

#### A Roadmap for US Robotics

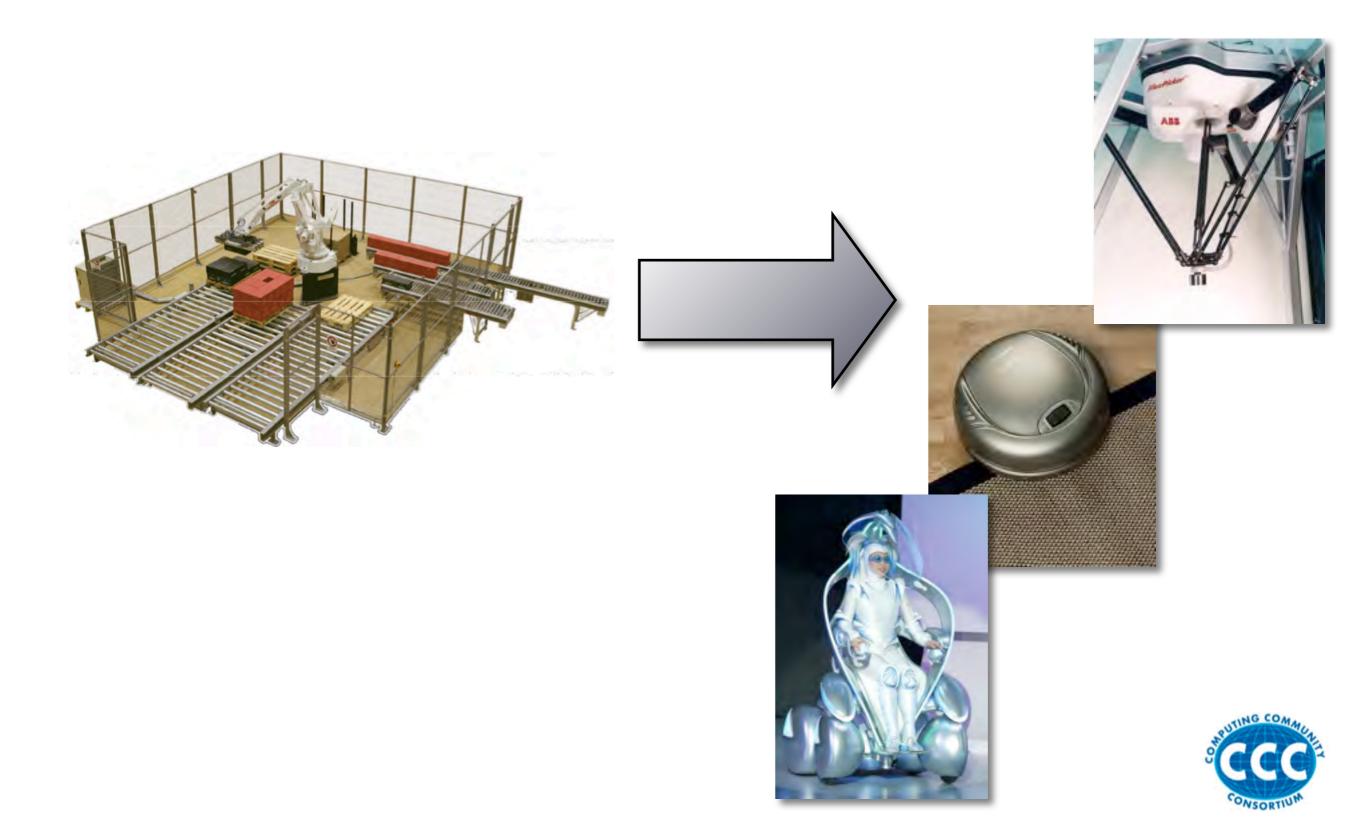
#### Henrik I Christensen KUKA Chair of Robotics







## Robot Evolution





Objective

- To understand how robots can help improve quality of life
  - In the workplace as an assistant
  - In our homes
  - In leisure activities





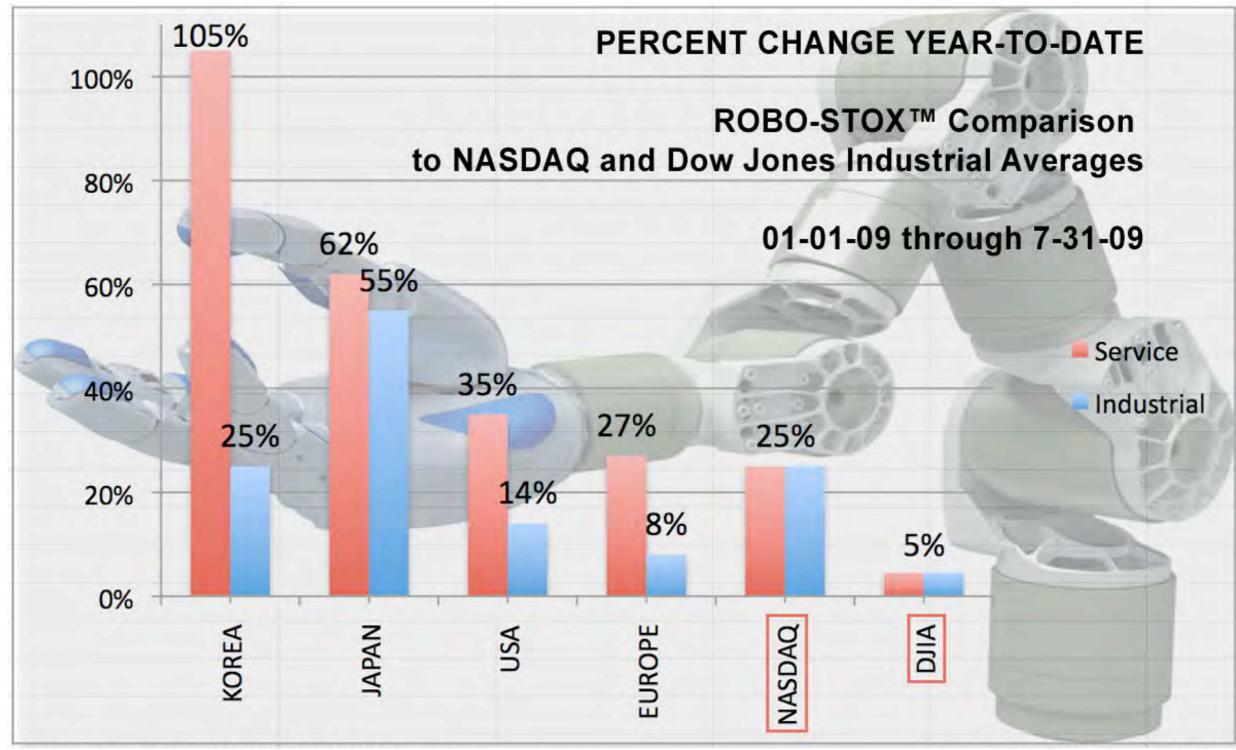


Where to go? - Roadmap

- Effort to investigate a roadmap for robotics in US
- What are the promising opportunities/applications
- •What are the main obstacles to progress?
- What are the key science challenges?
- What is a good strategy to make progress?





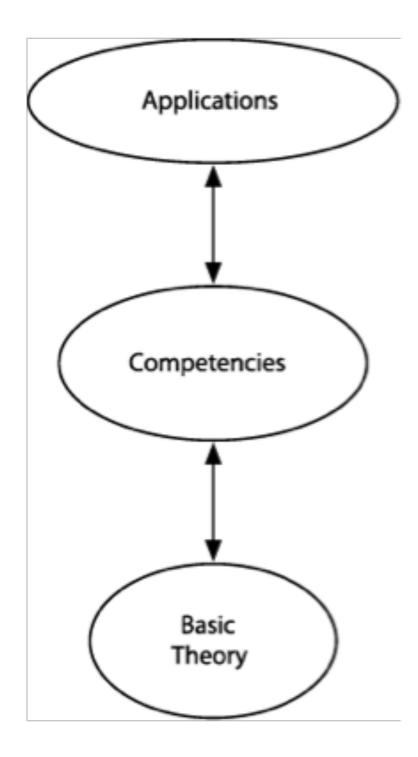


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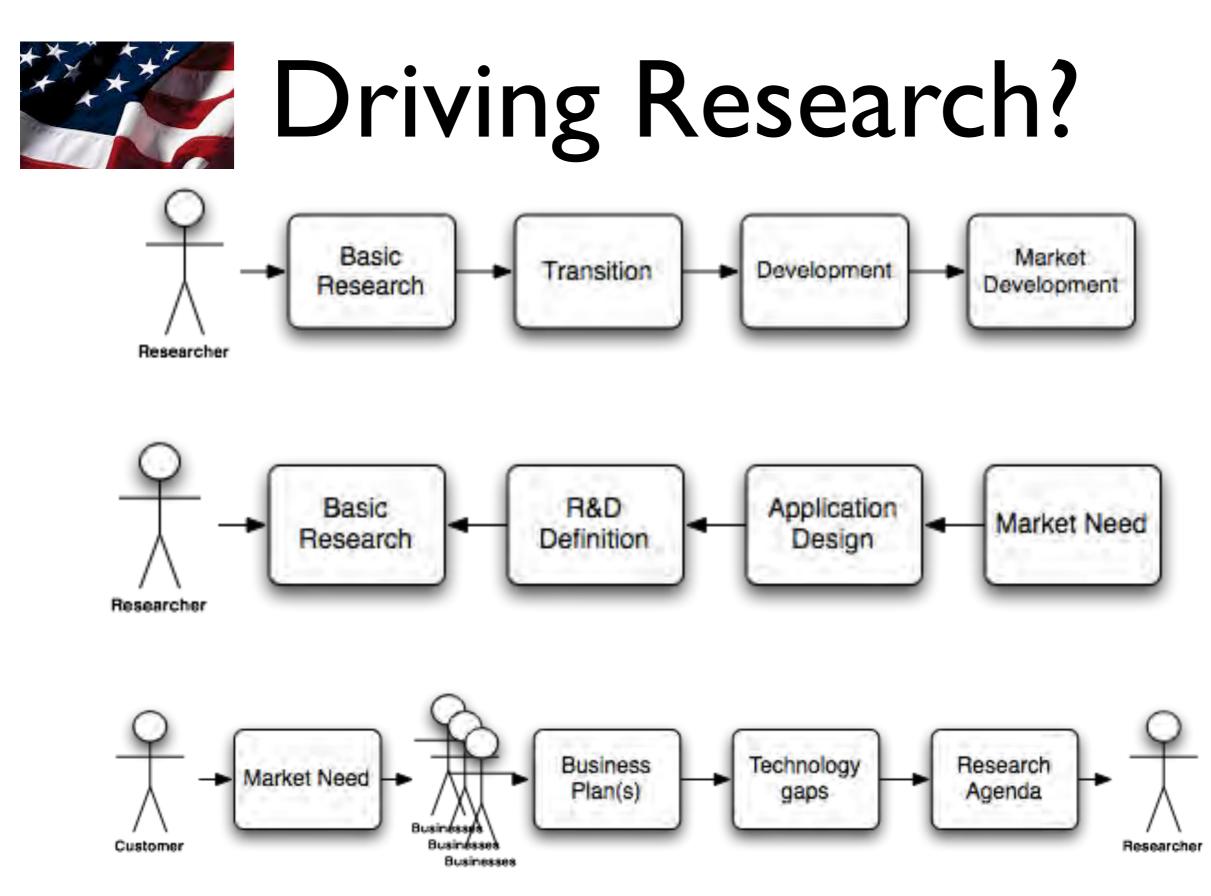
DATA MANAGEMENT: H. ROUSSO



#### Process











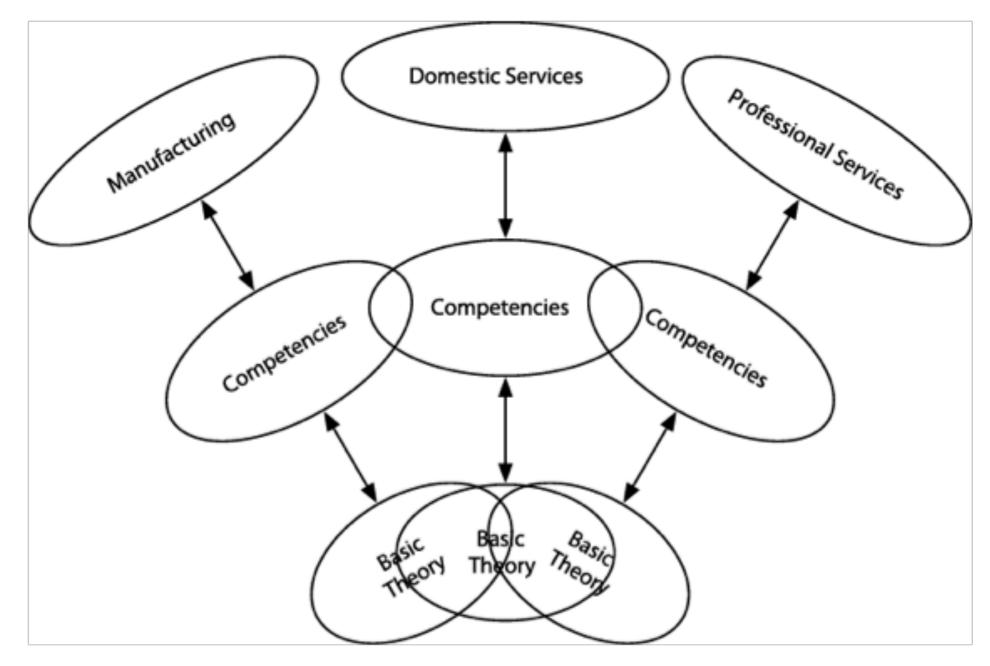
# 4 topical workshops

- Manufacturing & Logistics
  - Trinkle, Kumar, Goldberg, Christensen
- Service Robotics
  - Brock, Thomasmeyer, Christensen
- Medical / Healthcare
  - Mataric, Okamura, Christensen
- Emerging Technologies
  - Mason, Hollerbach, Christensen





## Synthesis?







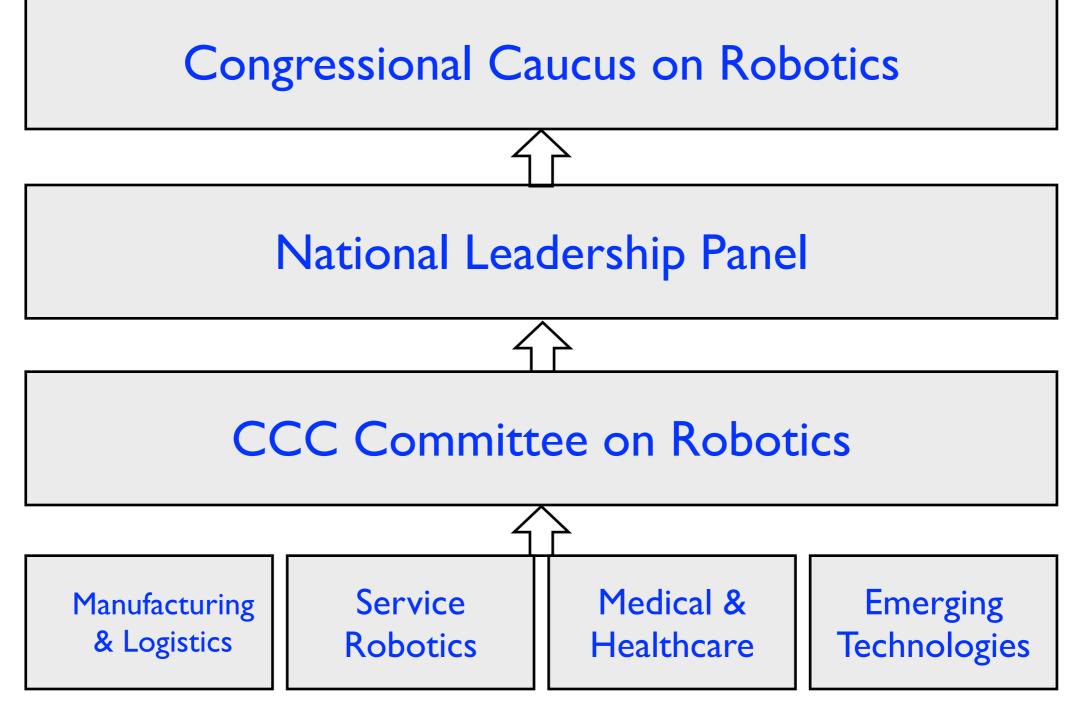
# Timeline

March 08	Start of Effort, Call for Proposals	
June/Aug 08	Workshops	
Oct 08	Draft Topical Roadmaps	
Dec 08	Completed Roadmap Draft	
Mar 09	Community Feedback	
May 09	Presentation to Congress	
Jul 09++	Agency Discussions	
Fall 09	Discussion of Programs	
2011	Launch of Efforts	







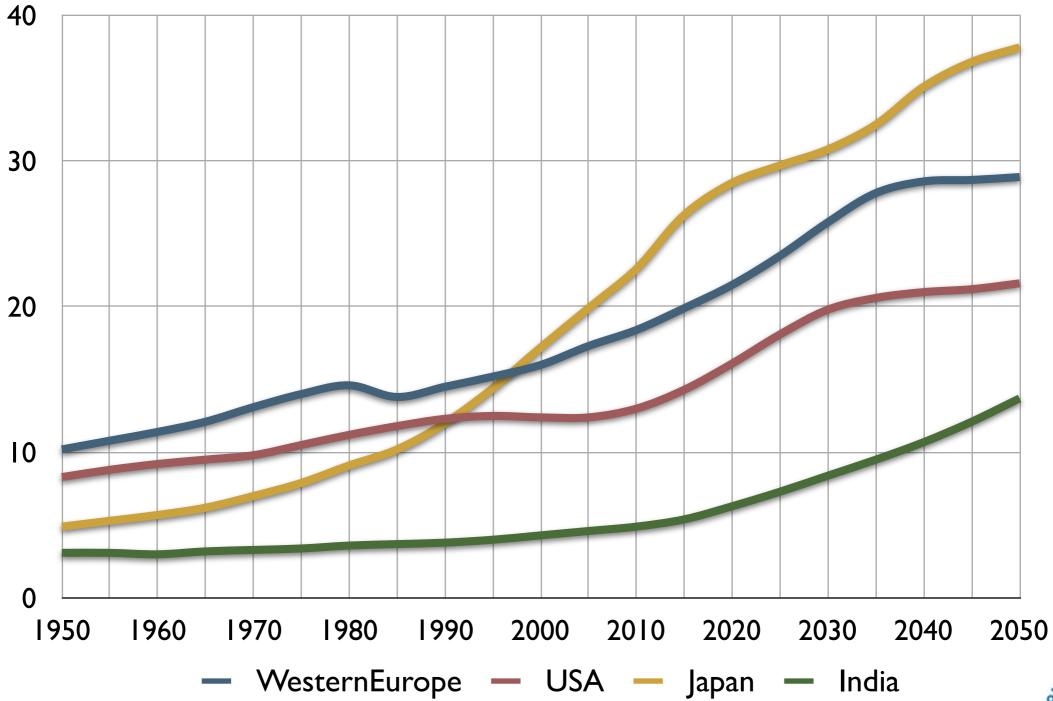






## Societal Drivers

% of population above 65 (UN 2008 Data Series)







# Background Analysis

Average Growth	Growth
20%	0-120%
21%	15-26%
62%	6-542%
6%	4-17%
14%	2-36%
1%	-4-7%
8%	-4-20%
0%	-11-13%
21%	4-96%
4%	2-8%
	20% 21% 62% 6% 14% 14% 8% 0% 21%

Consolidated annual growth rates over a set of 280 U.S. companies for the period 2004-2007.





## Analysis for each area

#### Economic / Societal Drivers

Core capabilities needed for applications

R&D challenges • 5, 10 and 15 year expectations





# Manufacturing

- Large Scale Manufacturing
- Lack of SME Focus
- Flexibility is key to progress
- Logistics is major target
- Process consideration is key
- Perception, Learning & Safety







#### Issues

Architecture and Representations	Perception for operation in unstructured environment	
Control and Planning	Human-like dextrous manipulation	Mining
Formal Methods	Adaptable and reconfigurable assembly	
Learning and Adaptation	Robots working with humans	Processing
Modeling, Simulation and Analysis	Autonomous navigation	Discrete Part Manufacturing
Novel Mechanisms and High- Performance actuators	Rapid deployment of assembly lines	
Perception	Green Manufacturing	Assembly
Robust High Fidelity Sensors	Model-based integration and design of supply chains	Logistics (transport & Distributions)
Physical Human Robot Interaction	Interoperability and component technologies	
Socially Interactive Robots	Nano Manufacturing	





# Medical & Healthcare

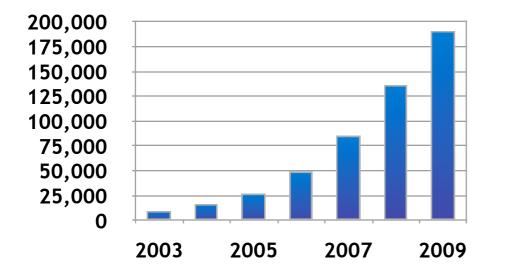
- Medical robotics the fastest growing area
- Surgery: less invasive, faster recovery, less side effects
- Rehabilitation: access to resources, adaptability, and home use
- Growing fast and has a lot of promise
- Perception, Dexterity, HRI, Learning





# Medical Robotics





- Aging of society is seriously challenging the healthcare system
- Medical robotics facilitate faster, better and cheaper intervention
- Early results demonstrated for prostate and cardiac procedures.
- Need to develop and transition technologies from bench to bedside
- Where electronic patient record meets intervention





## Healthcare

- Baby boomers/wounded veterans require services/ quality of life
- Significant benefits to home-care services
- Freedom and personalized assistance
- New generation of flexible systems, ease of use, tied to home services





#### Issues

Architecture and Representations	Intuitive Physical Human-Robot Interaction and Interfaces	
Control and Planning	Automated Understanding of Human Behaviour	Surgical Robots
Formal Methods	Automated Understanding of Emotional and Psychological State	Replacement of function
Learning and Adaptation	Long-term adaptation to user needs	Robot Assisted
Modeling, Simulation and Analysis	Quantitative Diagnostics and Assessment	Rehabilitation / Recovery
Novel Mechanisms and High- Performance actuators	Context Appropriate Guidance	Behavioral Theraphy
Perception	Image Guided Intervention	
Robust High Fidelity Sensors	High Dexterity Manipulation	Personalized Care
	at Any Scale Sensor-Based Automated	Health/wellness promotion
Physical Human Robot Interaction	Health Data Acquisition	
Socially Interactive Robots	Safe Robot Behavior	





# Service Robotics

- Professional Services
  - Agriculture, Mining, ...
  - Autonomy & HRI are key to success
- Domestic Services
  - Cleaning, Surveillance, ....
  - HRI, Autonomy, Perception and Dexterity
  - Price is very challenging





# Professional Services



- Agriculture / Forestry
  - Automated Farms
  - Efficient use / HRI
- Mining
  - Logistics / Risk elimination





### Domestic Services



- Cleaning
- Fetch & Carry
- Surveillance
- Gardening
- Time-savers





## Introduction

Robotics is a transformative technology

 Objective to define a roadmap for commercial use of robotics in the US

Robots empower the american workforce





#### Issues

Architecture and Representations	Human-Dextrous	Logistics
Control and Planning	Manipulation	Transportation
Formal Methods	Real-World 3-D	Healthcare
Learning and Adaptation	Planning & Navigation	Security
Modeling, Simulation and Analysis	Cognition	Education
		Quality of Life
Novel Mechanisms and High- Performance actuators	Robust Perception	Energy and Env Monitor
Perception	Human-Robot Interaction	Infrastructure
Robust High Fidelity Sensors	Skill Acquisition	Agriculture
		Manufacturing
Physical Human Robot Interaction	Safe Robots	Search & Rescue
Socially Interactive Robots		





# Blue Sky Research

New technologies will change our perspective
Nano - new material, scaling down, medicine
Computing - ubiquitous access / embedding
Cheap / Reliable perception - closing the loop
Real world planning





#### Education



- Developing the workforce
- Engaging students in STEM



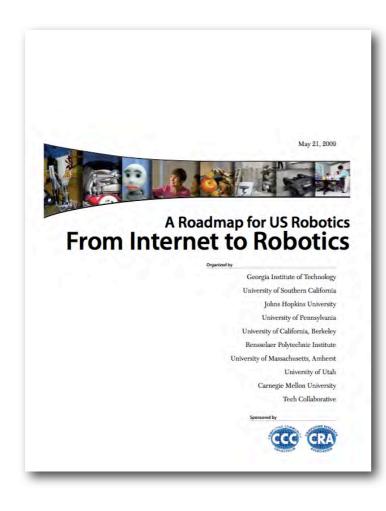


Educational outreach





# CCC Study





- GT Coordination (0806-)
- Congress Presentation (0905)
- OSTP/White House (0912)
- Roll-out (10-Spring)
  - Job Creation
  - Healthcare
  - Security/Services





# Moving forward

- Academia / Industry / Government alliance
- Pushing for a broad agenda
- Roadmap has many of the details
  - http://www.us-robotics.us
- Creation of coordination across agencies and industries
  - National Summit on Robotics across agencies





# Co-X Program

- Co-Workers
  - Manufacturing, Logistics & Medical Robotics
- Co-Inhabitant
  - Safe Cars, Home Assistance, Rehabilitation,
- Co-Protectors
  - Defense, Home Security, Private Security, Economic Security

