Emerging Technologies & Security

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Introduction to
Emerging Technologies Panel
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Assessing Emerging Tech

- **Understanding "emerging technologies"**
  - What are those new developments at cusp of science and application that may have major impacts on global society overall and in particular on "security" aspects of society?
    - **What are tech trends and prospects?**
    - **Who is likely to have what capabilities?**

- **What are implications of "emerging technologies" on security?**
  - Must also understand the policy processes and mechanisms for "emerging techs" and their prospects—who is doing what to explore, develop and *implement* the technology?

Emerging technologies don't "just emerge"—they're made to emerge through purposive action

Emerging Technologies [one list…]

- **Technotronics**—from microelectronics to nanotronics, quantum-spintronics and biotronics
- **MEMs**
- **Nano Tech**—nanomachines, self assembly, nanotubes
- **Mobile telecommunications networks**
- **Sensors and Sensing systems**—smart sensors, distributed sensing, RFID, sensor nets and swarms, biosensors
- **Info tech**—virtual reality, ubiquitous computing, grid computing
- **Robotics**—intelligent systems, robot teams, nanobots, human augmentation
- **Autonomous Systems**—unmanned combat air vehicles, organic air vehicles, micro air vehicles, UGS, UUVs/USVs
- **Biotech**—genetic engineering, bio-diagnostics, bio-remediation, bio-weapons
- **Energy & Propulsion**—fuel cells, directed energy, superconductors

Emerging Technology—other prospects…

- Engineered materials—application-specific materials--electrically active polymers, bio-engineered materials
- Advanced displays—flexible displays, holographics
- Cognitive processing—aided cognition
- Universal translation
- Alternative energy—biomass; solar; fusion…
- T-rays (terahertz radiation)
- Synthetic fuels
- Alternative propulsion—nutating engine, etc.
- Microfluidic optical fibers
- Volumetrically controlled manufacturing
- Telegenics—virtual tele-presence
- Psycho-pharmaceuticals
- Synthetic biology
- Bayesian machine learning
- Humanoids……

Any list of emerging tech is
[1] arbitrary
[2] judgemental
[3] partial

Technotronics

The technological wherewithal that makes cyberspace possible

**Cyberspace--**nexus of computer systems and networks, in which electronic data are stored and communication takes place.
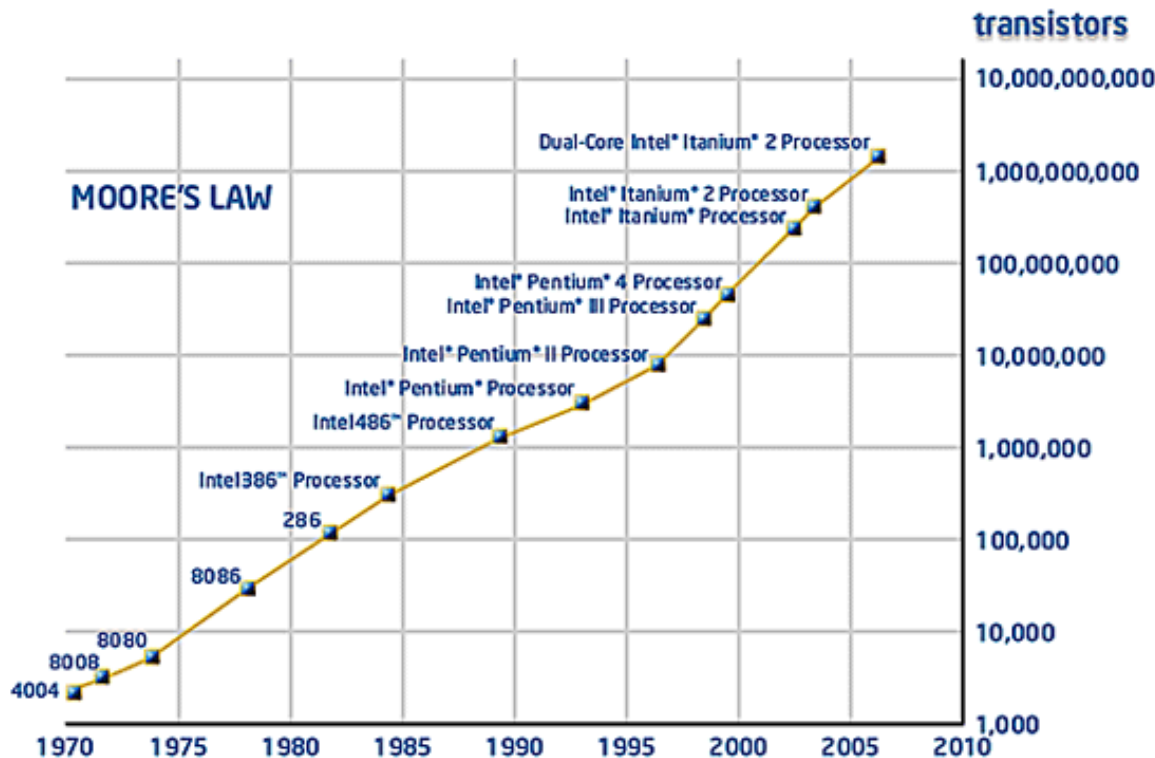
– **Approaching physical limits**
  - **"Moore's Law"—the implications of smaller feature size**

- **Moore's Law is a *behavioral projection* based on faith in human ingenuity and business opportunity—it is not a physical law.**

Beyond Moore's Law: Spintronics / Biotronics?

- ## Spintronics
  - Uses electron's "spin" to determine its state with potential to create computing devices that are considerably faster than current silicon devices.
  - Spintronics should also, in theory, dissipate little heat

- ## Biotronics?

C   G
A   T
H-bonds

(a) T and G imino complex

T-A   C-G

metal ion[++] in, H^{+} out
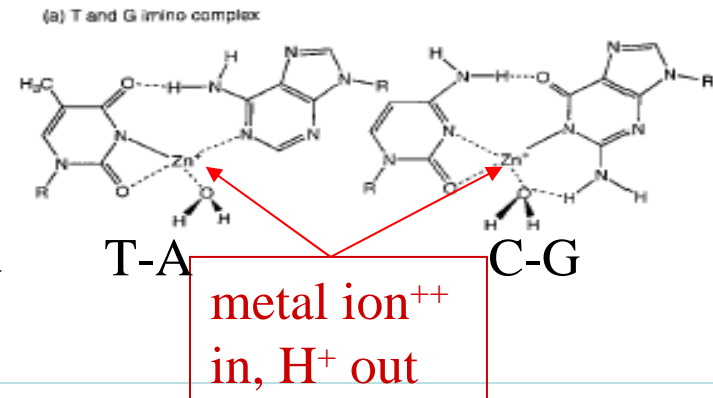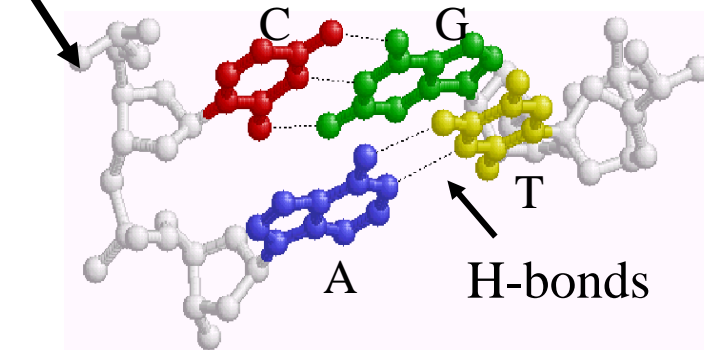
Molecularly changing DNA's conductivity by replacing imino protons of base pairs by metal ions

What do we get?

Metallic Conduction through Engineered DNA: DNA Nanoelectronic Building Blocks

A. Rakitin,[1] P. Aich,[2] C. Papadopoulos,[1] Yu. Kobzar,[1] A. S. Vedeneev,[1,3] J. S. Lee,[2] and J. M. Xu[1]

MEMS � MEMSification

- Accelerometers for controlling auto air bags, arming and safing of weapons
  - Today, because of MEMS, the accelerometer and electronics are integrated on a single chip at a cost of under $10. The small size (about the dimensions of a sugar cube) provides a quicker response to rapid deceleration.
  - Intelligent tires….
- Fail-safe locks for nuclear weapons
- Micronozzles that direct the ink in inkjet printers
- Miniature robots (micro-robots);micro-tweezers
- Video projection chips with a million micro-mirrors
- Defense and aerospace
  - Navigational gyroscopes,
  - Sensors--border control, environmental monitoring
  - munitions guidance
- Medicine
  - Microfluidic DNA Analysis
  - Disposable blood pressure transducers
  - Hearing aids
- Telecommunications
  - Cell phones—integrated systems-on-chip
  - MEMS-based optical switches

UCB 15KV 100μm X70 18mm
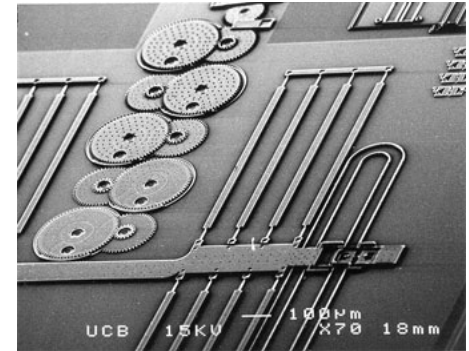
Nanomems

Nano-MEMS

- Nano$\rightarrow$ molecular-level, self assembly of system
- Chemical
  - Nano-wires
  - "Three-dimensional MEMS with functionalized carbon nanotubes"
  - Nanoelectronic building elements for nanoMEMS and bioMEMS
  - Carbon and ceramic microcoils for MEMS by microwave CVD

- Biological
  - DNA-based structures
  - Virus generated

MEMS-based nano-systems may be key to future sensing and perhaps future autonomous robotics

3rd Generation
Information
Technology

DARPA impact — From computers to Interactive Information
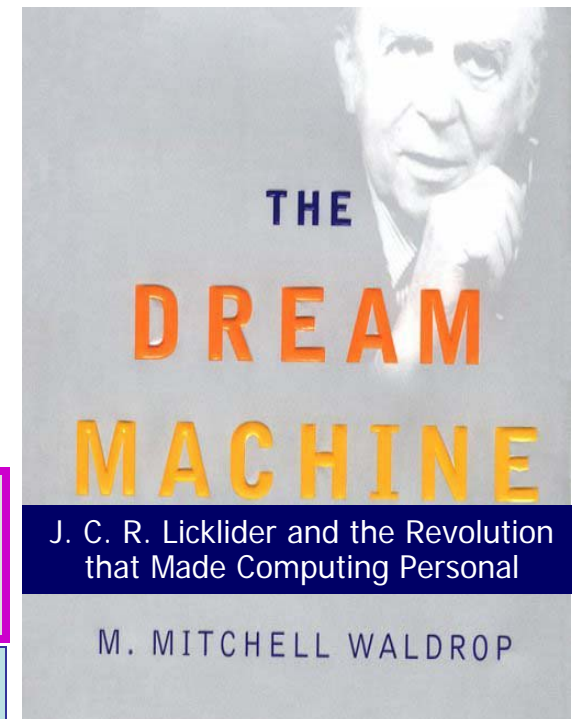
- DARPA and Info Tech—"Toward Man Computer Symbiosis"
  - Making computers interactive
  - Internetted computing
  - Virtual reality
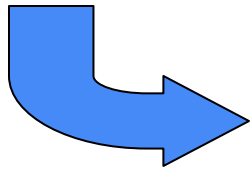
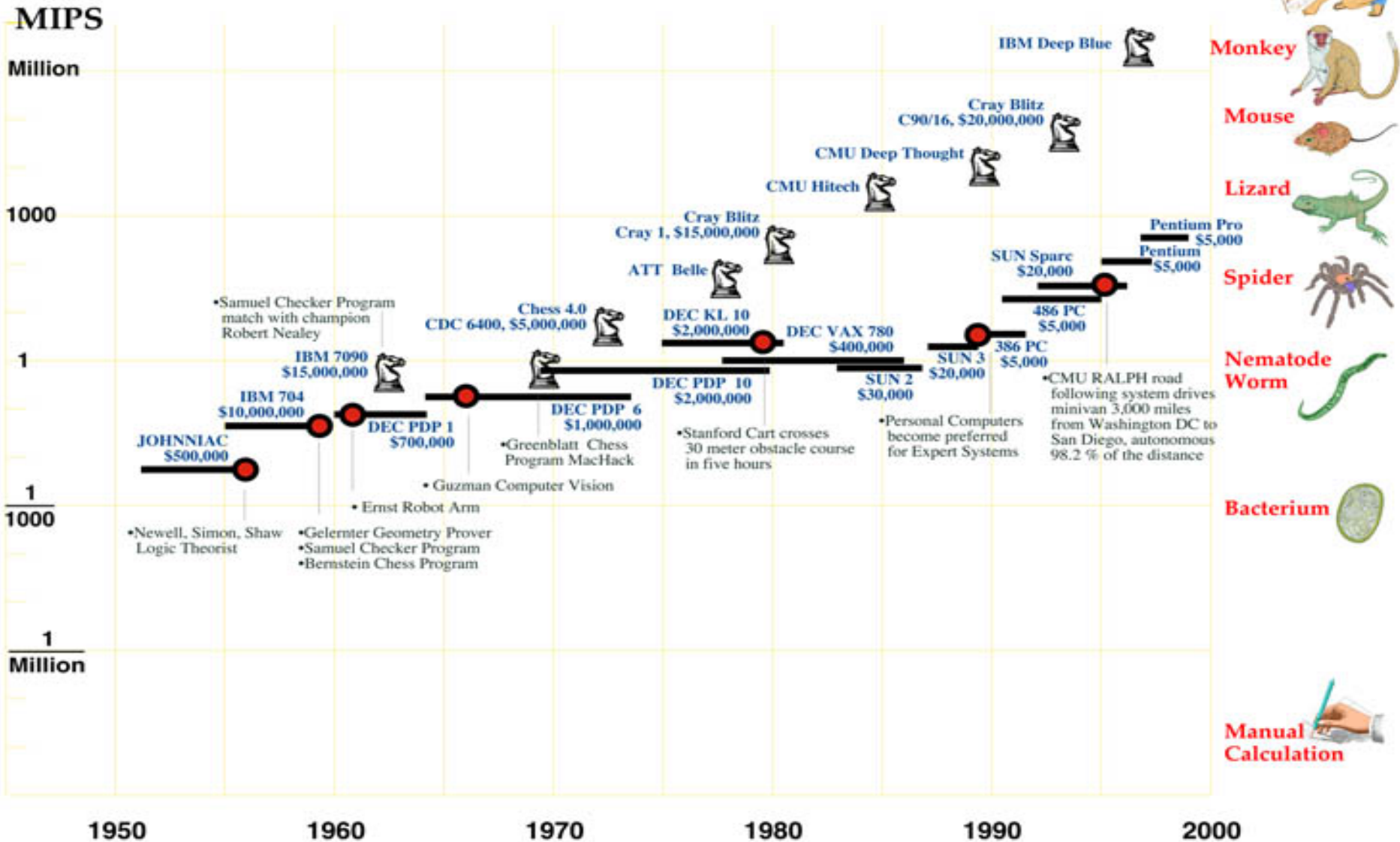**Intelligent systems**

- **Are "cognitive" cybersystems our goal?**
- **Should they be?**

How close to Licklider's Vision are we getting?

J. C. R. Licklider and the Revolution that Made Computing Personal

THE DREAM MACHINE

M. MITCHELL WALDROP

COGNITIVE COMPUTING

Computer power available to AI and Robot programs

Brain Power Equivalent
Human
Monkey
Mouse
Lizard
Spider
Nematode Worm
Bacterium
Manual Calculation

MIPS
Million
1000
1

IBM Deep Blue

Cray Blitz
C90/16, $20,000,000

CMU Deep Thought

CMU Hitech

Cray Blitz
Cray 1, $15,000,000

ATT Belle

•Samuel Checker Program
match with champion
Robert Nealey

Chess 4.0
CDC 6400, $5,000,000

DEC KL 10
$2,000,000

DEC VAX 780
$400,000

Pentium Pro
$5,000
SUN Sparc   Pentium
$20,000 $5,000

486 PC
$5,000

IBM 7090
$15,000,000

IBM 704
$10,000,000

DEC PDP 1
$700,000

DEC PDP 6
$1,000,000

DEC PDP 10
$2,000,000

386 PC
$5,000

SUN 3
$20,000

SUN 2
$30,000

•CMU RALPH road
following system drives
minivan 3,000 miles
from Washington DC to
San Diego, autonomous
98.2 % of the distance

JOHNNIAC
$500,000

•Greenblatt Chess
Program MacHack

• Guzman Computer Vision

•Stanford Cart crosses
30 meter obstacle course
in five hours

•Personal Computers
become preferred
for Expert Systems

• Ernst Robot Arm

1
1000

•Newell, Simon, Shaw
Logic Theorist

•Gelernter Geometry Prover
•Samuel Checker Program
•Bernstein Chess Program

1
Million
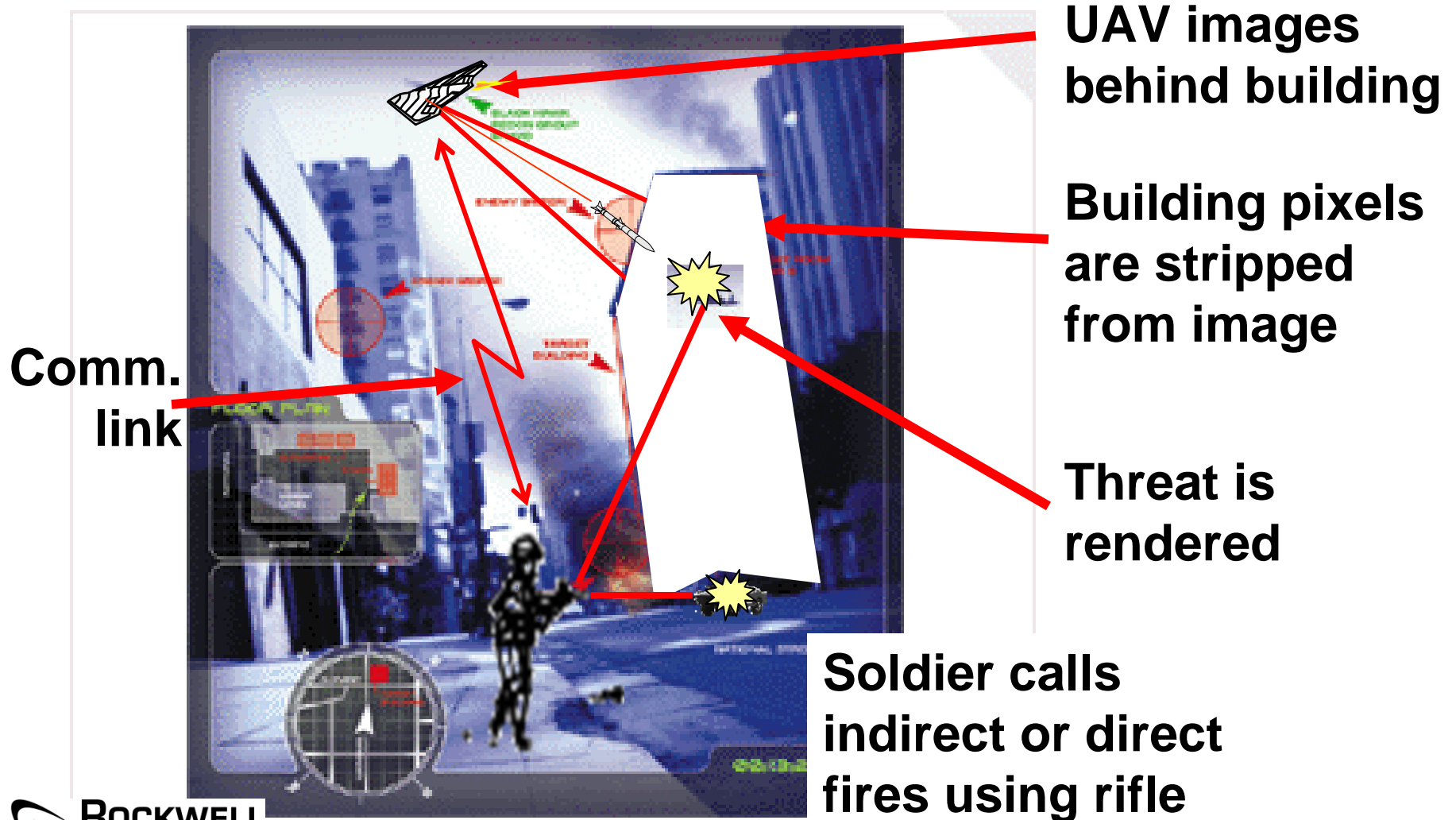
1950   1960   1970   1980   1990   2000

Cognitive Systems:

"Systems that know what they're doing"

- **A cognitive system**
    - can **reason**, using substantial amounts of appropriately represented knowledge
    - can **learn** from its experience so that it performs better tomorrow than it did today
    - can **explain** itself and **be told** what to do
    - can be aware of its own capabilities and **reflect** on its own behavior
    - can **respond robustly** to surprise

# Augmented Reality: Virtual "X-Ray" Zoom Vision with Intelligent Rifle

UAV images behind building

Building pixels are stripped from image

Comm. link

Threat is rendered

Soldier calls indirect or direct fires using rifle

A Possible Vision:
Tactical-Level "ISR/Weapon" System of Systems

Functions Performed By ISR/Weapon System
- C²
- Detection/Classification
- ID
- Tracking
- Sensor-Shooter Link
- Shooter-Weapon Link (<5sec Engage Latency)
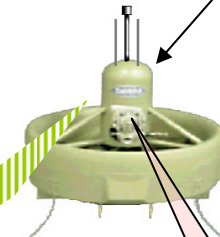- BDA
- Weapon Resupply

Arsenal UAV
- Delivers lethal & ISR UAVs
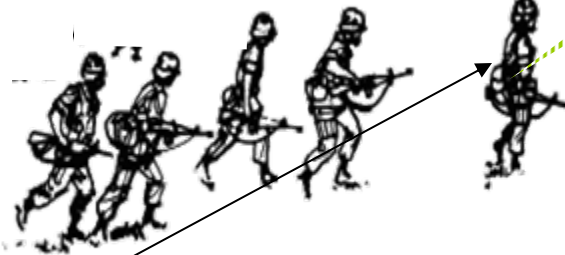- Maintains needed types and numbers
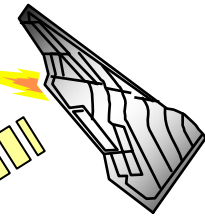
Deploy

VTOL UAV
- Identifies Targets
- VIS/LWIR Imager
- 3D Ladar
- Magnetometer
- MMW Designator
- Tasks Lethal UAVs

Loitering Lethal UAVs
- RDX airframes
- MMW all-weather seekers

Cell Leader
- Interactive Display
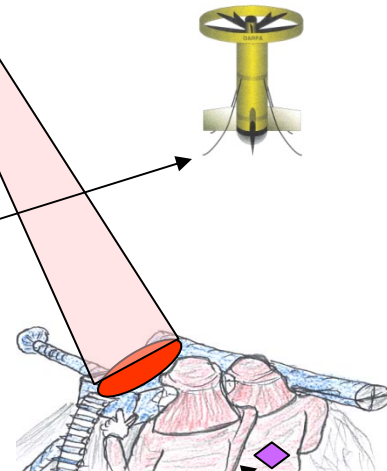- Controls VTOL UAV

Detection Sensors
- ISR UAVs
- UGS
- Cell Troopers

MMW Tags
- Tracking

Emerging Technologies and Security: Issues

- Information technology has fundamentally transformed our society economy and our lives

- Emerging technologies will transform information technology in fundamental ways—and this emerging infotech will provide the basis for greater wealth, healthier and longer lives, and improved security capabilities

- Technological convergence of bio-nano-info techs present phenomenal new prospects—and raise daunting ethical concerns

- All of these developments raise potential as well for misuse and have security down sides…..

Emerging Technologies and Security: Issues

- Security cannot be **assured** by technological measures
  - Security is an on-going process
  - Security requires forethought and constant vigilance
  - If it can be used for bad—it will be…. And others will have access to it….

- A fundamental flaw in our thinking has been the assumption that we can maintain technological superiority without making substantial investments in it….

- Others globally are becoming just as good as we are—we have to recognize this as the new reality