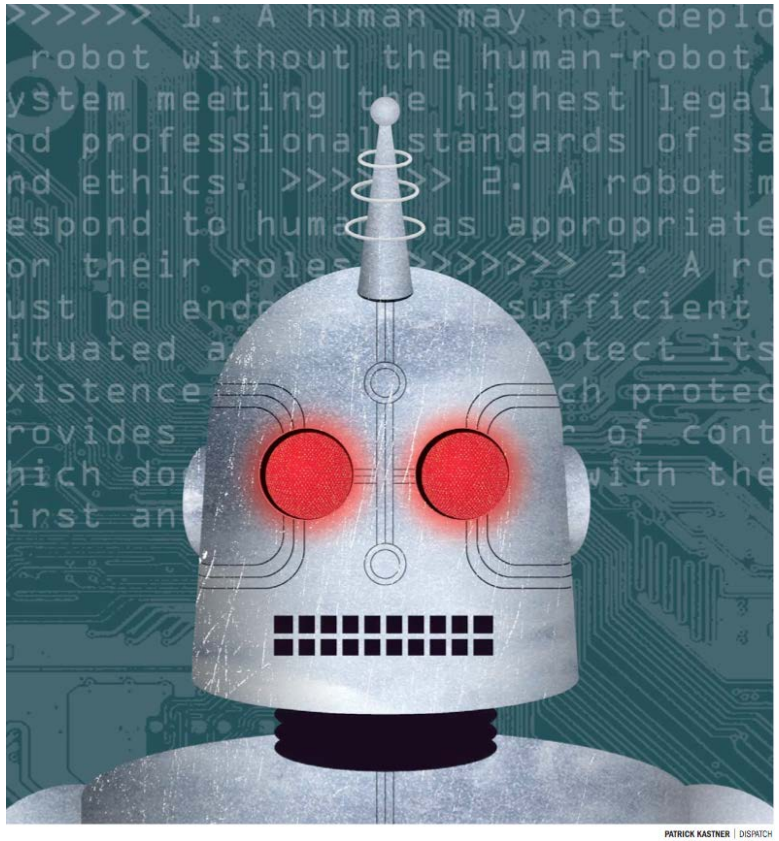
Autonomy and Resilience



David Woods

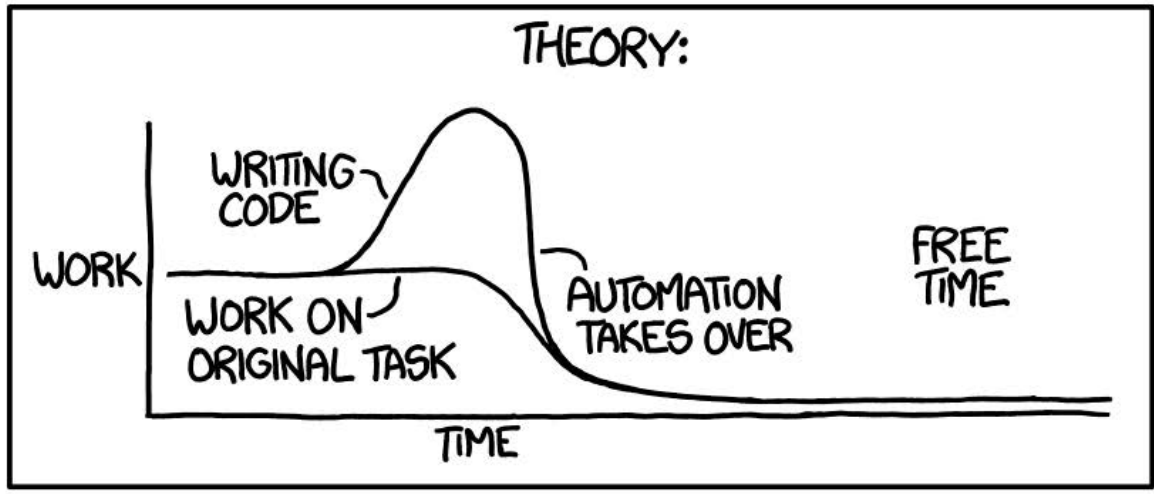
Ohio State University

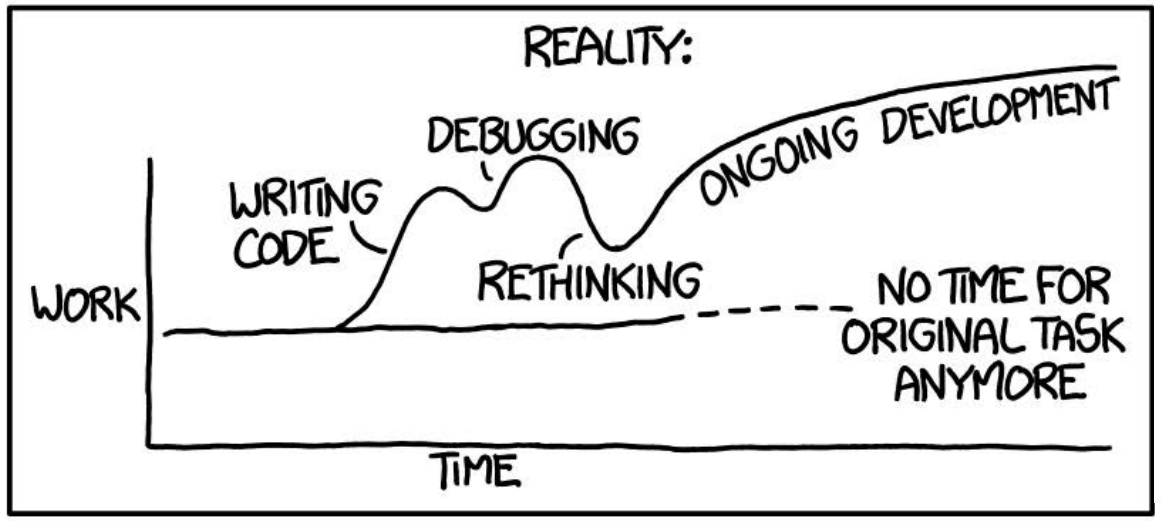
Deploying Autonomous capabilities:

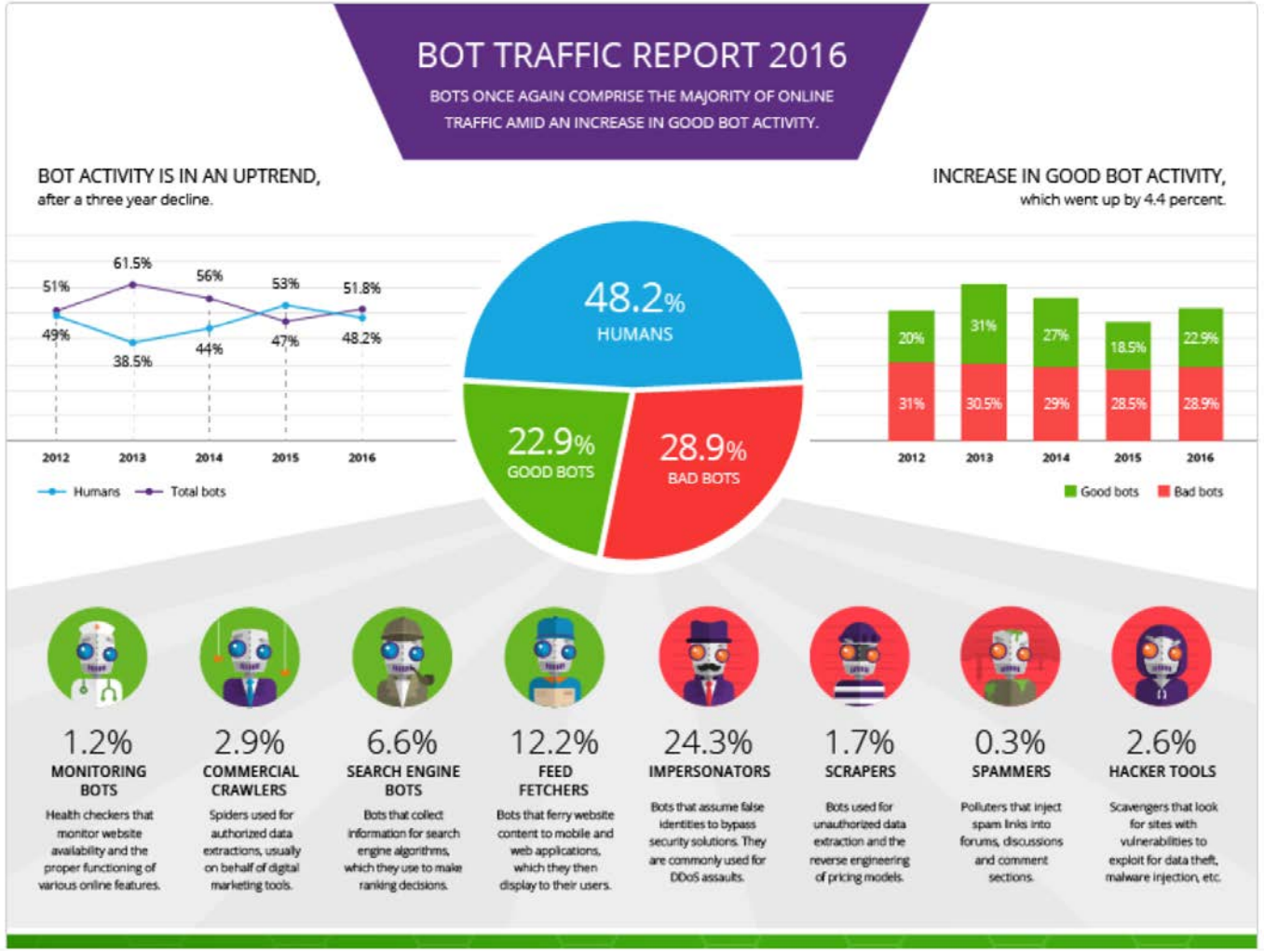
stories of technology change describe or envision
the *congestion, cascades & conflicts* that arise
when apparent benefits get hijacked

SNAFU CATCHERS

"I SPEND A LOT OF TIME ON THIS TASK.
I SHOULD WRITE A PROGRAM AUTOMATING IT!"

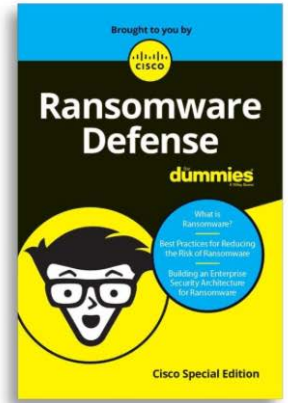






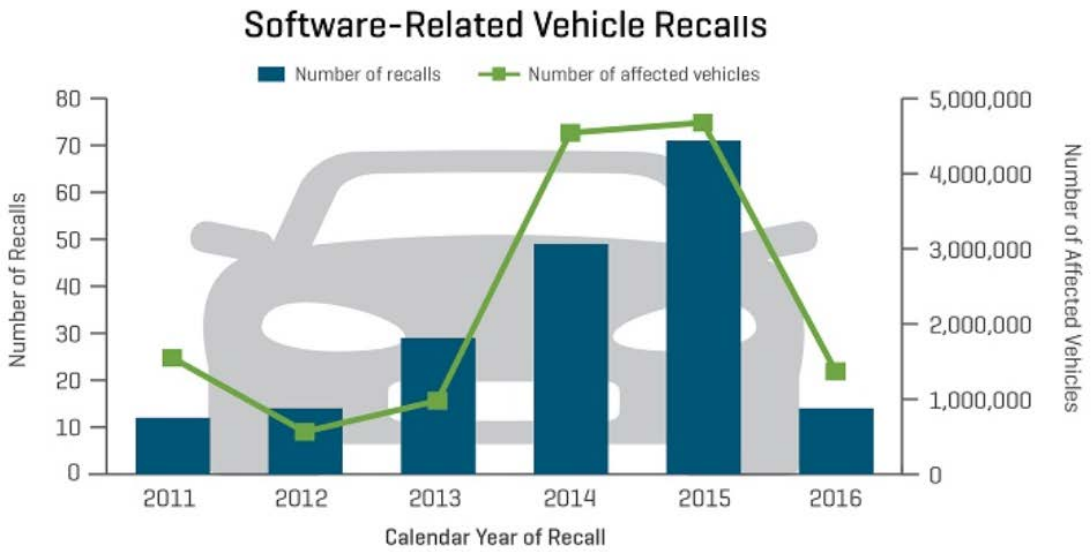
Adaptive Behavior Hijacks Success

Ransomware Defense for Dummies



Should you pay the ransom? How do you respond to an attack? We'll break it down for you. **Access this new complimentary eBook**, full of key insights, to explore:

- **Best practices** for slashing ransomware risk
- Building new **best-of-breed** security architecture
- Identifying ransomware in new threat landscapes
- Implementing proactive **defense strategies**
- **Regrouping** after an attack: contain, mediate



New forms of congestion, conflict

THE OHIO STATE UNIVERSITY

RESEARCH ARTICLE

Even good bots fight: The case of Wikipedia

Milena Tsvetkova[1], Ruth García-Gavilanes[1], Luciano Floridi[1,2], Taha Yasseri[1,2]*

1 Oxford Internet Institute, University of Oxford, Oxford, United Kingdom, **2** Alan Turing Institute, London, United Kingdom

* taha.yasseri@oii.ox.ac.uk

In 2015, three new software-related categories reported data for the first time:

- **Automatic Braking, listed on 21 EWR reports, resulting in 26 injuries and 1 fatality**
- **Electronic Stability, listed on 6 EWR reports, resulting in 7 injuries and 1 fatality**
- **Forward Collision Avoidance, listed in 1 EWR report, resulting in 1 injury and no fatalities**

Drivers of Change & Innovation

1. **People** seeking *advantage*
2. **Connectivity** new forms of sharing b/w people
3. **Sensing** provides information to people

———> New Scales

4. Requires **Automation/Autonomy**
5. inevitably, gaps, anomalies, surprises, …
6. **People adapt to fill shortfalls**

always serves and changes with human purposes

High Frequency Trading / Critical Digital Services

People seize opportunities for advantage

Scale of transactions, reach, data flows, actors, all grow rapidly

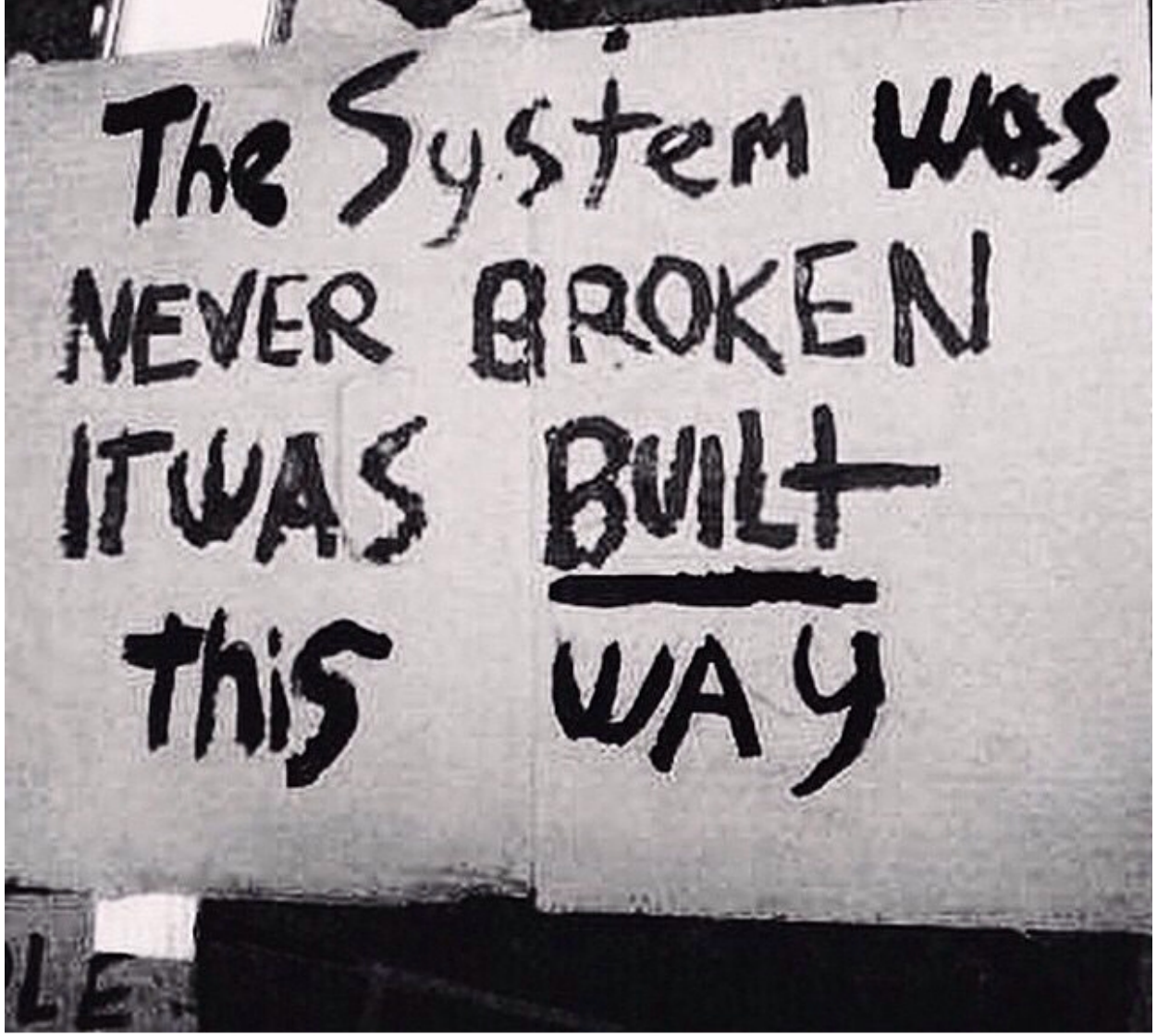
Monitoring /anticipation demands grow

Keeping pace as events cascades

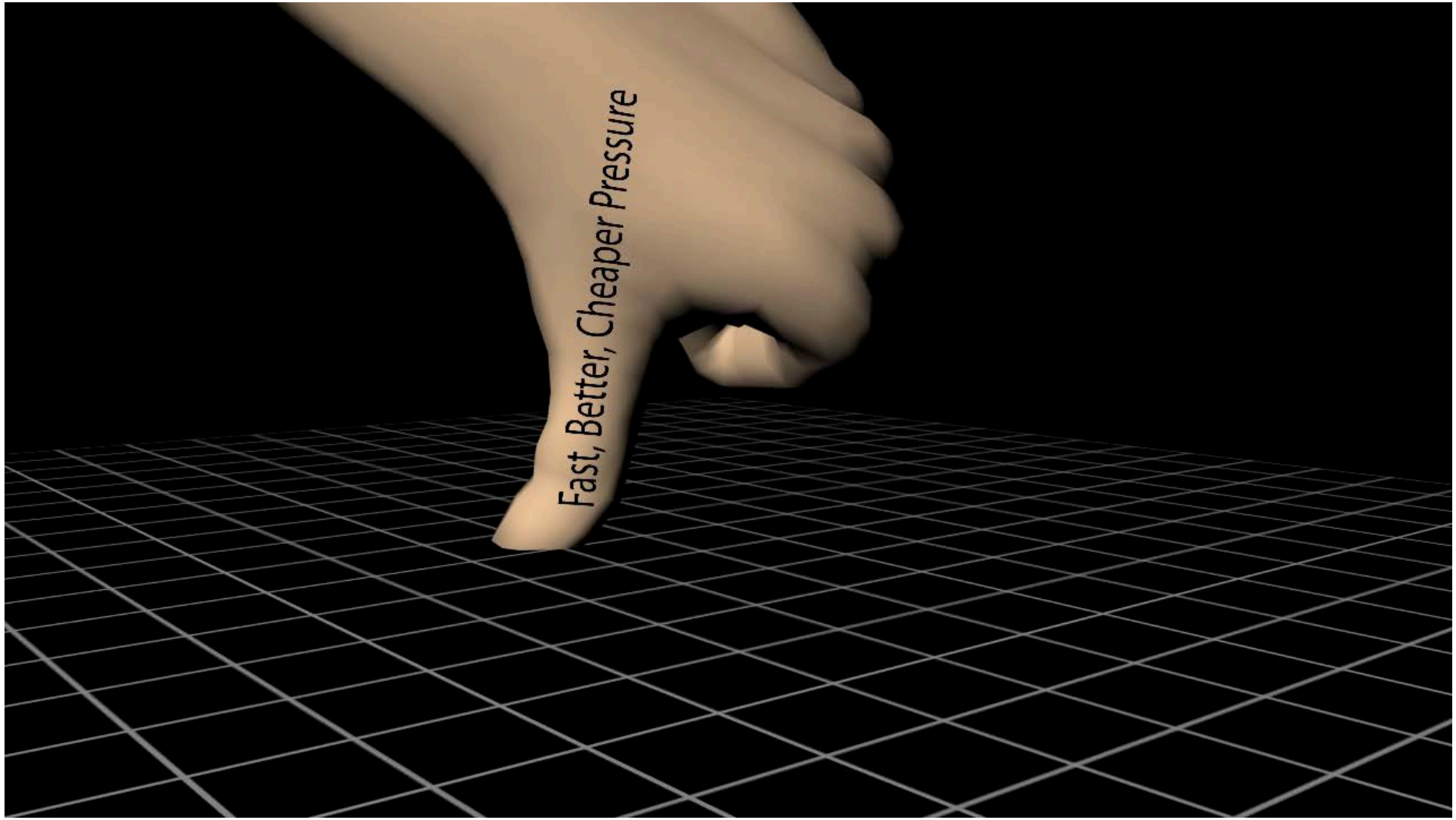
Re-prioritizing as conflicts occur

Pressures grow / Brittleness appears

new forms of SNAFU CATCHERS

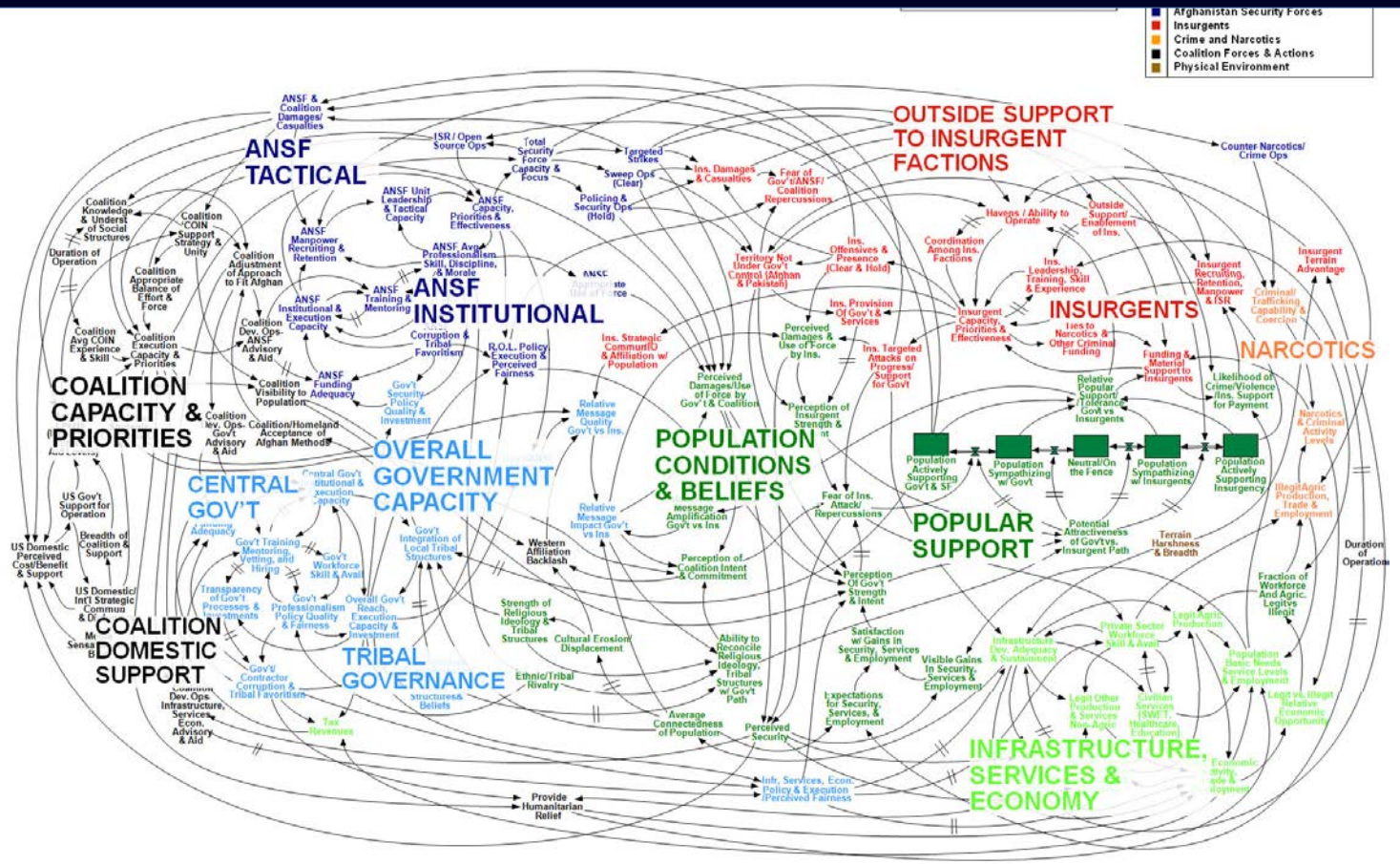


A system does what it is designed to do, except that is not what the designer intended.

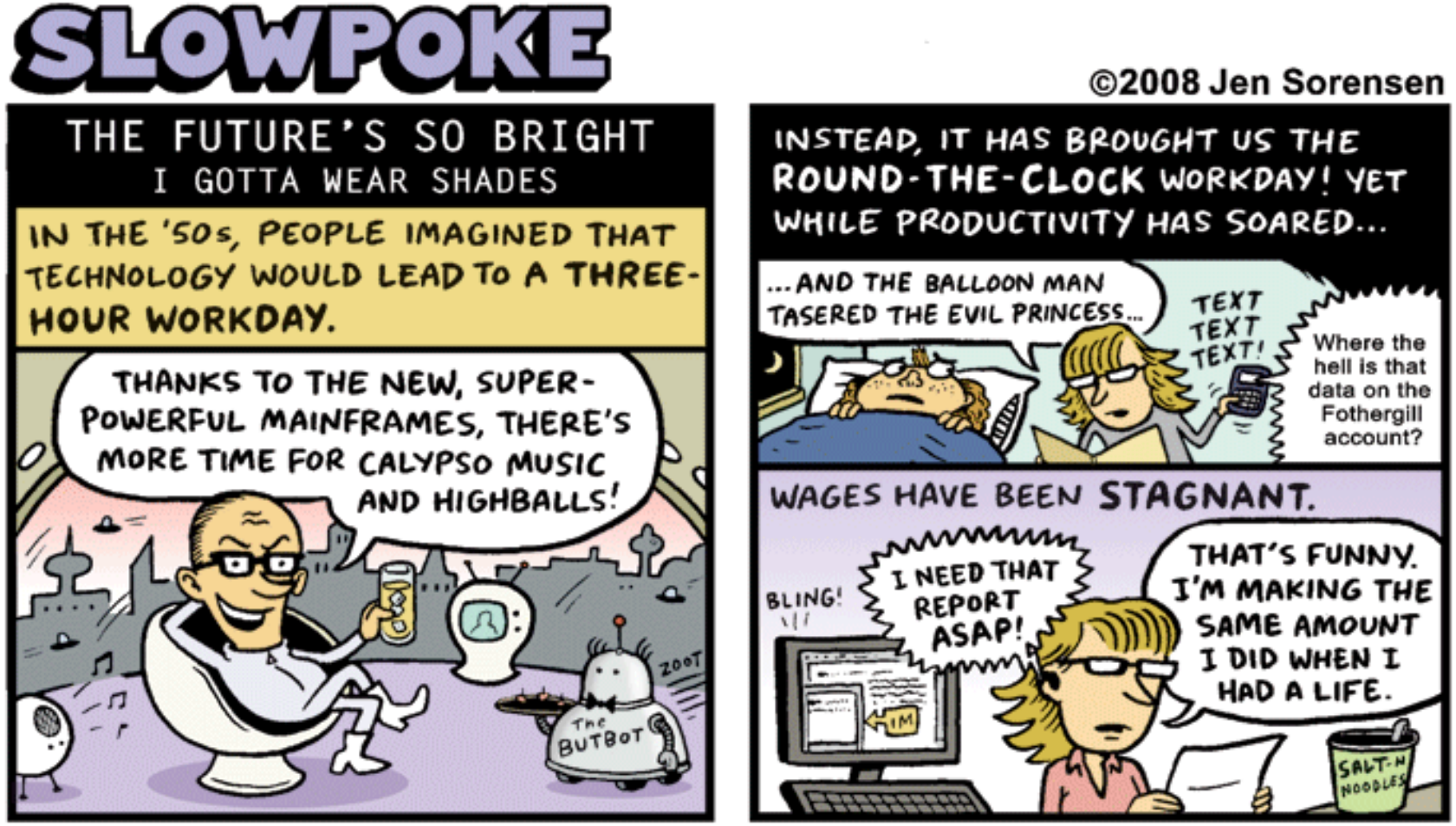


Seeking Advantage Increases Complexity

law of unintended consequences
surprising cascades of effects
sudden failures
linear simplifications don't work anymore



Extensive and Hidden Interdependencies



Surprising reverberations in tangled layered networks

Law of Stretched Systems

With change every system is continuously stretched to operate at its new capacity.

People as problem holders exploit 'improvements' to better achieve goals by pushing the system out to operate near the edge of its new capacity boundaries. The process of adapting to exploit the improvement results in a new intensity, complexity, and tempo of activity.

NASA failure history captures creeping complexity

circa 2000

Creating Safety Under Pressure

NASA in a changing environment under performance demands and resource pressures:

- Drive down the cost of launch
- Shorter, aggressive mission schedules
- New partners and relationships
- New roles
- Skill erosion
- Heightened public interest

"Risk, therefore, becomes the "fourth dimension" of project management—treated equally as important as cost and schedule."

NASA failure history captures creeping complexity

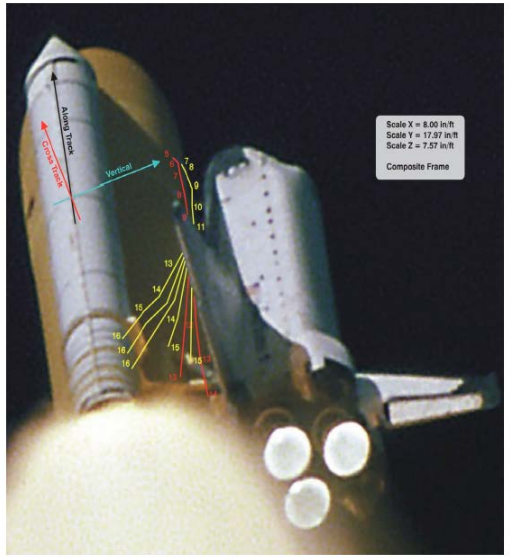
1999: 3 space exploration failures

Report
on
Project Management in NASA

by the
Mars Climate Orbiter
Mishap Investigation Board

March 13, 2000

2003: Run up to Columbia accident



STS-112/ET-115 Bipo

- Rationale for Flight
  - Current bipod ramp closeout has not b
  - The Orbiter has not yet experienced "S of Flight" damage from loss of foam in 112 flights (including 3 known flights with bipod ramp foam loss)
  - There have been no design / process / equipment changes over the last 60 ETs (flights)
  - All ramp closeout work (including ET-115 and ET-116) was performed by experienced practitioners (all over 20 years experience each)
  - Ramp foam application involves craftmanship in the use of validated application processess
  - No change in Inspection / Process control / Post application handling, etc
  - Probability of loss of ramp TPS is no higher/no lower than previous flights
  - ***The ET is safe to fly with no new concerns (and no added risk)***

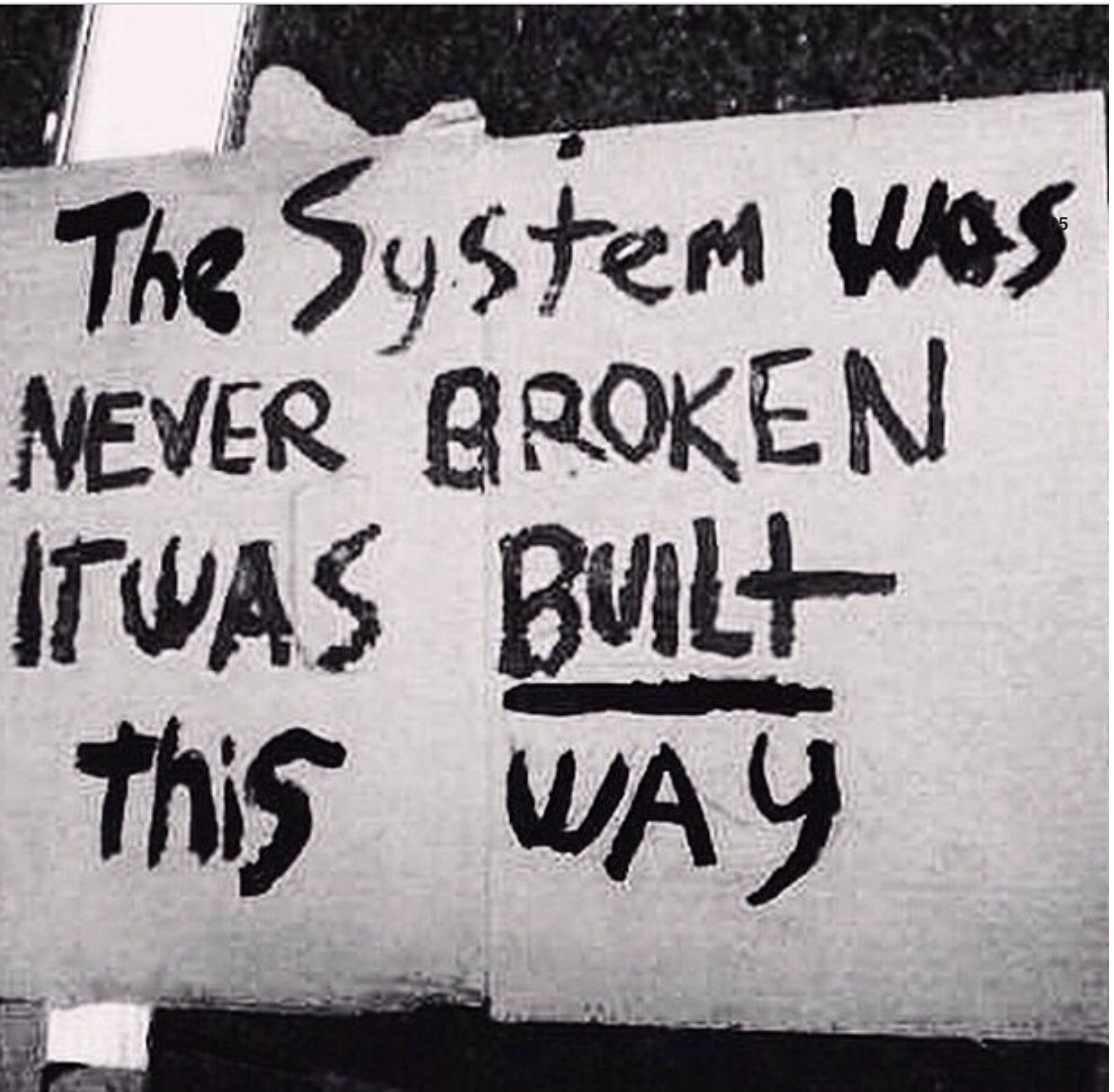
increasingly brittle systems
under
faster, *better*, cheaper (FBC) pressure


PLAN


PLAN

SNAFU Catching is Normal

find resilience in how systems succeed despite their design



Finite Resources / Change

Pressures

SNAFU is normal

Poised to Adapt

SNAFU CATCHERS

Resilient Performance (graceful extensibility)

- positive capability to stretch near and beyond boundaries when surprise occurs;
- opposite of brittleness

SNAFU CATCHERS

Resilience in Action

places where surprise is tangible

NASA ISS
JULY 9, 2013
after EVA 22, then EVA 23

Roles:

Astronaut

Flight Director

Head of Safety

EVA 22:

On July 9, 2013, ISS crew members conducted US EVA 22. During EVA 22, EV1 and EV2 wore the same EMUs that are planned to be worn on EVA 23.

When EV2's helmet was removed post-EVA 22, 1/2 to 1 liter of water was discovered in the helmet.

EV1 reported that when EV1 was face-to-face with EV2 at the airlock hatch prior to ingress, no sign of water was evident in EV2's helmet. Therefore, the crew concluded that the water must have entered the helmet during re-pressurization. Also, during EVA 22 re-pressurization, EV2 was looking down and leaning forward & likely had pressed on the drink bag with his chest and could have pinched the bite valve open with his chin, releasing water into his helmet.

The ground team accepted the crew's drink bag leak assessment & the presence of excessive water in the helmet was not investigated further.

The crew cleaned up the residual water, and the ground team sent up procedure deltas for EMU stowage to help the equipment dry out. The ground team instructed the crew to use a new drink bag for the upcoming EVA 23.

No modifications were made for the pre-briefs prior to EVA 23 on July 11, 2013 or July 15, 2013.

Role: Astronaut as **Ground Advisor**

1. Is the assessment of the water intrusion found on EVA 22 sufficiently rigorous?
2. Proceed as scheduled or delay EVA 23?

Keep in mind, the mission schedule is very tight and any changes to the next scheduled activity have knock-on effects that squeeze other mission activities and goals.

Role: Ground : **Flight Director**

1. As Flight Director in MCC, the mission schedule is very tight and any changes to the next scheduled activity have knock-on effects that squeeze other mission activities and goals.

   1A. Proceed as scheduled or delay EVA 23? Explain your decision to ground control staff and on-board crew.

   1B. If you decide on a delay, what activities will you launch in order to decide to go ahead wit EVA 23?

2. As Flight Director you are required to provide Safety Department with a report on any anomalies that occur, how they have been analyzed, and the actual or potential impact on mission schedule.

   2A. Does the water intrusion on EVA 22 require a report to Safety?

   2B. If you decide EVA 22 requires a report, what are the key points in the report?

Role: Management: **Head of Safety Dept.**

Before EVA 23 is scheduled to begin, as head of safety, you receive a report from the mission lead about an unplanned occurrence on the previous EVA.

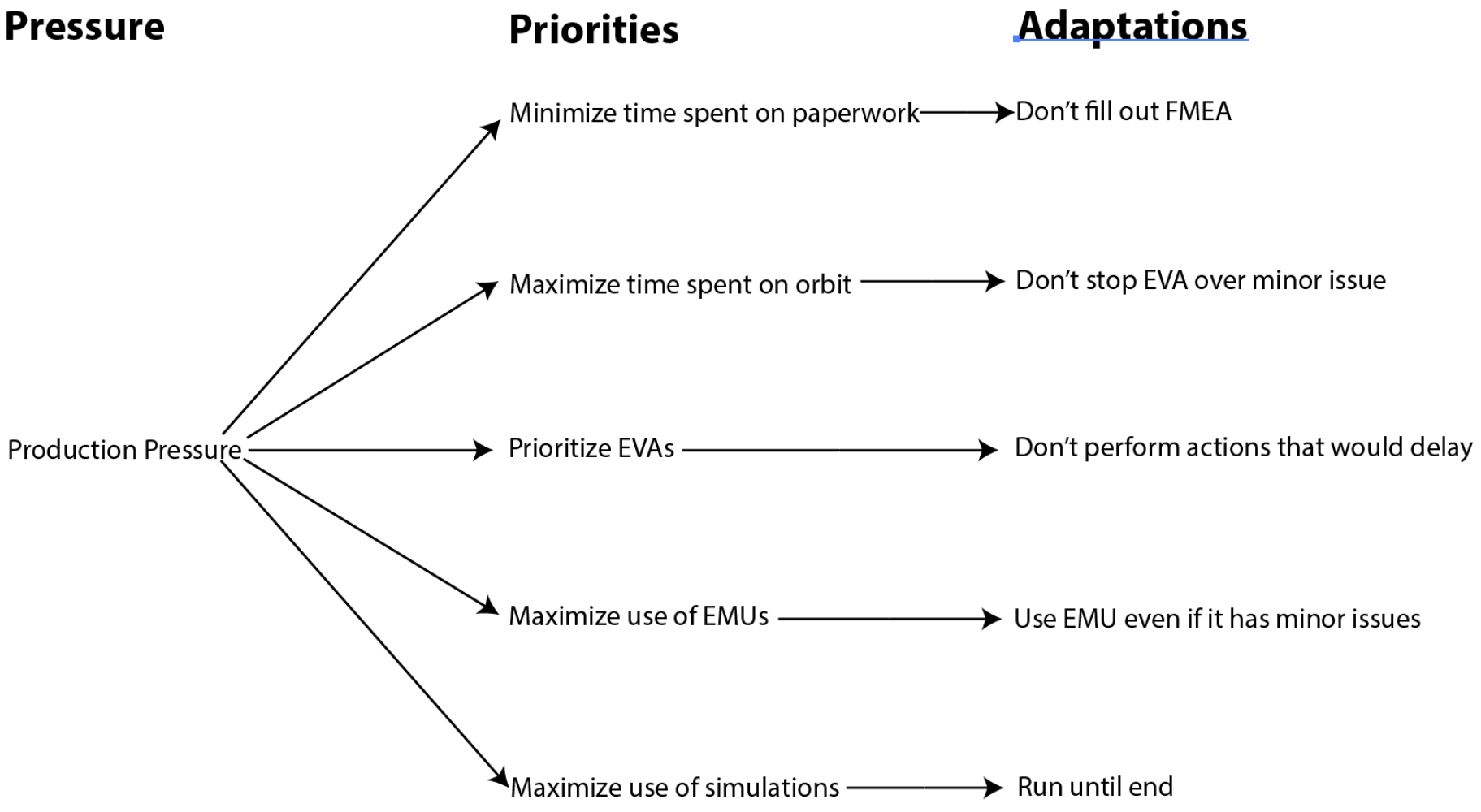
The report says that 1/2 to 1 liter of water was discovered in the helmet of one the astronauts (EV2) when his helmet was removed post-EVA 22. The crew investigated and concluded the water came the drink bag, which frequently leak, and entered the helmet during re-pressurization. The ground team concurred that the water intrusion was due to a leaky drink bag. The crew was advised on clean up of residual water, and the ground team sent up procedure deltas for EMU stowage to help the equipment dry out. The ground team has instructed the crew to use a new drink bag for the upcoming EVA 23. No further actions needed. EVA 23 will proceed as scheduled.

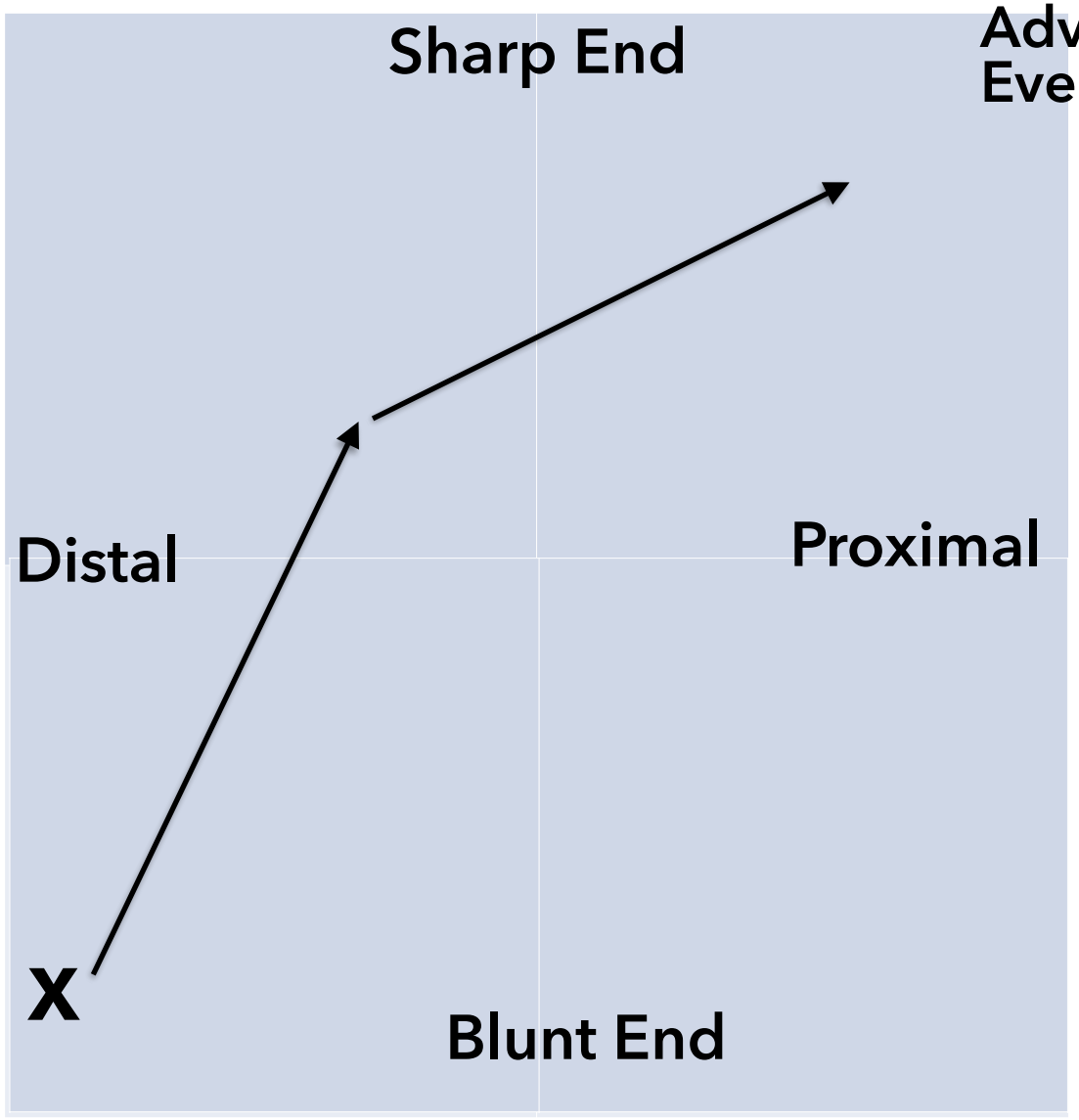
As head of safety,

1A. Do you approve the report, allowing EVA 23 to proceed as scheduled?

1B. How do you assess if the analysis and re-planning of the unplanned occurrence is sufficiently rigorous?

1C. Under what conditions would you intervene and delay EVA 23 to better analyze and assess the event and its implications?


Pressure
Priorities
Adaptations
Production Pressure
Minimize time spent on paperwork
Don't fill out FMEA
Maximize time spent on orbit
Don't stop EVA over minor issue
Prioritize EVAs
Don't perform actions that would delay
Maximize use of EMUs
Use EMU even if it has minor issues
Maximize use of simulations
Run until end



Pressures over goals –> conflicts/priorities –> adaptations

Program emphasis was to maximize crew time on orbit for utilization

ISS Community perception was that drink bags leak.

Flight Control Team's perception of the anomaly report process as being resource intensive made them reluctant to invoke it.

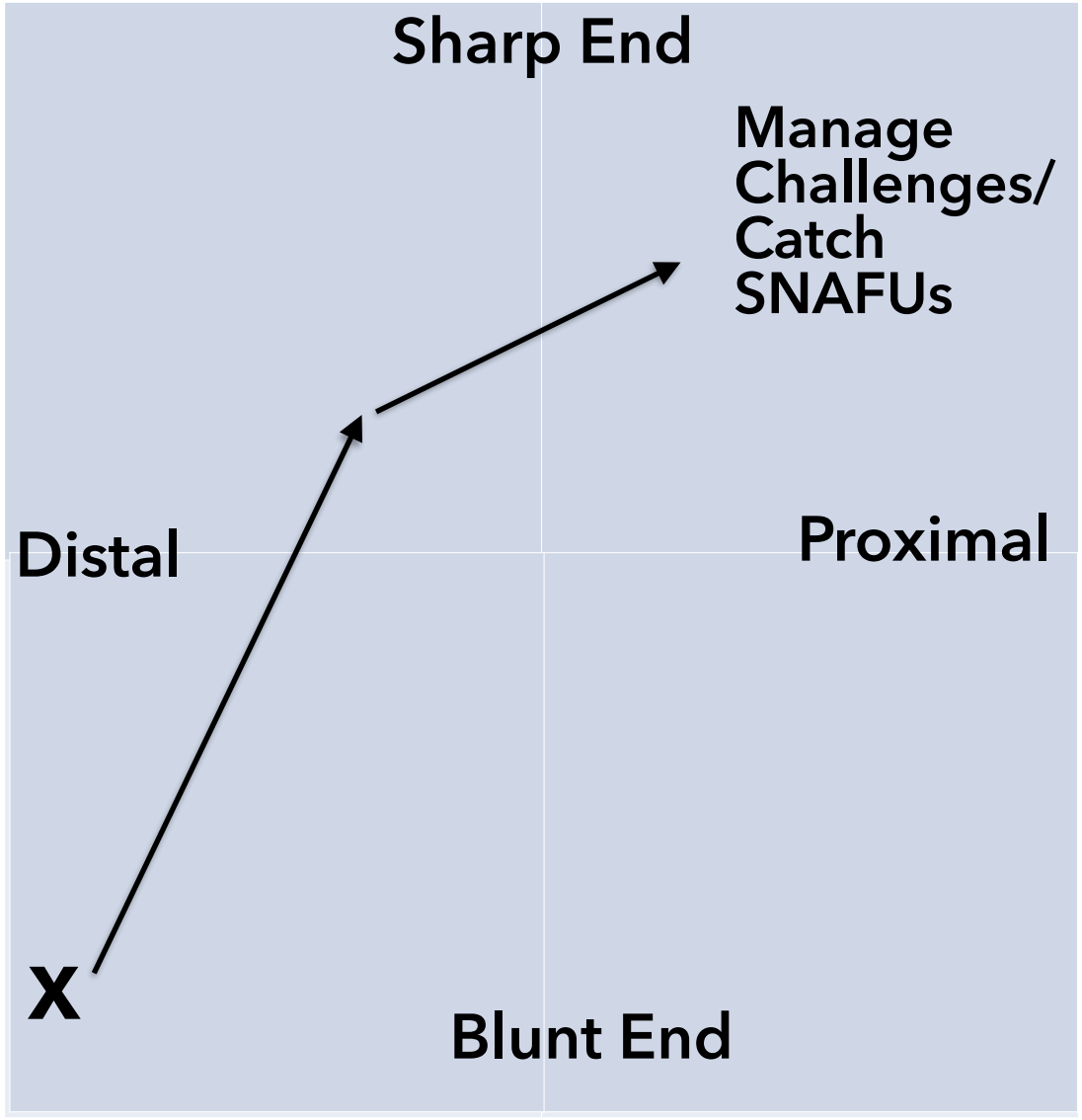
No one applied knowledge of the physics of water behavior in zero-g to water coming from the PLSS vent loop

The occurrence of minor amounts of water in the helmet was normalized

The ISS Program conducted EVA 23 without recognizing the EMU failure which occurred on EVA 22

Flight Control Team/Crew did not terminate EVA 23 as soon as water was reported in the helmet.

The Crew and ISS were exposed to a potential fire hazard due to inadvertent activation of the EMU 3011 Secondary Oxygen Pack during EMU dryout activities



anomalies/surprises at edges –> poised to adapt –> success

With complexity,

Failure is due to **brittle** systems, not human error.

Systems operate successfully due to sources of **resilience**, usually hidden or under appreciated.

Our *responsibility* in ***systems*** safety is to

"*Create Foresight* -- anticipate the changing shape of risk, before any one is harmed"