI
- Repair history
- Repairers
- Repair decision
- Cost and Lead time
- Budget
- Process
- RI Previsions
- Sustainment plan

Air
Land
Sea
Joint

Joint Data Supply – Decision Demand Chain
Data Supply – Decision Demand Chain

- Views
- Data Marshalling
- Representation
- Drop/Create
- Data Mining
- Reconciliation
- Data Meshing
- Recommendation
- Acquisition
- Capability
- Disposal
- Priority
- Item
- Repair history
- Repair deciders
- Design/Repair
- Cost and Lead
- Budget
- Air
- Sea
- Joint

3M + 3R
User Behaviours Mining, Log Mining and Usage Mining for Data Supply Chain

• We track the logs from a configured user’s windows. The dashboard shows number of areas, each area we track number of sessions, number of distinct users, peak concurrent sessions, cumulative duration of sessions and a user ratio.

• It is a forward and backward loop that carries out 3M and 3R functions, that provide forward data supply chain and backward demand Chain
3M – Data Supply Chain

• **Data Mining**: mining the application log, that mines the user’s behaviours/user’s decision makings and usage rates of each view and window widgets clicks, providing usage rates.

• **Data Marshalling**: for low usage rate views, we collect the data set, put them on Rest or probation area, evaluate use and reuse.

• **Data Meshing**: based on the data mining and Logs, we create new views that potential will attract the usage.
3R – Decision Demand Chain

- **Recommendation**: Following up 3M, we provide decision recommendation to the user, just like how Amazon.com gives it to people who have purchased a book by recommending them other similar books that other people have bought to the RI managers, that are likely to use the similar data set and making similar decision, but this decision making is now recorded and reused.

- **Reconciliation**: If the data with high hit rate, but the decision is not useful to finish a task, we reconcile all the window view widgets and data set, provide new decision workflows or view workflows.

- **Representation**: We then represent a new decision view to replace the old decision view to the user.
Data Supply Chain and Decision Demand Chain

• Our 3M3R engine analyses peak concurrency events, solution adoption, decision making process, most active users, and it drills down to individual session details (sessions tab) at each Window Area. Use the trend chart on the concurrency tab to drill down to the minute level of detail!

• We track how many times users open the model through the server log files and which user accessed the dashboard. By using Audit Logging you can track which objects and tabs are accessed by users, for this you have to select an option Enable audit log.
User and Usage mining, drop the views

Capability
- Item
- Maintenance
- Users
- RI
- Repair history
- Repairers
- Repair decision
- Cost and Lead time
- Budget

Acquisition

Sustainment

Time Critical Situation
- Item Warranty
- Item purpose
- Repair Frequency
- Stock on Hand
- Optimal Pool Size

Daily Repair To Do List
- Item Priority
-...
User and Usage mining, create the views
Traditional DW solutions

DW – ERP Back-End Operation

Enterprise 50+ IS

Front-end

Parallel Access

Parallel Access

Parallel Access
Dynamic Data Ecosystem (DES) – Future 25 years

Cloud migration

Our-sourcing

In-House Capability
5. Smart City

- Where we are going
- Hot Research
Enabling Technologies – In-Memory

Time, Speed, Space, Heterogeneity, Flexi, Simplicity


CPU

Parallel

Transporter

GPU

1000s core
Big Data Management - 2025

Where we are going

**BI 1.0 (DBMS)**
- Databases
- Inventory Control
- Customer Service
- Account Management

**BI 2.0 (Web/Network)**
- Data Warehouses (DW)
- Process Re-Eng.
- Workflow Mgmt
- Business Modelling
- AI, Expert Sys, DM
- Quality Standards
- SLA
- DBMS, UIMS, etc

**BI 3.0 (Wireless/Mobile)**
- Big Data, NoSQL DB
- Guided BI
- Semantics and Ontology
- Data storage
- Data cleansing & quality
- Multi-agents
- Search Engines
- Trust, Recommender sys
- Document handling
- MW, Grids, MDA, and SOA
- Autonomous computing
- Data security & privacy

**BI 4.0 (Clouds)**
- Dynamic Data Ecosystems
- Data lakes, data farms
- Mobilised DS BI
- On-Demand DS BI
- Geo-Mobile enabled BI
- Augmented reality for BI
- Hybrid Clouds
- Open Source Ecosystems
- Smart Digital Enterprises
- Cyber and mobile security
- Cognitive UX

**BI 5.0 (SmartDV - DES)**
- Empower Data
- Empower People

*Figure 14.1* 50 Years of Business Intelligence Development Paradigm (Chang et al 2006, 2015)
Highlight hot areas

1) Big data
2) IoT and CPS
3) Mobile Security
To address top 8 Enterprise issues

1. Inflexible
2. Single source of truth
3. Not Required Expert to operate
4. Not for managers or end-users (of BI)
5. Low RoI
6. Customer in control
7. Security, privacy, trust
8. Data Sharing – Ecosystems inspired Data Management
A Dream World of Data Intelligence

- **Not** a lot of data, tables, graphs, reports etc => but a Picture worth of 1000 of words
- **Not** the patterns or discoveries => but a decision support or recommendation(s)
- **Not** what you have or you do not have => but what you got to do => such as 1,2,3,4
- **Not** visualisation of data => but interpretation of data
Big Data, Big Impact

- Mobilised Decision Supported
- Mobile and smart device enabled. No office, no desktop, anytime, anywhere and in real time
- Agile, dynamic, and automated
- On-Demand Decision Support
- Rapid recommendation support
- Sustainable through Self-organization
- Smart Usage capture => capture Knowledge or knowledge discovery => have data and knowledge = enables rapid decisions and decision support
Where Big Data research goes?
Conjoint DM and In real time

• The co-joint data and content mining on Big Data including the combined RFID and wireless sensors data on the goods and assets handling, warehousing and transportation, GPS, GPRS and position location system for transport vehicle and shipment tracking, Surveillance Systems for Operator Performance and situation awareness, provenance of Goods and Asset tracking.

• The conjoint data and content mining are also needed for Inter- and intra-ship, on-shore and off-shore transactions; data monitoring,

• Black-box (on ships vessels) communication and auto and semi-automated physical flow and information flow
Where the World is going?

- Economic world:
  - 1970s: Products
  - 1980s: Tools
  - 1990s: Platforms
  - 2000s: Services
  - 2010s: Resources
  - 2020s: Environments

- Cyber world:
  - 1970s: Database
  - 1980s: Information Systems
  - 1990s: Knowledge Base Systems
  - 2000s: Web Repositories
  - 2010s: Digital Resources
  - 2020s: Big Data on Cloud

- Social World:
  - 1970s: Network
  - 1980s: Internet
  - 1990s: Wireless & Mobile
  - 2000s: Sensors actuators
  - 2010s: Cyber-Physical Systems
  - 2020s: Digital Ecosystems
Innovation in Information Technology

Source: VDMA Future Trend Analysis
New techniques are needed for mastering growing complexity

Steadily increasing complexity of automation software
1) Big data
2) IoT and CPS
3) Mobile Security
IoT – tightly coupled systems

• The Internet of Things (IoT, also Cloud of Things or CoT) refers to the interconnection of uniquely identifiable embedded computing like devices within the existing Internet infrastructure. Example: Smart Grid

• Networks of functional tightly coupled system

• the Internet of Things is primarily focusing on using various technologies such as RFID, Zigbee, Bluetooth or 6LoWPAN.

• Things, in the IoT, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, automobiles with built-in sensors, or field operation devices.
IoT - example

Silicon, Security, and the Internet of Things

The Smart Transportation IoT will help preserve human lives, fuel, and time.

A Smart Shipping IoT could allow materials to pass through customs in minutes instead of days.

The Smart Grid IoT helps us manage the planet’s limited energy.

A Smart Home IoT could connect home media, security, and energy applications to our cell phones.

A Medical IoT could allow vigorous tracking of patient care history.
WoT - Systems of systems

• The **Web of Things** (or **WoT**) is a concept and plan to fully incorporate every-day physical objects into the **World Wide Web**.

• The Web of Things is primarily an evolution of the **Internet of Things**.

• On the other hand, just like what the **Web** is to the Internet, allow building an application layer for physical objects, or use 3rd party applications.

• The use of embedded devices.
WoT - Examples
CPS - Globally connected systems of systems

- A cyber-physical system (CPS) is a globally connected WoT.
- Bring embedded systems to the Web. ie: aerospace, automotive, chemical processes, civil infrastructure, energy, healthcare, manufacturing, transportation, entertainment, and consumer appliances.
- Adaptations: collision avoidance; precision (e.g., robotic surgery and nano-level manufacturing); operation in dangerous or inaccessible environments (e.g., search and rescue, firefighting, and deep-sea exploration); coordination (e.g., air traffic control, war fighting);
- The US National Science Foundation (NSF) has identified cyber-physical systems as a key area of research. Starting in late 2006.
Ongoing advances in science and engineering will improve the link between computational and physical elements, dramatically increasing the adaptability, autonomy, efficiency, functionality, reliability, safety, and usability of cyber-physical systems.
Underlying Technologies

– Wireless Communications

• Wireless Sensor Networks (WSN)
• Embedded devices, with tiny computers, sensors, actuators and network interfaces,
• Ability to deploy sensors with flexibility and mobility, on the Web
• Allows to retrieve data about objects and interact with them
• New global networks, enabling new applications and providing new opportunities for humanities and business
Smarter World, Smart Planet, Smart City – Smart starts here

- Today, the world has 340 trillion trillion trillion unique IP addresses [Maxim Integrated 2014]
- Each Person could have zillions of sensors with unique address [Maxim Integrated 2014]
- 60 billions RFID Tags embedded across entire ecosystems
- Many manufactured items, goods or assets today utilizing the Internet of Things are already Internet enabled, they have capability to talk to Internet, talk to each other, talk to service providers and talk to infrastructure and environment

Smart Things – are here to stay
Support for CPS - 2010

- $30,000,000 over 5 years in CPS research programs (40 awards) by the US NSF.
- £5,000,000 initiative for development of CPS applications by UK’s Technology Strategy Board.
- $5,5000,000 to transform future electricity grid using CPS by the US Power Systems Energy Research Centre (PSERC).
IoT for Smart Ship

Our solution (IoT, Voice, RFID, MobApp)
Tightly coupled and controlled system

Our proposed work

- Voice headset, locations of each item...
- Share this information inside a single ship
- Use voice for managing the ship and sending information.
- Monitoring, navigation, asset movement
- Location of operators, assets, and via a sensor or the headset
- Managers to assign orders

Ship Top Issues
Security and Safety
Communication issues
On-Shore and Off-Shore Asset Visibility
Manual Data Entry System on-board ship
Engineering Reliability and Maintenance
Smart Ship with CPS

Our solution (on-shore+ Off-shore, Sys Integration, E-to-E Visibility)

Globally connected Systems of Systems

Ship Top Issues
- On-Shore and Off-Shore Asset Visibility
- Engineering Reliability and Maintenance
- Ship Tracking and Sustainment
- Long Lead Time
- Repairs n Overhaul
IoT for Smart Ship

Our Smart Ship Solution Process

1. Ships, Containers, Sensors, IDs
2. Collect
3. Key Attributes
   - Id
   - Location
   - Items
   - Equipment Status
   - Worker behaviour
   - Time
4. Transmits
5. Process
   - Secure Data Centers
6. Information
   - Tablets, Headsets accessible reports & analytics
Software Integration for Smart Ship

Our Smart Ship Solution integration of RFID, Voice, Data, MobApp,+
Voice + IoT, Enable Automation

Powered by Honeywell Voice link Technology

- How does it work
  - Assignment from WMS/ERP transmitted to voice-enabled platform via 802.11a/b/g WLAN
  - Voice-enabled platform translates assignment data into audible commands
  - User provides spoken responses to confirm actions
  - Check-digit ensures accuracy
  - Translated back to data
  - Transmitted from voice-enabled platform via 802.11a/b/g WLAN
  - Host data sources updated using enterprise connector

Voice Advantage

1. Engineering Diagnostics (repair or overhaul)
2. Breakdown scenario outline
3. FastTrack of asset on the on-board ship
4. Urgent demand description
5. Accurate recording of asset usage rate
6. Tracking “Return” of the assets
6. Conclusion

Do Smart Research

Face the issues, embrace technology,
Make our World Smarter
Acknowledgement:
Google images and CASG at Australian Defence Force

UNSW @ ADFA

Comments and Questions to: E.Chang@adfa.edu.au