| galois |

Human-Machine Teaming: Theme and Variations

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C3E 2019

Spectrum of Themes

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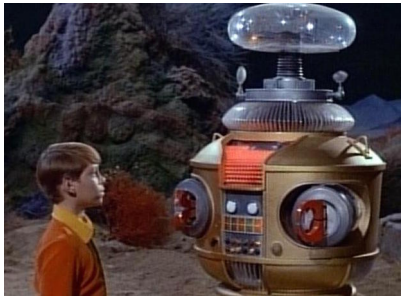
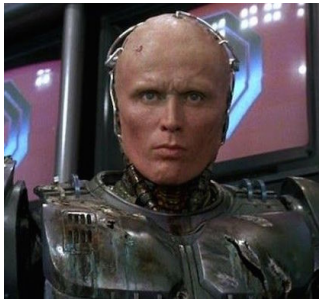
Replacement — Tool — Partnership — Augmentation — Symbiosis

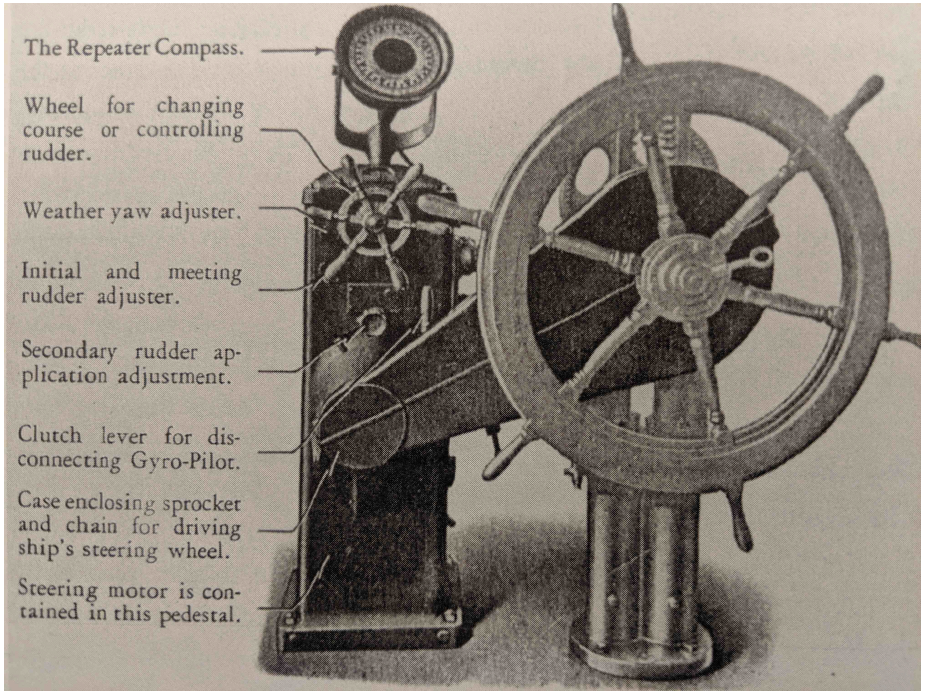
Loosely Coupled — Tightly Coupled




Elmer Sperry and Early Control Systems

Sperry Gyro-Pilot - “Metal Mike”

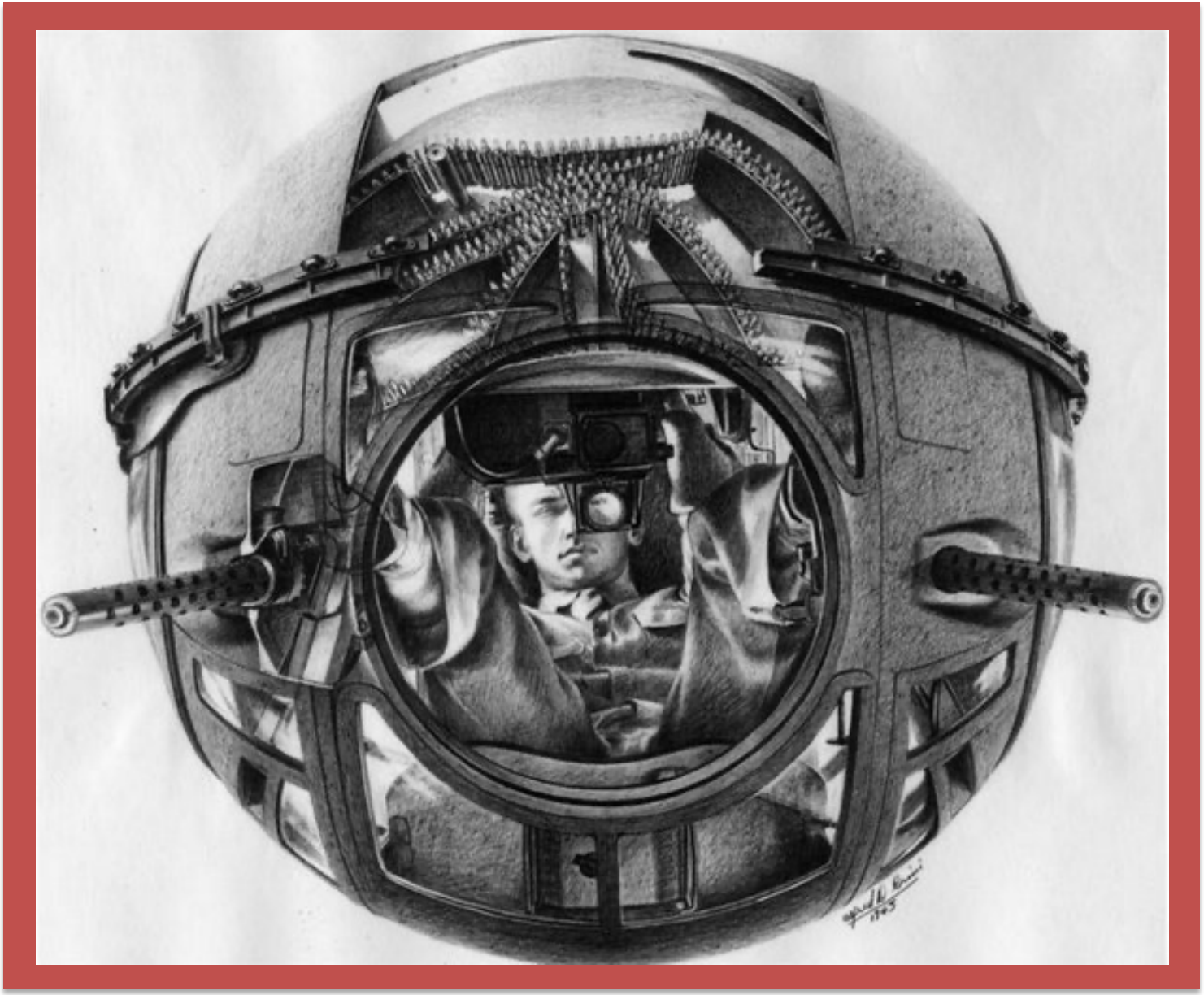


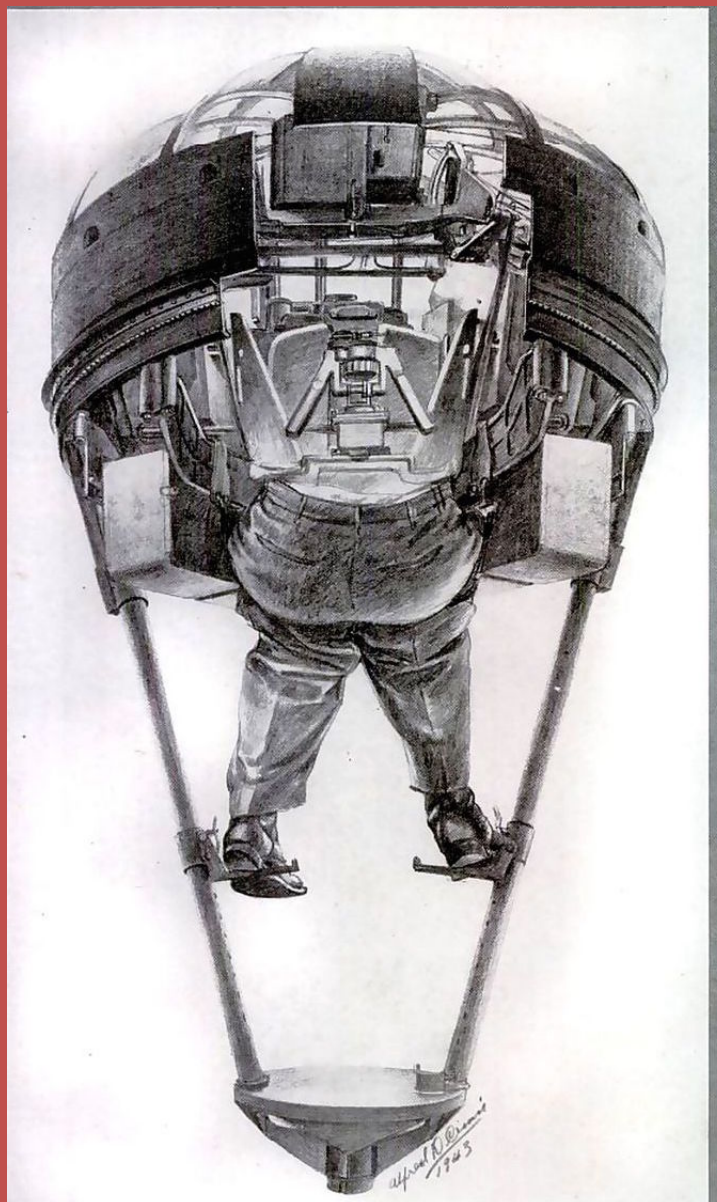
“Wanted – a permanent position on board ship as a wheelsman. Have had experience in steering every type of merchant ship, can steer courses more accurately than others and use less rudder. Am sober, intelligent, strictly attentive to business, never ask for time off, do not talk back, am not affected by … poor cooking, in fact do not eat at all. Wages wanted, only 54 cents per day for 24 hours service.”

[signed]
Sperry Gyro Pilot

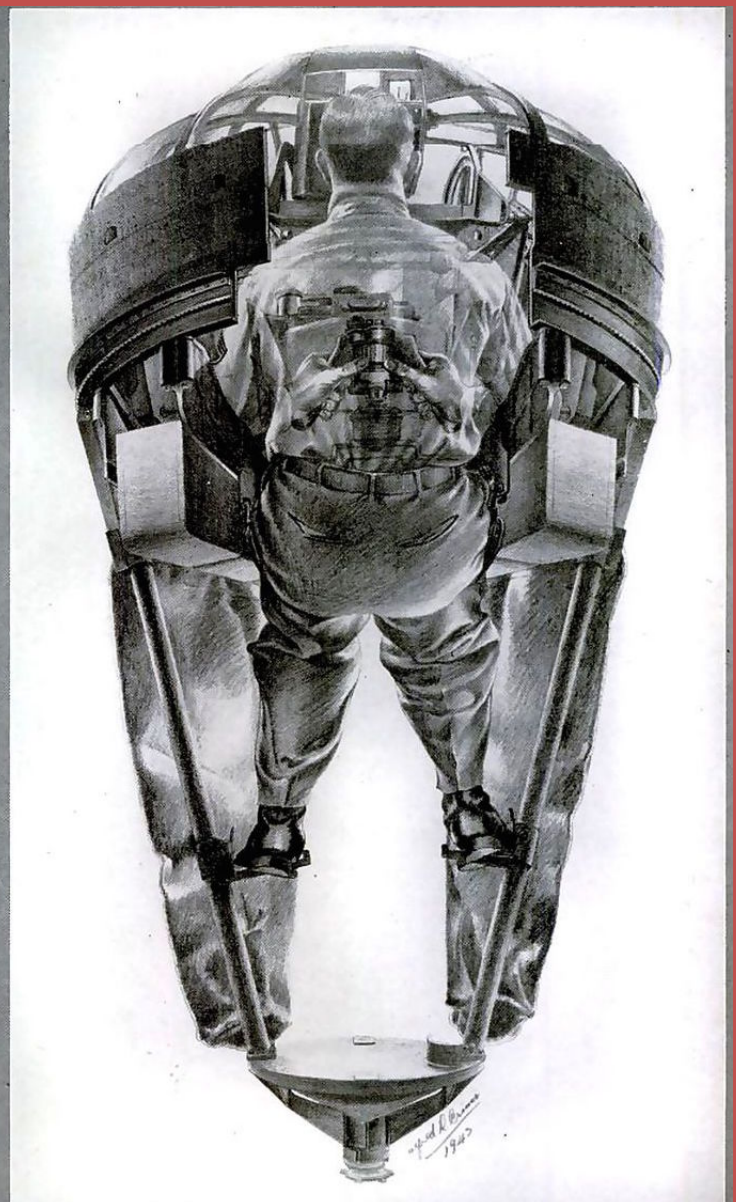
Sperry Advertisement

Human-Machine Interface: WWII B-17 Bomber





Inside the turret, gunner (made invisible from waist up in this drawing) sits in a sling with his feet braced on adjustable stands. Or, if long-legged, he may stand on the turret bottom. This view shows clearly the levers and range dial with which gunner aims.



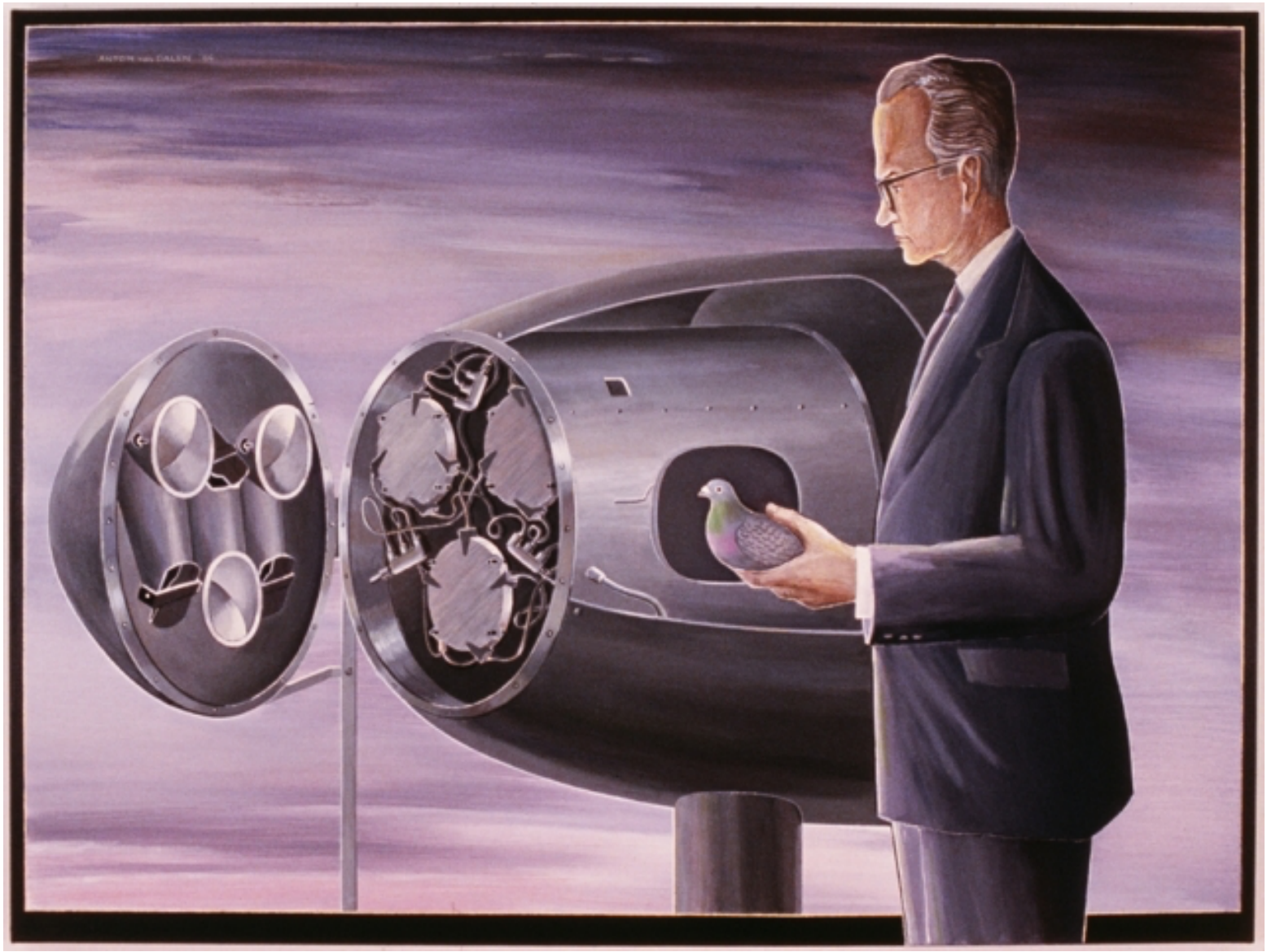
Full view of turret with the gunner's body partially transparent is a composite of other drawings. Gunner never has to worry about hitting a part of own plane, such as the tail. Turret is built so that the guns automatically stop firing if they point at part of the plane.

Project Option

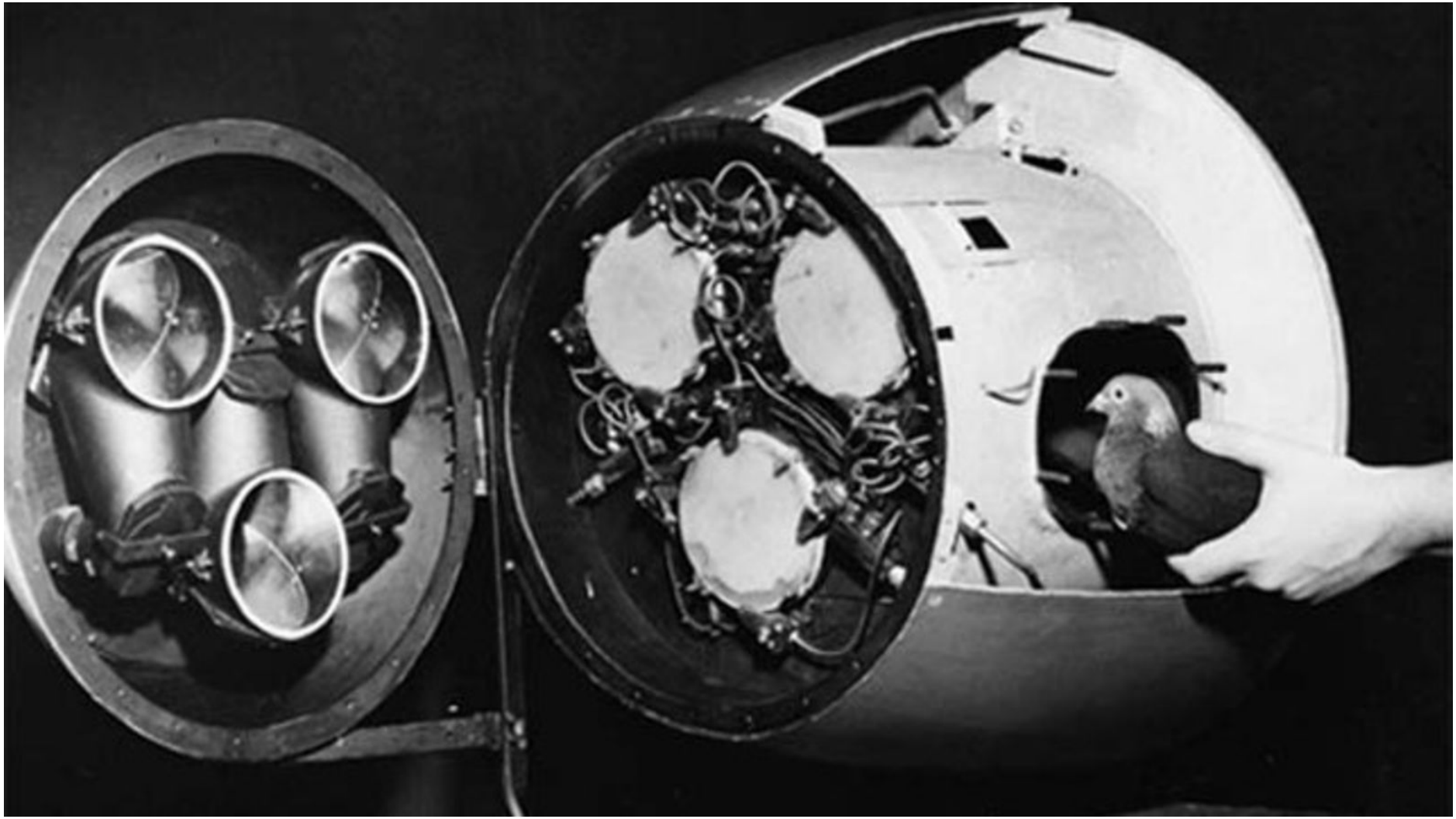
Fleet Admiral Ernest King

TDN-1 Drones on the USS Sable

B.F. Skinner and Project Pigeon



Project Pigeon Prototype



Mark 56 Gun Fire Control System

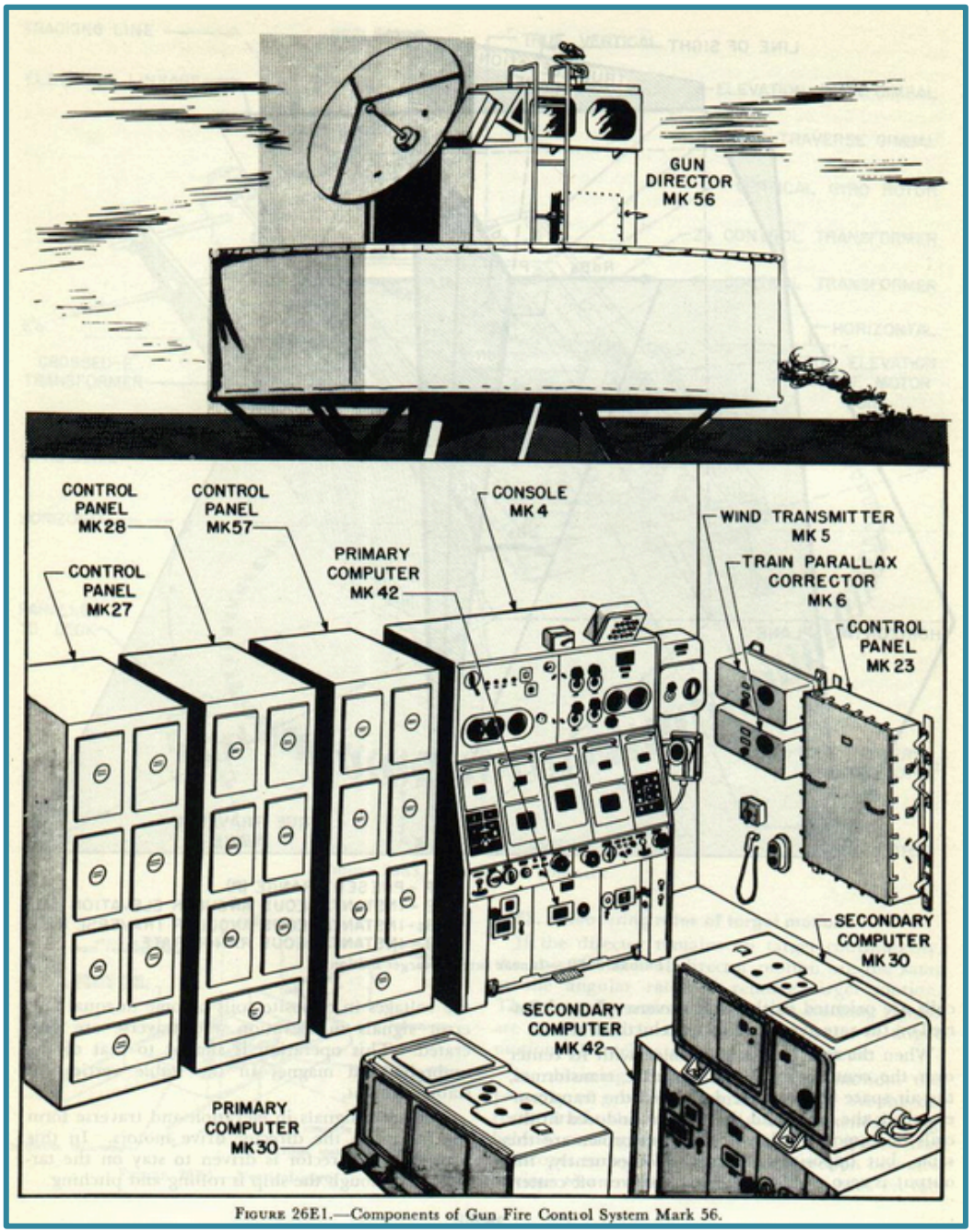
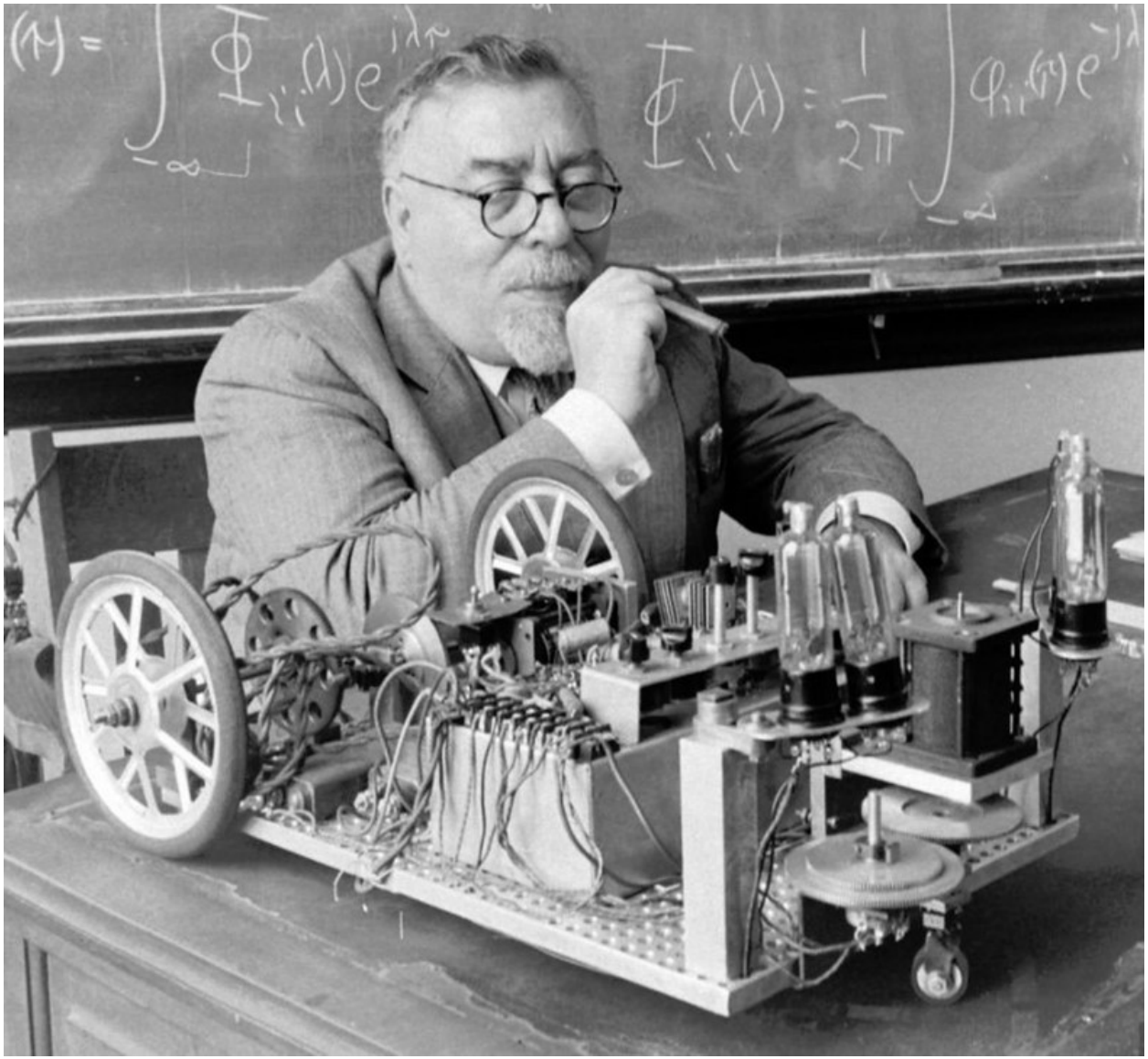
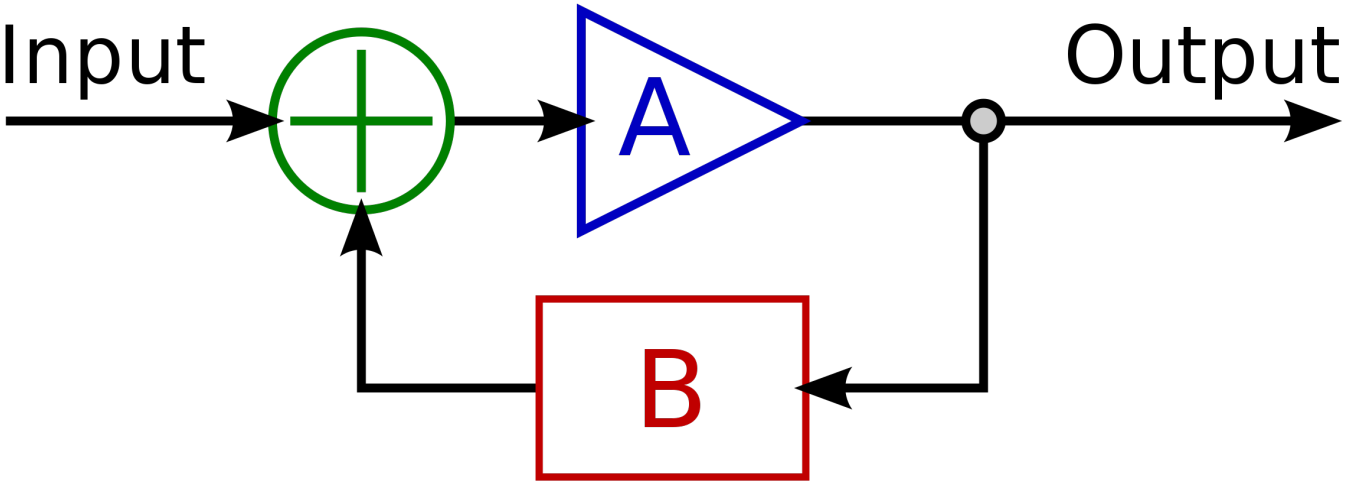


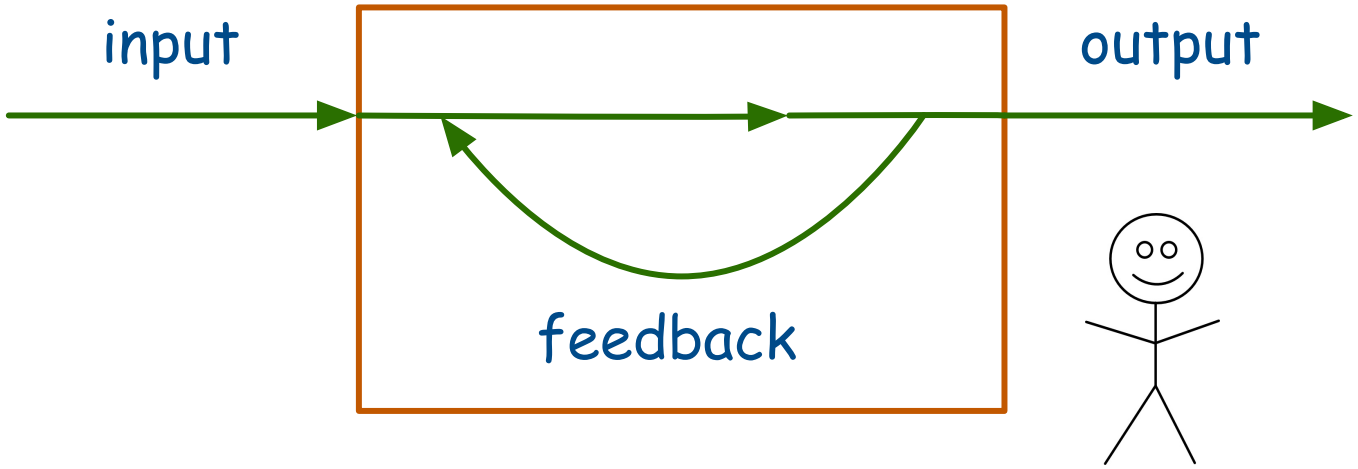
FIGURE 26E1.—Components of Gun Fire Control System Mark 56.

Norbert Weiner and Cybernetics

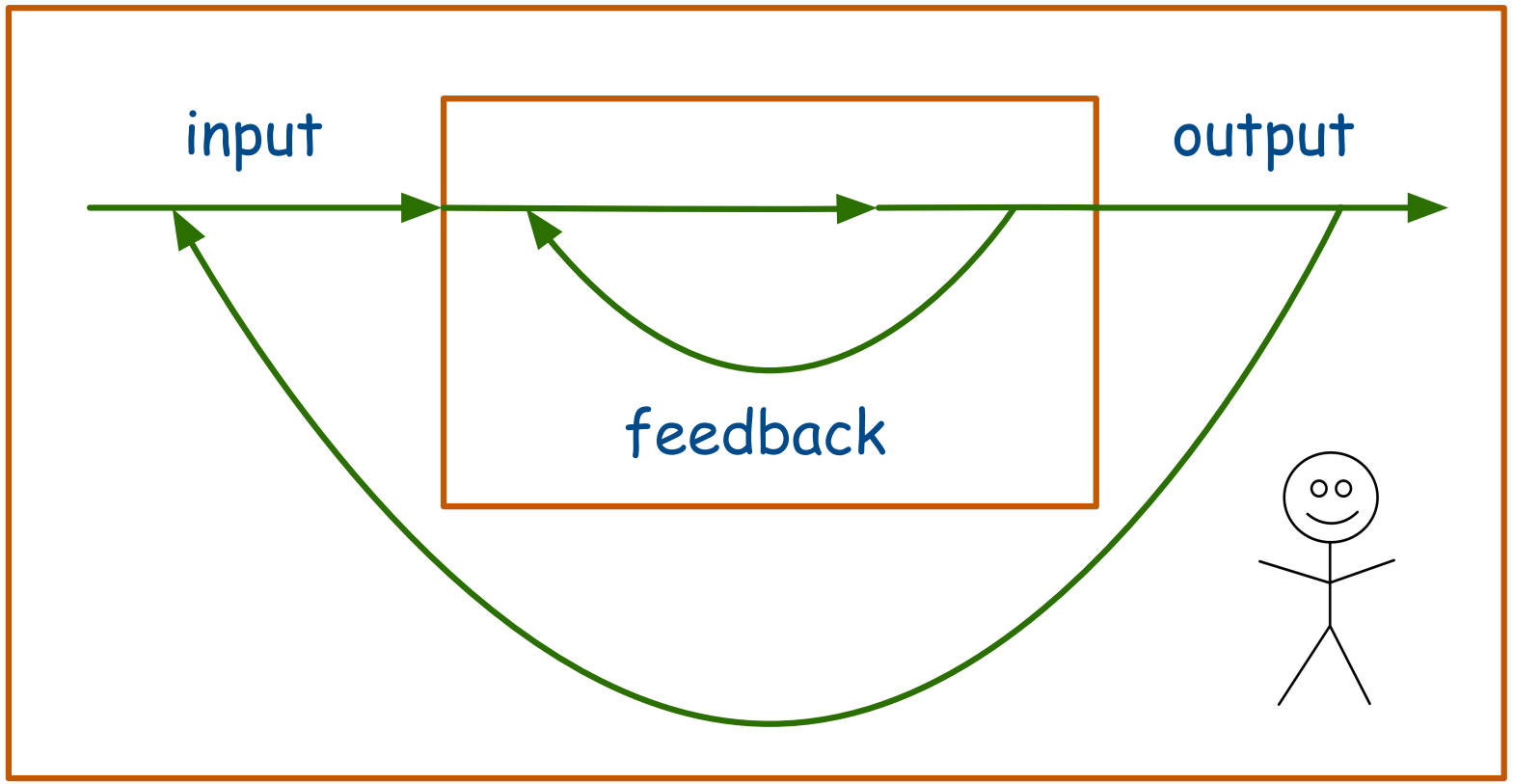


Cybernetics and Feedback Loops





2nd Order Cybernetics



In 2nd Order Cybernetics, observers are part of the system under study.

HABA-MABA (Fitts, 1951)

Humans are better at

HABA

Detecting small amounts of visual and auditory energy.

Perceiving patterns of light and sound.

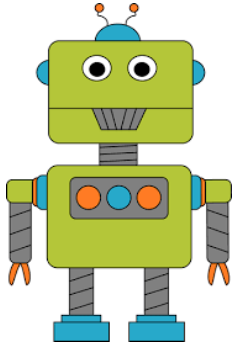
Improvising/using flexible procedures.

Storing large amounts of information and performing selective recall.

Reasoning inductively.

Exercising judgment.

Machines are better at



MABA

Responding quickly and applying great force smoothly and precisely.

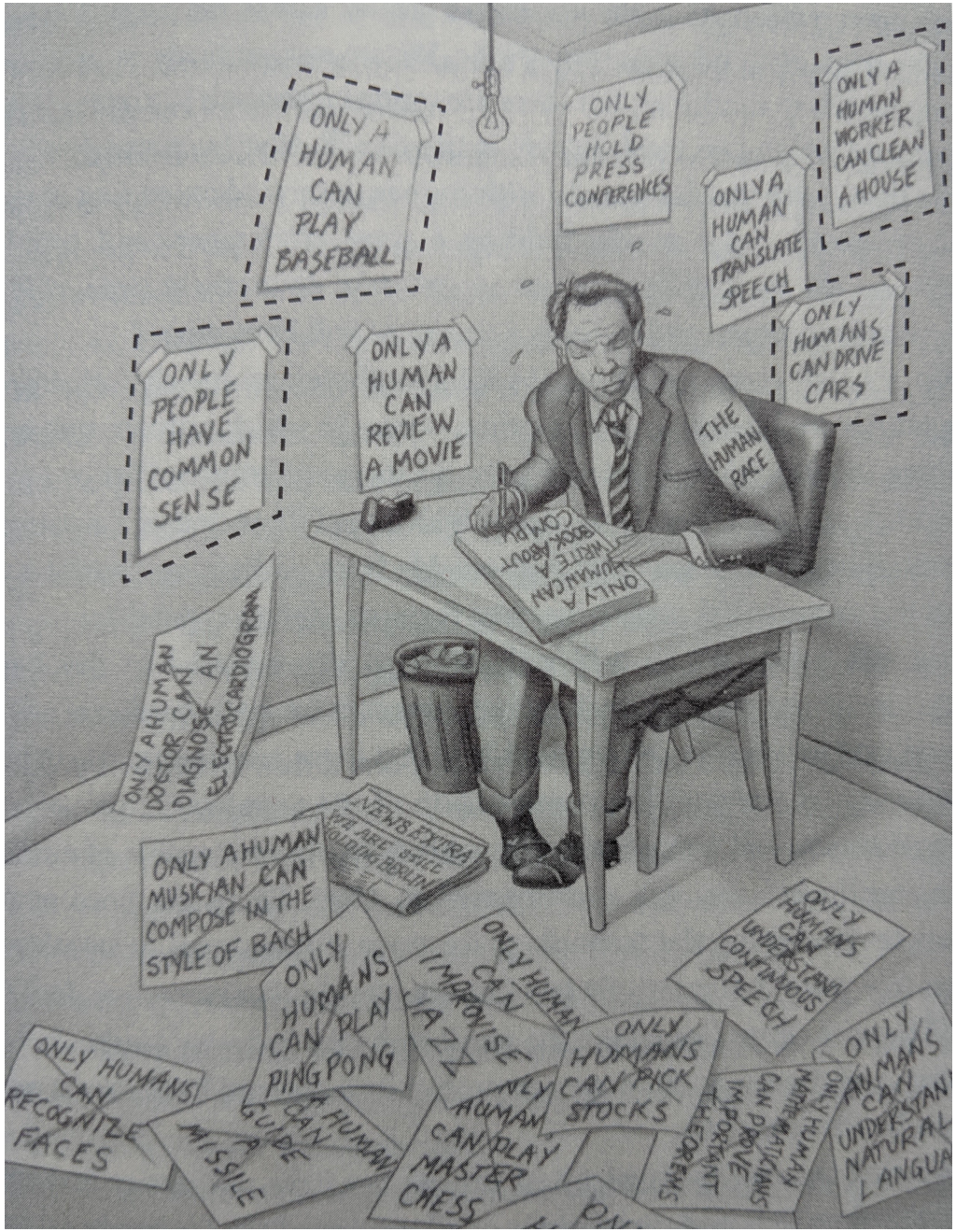
Performing repetitive, routine tasks.

Storing information briefly, then erasing it completely.

Reasoning deductively.

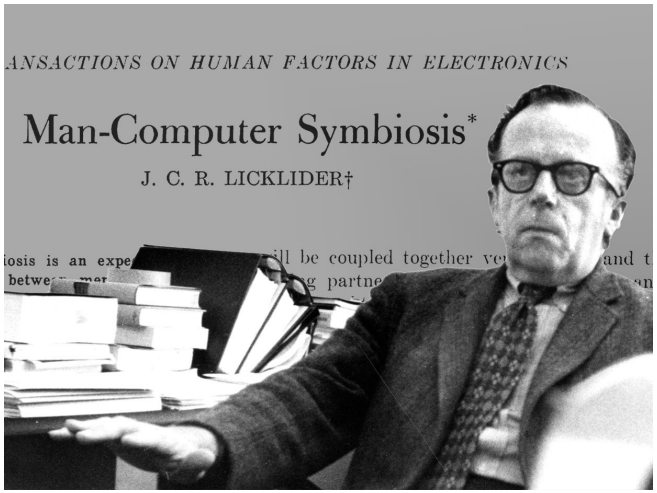
Multitasking.

HABA-MABA as a moving target



Source: "The Singularity is Near" by Ray Kurzweil

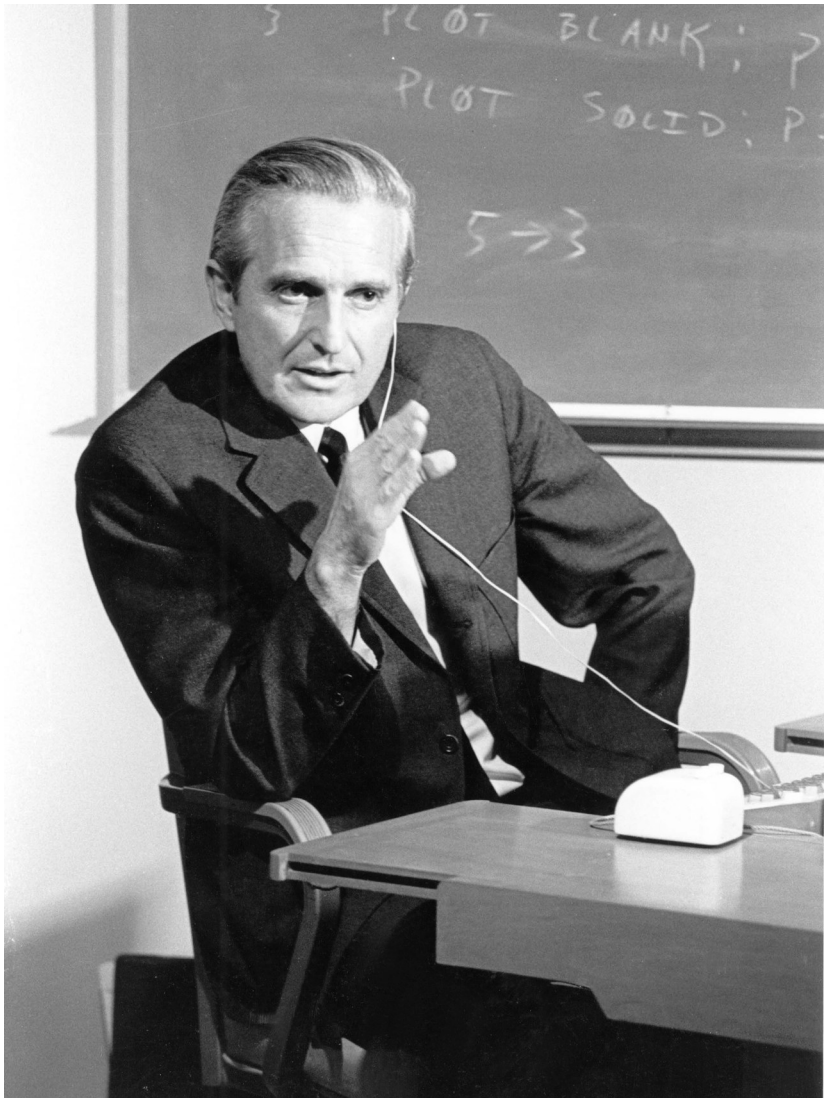
J.C.R. Licklider and Human-Computer Symbiosis

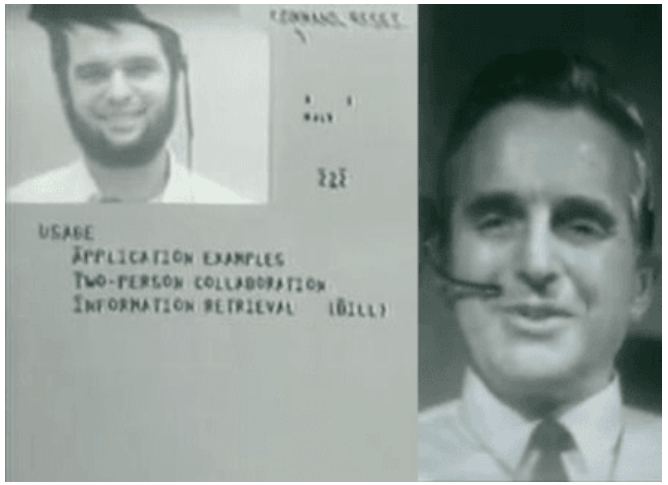


"The hope is that in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today."

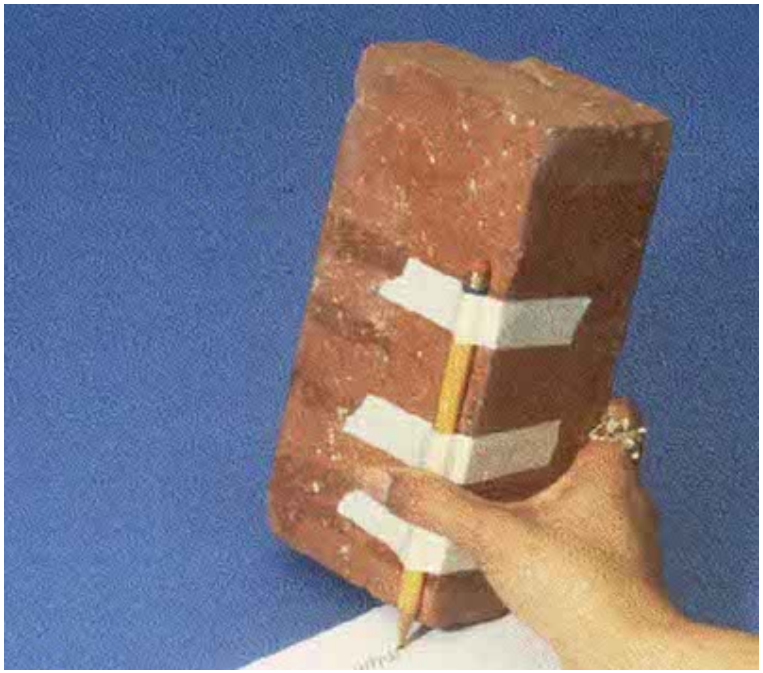
"Men will set the goals, formulate the hypotheses, determine the criteria, and perform the evaluations. Computing machines will do the routinizable work that must be done to prepare the way for insights and decisions in technical and scientific thinking"

Dec 9th, 1968 – The "Mother of All Demos"





- mouse
- interactive real-time computing;
- the graphical user interface;
- hypertext linking;
- cut-copy-paste editing;
- collaborative document sharing by multiple users
- modern teleconferencing



“Augmentation is fundamentally a matter of organization.”

Augmentation is fundamentally a matter of organization.
(typewriter, 7 seconds)

Augmentation is fundamentally a matter of organization. (cursive script, 20 seconds).

Augmentation is fundamentally a matter of organization. ("de-augmented" cursive script, 65 seconds).

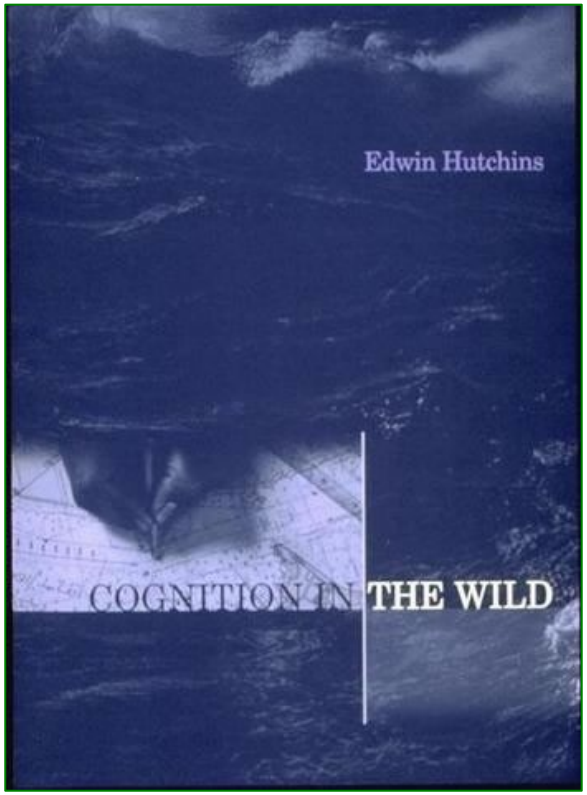
Augmentation is fundamentally a matter of

[de-augmented cursive script, large size--42 seconds to complete whole passage (completed on separate sheet)].

Heidegger and Representations

Maxwell Smart and Robot Colleague

Edwin Hutchins and “Cognition in the Wild”



Naturally Situated Cognition

Big idea: Cognition is *socially distributed.* Systems of activity have cognitive properties of their own than are different than the cognitive properties of individuals.

Hutchkins found "too much emphasis on finding knowledge structures inside an individual instead of knowledge being situated in a complex sociocultural world"

Distributed cognitive systems are hybrid systems where cognition is distributed among humans and material/computational artifacts.

"Humans create their cognitive powers by creating the environments in which they exercise those powers"

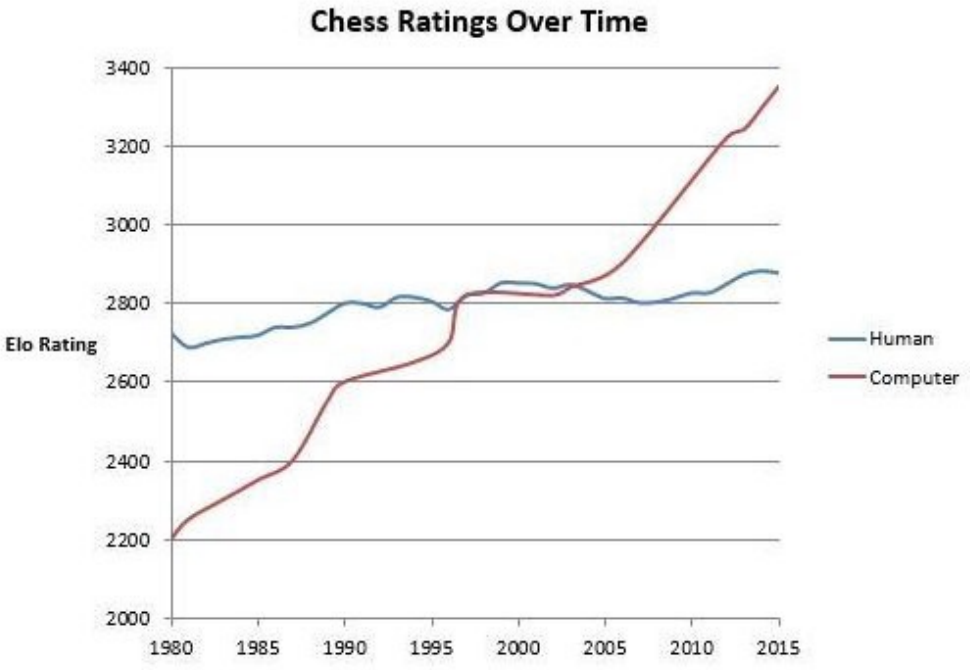
Paradoxes of Judgment Aggregation

	p	p -> q	q
Judge 1	True	True	True
Judge 2	True	False	False
Judge 3	False	True	False
Majority	**True**	**True**	**False**

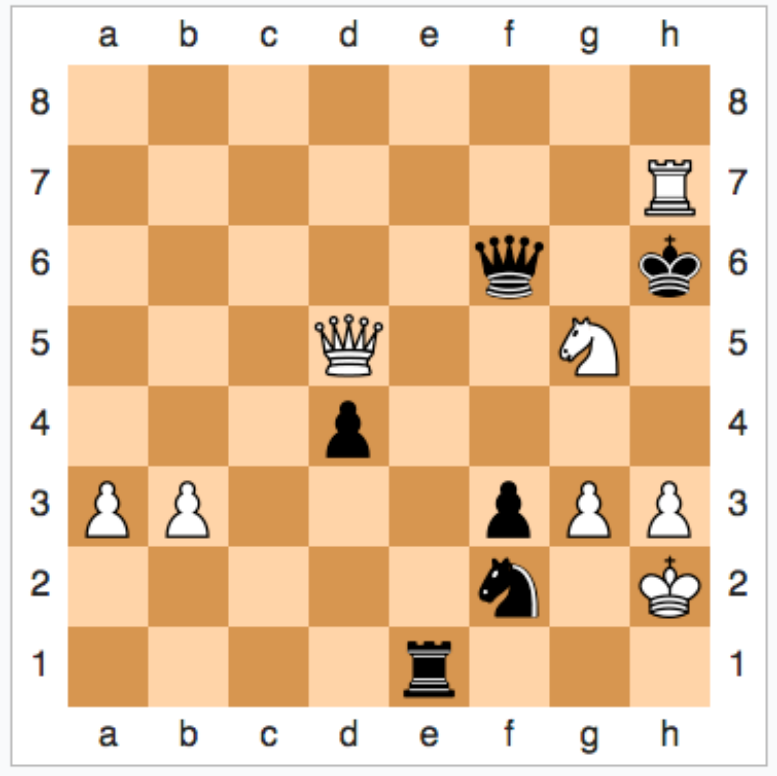
Each of three judges uses their judgments of the premises p, p->q and propositional logic to draw conclusions about q (first three lines of the table)

However, if we simply aggregate each column by taking the majority vote, we have both p and p-> q both being true, and q as false.

Progress in Computer Chess



Source: Erik Brynjolfsson



Deep Blue (white) vs. Kasparov (black):
Game 1 final position (black resigns)

Freestyle Chess

Garry Kasparov introduced the idea of “centaur chess” or “cyborg chess” as a way to further increase the level of chess play – a player can use a chess program as a consultant.

Freestyle Chess is an “anything goes” variant: any number of humans and machines play chess under time controls.

The first Freestyle Chess tournament took place in 2005, with 48 entrants, including several Grandmasters (ratings 2500 or above).

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The winning team:

Steven Cramton (1685 USCF) and Zackary Stephen (1398 USCF) with 3 computers running chess engines.

“We had really good methodology for when to use the computer and when to use our human judgment, that elevated our advantage,”

Kasparov on Freestyle

"[A] weak human plus machine plus *better process* was superior to a strong computer alone and, more remarkably, superior to a strong human plus machine plus *inferior process*."

Garry Kasparov

Kasparov on Freestyle

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Garry Kasparov

Excerpt from a recent interview with Kasparov:

***Interviewer**: Today, 2017, do you still think it's the case that a human paired with a set of programs is better than playing against just the single strongest computer program in chess?*

***KASPAROV:** There's no doubt about it.*

Credit: U.S. Navy photo by Journalist 1st Class Jeremy L. Wood.

Cockpit of the Future

“Finally, Driverless Vehicles Have Arrived in New York City”

(says *Architectural Digest* Magazine)

Source: Optimus Ride

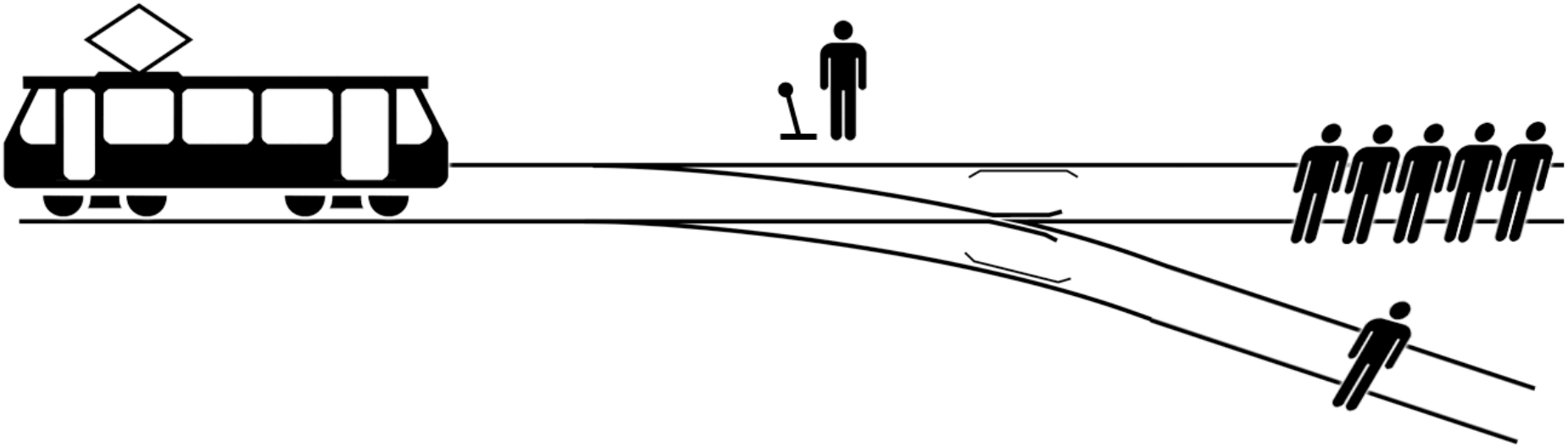
“Aoccdrnig to a rsceareh at Cmabrigde Uinervtisy, it dseno’t mtaetr in waht oerdr the ltteres in a wrod are, the olny iproamtnt tihng is taht the frsit and lsat ltteer be in the rghit pclae.”

Repair, Attribution, and all That (RAT)

"Human users constantly 'repair' the inadequacy of computer behavior, then attribute the results to intelligence on the part of the machine, while discounting the actual intelligence that was supplied in the process of repair."

From Collins and Kusch (1999)
"The Shape of Actions: What Humans and Machines Can Do"

Trolley Problem



Two Scenarios

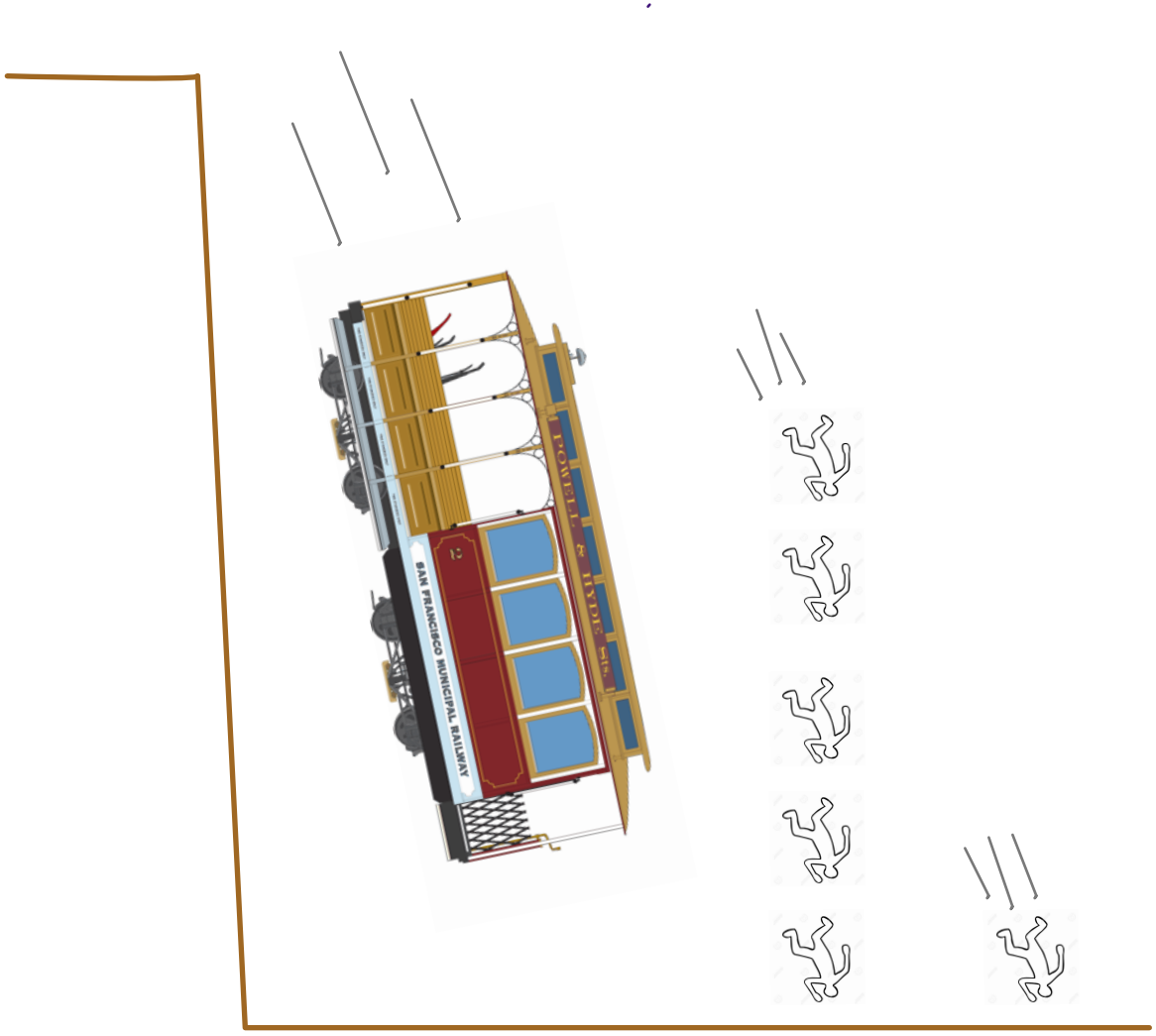
Trusted robot, whom you've known for many years.
Intelligent, dependable, and wise.

"Pull the switch!"

Trusted human, whom you've known for many years.
Intelligent, dependable, and wise.

"Pull the switch!"

Denouement



Empirical Findings

Almost half the participants didn't want to pull the switch:

"people shouldn't take decisions like this upon themselves"

"saving five people doesn't warrant the death of an innocent person"

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When the switch *was* pulled, who is to blame for the death of the innocent bystander?

1. In the case of the human advisor:

   The majority of respondents wanted to share blame equally between the advisor and the switch puller.

2. In the case of the robot advisor:

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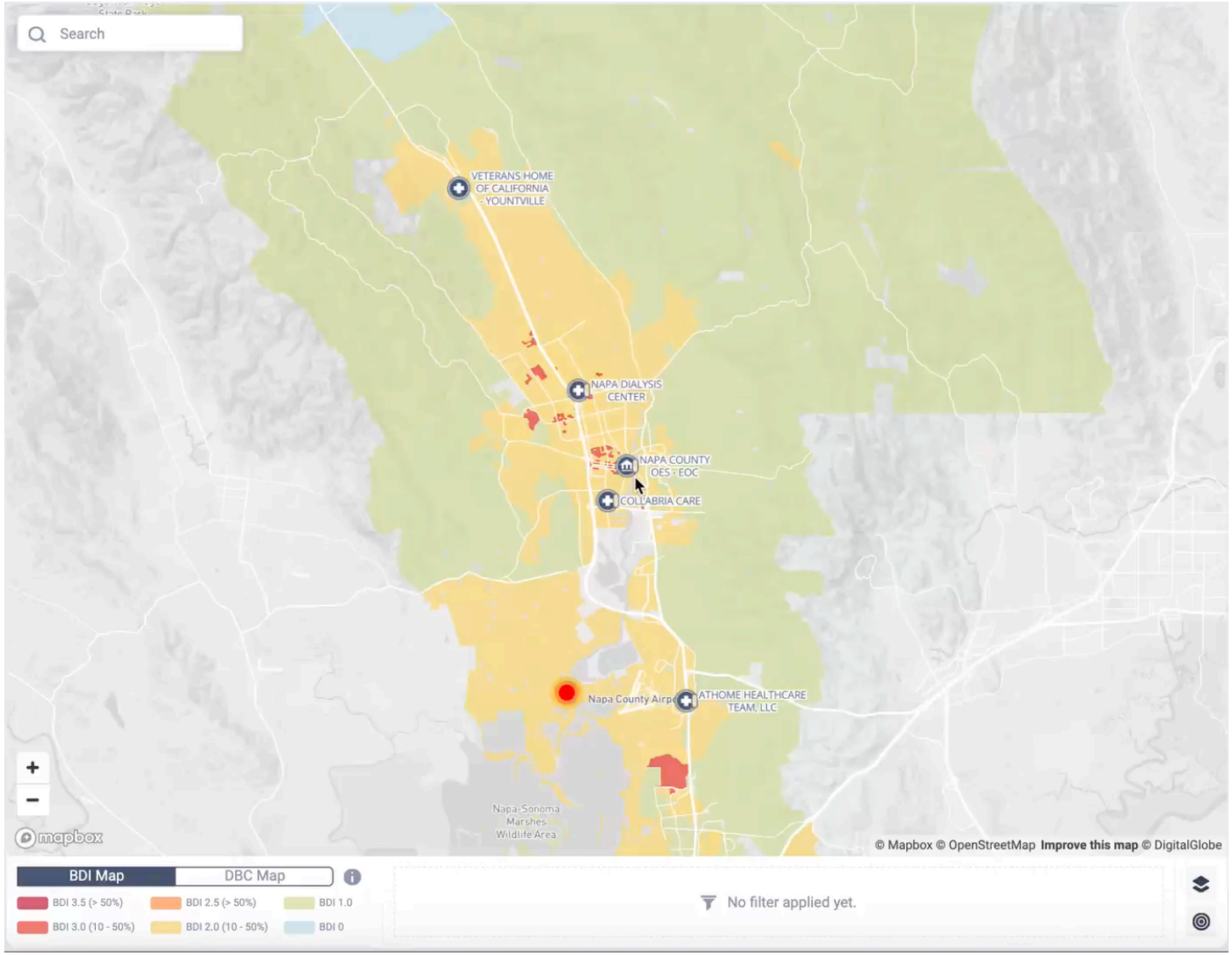
   The majority of respondents wanted to share blame equally between the advisor and the switch puller.

2. In the case of the robot advisor:

   None of the respondents blamed the robot!

One Concern – Emergency Responder Tools



Caveats

"We are in no way ever telling these first responders that we are replacing your decision-making judgment or capability."

As the reach of artificial intelligence expands, *"… it remains difficult to convey concepts of uncertainty to officials who often*
do not have technical backgrounds and who want clear-cut answers."

Source: https://www.nytimes.com/2019/08/09/us/emergency-response-disaster-technology.html

How Machines Learn

1. Machines can share their knowledge at extremely high speeds compared to humans, who must do knowledge sharing via language.
2. Machines will have access via the Internet to all of the knowledge of our human-machine civilization, and will master all of this knowledge.
3. Nonbiological intelligence will be able to download skills and knowledge from other machines, as well as absorbing all knowledge from humans.

Adapted from Ray Kurzweil's "How to Create a Mind: The Secret of Human Thought Revealed" (2012)

How Humans Learn

Myths of Autonomy

Myth 4: Autonomous systems are autonomous.

Myth 5: Once achieved, full autonomy obviates the need for human-machine collaboration.

Myth 7: “Full autonomy” is not only possible, but is always desirable.

Source: *The Seven Deadly Myths of “Autonomous Systems”*
Bradshaw, Hoffman, Johnson and Woods (2013)

Takeaways

- Identification of Interaction Dimensions
- Attention and Cognitive Loading
- Autonomy isn't one-dimensional
- Observability & Predictability
- Feedback & Causality
- Augmentation/Symbiosis as organizational design
- Explicitness of Representations
- Context
- Distributed Cognition
- Resource Allocation
- Repair and Skill Attribution
- Explainability
- Trust
- Learning

Good online resource:
MITRE's "Human-Machine Teaming Systems Engineering Guide" (2018)

To continue the discussion…

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Backups

Human-Machine Difficulty Matrix