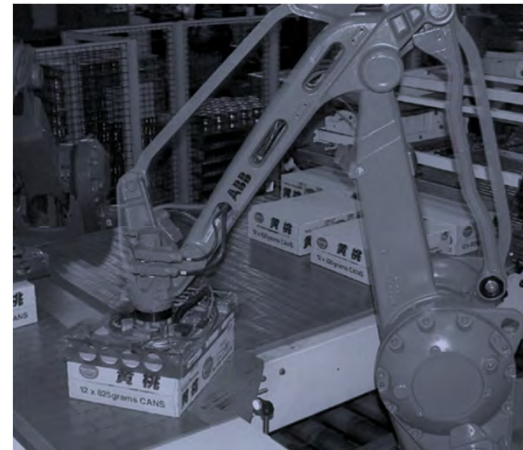
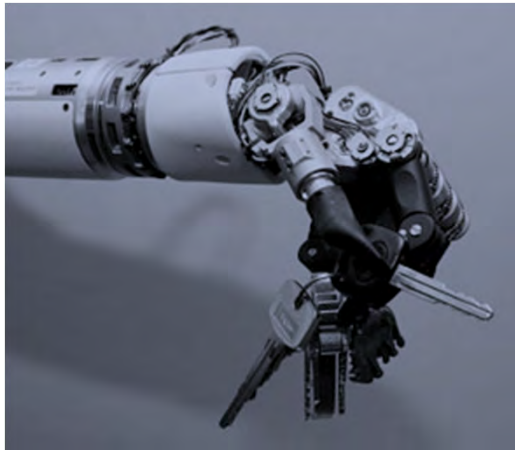


Where Are We Now? Where Are We Going?



About Myria RAS

Research and Analyst Services, Publishing and Events

Myria RAS, Inc. provides business and technology professionals with a single source for independent, accurate and in-depth analysis, research and best practices focused on the application of automation, robotics and intelligent systems technologies in multiple markets.

ARISplex.com provides informed analysis of, and insights into, robotics and automation news, announcements, breakthroughs and other initiatives. The resulting “research lite” is designed to be actionable by business and technology decision makers across a variety of vertical market sectors. In addition, primary research from MYRIA and other sources is freely available to registered users.

ARISplex
Automation, Robotics, Intelligent Systems
A MYRIA OPEN PORTAL

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National Robotics Initiative Research a Valuable Resource for Strategic Business Planning
Agriculture, Healthcare, Manufacturing, Industrial Systems, Service Systems

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Where Are We Now? Where Are We Going?

A Full, Thorough and Highly Detailed Study of the Entire Robotics Industry in 40 Minutes!

Extraordinary Progress

Government, Business, Society, Technology

Sectors

Just Breaking

Final Thoughts



Motoman SDA5D

Market Drivers

Act in confluence to promote, expand the size of the market and solidify role of robotics in society.

- **Social Drivers**

- Act at the level of the individual to facilitate or promote
- Include education, value systems, lifestyles, adoption patterns and culture
- Drivers = STEM education, social development and causality reduction

- **Political Drivers**

- Facilitate or promote markets that increase the status, position or competitiveness of nations or political/economic entities
- Drivers = Economic development, international competitiveness, cost reduction and jobs

- **Technology Drivers (Enablers)**

- Advances in hardware & software enable the development of new classes of robotics systems

- **Business Drivers**

➔ **Market drivers and other enablers come in many forms and often intersect, resulting in an overall effect that is additive, if not exponential.**

Robotics Sectors



An Automation Continuum

Also Adding Mobility and Autonomy

Mechanization

Act

Automation

Sense
Act

Robotics

Sense
Think
Act

Sensors – Robots employ sensing technology to acquire information about their environment.

Intelligence – Robots process information captured through sensor technology and produce outputs for decision making, coordination and control.

Motion – Robots automatically follow instructions that are pre-programmed, or generated in real-time based on sensor input, to perform deliberate, controlled, and often repeated, mechatronic action.

Reprogrammable



Robotics Industry Taxonomy

By Markets and System Type

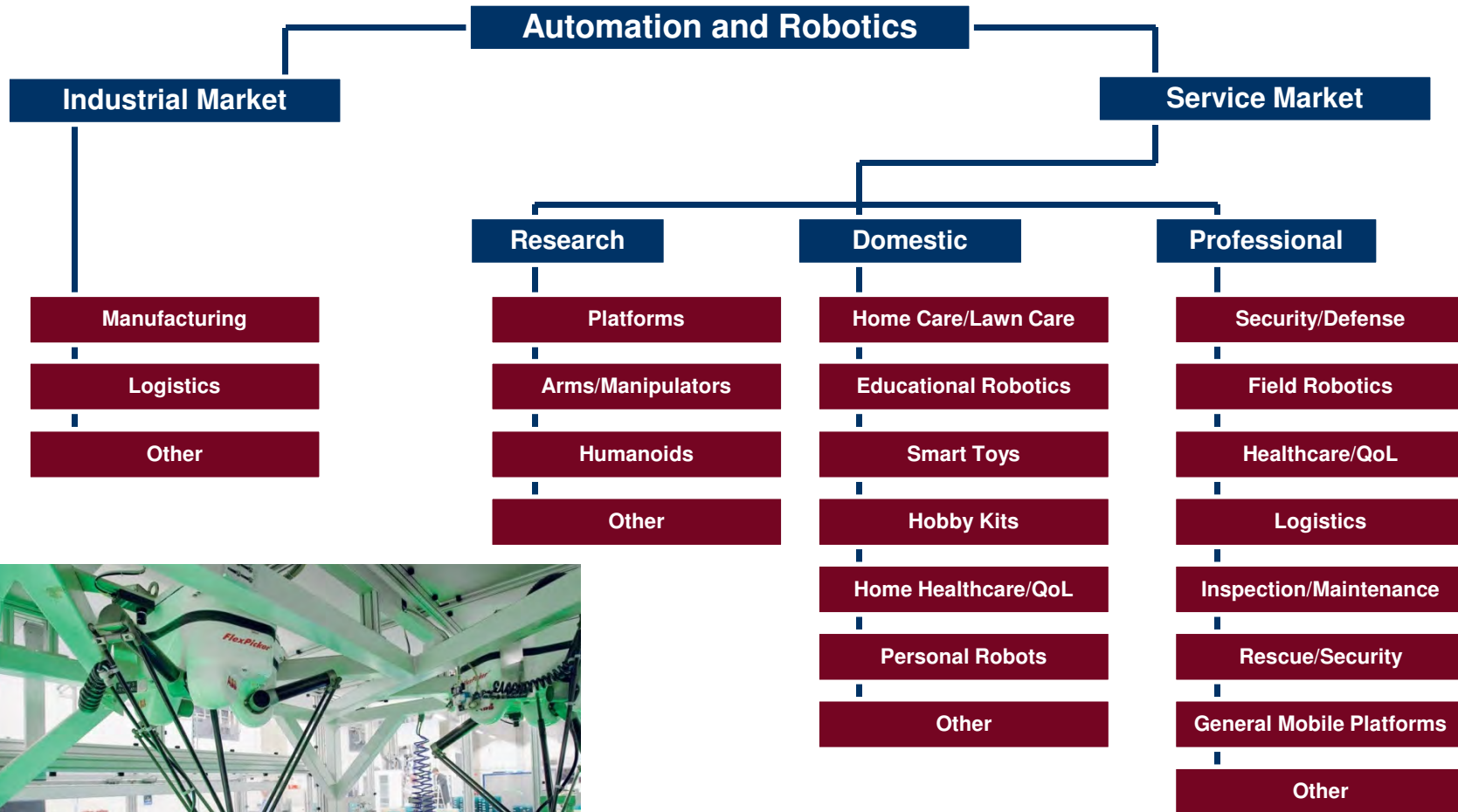
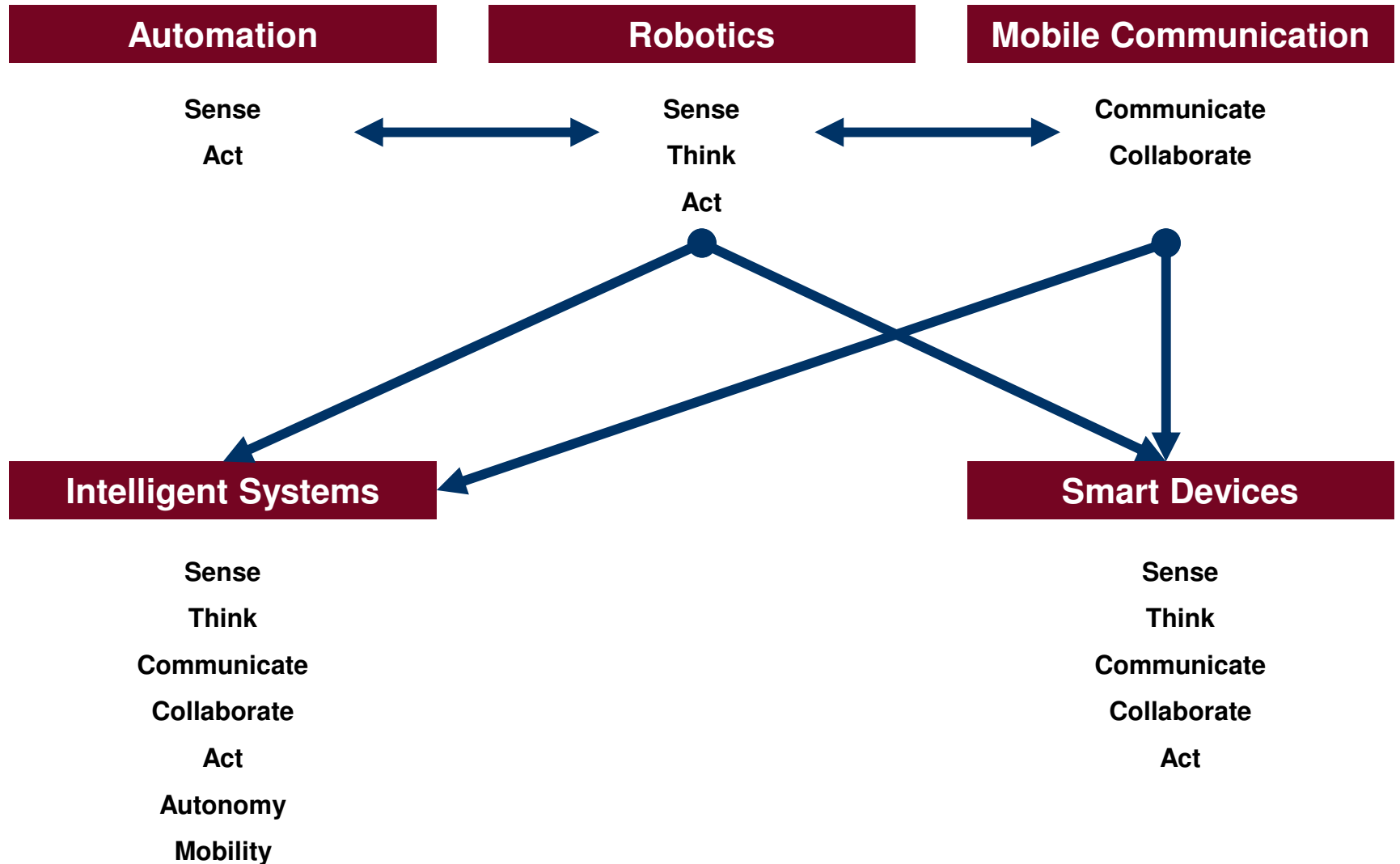


ABB 340 FlexPicker

The Larger Picture (Much Larger)

Also Adding Mobility, Autonomy and Learning



→ Emphasis on links to existing IT infrastructure and business process... driving business.

Industrial Systems



Examples of Industrial Robotics

All Types, All Sizes, All Capabilities

Palletizing Systems



Kongsberg REMUS 6000

Assembly Robots



Denso VS Series

Food Handling Systems



FANUC LR M-430iA/2F

Warehouse Automation Systems



Seegrid GP8

Arc Welding Systems



Motoman MA 1900

Materials Handling Systems



Kuka KR 1000 TITAN

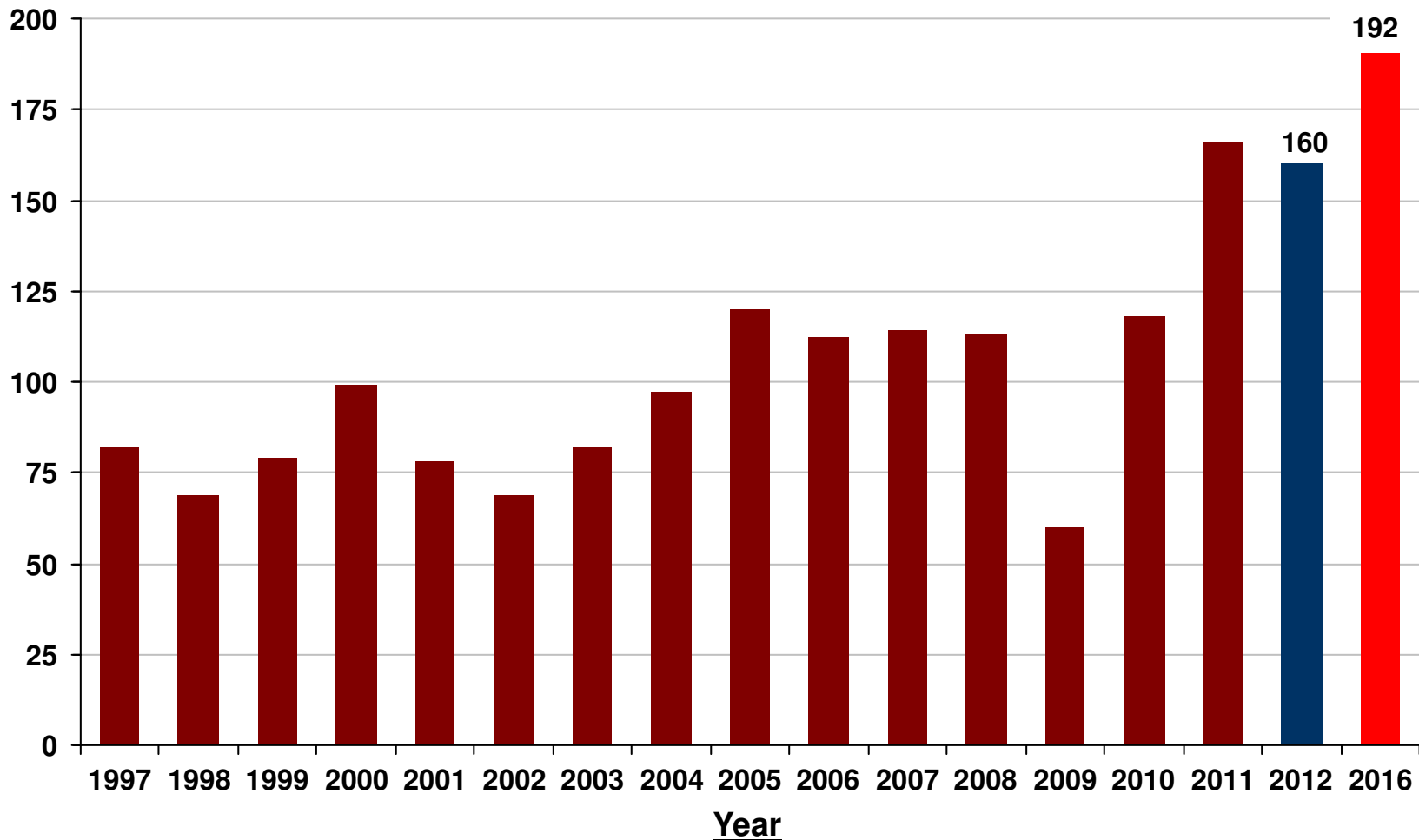
Yearly Installations of Industrial Robots

Trending Upward

Total Sales = @ \$9B

Including software, services etc. = @ \$26B

Units (x1000)



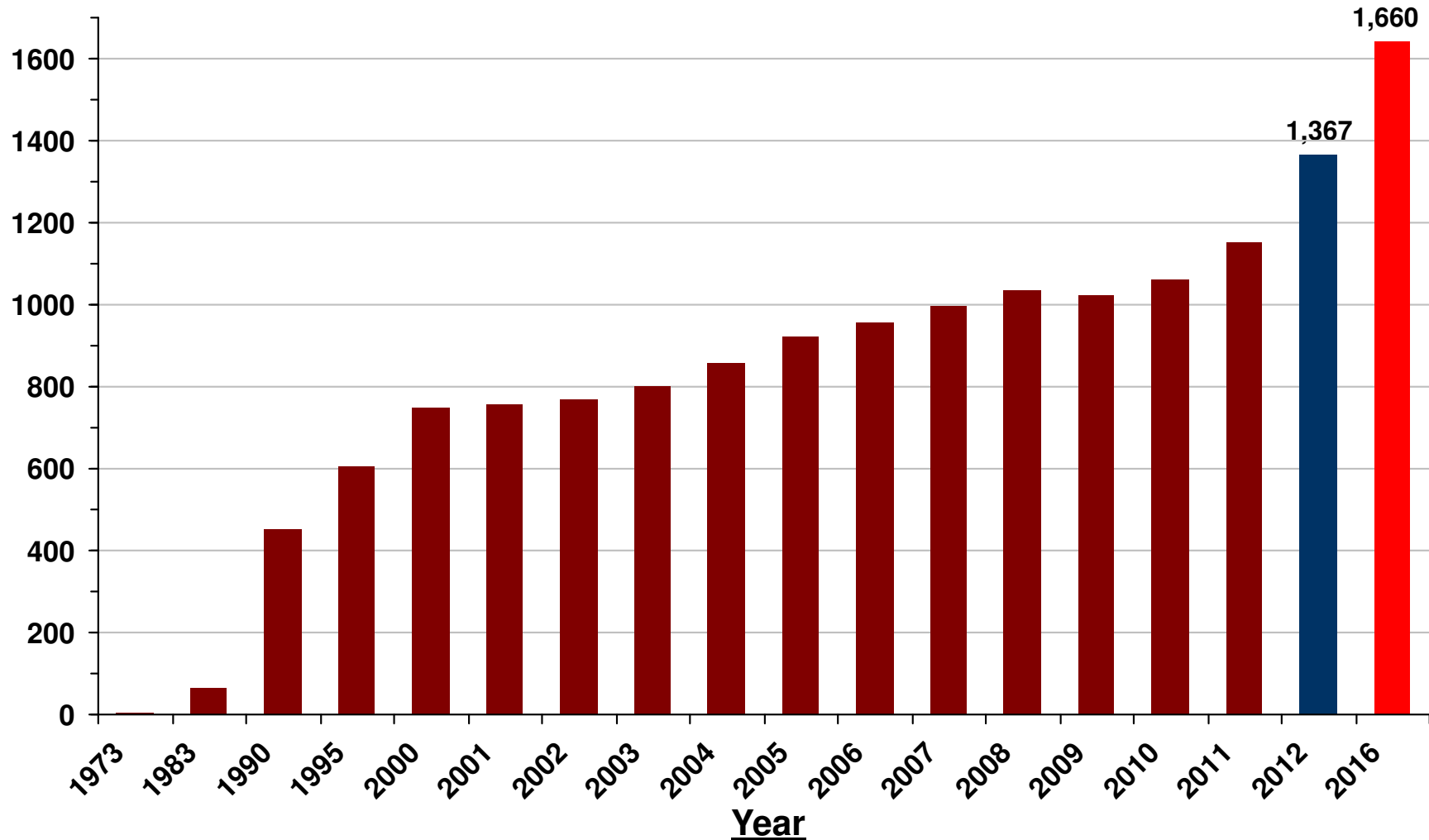
→ Sales decreased by 4% over 2011, 2nd highest level for one year

→ China the largest market, China the most rapidly growing.

Worldwide Estimated Operational Stock of Industrial Robots

Over 1.3M industrial robots in operation

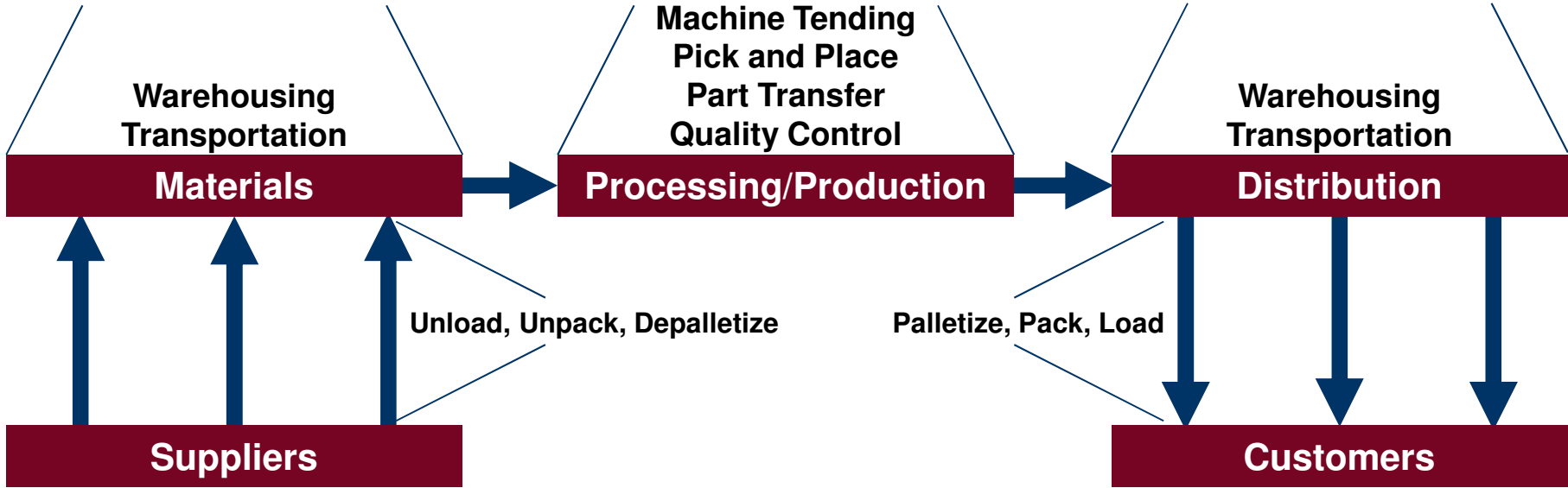
Units (x1000)



➔ In 2012, operational stock increased by 7%.

Material Handling Automation

Assistant Processes for the Primary Operation



The Usual Suspects...			
↑ Productivity	↑ Accuracy	↑ Quality	↓ Costs
↑ Safety	↑ Flexibility	↑ Floor Space	↓ Damage
↑ Reliability	↑ Speed		↓ Injury

➔ - Rapid ROI
 - Increased competitiveness

Packing and Packaging

Speed, Flexibility

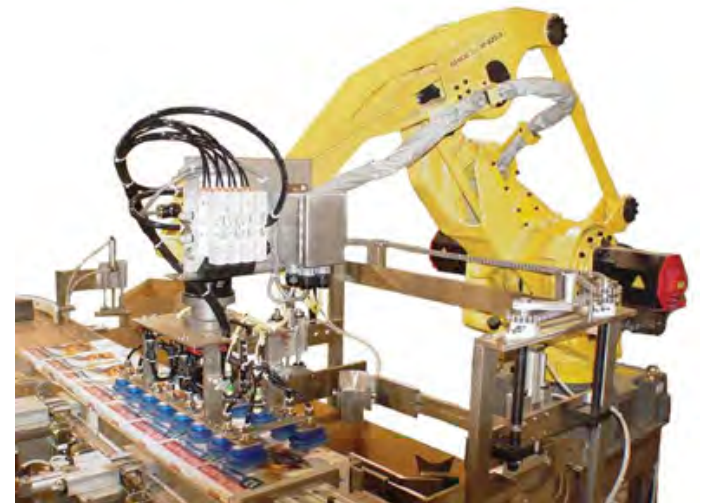
- Items and Layers
- All Manner of Products
- Range of Robots
- Custom End of Arm Tooling
- Combined With Palletizing Systems
- Other Options



Motoman UP20



DENSO SCARA HSS-45552



Fanuc

Palletizing

Loading/Unloading To/From Pallets

- Many Solutions, Many Applications
- Great Flexibility
- Great Success
- Maximizing Payload
- Repeatability

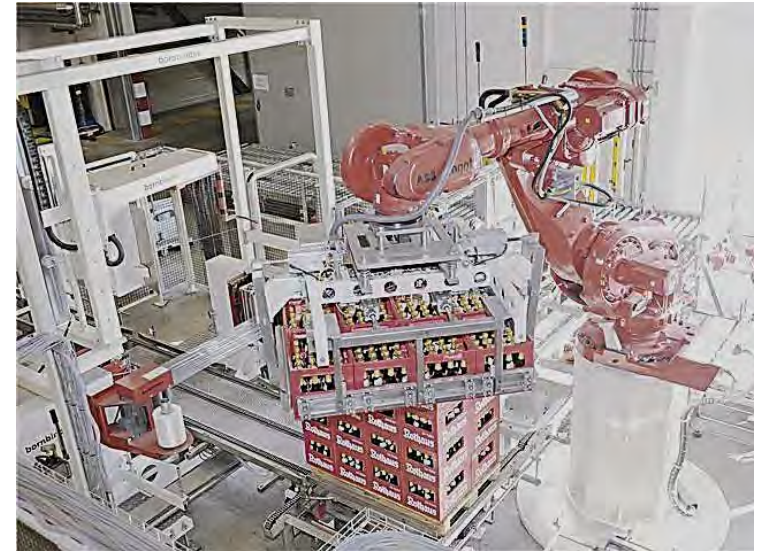


ABB IRB 6640

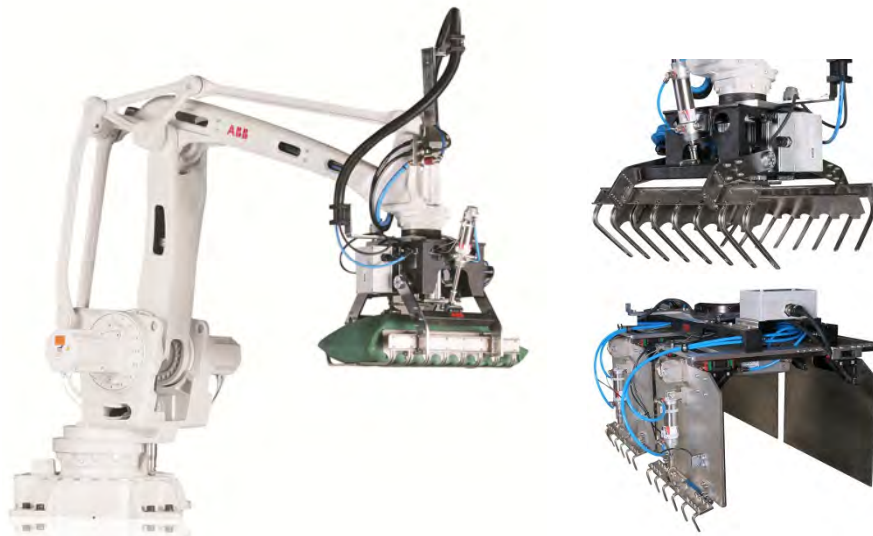


ABB IRB 460

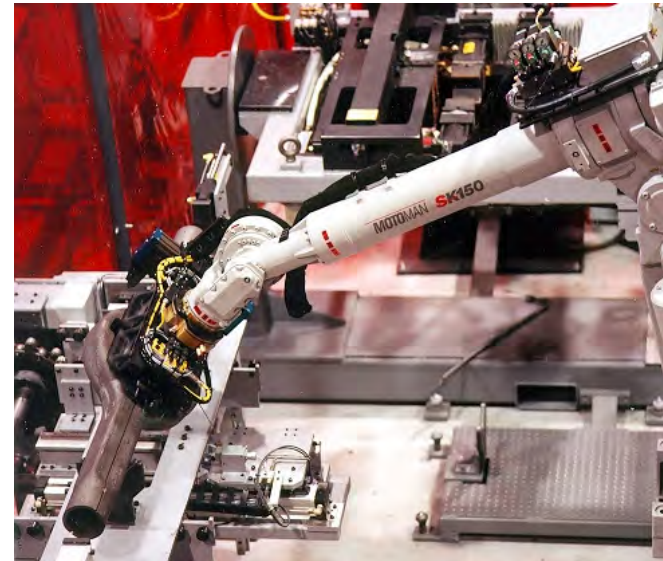


Motoman MPL100

Piece/Part Transfer

Parts Transferred From One Location to Another During Processing/Production

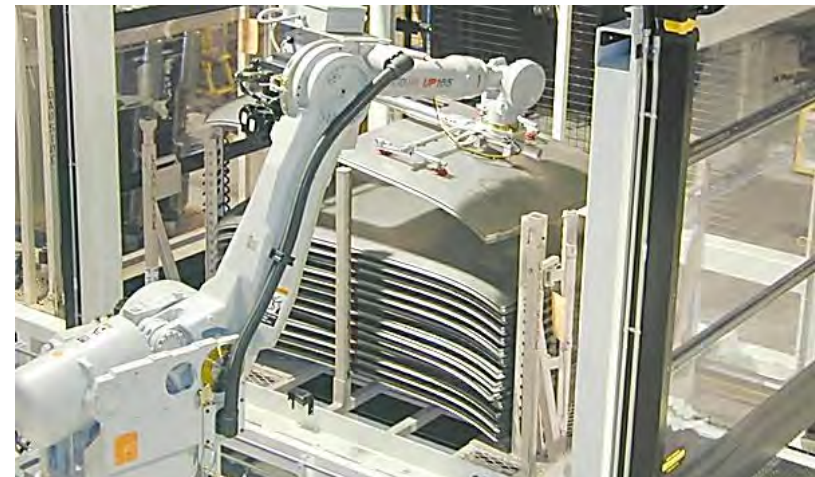
- Repetitive Lifting, Accurate Placement
- High Quality, High Throughput
- Multi-stage Processes
- Now Practical for Smaller Businesses
- Flexibility



Motoman SK150



Fanuc LR Mate 200iC



Motoman UP 165

Pick and Place

Moving Parts From Place to Place

- Precision
- Speed, Strength or Both
- Application Requirements



ABB 340 FlexPicker



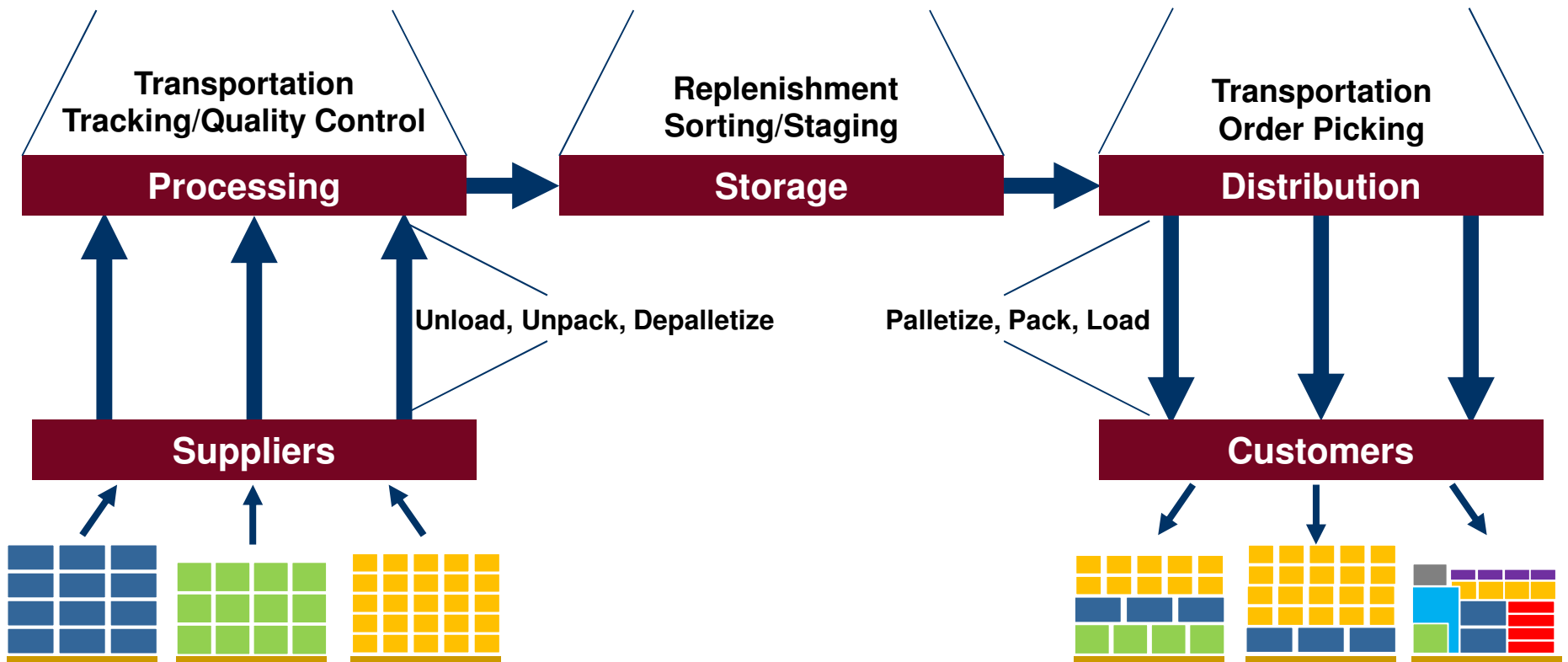
Motoman MPK2 - MPK2F



Denso VS Series

Warehousing/Distribution

Roughly Speaking...



The Usual Suspects...

↑ Productivity	↑ Accuracy	↑ Quality	↓ Costs
↑ Safety	↑ Flexibility	↑ Floor Space	↓ Damage
↑ Reliability	↑ Speed		↓ Injury

Unloading

Solutions Are Available

- Cargo Containers and Trailers
- Self Guided
- Vision Based
- Regular and Irregular Stacking
- Other Options



Fanuc M-900iA



YASKAWA Motoman



Wynright

Automated Guide Vehicles (AVGs)

Slow, Steady, 7x24...

- Many Applications / Types
- Navigation and Guidance
- Wide Range of Payloads
- Versus Conventional Fork Lifts
- Strengths / Benefits



Seegrid GP8



Jervis-Webb SmartCart



Swisslog AGVPick

Picking Operations

Good-to-Man With Mobile Robots

- Tugs
- Autonomy
- Flexibility
- Ease-of-Use
- Software Key



Kiva System's Warehouse Automation System



Swisslog's AutoStore



Symbotic's Matrix Rover

Loading / Unloading

Automating the Last Stage...

- Many Applications
- Versus Conventional Fork Lifts
- Combination AGV and Fork Lift
- Strengths / Benefits



Jervis Smart Loader

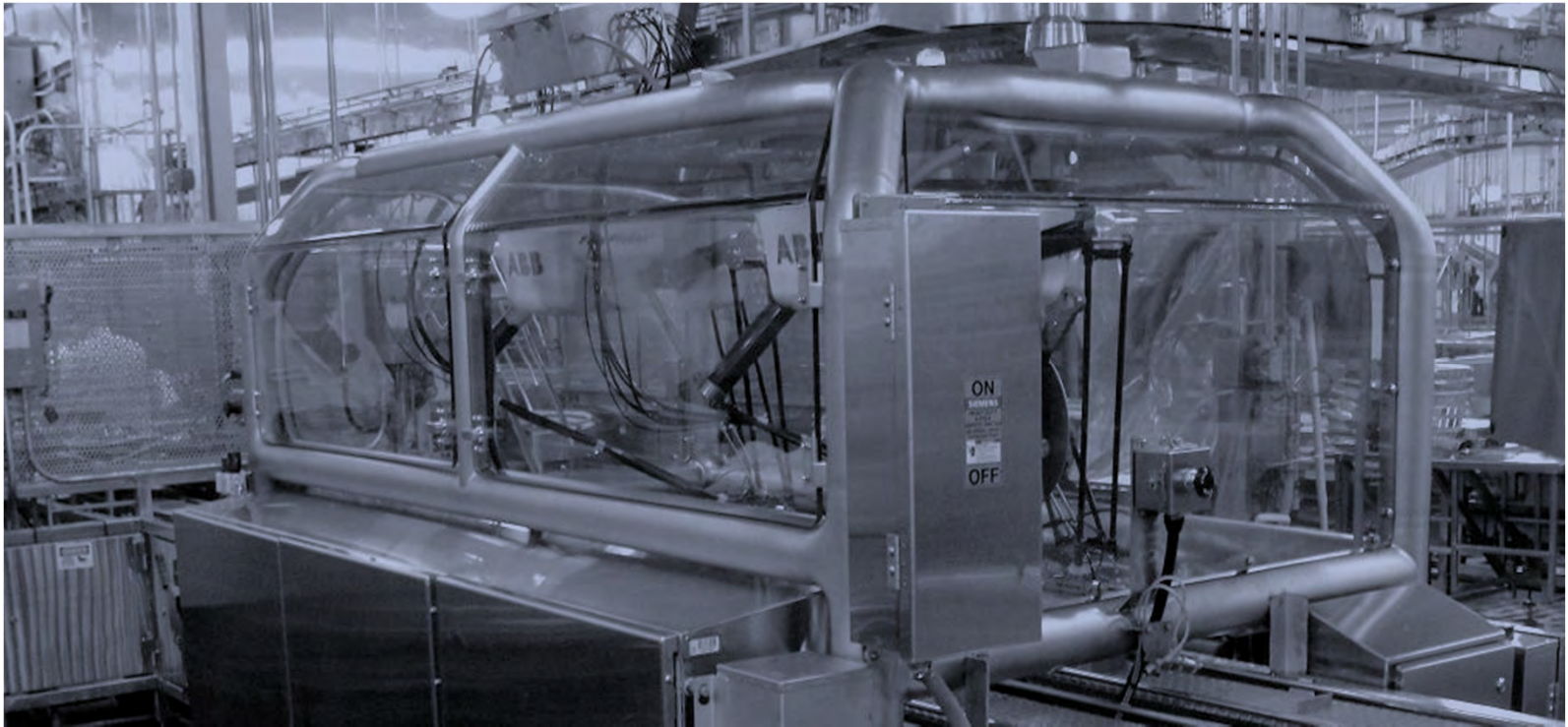


Egemin ETL



STORACT LOG ATL System

The Next Generation (Is Here)



Co-Worker Robots

Intelligent Systems Working in Close Approximation With Humans

- Complement to Traditional Systems
- Human-Robot Cooperation
- Adaptive, Flexible Automation
- Complex Manipulation
- Programming Ease
- Safe Operation
- Low Cost



Rethink Robotics Baxter



Universal Robots UL5 Double



Kawada Industries Nextage



ABB Frida

Future Systems

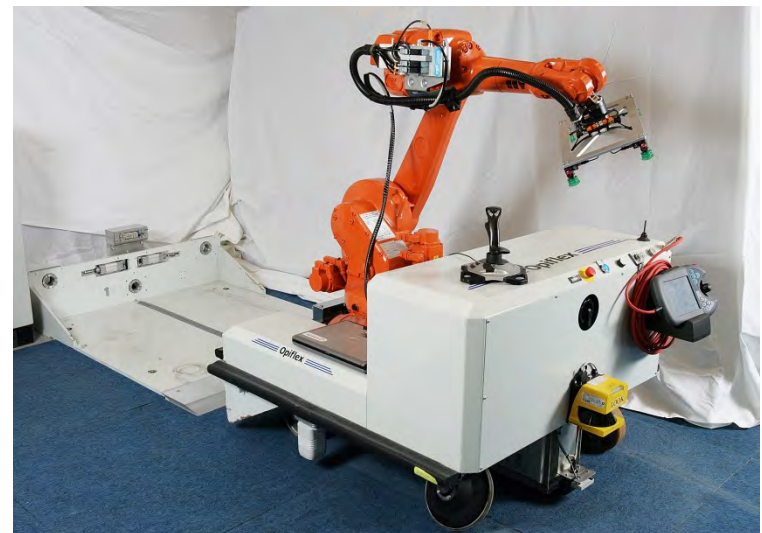
More Robots, More Applications, More Opportunities

- **Greater Mobility**
- **Mobile Manipulation**
- **Grasping and Manipulation**
- **Sensing and Intelligence**
- **Flexibility**
- **Ease-of-Use**
- **Greater Autonomy**
- **7x24 Lights Out**
- **Non-Traditional Vertical Markets**
- **Non-Traditional Roles**
- **Small-to-Medium-Enterprises**

- ➔
- Increase international competitiveness
 - Revitalize industrial manufacturing base
 - Reduce cost of goods
 - Reduce workplace injury



Fraunhofer Institute's Multishuttle Moves



OpiFlex Automation's OpiFlex

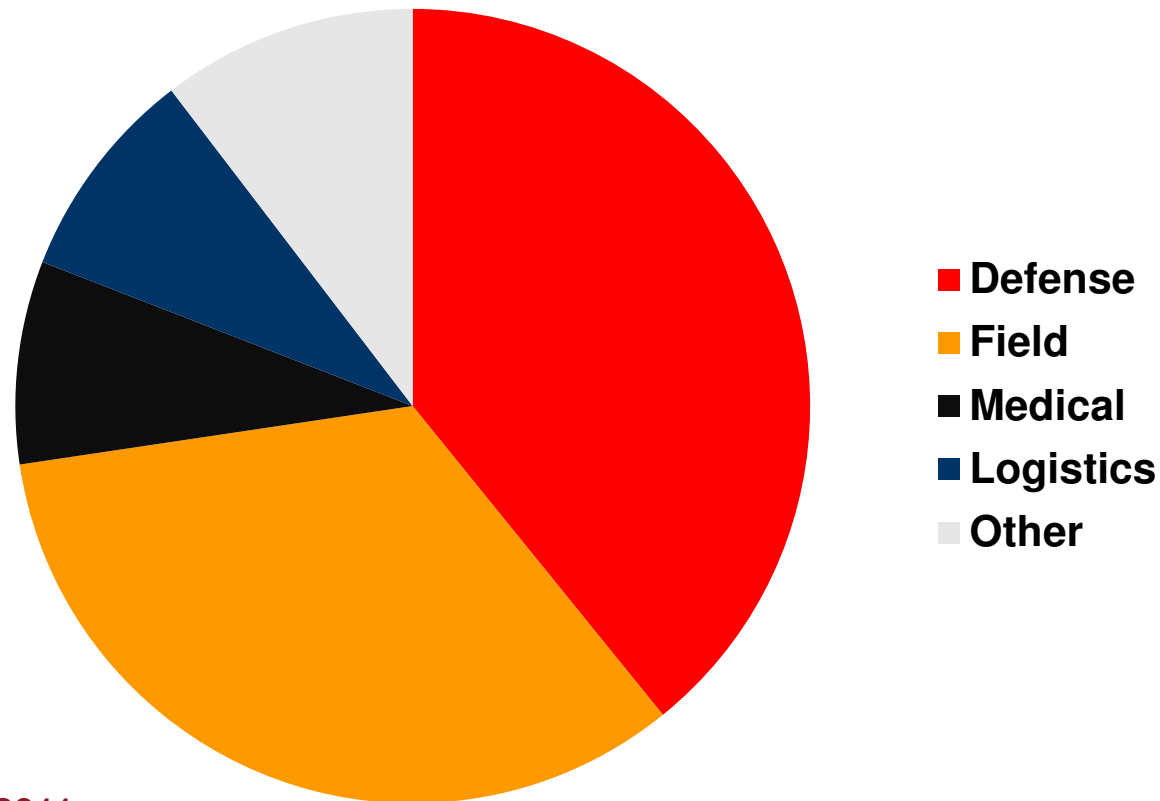
Service Robotics - More Than Stars in the Sky

Agriculture, Forestry, Mining **Smart Toys** **Micro and Nano Robots**
Medical, Surgical Robots **Security and Surveillance**
Automatic Refueling **Industrial\Professional Cleaning**
Data Acquisition & Mobile Sensors
Homeland Security **Intelligent Vehicles**
Equipment Maintenance and Servicing **Picking and Palletizing Robots**
Exploration **Marketing, Sales, Animatronics**
Food Industry Robots
Office Robots **Educational Robotics** **Humanitarian De-mining**
Fire Fighting **Prosthetics and Orthotics**
Construction, Demolition
Laboratory, Clean room
Rehabilitation, Assistive, Home Care
Guide, Information, Greeting **Military, Combat**
Unmanned Aerial Vehicles
Search and Rescue Robots **Humanoid and Anthropomorphic Robots**
Unmanned Underwater Vehicles **Space Exploration**

2012 Sales of Professional Service Robots

Total Sales = @3.4B

Total Units = 16,067



→ Sales up 2% over 2011.

→ Defense is largest in unit sales (6,200– 40%).

→ Medical robotics market is @ \$1.5B Surgical systems up 14%.

→ 2013-2016: @ 94,800 new service robots for professional use to be installed.

Source: International Federation of Robotics' World 2012

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Examples of Defense Robotics

All Types, All Sizes, All Capabilities

Unmanned Underwater Vehicles



Kongsberg REMUS 6000

Unmanned Ground Systems



QinetiQ Talon

Unmanned Aerial Vehicles



Northrop Grumman MQ-8B Fire Scout

Unmanned Aerial Vehicles



General Atomics MQ-1 Predator

Small UAV



AeroVironment RQ-11 Raven

Combat Aerial Vehicles



Boeing X-45 Phantom Ray

Security and Defense

New Phase, New Opportunities

- **Air and Ground Systems Mainstreamed**
- **New Systems**
- **Moving to New Markets...**
 - Expanding globally but...
 - Going commercial
- **Opportunities**
 - Communication
 - Lightweight Power Storage
 - Autonomy
 - Perception
 - Mobility
 - Cooperation
 - Manipulation



iRobot Packbot

➔ Expansion into new, international markets alone will not offset expected budget cuts.

➔ Commercial markets support defense.

Field Robotics

Working Outdoors in Unstructured Environments

Material Handling



Harvest Automation

Spraying



Yamaha's RMAX

Farming



Vision Robotics "Snippy"

Oil Exploration



Seabed Rig AS Seafloor Drilling Robot

Mining



Rio Tinto ATH

Herding



Australian Center for Field Robotics

Healthcare Robotics

Intelligent Systems in Healthcare and QoL

Hospital Automation



Aethon Tug

Rehabilitation Systems



Hocoma Lokomat

Surgical Robotics



MAKO Surgical RIO MAKO

Lower Extremity Prosthetics



iWalk PowerFoot

Upper Extremity Prosthetics



Touch Bionics i-LIMB Pulse

Mobile Telepresence



iRobot RP-VITA

Consumer Robotics

All Markets Moving Forward, But...

- **Dominate Markets**
 - Robotic Laboratory Automation
 - Robotic Interventional Systems
 - Robotic Hospital Automation Systems
- **Niche Markets**
 - Robotic Rehabilitation/ Therapeutic Systems
 - Robotic Prosthetic and Orthotic Systems
 - Intelligent Capsules
- **More Niche Markets**
 - Robotic Learning/Training Systems
 - Robotic Diagnostic Systems
 - Robotic Support Systems
 - Robotics Nursing Assistants
- **In the Lab**
 - Robotics Lifestyle Enhancement Systems
 - Robotic Smart Living Spaces
 - Robotic Assistive Technology Systems
 - Robotics Surgical Assistants



IntelliFill by ForHealth Technologies

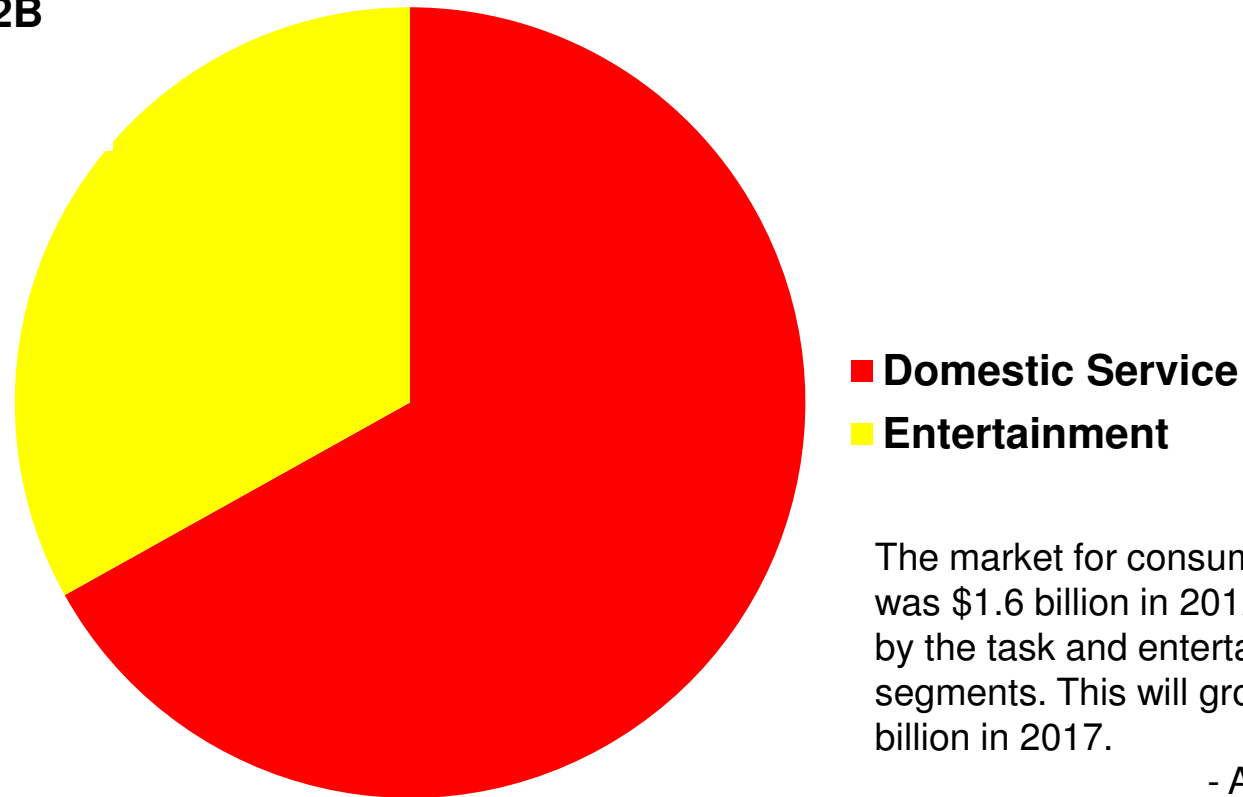


Intuitive Surgical da Vinci Surgical System

2012 Sales of Consumer Robots

Total Sales = @ \$1.2B

Total Units = @3M



The market for consumer robots was \$1.6 billion in 2012, dominated by the task and entertainment segments. This will grow to \$6.5 billion in 2017.

- ABI Research

→ Sales up 20% over 2011.

→ Estimated @ 2M domestic robots at a value of \$697M (up 54% compared to 2011).

→ Estimated 1.1M entertainment robots at \$524M.

→ 2013-2016: About 22 million units of service robots for personal use to be sold.

Source: International Federation of Robotics' World 2012

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Personal Robots

Purchased by Individuals To Educate, Entertain or Assist in the Home

Home Care/Lawn Care



iRobot Roomba

Smart Toys



Anki's Anki Drive

Hobby Robots



Parrot AR.Drone

Educational Robots/ Hobby Kits



Lego Mindstorms EV3

Home Care / Home Services



Hocoma AG's Armeo

Personal Robots

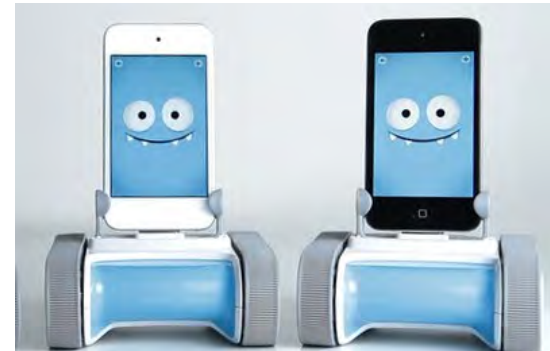


NEC PaPeRo

Consumer Robotics

Homecare/Lawncare Beginning to Mainstream

- **Homecare/Lawncare Dominates**
 - Additional Features/Functionality
 - Seamless Automation
- **Smart Devices Proliferate**
- **Smart Toys Rise and Fall (Repeat)**
- **Home Healthcare Still on Hold**
 - Business Models
 - Applications
- **Security/Telepresence Makes Inroads?**
 - Business Models
- **Nothing Personal**



Robomotive's Romo



Neato Robotics' XV-15



Robomow RM200

→ Industry giants Honda, Robert Bosch, Husqvarna, John Deere and others offer robotic lawn mowers .

Commercial Research Robots

Current and Future Research Needs Drive Opportunities

Past Emphasis

Current and Future Emphasis

Platforms



- Single Systems
- Mapping, Localization, SLAM
- Navigation
- Sensors
- Teleoperation
- Proprietary Software Stack
- High Cost
- Focus on Pure Research

- Vision
- Autonomy
- Mobile Manipulation (bi-manual)
- Multisensory/Modal Fusion
- Multi-robot Systems and Cooperation
- Unstructured, Dynamic Environments
- Complicated Tasks
- Close Interaction With Humans
- Standard Software Stack
- Focus on Applications

Arms/Manipulators



- Manipulation
- Single Armed Systems
- Structured Environments
- Focus on Pure Research
- High Cost
- Simple Tasks

Humanoids



- Navigation and Bipedal Locomotion
- Proprietary Software Stack
- Focused on Pure Research
- Very High Cost

- Autonomy
- Manipulation
- Social Interaction
- Close Approximation to Humans
- Focus on Applied Research
- Standard Software Stack
- Reasonable Pricing

Autonomous Driving

Finally, the “Killer App”

- All Automotive Companies
 - At Least Advanced Assistive Technologies
- Evolutionary Process
- Great Variability of Options
- Non-Automotive Companies
- New Markets / New Business Models
- Policies

Nissan



General Motors



Toyota

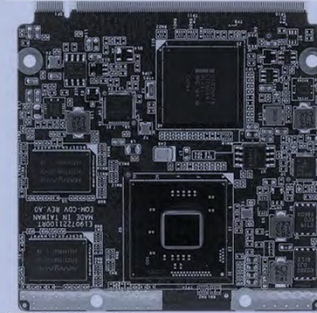
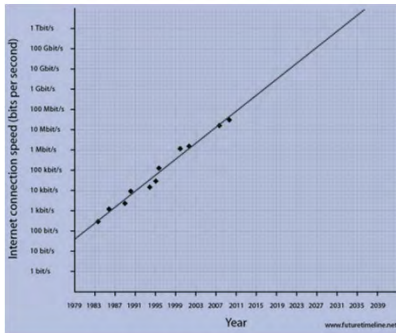


BMW



→ Legal and social issues, not technology, limiting factors over time.

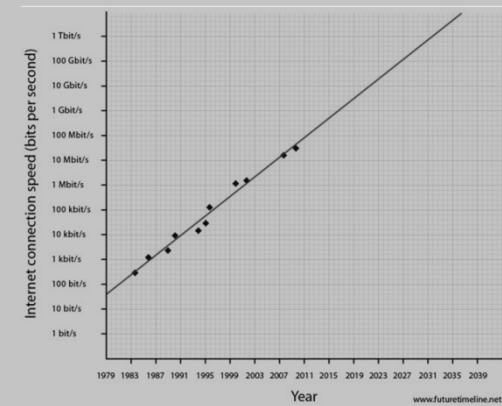
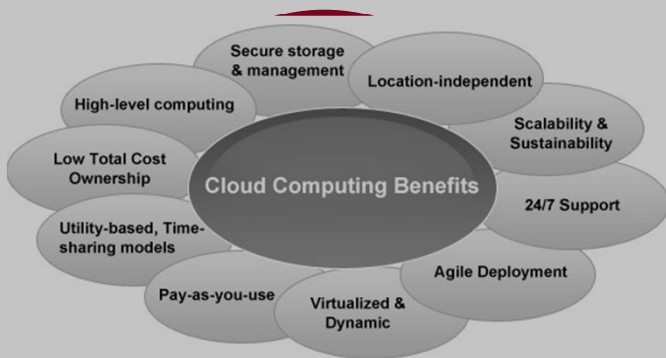
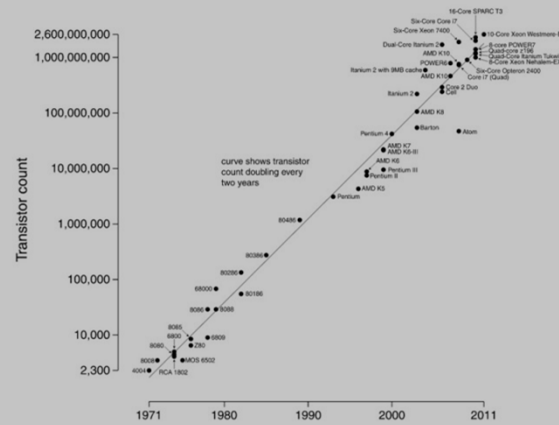
What are Key Robotics Enablers?



Technology Drivers

Just a Few of the More Obvious

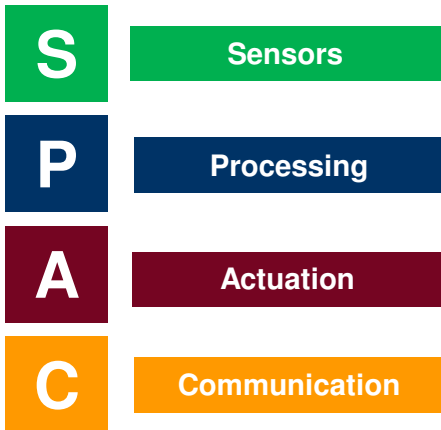
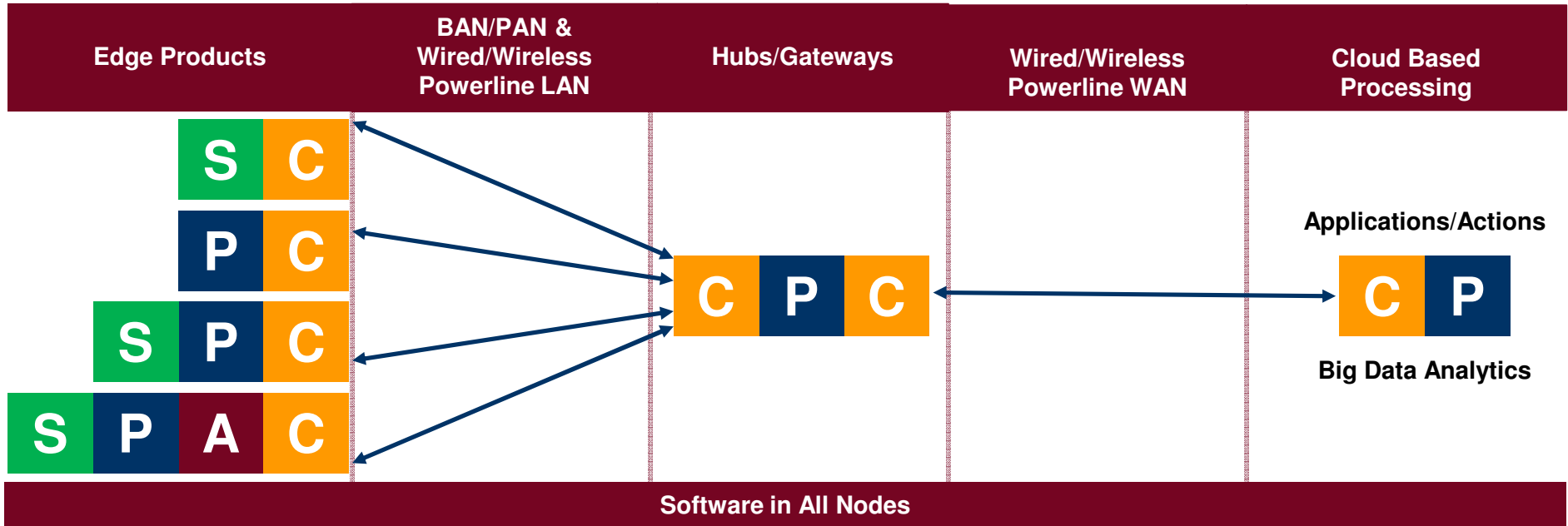
ROS.org



➔ Plus ongoing technological innovation and dropping prices, of course.

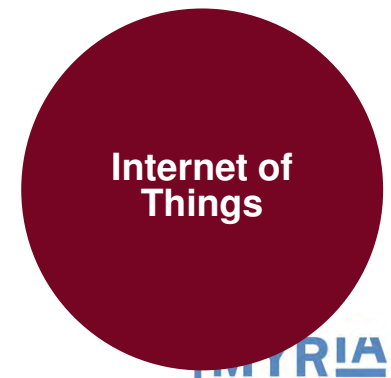
Robotics and the Internet of Things*

Four Classes of Target Customers

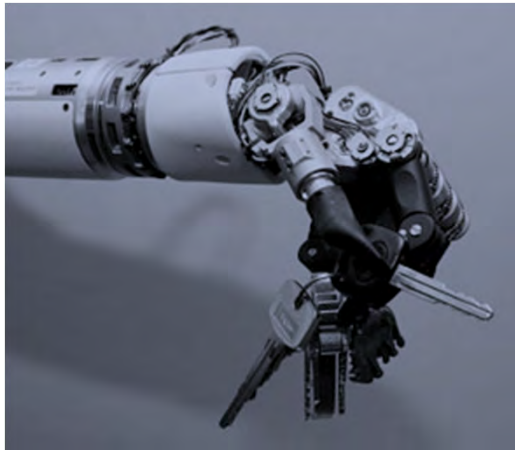


General Electric, IBM, Intel, Qualcomm, Sprint, Microsoft, Sony, Ericsson, Oracle, Broadcom, Freescale, Cisco, Google, AT&T, Samsung, Verizon, and on and on...

* From Freescale Semiconductor With Alterations

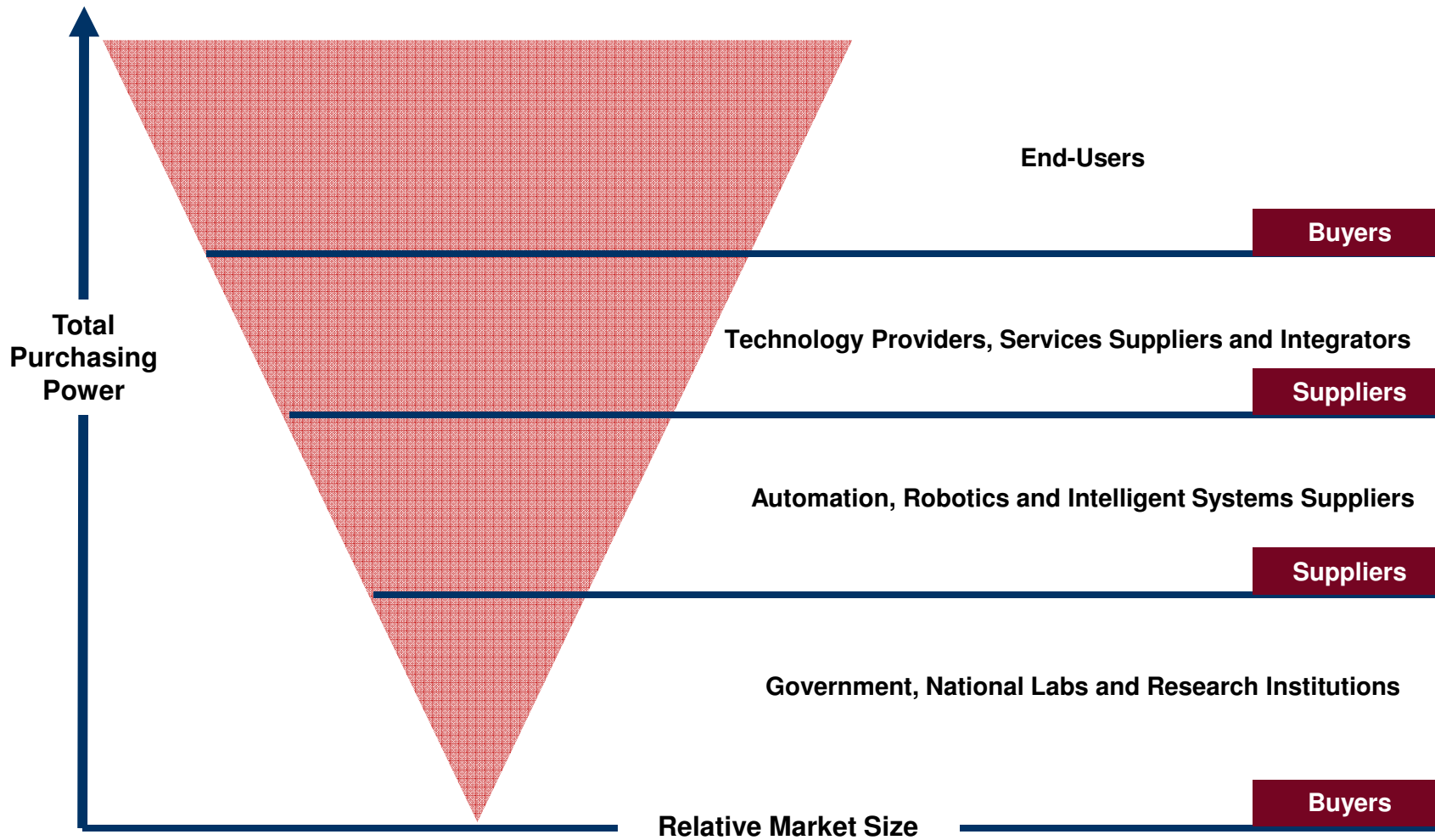


Final Thoughts



Target Customers

Four Classes of Target Customers



**Global Manufacturing Sector
@ \$8T**

Where Are We Now? Where Are We Going?

Mobility
Autonomy
Proximity
Flexibility
Dexterity
Ubiquity



Can Do, Should Do, and Must Do Robotics?





Thank You!



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