

ROBOTICS IN FUTURE WARFARE

Presented By:

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Presented To:

Panel on Robotics & Contemporary/Future Warfare

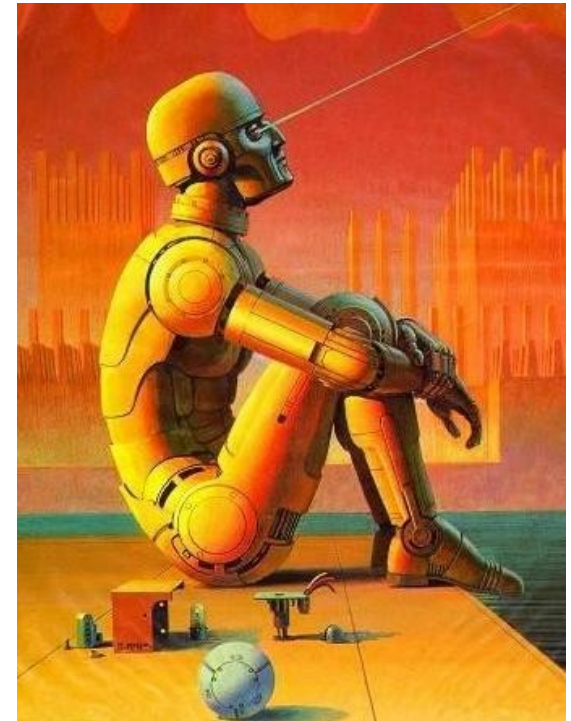
Conference on the

Strategic Implications of Emerging Technologies

at the

U.S. Army War College Strategic Studies Institute

14-16 April 09



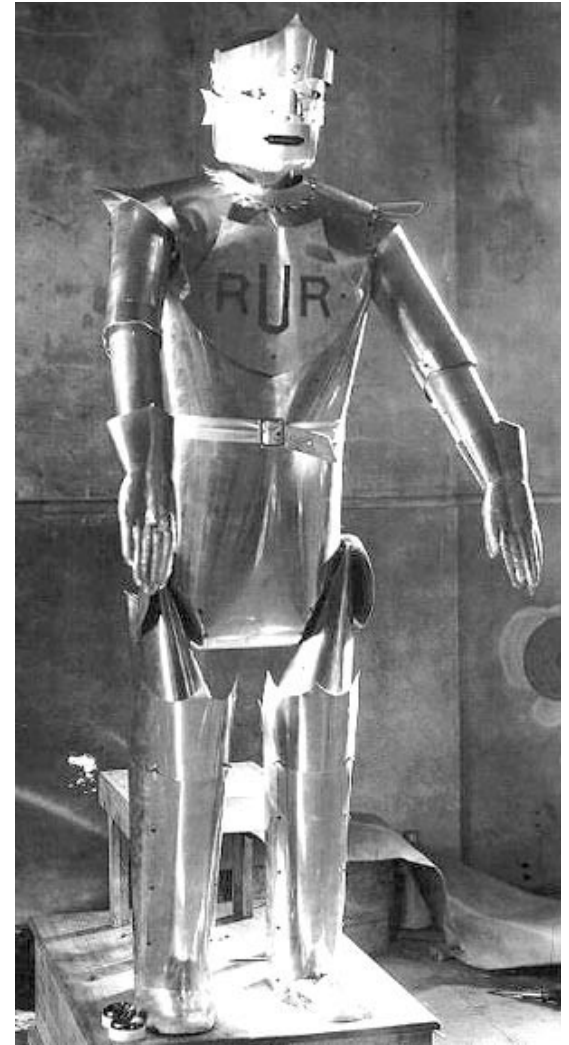
WHAT IS A ROBOT?

- Neologism derived from Czech noun "robota" meaning "labor"
 - Contrary to the popular opinion, not originated by (but first popularized by) Karel Capek, the author of RUR
 - Originated by Josef Capek, Karel's older brother (a painter and writer)
- "Robot" first appeared in Karel Capek's play *RUR*, published in 1920
 - Some claim that "robot" was first used in Josef Capek's short story *Opilec* (the *Drunkard*) published in the collection *Lelio* in 1917, but the word used in *Opilec* is "automat"
 - Robots revolt against their human masters – a cautionary lesson now as then



WHAT IS A ROBOT?

- **Many taxonomies**
 - **Control taxonomy**
 - Pre-programmed (automatons)
 - Remotely-controlled (telerobots)
 - Supervised autonomous
 - Autonomous
 - **Operational medium taxonomy**
 - Space
 - Air
 - Ground
 - Sea
 - Hybrid
 - **Functional taxonomy**
 - Military
 - Industrial
 - Household
 - Commercial
 - **Etc.**

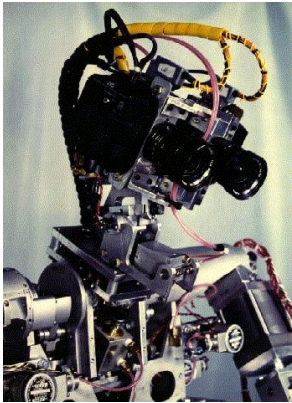
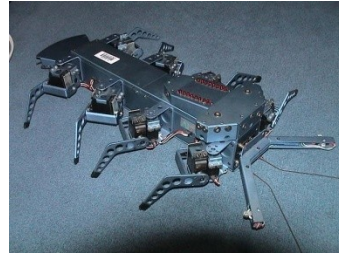


WHAT IS A ROBOT?

- The emerging robot is a machine with sensors, processors, and effectors able to perceive the environment, have situational awareness, make appropriate decisions, and act upon the environment
 - **Various sensors:** active and passive optical and ladar vision, acoustic, ultrasonic, RF, microwave, touch, etc.
 - **Various effectors:** propellers, wheels, tracks, legs, hybrids
 - **Various control system architectures:** deliberative, reactive, hybrid
 - **Various command, control, and communications systems:** cable, fiber optic, RF, laser, acoustic
 - **Various human/machine interfaces:** displays, telepresence, virtual reality
- **Military unmanned vehicles are robots**
 - Space, air, ground, water

























A POTPOURRI OF ROBOTS



A POTPOURRI OF ROBOTS

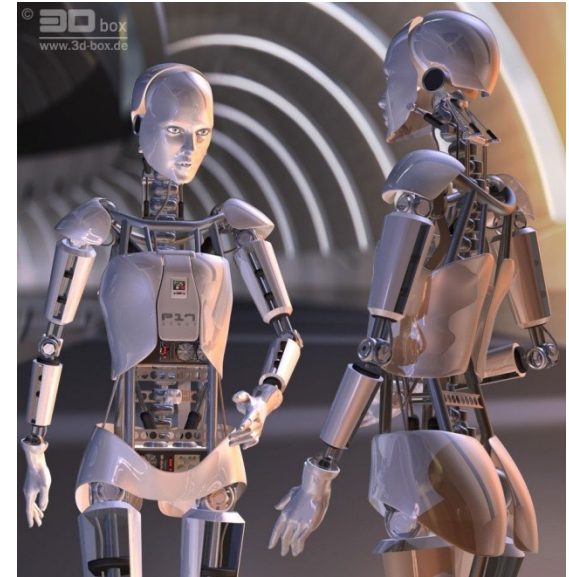
- Many taxonomies have been used for robotic air, ground, and water vehicles: based on size, endurance, mission, user, C3 link, propulsion, mobility, altitude, level of autonomy, etc., etc.

Summary of JRP Weight Classes						
Small (Light) 31 to 400 lbs	 MATILDA 40 lbs	 PackBot 40 lbs	 ODIS 40 lbs	 TALON 80 lbs	 T3 110 lbs	 EOD MTRS 145 lbs
Small (Medium) 401 to 2500 lbs	 RONS 600 lbs	 SARGE 650 lbs	 REDCAR 1000 lbs	 GLADIATOR 1600 lbs	 Mini-Flail 2500 lbs	
Small (Heavy) 2501 to 20K lbs	 MDARS 2640 lbs	 DEMO III XUV 3000 lbs	 MULE 5000 lbs	 ARTS 8100 lbs	 RCSS 11,220 lbs	 Smoke HMMWV-CRS 11,500 lbs
Large Over 30K lbs	 DEUCE-CRS 18 tons	 D7G-CRS 28 tons	 A-AOE 34 tons	 Panther-CRS 40 tons	 Abrams Panther-CRS 43 tons	

*No systems currently exist in the Micro (<8 lbs), Miniature (8-30 lbs), or Medium (20K-30K lbs) classes.

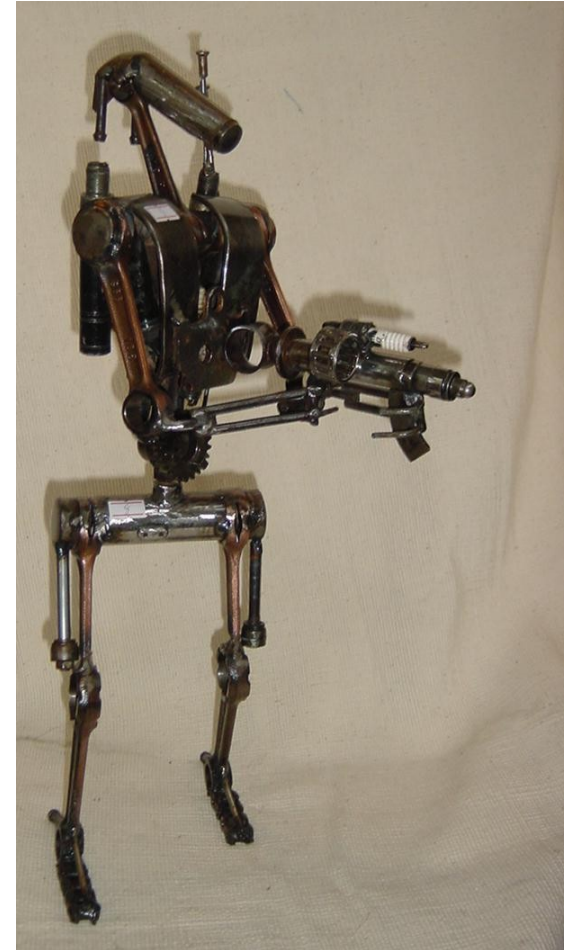
RATIONALE FOR ROBOTS

- **Three Hs: hot, heavy, hazardous**
- **Three Ds: dull, dirty dangerous**
- **Ideal for the increasing lethality of warfare**
 - **No casualties or POWs**
 - **No high attrition of expensive manned systems**
 - **Reduced public backlash**
 - **Flexibility to counter terrorist, insurgent, and tribal warfare**
- **Increasing personnel costs & changing demographics**
- **Changing geopolitical climate & doctrine**
- **Proliferation of weapons of mass destruction (CBR)**
 - **Render large areas toxic, uninhabitable**
 - **Protective garments limit manned efficiency and effectiveness**



RATIONALE FOR ROBOTS

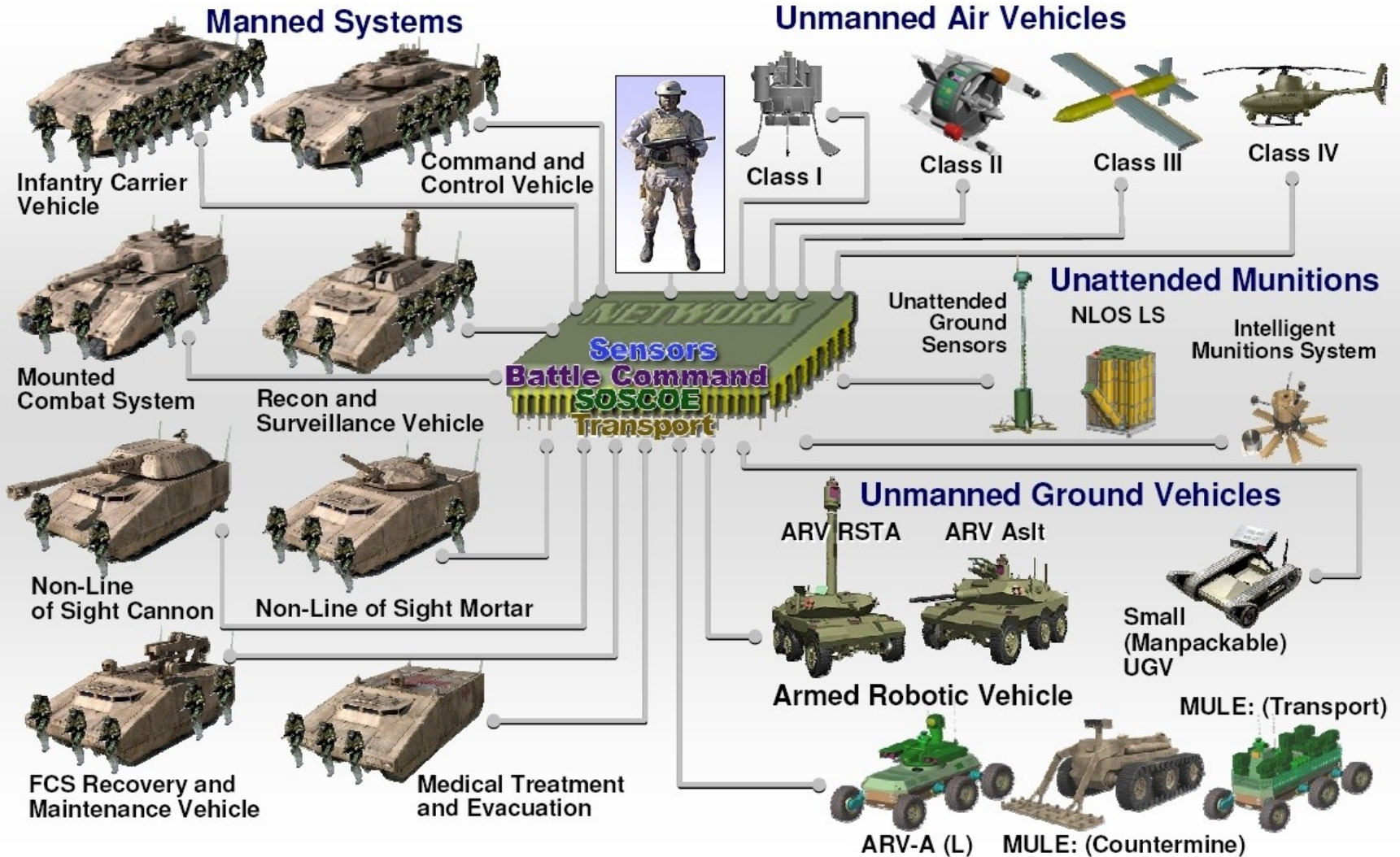
- No need to encase and protect humans in vehicles: **smaller, lighter, less expensive**
- Expendable: **suicide missions**
- More survivable: **small signature**
- More maneuverable: **faster, higher acceleration**
- Faster response time: **pre-positioning**
- No casualties: **riskier maneuvers and tactics**
- Fearless and aggressive: **not deterred by near misses**
- Indefatigable: **no need for sleep or rest**
- Autonomous: **fewer personnel can supervise more systems**
- Advancing, emerging technology: **advantage of U.S. strength and decreasing cost**
- Disruptive, transformative technology: **can counter new threats**
- Swarm tactics: **equivalent of ESP**



RATIONALE FOR ROBOTS

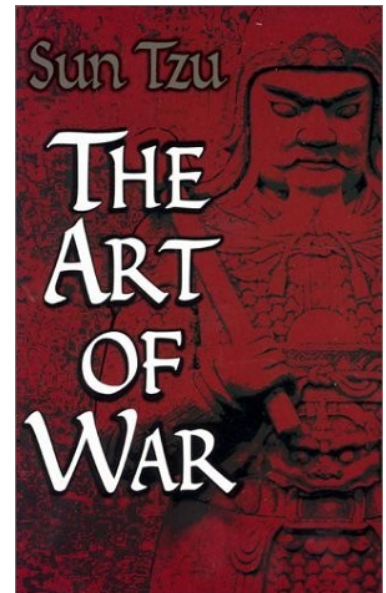
Congress: one-third of all combat vehicles to be robots by 2015

Future Combat System (FCS) Development cost by 2014: \$130-\$250 billion



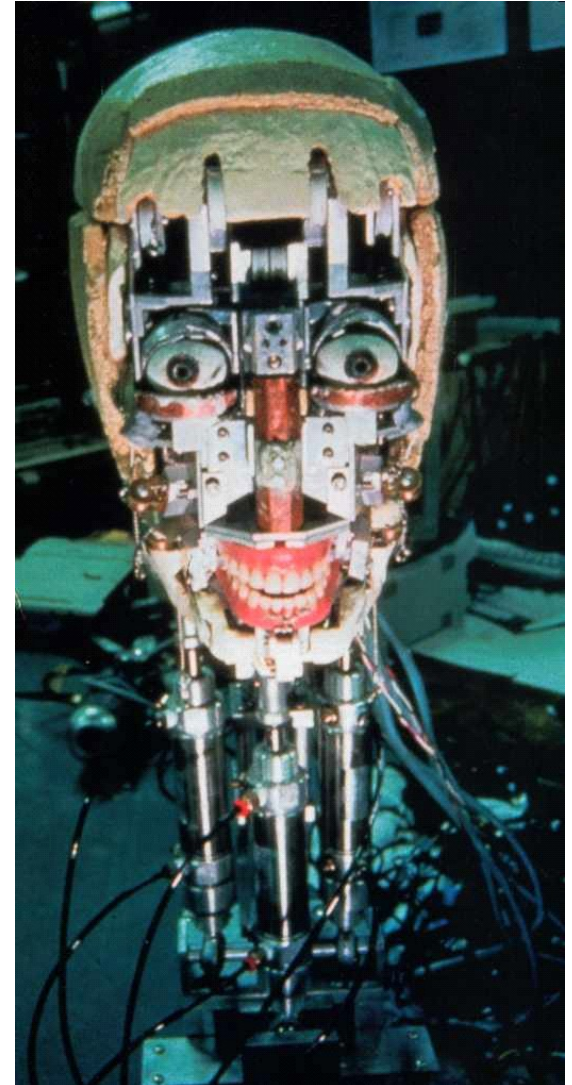
MILITARY ROBOTICS AND THE ANCIENT WISDOM OF SUN TZU

- *Sun Tzu On The Art Of War* – oldest extant military treatise (2400 years old)
- ***The art of war is vital to the state***
 - U.S. military must seek transformational technology to meet new threats
- ***As circumstances are favorable, one should modify one's plans***
 - Robots will be flexible, adaptable, resilient; reconfigurable and transportable
- ***All warfare is based on deception***
 - Robotic systems can take many forms; they can be stealthy or intentionally noisy, or they can cloak themselves and deceive the enemy physically, electronically, and behaviorally



MILITARY ROBOTICS AND THE ANCIENT WISDOM OF SUN TZU

- *If he is taking his ease, give him no rest. If his forces are united, separate them*
 - **Robotic systems are tireless and will implacably and remorselessly hound the enemy**
 - **Robotic swarms can infiltrate enemy forces and cause them to scatter**
- *Attack him where he is unprepared, appear where you are not expected*
 - **With a profusion of linked sensors in space, in the air, on the ground – unattended and mobile – the robotic system of systems can pinpoint where the enemy is unprepared**
 - **Robotic forces can appear where they not expected (e.g., stealthy and travel without rest)**



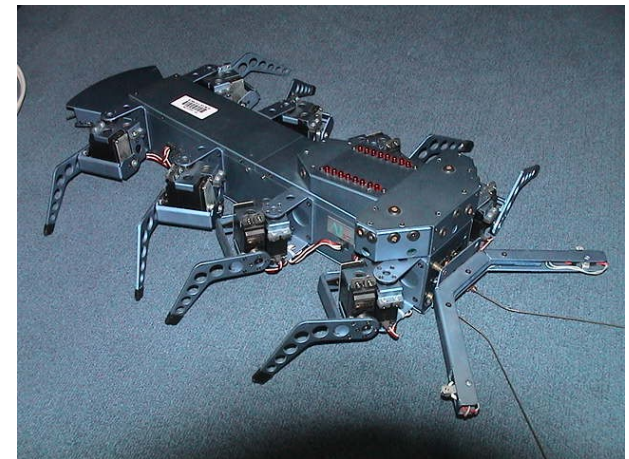
MILITARY ROBOTICS AND THE ANCIENT WISDOM OF SUN TZU

- *Though an obstinate fight may be made by a small force, in the end it must be captured by the larger force*
 - **A robotic force can put up an “obstinate fight” if it will contribute to the mission – and not be concerned about being captured**
- *Hold out baits to the enemy. Feign disorder and crush him*
 - **Robotic systems, being expendable, can be used as bait to lure the enemy into the killing zone**



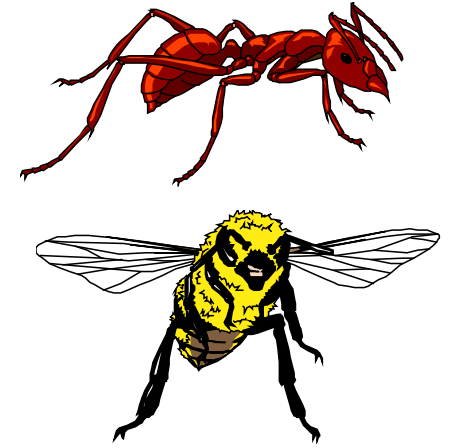
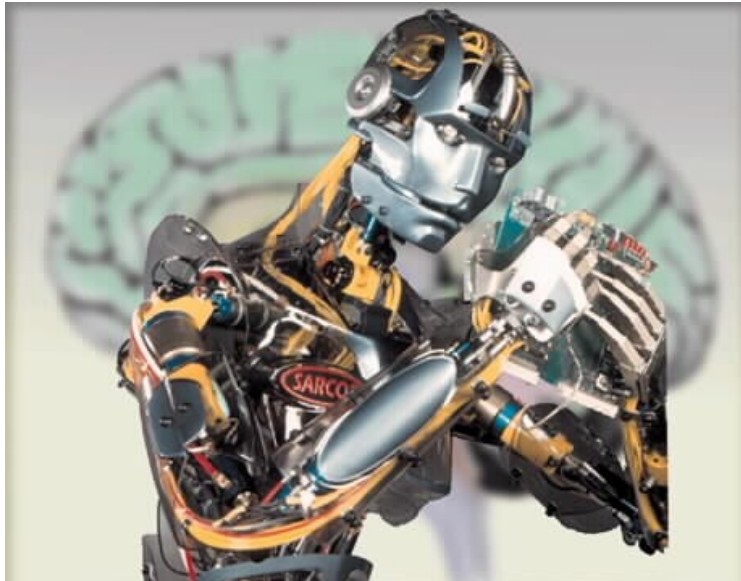
MILITARY ROBOTICS AND THE ANCIENT WISDOM OF SUN TZU

- *Do not repeat the tactics which have gained you one victory, but let your methods be regulated by the infinite variety of circumstances*
 - **The tactics for combat robotics (which are yet to be developed) can be far more varied than for conventional systems**
 - **Prospective tactics can be tested in near-real time by distributed interactive simulators embedded within the systems**
- **Hence that general is skillful in attack whose opponent does not know what to defend; and he is skillful in defense whose opponent does not know what to attack**
 - **The “shape-shifting” nature of the agile robotic collective, reconfiguring into forces with different elements and abilities, will leave the enemy with an inability to know how to best defend or attack**

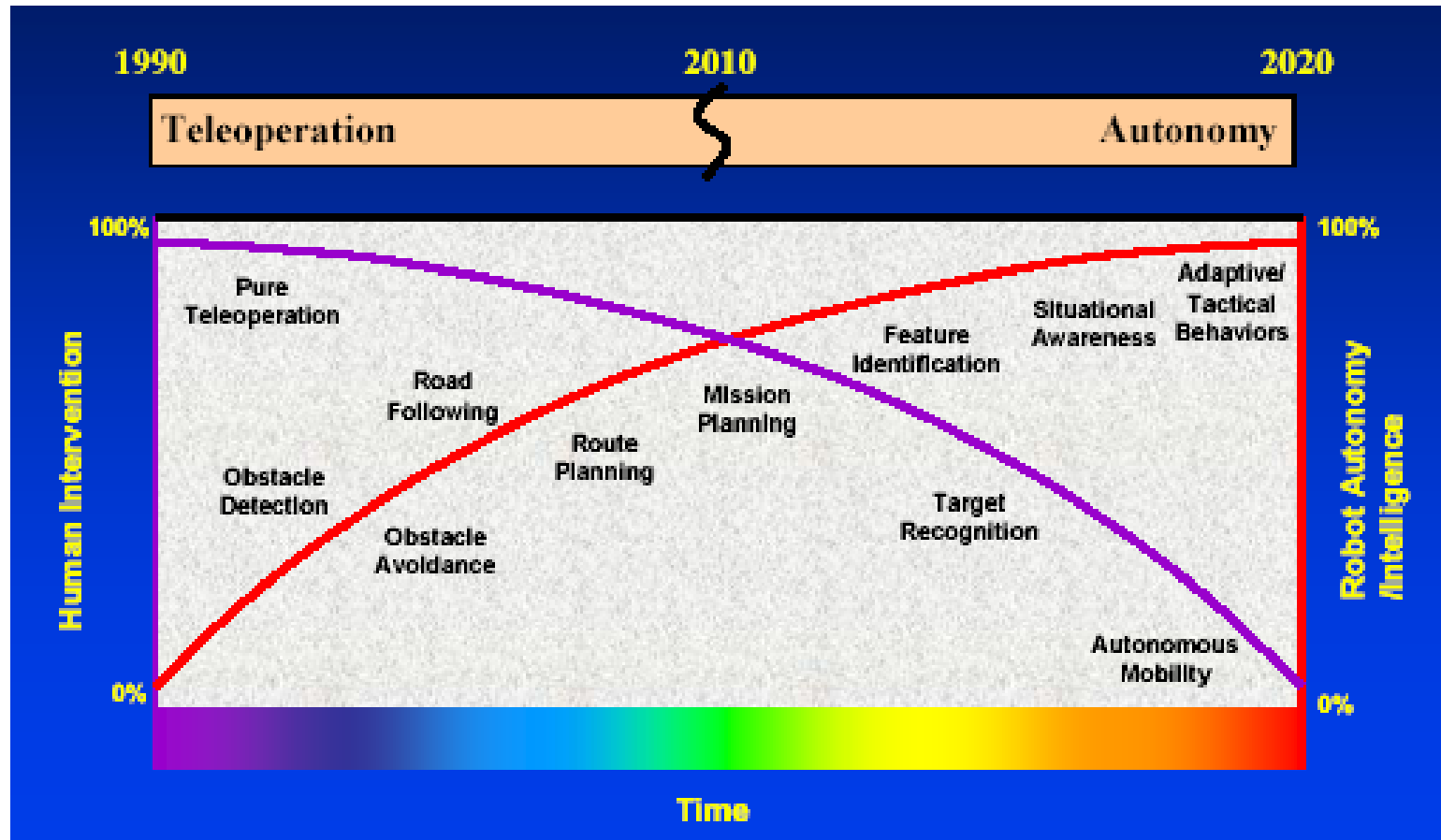


WHAT IS INTELLIGENCE?

- Pragmatic definition of intelligence: “an *intelligent system* is a system with the ability to act *appropriately* (or make an appropriate choice or decision) in an uncertain environment.”
 - An *appropriate* action (or choice) is that which maximizes the probability of successfully achieving the *mission goals* (or the *purpose* of the system)
- Intelligence need not be at the *human* level



DOD PATH TOWARD AUTONOMY



DOD ENABLING INTELLIGENT VEHICLE TECHNOLOGY PRIORITIES

- **Establishing common architecture**
 - **Open and modular**
 - **Standardized interfaces**
 - **Progress toward commercial standards**
- **Developing semi-autonomous mobility**
 - **With obstacle detection and avoidance, tactical behaviors, and man-machine interfaces**
- **Integrating mission payloads**
 - **Including manipulators, sensors, and weapons**
- **Vehicle intelligence sufficient for complete autonomy by 2020**
 - **Human intervention for missions will approach zero**

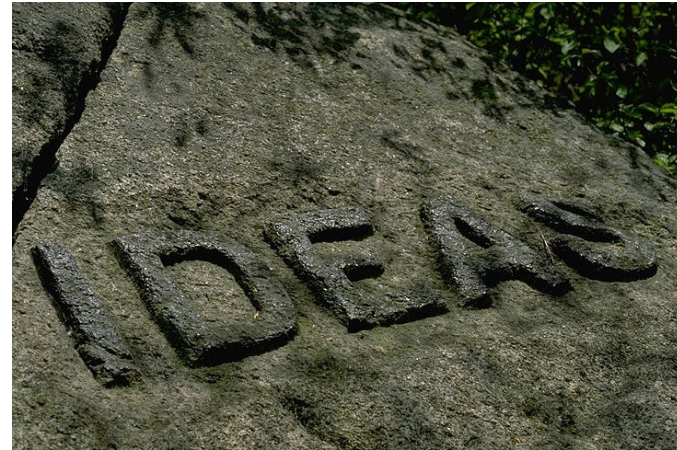


EXAMPLE AUTONOMY TAXONOMY

- 1) System offers no assistance – operator must do everything
- 2) System offers a complete set of action alternatives to operator
- 3) System narrows the action alternatives to a few
- 4) System suggests a selection, and
- 5) System executes a selection if operator approves, or
- 6) System allows operator a restricted time to veto before automatic execution, or
- 7) System executes automatically, then necessarily informs operator, or
- 8) System informs operator after execution only if operator asks, or
- 9) System informs operator after execution - if system decides to
- 10) System decides everything and acts autonomously, essentially ignoring the human

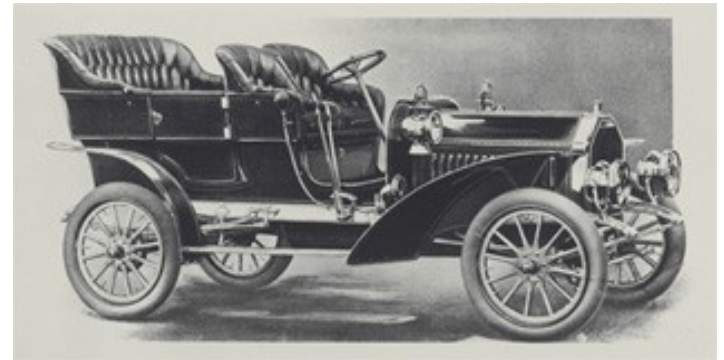


TECHNOLOGY FORECASTING: FEARLESS FORECASTS



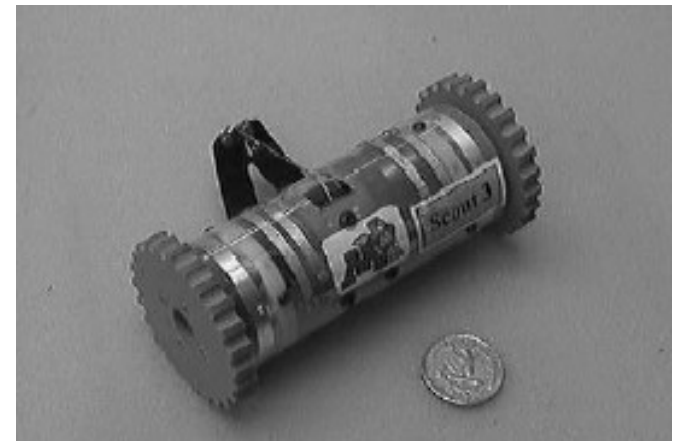
TECHNOLOGY FORECASTING

- **First order impacts: linear extrapolation – faster, better, cheaper**
- **Second and third order impacts: non-linear, more difficult to forecast**
- **Analogy: The automobile in 1909**
 - **Faster, better, cheaper than horse and buggy (but initially does not completely surpass previous technology)**
 - **Then industrial changes: rise of automotive industry, oil industry, road & bridge construction, etc.**
 - **Then social changes: clothing, rise of suburbs, family structure (teenage drivers, dating), increasing wealth and personal mobility**
 - **Then geopolitical changes: oil cartels, foreign policy, religious and tribal conflict, wars, environmental degradation and global warming**



ROBOTICS IN FUTURE WARFARE

- **First order impacts usually linear extrapolation: faster, better, cheaper**
 - **Greater accuracy for RSTA and weapons**
 - **Greater flexibility for forces**
 - **Fewer casualties**
 - **Faster deployment**
 - **Lower-cost systems**
- **Second and third order impacts usually non-linear, more difficult to forecast**
 - **Changes in organization, composition, and structure of forces (examples)**
 - **Smaller**
 - **More rapidly deployed**
 - **Mixed forces (air, ground, sea)**



ROBOTICS IN FUTURE WARFARE

➤ Second order impacts (Cont.)

➤ Changes in tactics

- Highly dynamic, very aggressive, 3-dimensional battlespace
- **Mixed Cyber-Forces: robots and humans in exoskeletons**
- Overwhelming swarms and collectives (like the Borg: “resistance is futile”)
- **Offensive defense**
- **Non-nuclear deterrent**

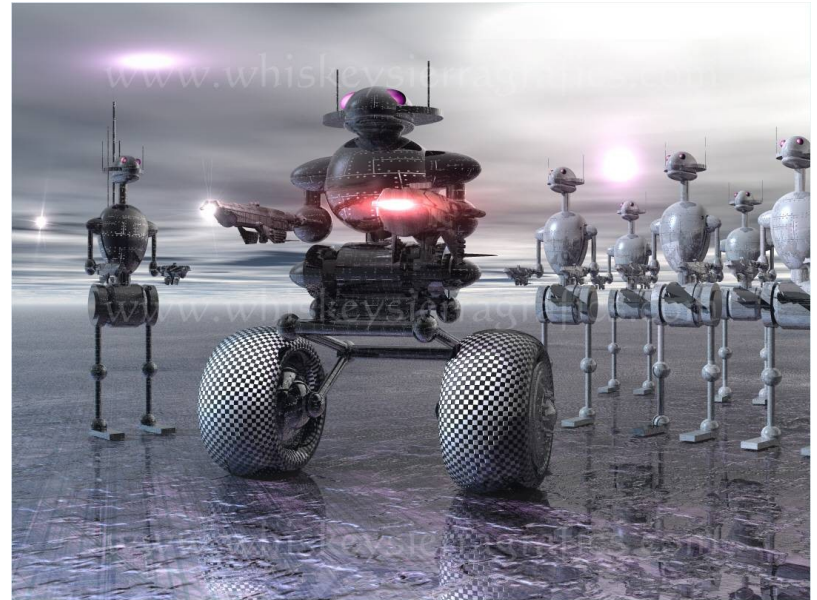
➤ Changes in personnel

- Fewer people, different skills
- **Training *by* and *of* robots**
- Reduced training time and costs
- **Recruiting changes (e.g., quantity and quality; age and sex; physical ability; terms of enlistment)**



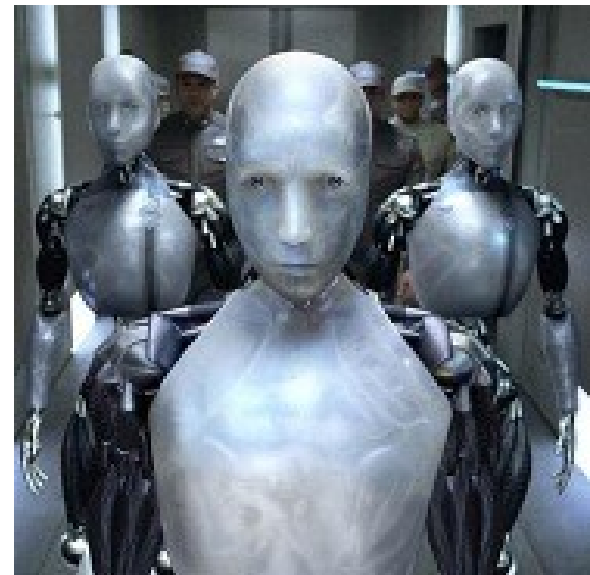
ROBOTICS IN FUTURE WARFARE

- **Second order impacts (Cont.)**
 - **Robotics – military and civilian – will become ubiquitous in peace and war**
 - **There will be almost no human combatants on the battlefield**
 - **Robots will generate \$12 trillion in annual U.S. revenue (2009 dollars) – approximately the U.S. GDP in 2007**



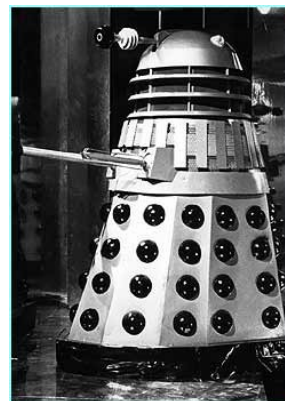
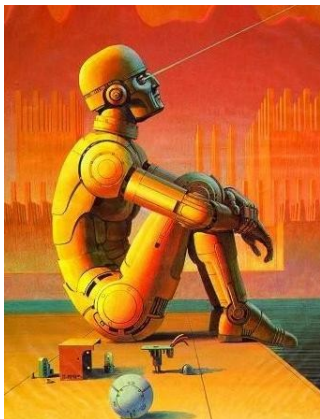
ROBOTICS IN FUTURE WARFARE

- **Second order impacts (Cont.)**
 - **A code of moral behavior for intelligent robots will be developed**
 - **Isaac Asimov's Three Laws are insufficient (especially for military)**
 - **A robot may not injure a human being or, through inaction, allow a human being to come to harm**
 - **A robot must obey orders given it by human beings except where such orders would conflict with the First Law**
 - **A robot must protect its own existence as long as such protection does not conflict with the First or Second Law**
 - **Human or near-human cognition and behavior will be achieved**



THIRD ORDER IMPACTS

- Tactical
- **Strategic**
- Doctrine
- **Organizational**
- Political
- **Cultural**
- Psycho-social
- **Economical**



ROBOTICS IN FUTURE WARFARE

➤ Third order impacts

- **More intervention?**
- **More humane?**
- **More hubris?**
- **More peace?**
- **More war?**

