

## A Pattern:

- “Computer technology capabilities advance in an organization.
- Stakeholders take advantage of this capability to introduce new services that perform new functions to gain value.
- But these same people know very little about how the service is supplied, what sorts of demands it will not be able to process efficiently, how it is interdependent on other services.”

## Pattern, continued:

- “When the service was built it was imagined that it would be used in a certain way, even though the service as provided permitted much wider range of uses.
- Developers wrote code that exploited the new service in ways that generated new forms of failure that were unexpected by the authors and for which no defenses existed.
- These uses brought the system to its knees.”

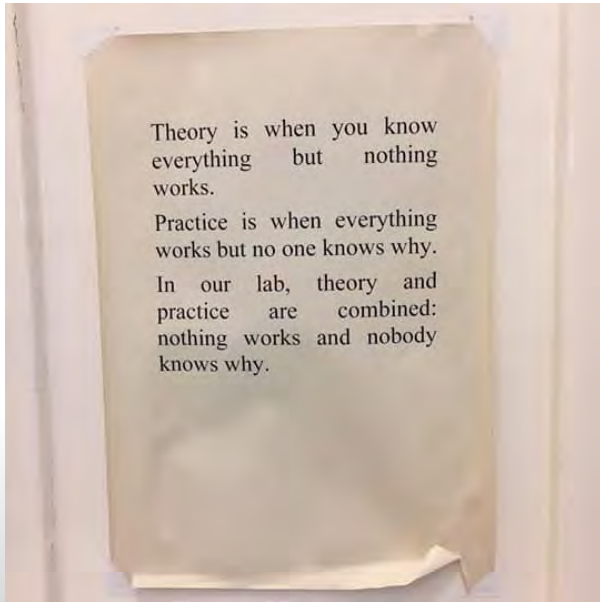
## Pattern, continued:

- “After gaining experience with these forms of failure it became clear that the developers who were using the service to run their jobs lacked a deep appreciation of what they were asking the service to do.
- They had no real opportunity to anticipate this, however, because the service was arcane, hidden, and the contextual assumptions about how it would be used were left unstated.”

# Rise of High Frequency Trading / Emergence of IEX as a 'Neutral' Exchange

To begin, Requires reference to previous adaptive cycles, to chart ongoing process of adaptation with unseen/ mis-seen reverberations:

- Some people seeking advantage begin to recognize and act to expand opportunities.
- Increased *scale* of operations: finer and multiple time scales; scale of transactions; more variability, more players; and cross-scale interactions matter.
- *Complexity Penalties* increase that produce new forms of gaps, anomalies, conflicts, and surprises.
- New roles arise at multiple levels.
- Partial, incomplete models fragmented over roles. Understanding the changes afoot lags the changes; old models persist long after they no longer apply.
- New goal conflicts arise – value for some comes at costs for others.
- *Anomaly recognition*: Many anomalous behaviors appear which fall outside previous models/ experience.
- *Discounting* of anomalies that conflict with past models.



<https://pbs.twimg.com/media/CrqtOsXXgAA6i4D.jpg>

via @CleveArguelles

[www.snafucatchers.org](http://www.snafucatchers.org)

Theory is when you know everything but nothing works.  
Practice is when everything works but no one knows why.  
In my lab, theory and practice are combined: nothing works and nobody knows why.

# Outmaneuvering Complexity in Worlds of Surprise

How adaptive capacities in human-technology systems are built, extended, sustained, degraded, and collapse

Adaptive universe:

we all live in it, always

pressures, capabilities, conflicts & successes drive it

it has a kind of rules

it doesn't work the way most think it does

breaking the rules has consequences

## Biological Root:

*"Life is a Verb."*

*"Life developed by networking not combat." Lynn Margulis*

- no role/title is exempt from the rules of the adaptive universe.
- exemplified by multiple levels: cells (glycolysis); bone remodeling, healthy heart; sick heart, neurobiology, joint cognitive systems, socio-technical systems, organizations, social systems
- all lines of inquiry contribute but are partial, incomplete and off axis to the new emergent synthesis
- special character of control laws, for *tangled* layered networks

# Poised to Adapt

Responding to surprise requires preparatory investments that provide the *potential for future adaptive action*. Model surprise is ubiquitous.

## Empirical Laws in Adaptive Cycles

Patterns from studies of people *adapt to cope with complexity*

## Discoveries

Fundamentals that explain the phenomena – *Graceful Extensibility*

## Capabilities

Different paths for pragmatic action – New Architectures

Outmaneuver complexity penalties



## Definition:

Adaptive capacity is the potential for adjusting patterns of activities to handle future changes in the kinds of events, opportunities, and disruptions experienced, therefore, adaptive capacities exist before changes and disruptions call upon those capacities.

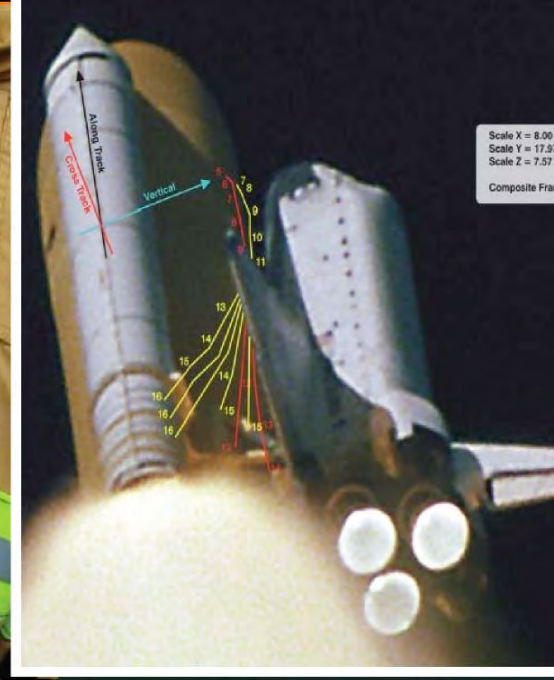
*Range of adaptive behavior:* adaptive capacity generates a range of behavior that is adapted to the patterns of change ongoing and upcoming; as a range adaptive capacity has limits or a boundary.

*Saturation:* Exhausting a unit's range of adaptive behavior or capacity for maneuver as that unit responds to changing and increasing demands.

*Risk of saturation:* Inverse of remaining range or capacity for maneuver given ongoing and upcoming demands.

Examples of architectures in biology that facilitate *future adaptability* continue to be uncovered.

# Operating in Seas of Complexity



places where surprise is tangible



**Adaptive Cycles/Histories** extract general patterns from corpus of stories of brittleness and adaptation across natural laboratories

e.g., **Critical Care**

- Being Bumpable - Intensive Care Units (ICUs)
- Patient Boarding in Emergency Rooms
- Underground adaptations /anticipating bottlenecks ahead

**Strong Silent Automation**

- Asymmetric lift incidents and accidents in aviation

**Business-critical digital services**

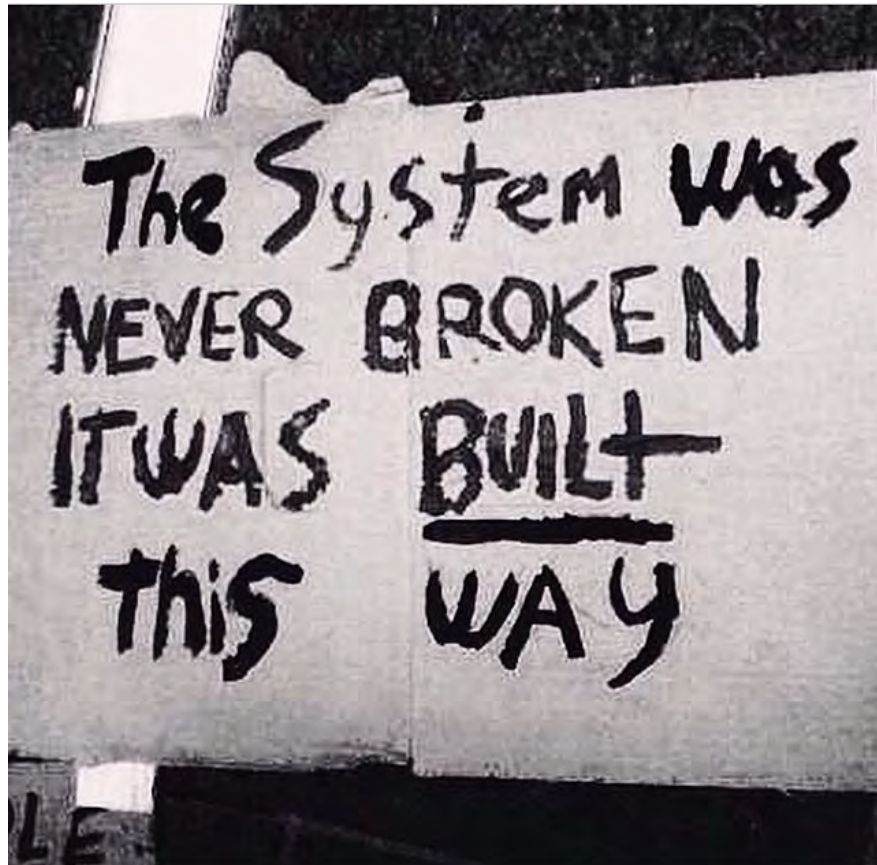
- High-frequency trading
- regular "flash crashes"

...



# Systems are Messy

(some) people provide resilient performance  
to overcome brittle systems



Finite Resources / Change  
Pressures

SNAFU is normal

Poised to Adapt



Failure is due to **brittle** systems, not erratic people.

Systems operate successfully due to people providing extra adaptive capacity, usually hidden or under-appreciated.

Law of Fluency:

“Well”-adapted activity occurs with a facility that hides the difficulty of the demands resolved and the dilemmas balanced



# Messy Systems

RyF: systems “which are robust to perturbations they were *designed to handle*, yet fragile to *unexpected perturbations and design flaws*” (Carlson and Doyle 2000, p. 2529).

- highly competent when events fall within the envelope of designed-for-uncertainties
- sudden, large failures occur in the face of events that challenge or go beyond the envelope

Given the pursuit of optimality increases brittleness,  
why don't more failures occur?

## SNAFU Catching

Adapting to handle the regular occurrence of SNAFUs makes the work of SNAFU Catching almost invisible

basic pattern to be explained





# Messy Systems

Unintended reverberations of change as success is hijacked by others adapting to seek advantage produce new forms of congestion, conflict and cascade

Healthcare IT News

TRACKING THE PULSE OF HEALTH IT

## Ransomware Defense for Dummies



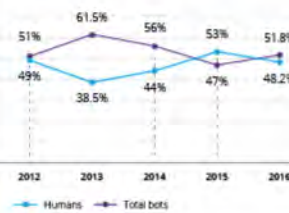
Should you pay the ransom? How do you respond to an attack? We'll break it down for you. **Access this new complimentary eBook**, full of key insights, to explore:

- **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

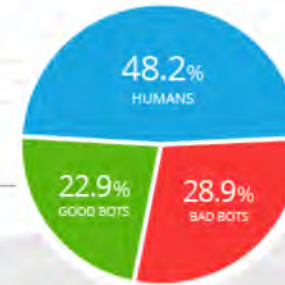
## BOT TRAFFIC REPORT 2016

BOTS ONCE AGAIN COMPRISE THE MAJORITY OF ONLINE TRAFFIC AMID AN INCREASE IN GOOD BOT ACTIVITY.

BOT ACTIVITY IS IN AN UPTREND, after a three year decline.



INCREASE IN GOOD BOT ACTIVITY, which went up by 4.4 percent.



## Malware

# WannaCry, Petya, NotPetya: how ransomware hit the big time in 2017

Most first encountered ransomware after an outbreak shut down hospital computers and diverted ambulances this year. Is it here to stay?



Pause

Verbs, not Nouns

Brittle

SNAFU is natural state (finite resources & change

Competence Envelope

Model Surprise

Adaptive Capacity (future oriented)

SNAFU Catching is essential

(some) People are the ad hoc source of SNAFU Catching



PLAN

## Perspective and Miscalibration



## Perspective and Miscalibration





## Perspective and Miscalibration

# *Discovery of Graceful Extensibility*

- graceful extensibility is a positive capability to stretch near and beyond boundaries when surprise occurs.
- opposite of brittleness
- graceful extensibility trades off with optimality

*Viability, over cycles of change, requires Extensibility*

places where model surprise is tangible



No plan survives first contact with a disaster-in-the-making



“perfect” software



production traffic

October 21 post-incident analysis | The GitHub Blog

<https://blog.github.com/2018-10-30-oct21-post-incident-analysis/>

 The GitHub Blog

**October 21 post-incident analysis**

In-depth analysis of the incident that impacted GitHub services on October 21 and 22.

Oct 30th (71 kB) ▾






No plan survives first contact with a disaster-in-the-making



“perfect” software



production traffic

 theregister.co.uk

[British Airways' latest Total Inability To Support Upwardness of Planes\\* caused by Amadeus system outage](#)

Stuck on the ground awaiting a load sheet? Here's why (100 kB) ▾



# Viability crushing events ?

MX, TSX, TSX V, and Alpha all down 4-27-18

troubles persist 4-30-18

## TSB online banking meltdown drags into second week

CBC

### TSX shut down due to trading issue | CBC News

The operator of the Toronto Stock Exchange and the Montreal Exchange says all of its markets have been shut down for the rest of the day after experiencing issues with trading. (41 kB) ▾



ALL of its markets. Its' like a horror story written especially for me. Hold me. 🙏

Customers still facing problems with internet and business services after bungled IT upgrade



New forms of congestion, conflict & cascade

# Patterns of Adaptive Breakdown - How Control Saturates

## **Getting stuck** in outdated models

the world changes but the system remains stuck in what were previously adaptive strategies.

## **Working at cross-purposes:** behavior that is locally adaptive, but globally maladaptive

inability to coordinate across roles, units, & echelons as goals conflict.

## **Decompensation:** exhausting capacity to adapt as disturbances/challenges cascade.

breakdown occurs when challenges grow and cascade faster than responses can be decided on and deployed to effect.



# Cognitive Work as Imagined



Comics created by Robert Hoffman

# Cognitive Work as Done



Comics created by Robert Hoffman



Cognitive Work as  
Done

Work as Imagined vs  
Work as Done

joint systems  
perspective



Comics created by Robert Hoffman

# NASA failure history captures creeping complexity

1999: 3 space exploration failures

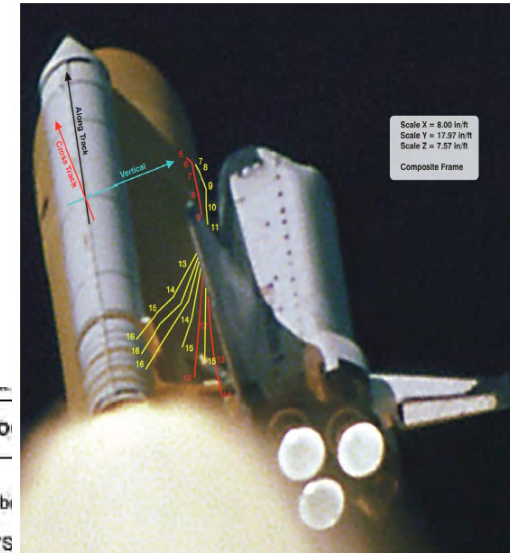
2003: Run up to Columbia accident

## Report on Project Management in NASA

by the  
*Mars Climate Orbiter  
Mishap Investigation Board*

March 13, 2000

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



**STS-112/ET-115 Bipod**

- **Rationale for Flight**
  - Current bipod ramp closeout has not been
  - 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 craftsmanship in the use of validated application processes
  - 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)**

After Final Foam Trim

Bipod Attach Fitting



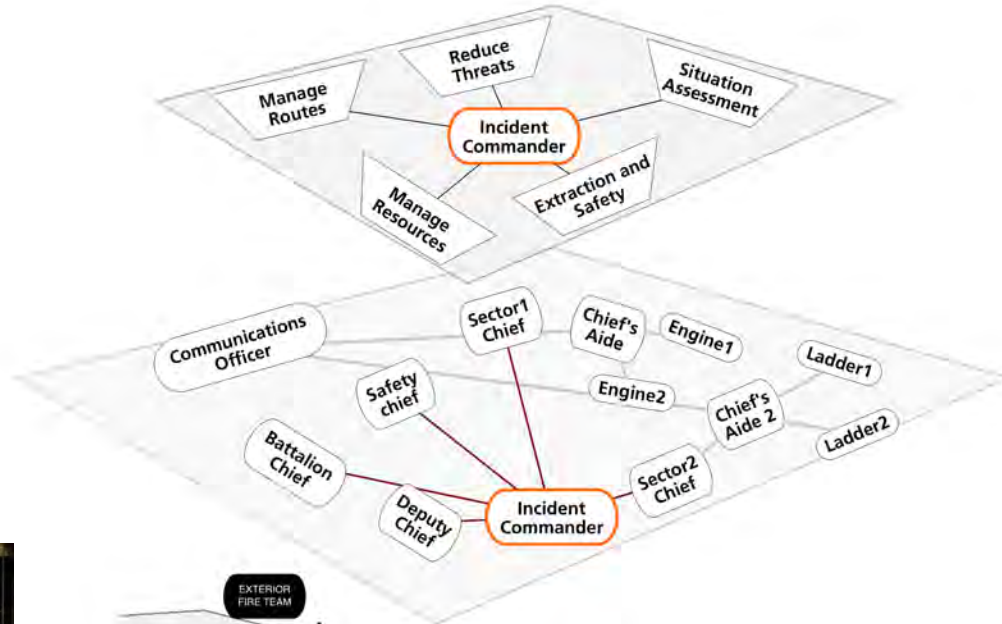
# Urban Firefighting

- ~ distributed roles
- ~ multiple echelons
- ~ disrupting factors
- ~ multiple goals
- ~ interdependencies

DISPATCH

EMERGENCY OPERATIONS CENTER

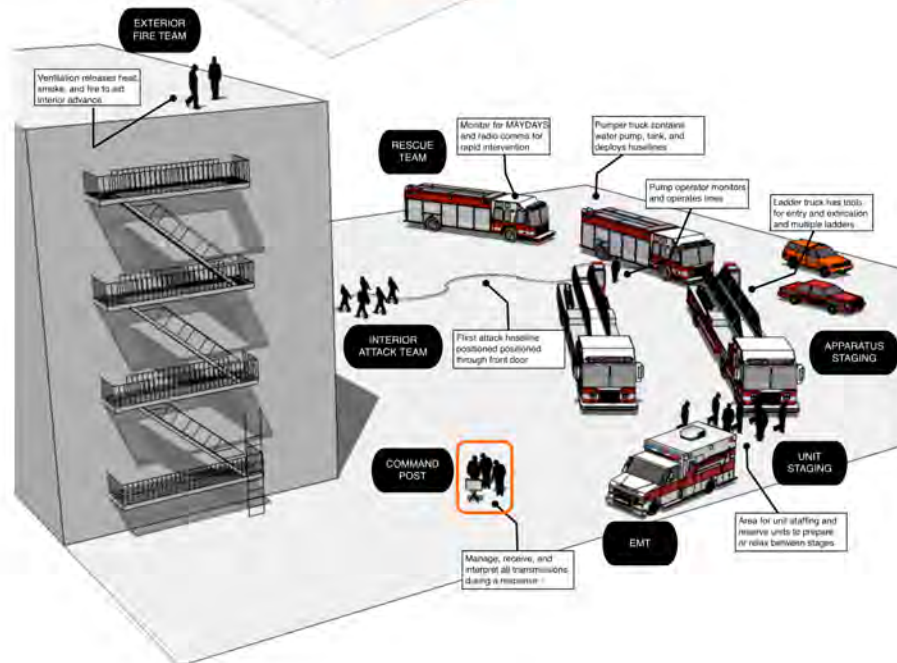
Command (offsite)



Functional

Local Command

Physical



a TLN

# Urban Firefighting Critical Incidents reveal

## **Working at cross-purposes** (both horizontal and vertical)

Actions of one group increase threats to other groups (opposing fire hoses; rendering escape routes or protected areas inaccessible)

## **Decompensation**

- If request resources when need is definitive, it is already too late
- Regulate additional adaptive capacity (tactical reserves)
  - ~ maintain **capacity for maneuver** (ability to handle next surprise)
  - ~ “avoid all hands situations” (incident command)

# Poised to Adapt or Brittle?

anticipate	vs	decompensate,
synchronize across units, roles, levels	vs	work at cross purposes
proactive learning to update models before failures	vs	stuck in stale models

ability to adapt to signals about future surprises  
as conditions continue to evolve

# Fundamentals

## Theory of Graceful Extensibility

first comprehensive / formal account of how human adaptive systems, at all scales, succeed and fail as the complexity of modern systems continues to grow.

(1) *explains* empirical regularities and phenomena,

(2) *reveals* new fundamentals that drive how all adaptive systems work, requires abandoning linear oversimplifications,

(3) *predicts* the impact of proposed changes to uncover unanticipated consequences that arise as people 'hijack' new capabilities for their own purposes,

(4) *directs* innovative pragmatic action paths to outmaneuver complexity and create proactive safety.