Releasing the Adaptive Power of Human Systems

35 years of Picking Up the Pieces After Explosions of Autonomy

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Complexity in Natural, Social & Engineered Systems
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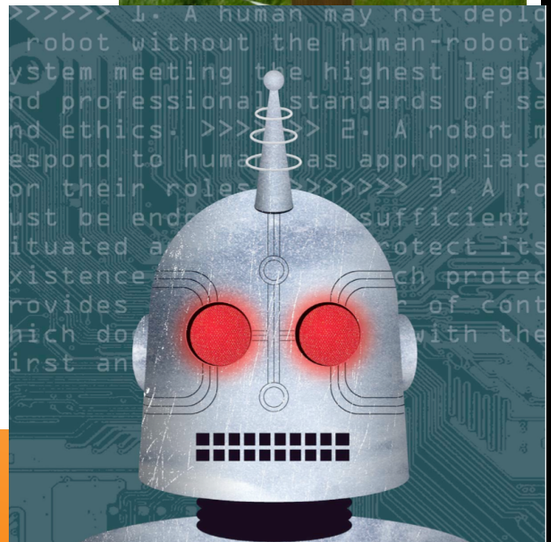


TRANSPORTATION More: Google Self-Driving Car Auto Industry Snow

The Enemy Of The Google Car Is — Snow!

MATTHEW DEBORD
JAN. 15, 2015, 2:33 PM 3,929 8

Autonomy is *powerful* -

just don't stand nearby when it goes off

Autonomy is ***not*** a solution

"A little more technology will be enough, this time" (1984)

Opposition or Substitution of people and machines is a parlour game

Autonomy contributes to **Transformation**

Coordinating joint activity over new ranges and scales

Creates gaps between responsibility and authority

New forms of data overload, …

Autonomy extends ***Human Reach***

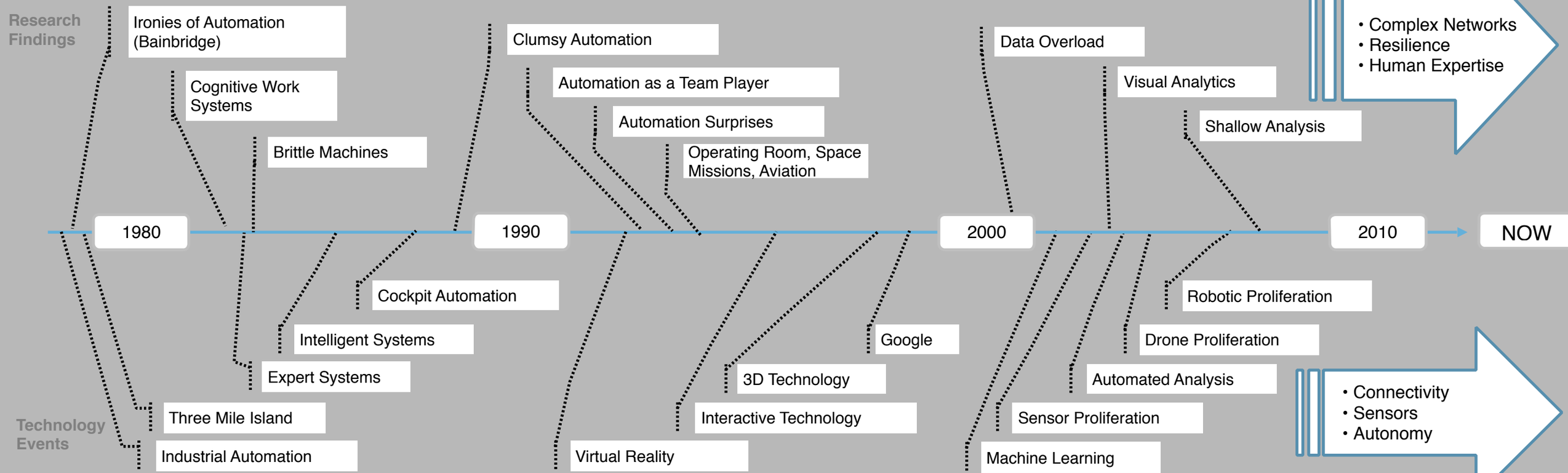
perception, action, speed, persistence, size, scale

↑ Autonomy, ↑ **Complexity**

Underuse results from coping with complexity

S&T: Complex Adaptive Systems & Engineering Resilience

Automation Surprises



A little more technology will be enough…

Automation Surprises

A little more technology will be enough…

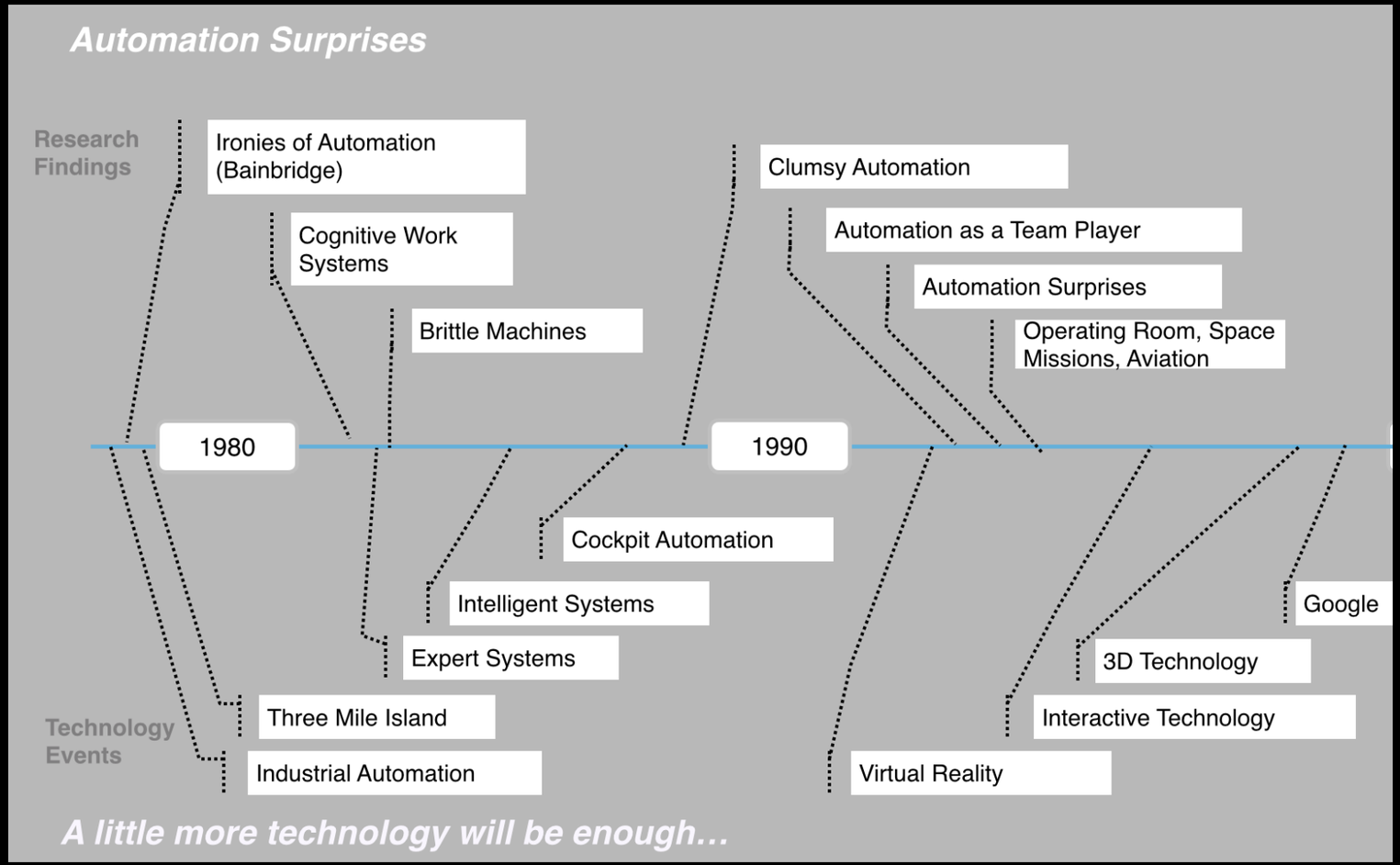
Key Questions to Seize Opportunity

What do we *know* now (or almost know) about harnessing the power of autonomy?

What *hobbles* putting this knowledge to use?

What is *different* about this explosion of autonomy?

How can we *harness* the power of new forms of autonomy?


Automation Surprises
Research Findings
Ironies of Automation (Bainbridge)
Cognitive Work Systems
Brittle Machines
Clumsy Automation
Automation as a Team Player
Automation Surprises
Operating Room, Space Missions, Aviation
1980
1990
Cockpit Automation
Intelligent Systems
Expert Systems
Google
3D Technology
Interactive Technology
Virtual Reality
Technology Events
Three Mile Island
Industrial Automation
A little more technology will be enough…

Timeline 1

Ironies of Automation*

LISANNE BAINBRIDGE†

Key Words—Control engineering computer applications; man-machine systems; on-line operation; process control; system failure and recovery.

NASA Contractor Report 177528

How in the World Did We Ever Get into That Mode? Mode Error and Awareness in Supervisory Control

Nadine B. Sarter

Cognitive Systems Engineering Laboratory, Ohio State University

David D. Woods

Cognitive Systems Engineering Laboratory, Ohio State University

THE PROBLEM OF AUTOMATION: INAPPROPRIATE FEEDBACK AND INTERACTION, NOT OVER-AUTOMATION

Donald A. Norman

University of California, San Diego

Human Factors of Advanced Technology ("Glass Cockpit") Transport Aircraft

Earl L. Wiener

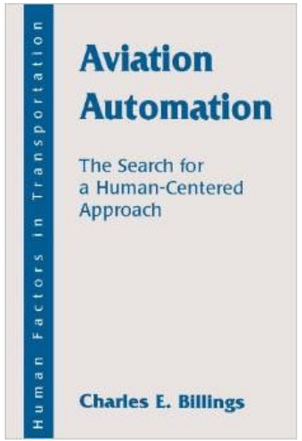
University of Miami, Coral Gables, Florida

NASA Technical Memorandum 104738

Human interaction with an "intelligent" machine

E. M. Roth, K. B. Bennett and D. D. Woods

Westinghouse Research and Development Center, Pittsburgh, PA 15235, U.S.A.



Making Intelligent Systems Team Players: Case Studies and Design Issues

Volume 1: Human-Computer Interaction Design

Jane T. Malin

Debra L. Schreckenghost

David D. Woods, Scott S. Potter, Leila Johannesen, Matthew Holloway

Kenneth D. Forbus

Automation-Human Coordination Breakdowns

interface *n* An arbitrary line of demarcation set up in order to apportion the blame for malfunctions.
Kelly-Bootle, 1995

Practitioners' View: Coping with Complexity

- → What's it doing?
- → Why is it doing that?
- → What will it do next?
- → How did we get into this mode?
- → How do I stop it from doing that?
- → Why won't it let me do what I need?
- → Stop interrupting me when I am busiest?
- → How did I get here? How do I get back?

Developers' View: Human Error

- → System performed as designed.
- → Erratic human behavior.
- → We are very good generally.
- → We are well-intended.
- → We are better than previously.
- → We only provided what the customer asked for.
- → Other parts of the system haven't kept up with us.
- → Our next version will be better (not that anything was wrong with previous models)
- → If we fixed that we would introduce new issues/problems/errors.

First Law Of Cooperative Systems:

→ It's not cooperation, if either you do it all or I do it all.

→ Cooperative problem solving occurs when the agents coordinate activity in the process of solving the problem.

Why didn't they stop the automation?

Global Hawk UAV, 98-2003, 19991206, FSPM 1201A

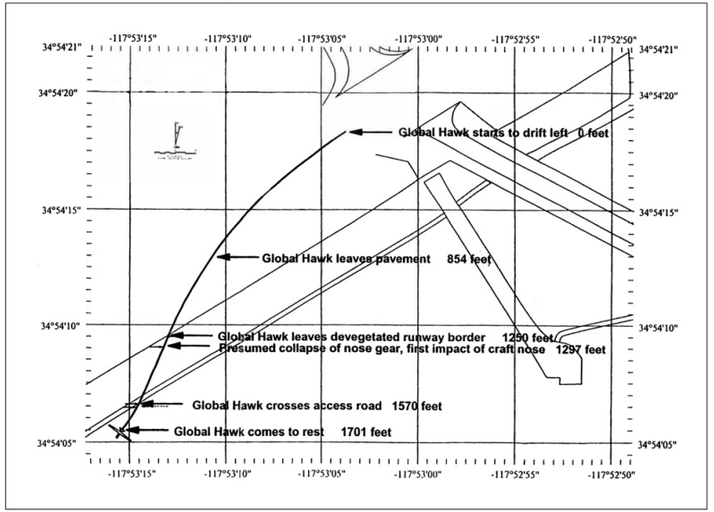
Photo #3

Global Hawk UAV, 98-2003, 19991206, FSPM 1201A

Photo #1

AERIAL VIEW OF AIRCRAFT

Global Hawk UAV, 98-2003, 19991206, FSPM 1201A



IMPACT SITE

Literal Minded machines

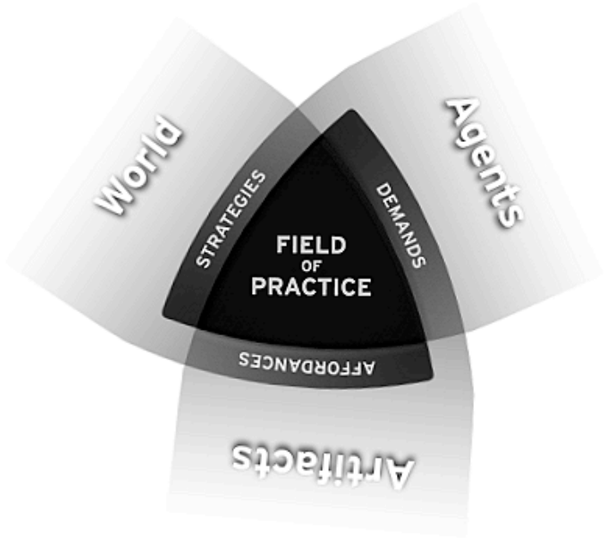
→ can't tell if their model of the world is the world they are in;
human role to align or repair the context gap.
→ The automation did the right thing [given its model of the world] when it was in a different world!
→ People failed to close the context gap.

Missing side effects

Cross checks

Norbert's Contrast (Wiener, 1950)

Artificial agents are literal minded and disconnected from the world, while human agents are context sensitive and have a stake in outcomes.

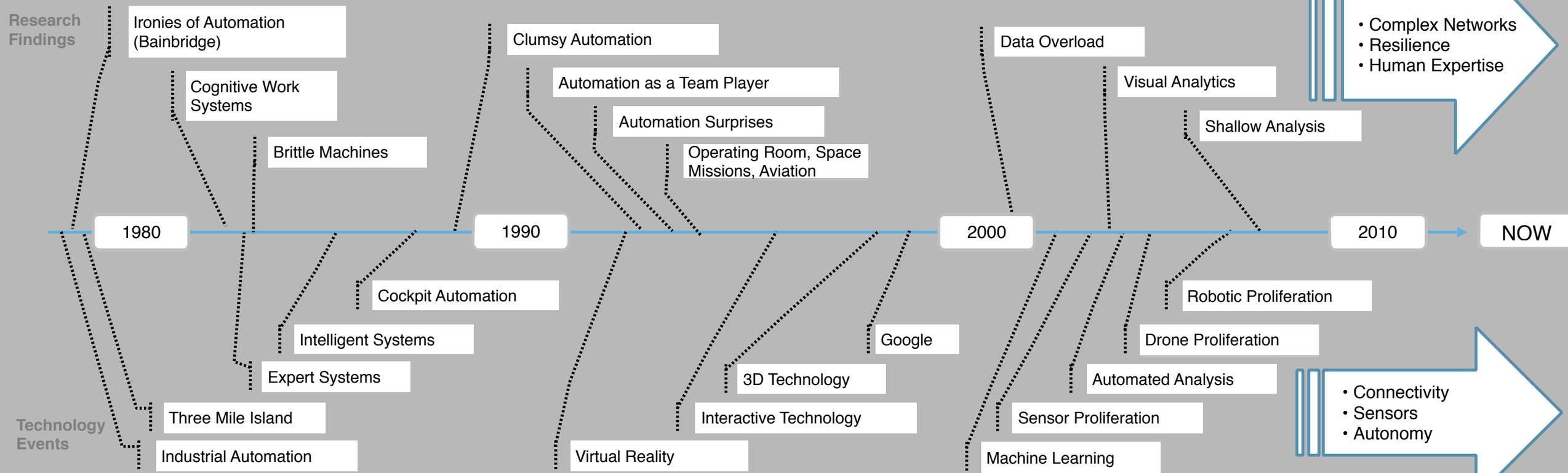


Multiple Cycles of Automation Surprise

Designer's claims contrasted with real operational experience

Putative benefit	Real complexity
better results, same system (substitution)	transforms practice, the roles of people change
frees up resources: 1. offloads work	create new kinds of cognitive work, often at the wrong times
frees up resources: 2. focus user attention on the right answer	more threads to track; harder to remain aware of and integrate all of the activity and changes
less knowledge/training	new knowledge/skill demands, more practice
autonomous machine	team play with people is critical to success
same feedback	new levels and types of feedback are needed to support peoples' new roles
generic flexibility	rigid; explosion of features, options and modes create new demands, types of errors, and paths towards failure
reduce human error	brittle machines; human-machine coordination breakdowns

Automation Surprises



A little more technology will be enough…

Automation Surprises

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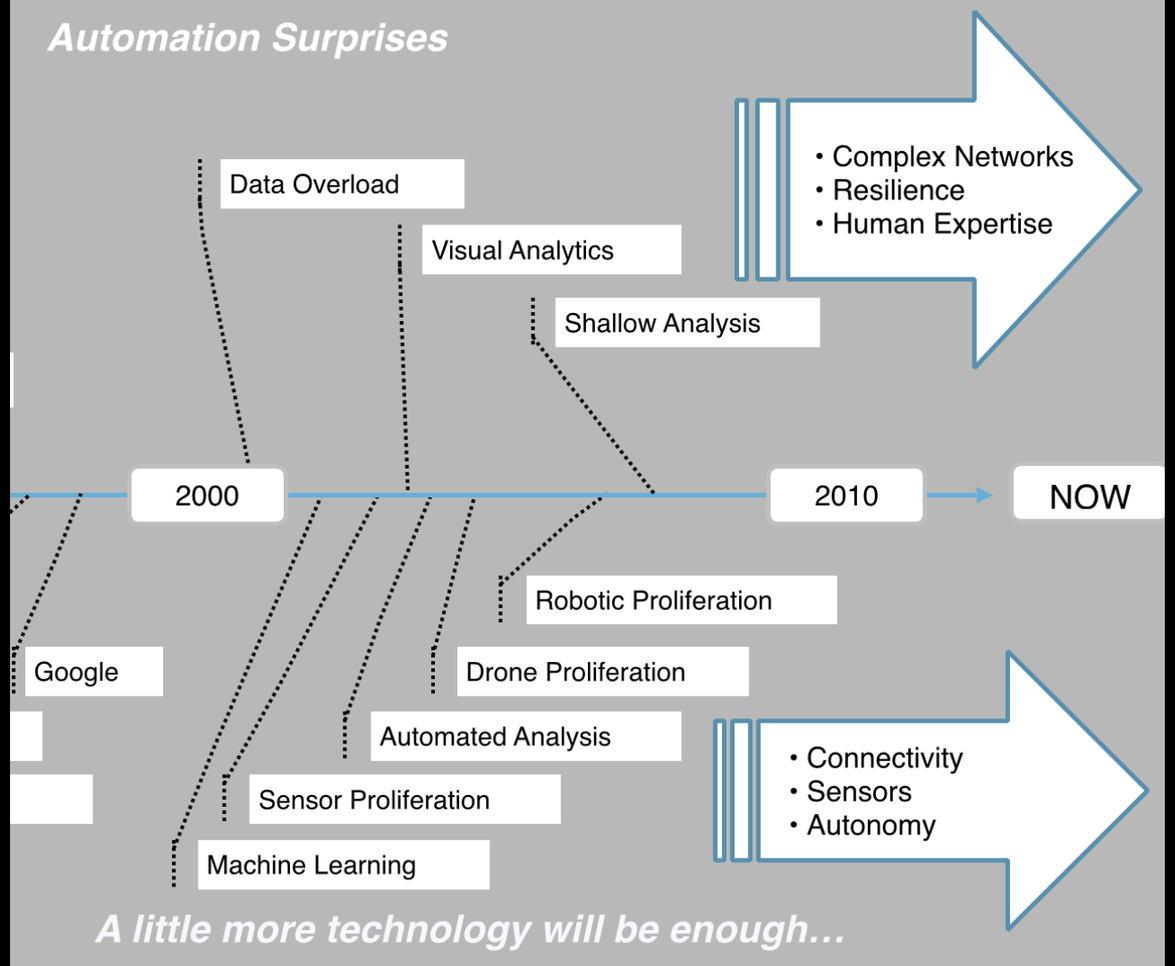
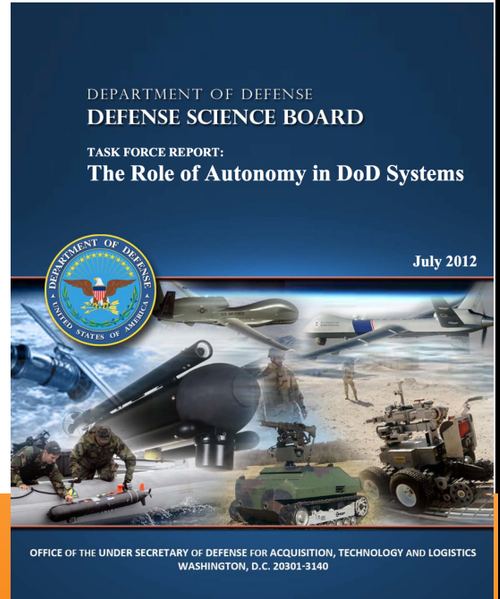

Automation Surprises
Data Overload
Visual Analytics
Shallow Analysis
• Complex Networks
• Resilience
• Human Expertise
2000
2010
NOW
Robotic Proliferation
Google
Drone Proliferation
Automated Analysis
Sensor Proliferation
Machine Learning
• Connectivity
• Sensors
• Autonomy
A little more technology will be enough…

Timeline 2

Defense Science Board Task Force on Autonomy

put **Mission**, not platform, first
software intensive, moving target network

- coordinate across multi-role, multi-echelon network
- dynamics of pacing, tempo, synchronization
- respect/navigate multiple trade-offs



C/S/E/L :2015 **Mission-oriented**

~ cycles of Automation Surprise
"A Little More Technology Will be Enough, This Time"

~ Autonomous capabilities of platforms will grow and reverberate
Seize opportunities these changes create, via systems approaches

~ Systems Approaches: Joint Systems, Complex Networks,
Critical Software Services, & still Human Systems

Systems Approaches:

- *Joint Systems*: people/sensors/machines as a distributed cognitive work system; literal minded automation; coordination, extended reach/perception
- *Complex Adaptive Networks*: co-adaptive, inevitable surprise, brittleness, resilience, polycentric, cascades
- *Critical Software Services*: moving target, life cycle, reuse
- *Human Systems*: problem holders, stakeholders, double binds, responsibility

Key Questions to Seize Opportunity

What do we *know* now (or almost know) about harnessing the power of autonomy?

Coordination & Synchronization

What *hobbles* putting this knowledge to use?

Substitution Myths

What is *different* about this explosion of autonomy?

Scale, Reach, Adaptiveness

How can we *harness* the power of new forms of autonomy?

Overcome Brittleness / Expand Resilience & Adaptive Capacities