



Outmaneuvering Complexity

Releasing the Adaptive Power of Human Systems

The Adaptive Universe

- emerging comprehensive account of complex adaptive systems that serve *human purposes*
- technical foundations emerging
- multi-role multi-echelons networks (tangled layered network)
 - with
- extensive, hidden interdependencies
- confront surprises that challenge boundaries





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- emerging comprehensive account of complex adaptive systems that serve *human purposes*
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 - with
- extensive, hidden interdependencies
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Live in the Adaptive Universe (it doesn't work the way you think it does)
Can't hide behind linear simplifications anymore
Our systems are more brittle than we realize.

The future is implausible, the past incredible

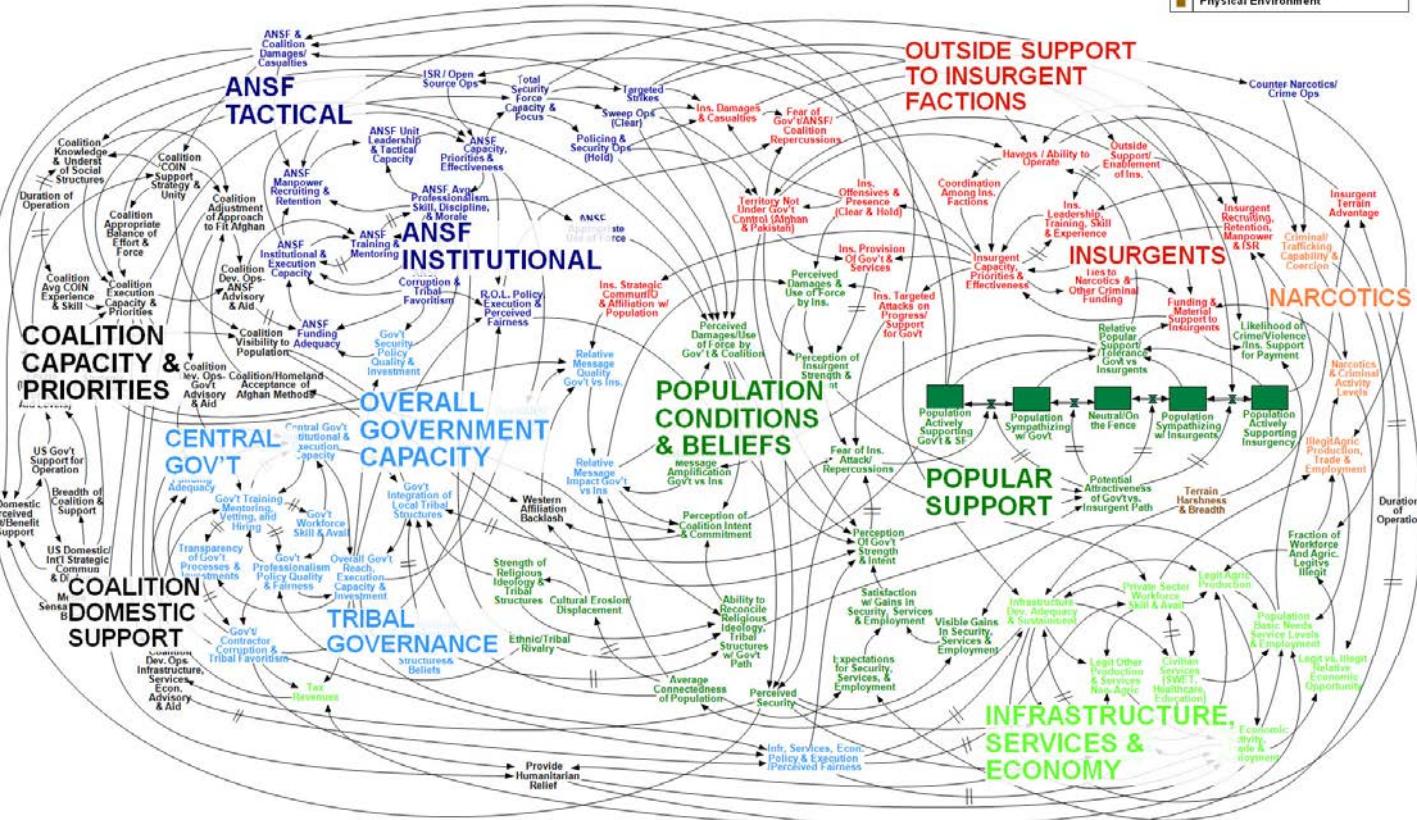
Human Systems regularly outmaneuver complexity (in some places).
What are the sources of success – a form of resilience, graceful extensibility?
How to sustain and value the sources of success?

Failure is due to brittle systems.

Success is created by graceful extensibility at the borders.

2 kinds of adaptive capacity: far from and near boundaries
separate P/R ratios for each; need both, but
these **trade-off** & increases as load, variation, and disruptions increase

how to value the sources of success in creating safety?



WORKING DRAFT - V3

Adaptive universe:
 You live in it & its basic rules
 it doesn't work the way you think it does
 When can you hide behind linear simplifications?

Extensive and Hidden Interdependencies



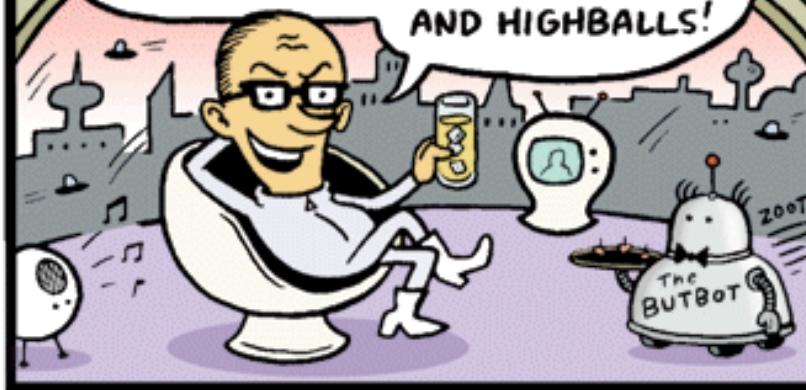
SLOWPOKE

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THE FUTURE'S SO BRIGHT
I GOTTA WEAR SHADES

IN THE '50s, PEOPLE IMAGINED THAT
TECHNOLOGY WOULD LEAD TO A THREE-
HOUR WORKDAY.

THANKS TO THE NEW, SUPER-
POWERFUL MAINFRAMES, THERE'S
MORE TIME FOR CALYPSO MUSIC
AND HIGHBALLS!



INSTEAD, IT HAS BROUGHT US THE
ROUND-THE-CLOCK WORKDAY! YET
WHILE PRODUCTIVITY HAS SOARED...

...AND THE BALLOON MAN
TASERED THE EVIL PRINCESS...

TEXT
TEXT
TEXT!

Where the
hell is that
data on the
Fothergill
account?

WAGES HAVE BEEN STAGNANT.

BLING!
I NEED THAT
REPORT
ASAP!

THAT'S FUNNY.
I'M MAKING THE
SAME AMOUNT
I DID WHEN I
HAD A LIFE.



Surprising reverberations in tangled layered network

Adaptive Behavior Consumes Success



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Unintended Consequences Offset Gains



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Resilience Engineering
Association



**IGNORE
SAT NAV &
ENGAGE BRAIN**

**NO THROUGH ROAD
SECURITY BARRIER IN PLACE
RELEASE FEE £100**

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**“Even if the world were perfect,
it wouldn’t be”**

Yogi Berra

Law of Stretched Systems

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.

progress uncovering the basic rules of the adaptive universe ...

Unintended Consequences of Change

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

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

2003: Run up to Columbia accident



STS-112/ET-115 Bipod Attach Fitting

- **Rationale for Flight**
 - Current bipod ramp closeout has not been used on any flight
 - 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)*

NASA failure history captures cumulative complexity circa 2000



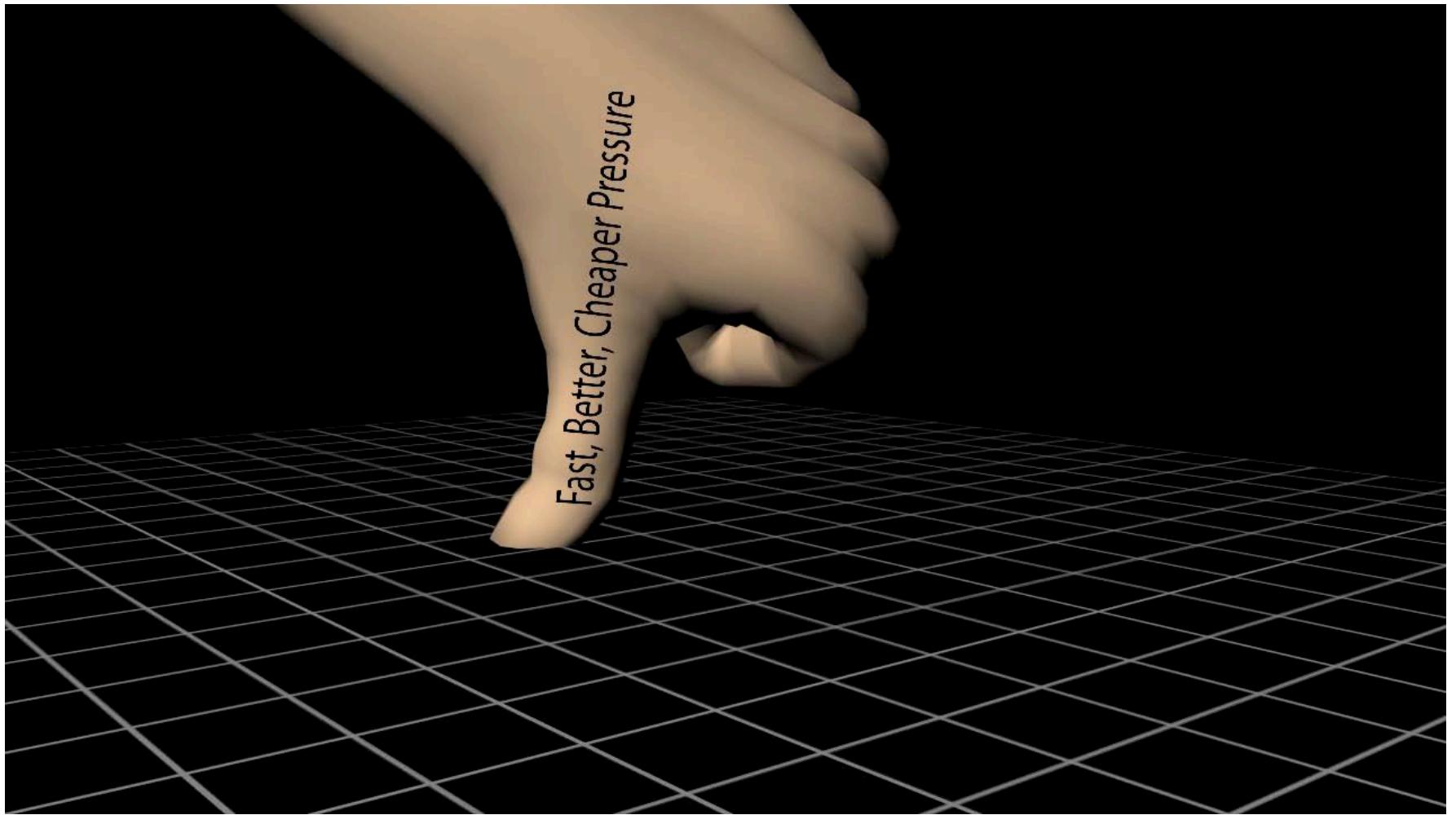
Creating Safety Under Pressure



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.”



FBC: faster, better, cheaper pressure



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Adaptive Universe:

What is needed to be sufficiently adaptive & resilient as challenges change?

Barriers

- too little of the right kinds → *brittle*, fails at boundaries,
- organizations are *miscalibrated*,
 - ~ miss challenges at the boundaries
 - ~ miss what produces resilient performances
- study how things go well to improve calibration
- match forms of adaptive capacity to changing demands to generate fitness

Risk of Saturation near and beyond Boundaries



- **Rebound** from traumatic event

- **Robust** expand base adaptive capacity to handle more, **well-modeled** disruptions

Linear
Simplifications

Adaptive
Universe

- **Graceful Extensibility** (vs. brittleness)
the capability to stretch/extend near and beyond boundaries
how to be prepared to be surprised
- **Sustained Adaptability** manage/regulate adaptive capacities.
governance and architectures that tend to find hard limits in
tradeoff spaces

contrast success/failure at managing complexity



Surprise: there be dragons



Competence Envelope



bounded

Borderlands



“here be dragons”

Surprise at boundaries

Competence Envelope

plans, procedures
automation,
contingencies

Borderlands

“here be dragons”

Surprise at boundaries

Competence (Base) Envelope

P/R ratio far from boundary

P/R ratio near boundary

Graceful Extensibility

Trade off

Borderlands

what Dragons lurking?



Cascades, Friction, changing Tempos

Surprise at boundaries

Borderlands



What adaptations produce
Graceful Extensibility?



what Dragons lurking
near, at and beyond boundary?

Anticipating crunches ahead
generating/sustaining a readiness to respond

Graceful Extensibility

Borderlands



Decompensation /Anticipation

**Working at cross purposes / Synchronizing
over units**

Stuck in Stale / Proactive Learning

Graceful Extensibility

Borderlands



Readiness to Respond:
Deploy
Mobilize
Generate

Competence (Base) Envelope

P/R ratio far from boundary

Trade off

P/R ratio near boundary

Graceful Extensibility

Borderlands

what Dragons lurking?



Surprise at boundaries

Competence Envelope

Perspective 1:
Work to rule/role

Borderlands



Perspective 2:
Handling Surprises
Regularly

Distant views miss the dragons regularly tamed
because others provide graceful extensibility

Fluency Law



FBC: faster, better, cheaper pressure



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Competence Envelope



challenges to
handle Surprises

steepness of transition

Smooth effortless

Steep Gradient

Competence Envelope

Borderland

change in dragons
handled **poorly**



Distant Perspective?
more rigidity

Up Close Perspective?
adjust taming of dragons

Breakdowns in Learning

Competence Envelope

Borderland

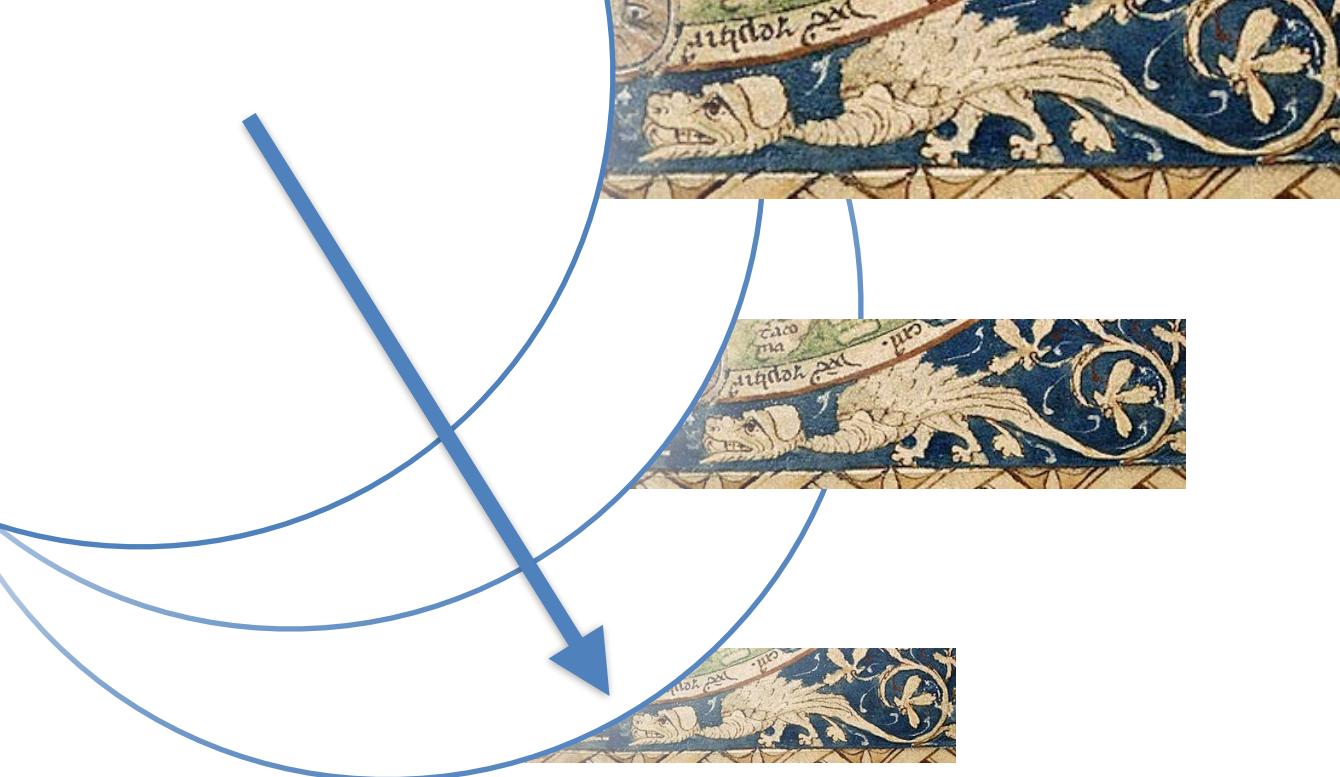
change in dragons
handled **well**



Distant Perspective?
normal

Up Close Perspective?
normal

Fluency Law



competence envelope expands to encompass more specific factors/events/disturbances,
dragons of surprise recede

Violates the Rules of the Adaptive Universe

Adaptive Universe:

What is needed to be sufficiently adaptive & resilient as challenges change?

Graceful Extensibility

- graceful extensibility is a positive capability to stretch near and beyond boundaries when surprise occurs;
- graceful extensibility trades off with robust optimality
- change lead to shortfalls, responsible people make up the shortfall

Graceful Extensibility in Action

places where surprise is tangible



pursuing FBC only ->

- creeping complexity
- more brittleness,
- erodes graceful extensibility
- encourages mis-calibration
- offsetting effects in trade spaces

as systems become more optimal under FBC pressure,
new forms of complexity and fragility emerge

paradoxical result:

- 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
- brittle, insufficient graceful extensibility



Steep gradient

Adaptive Universe:

What is needed to be sufficiently adaptive & resilient as challenges change?

Sustained Adaptability: ability to develop/sustain key abilities that build a readiness to respond:

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

the future is implausible, the past incredible

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

Prepared for Surprise at the Borderlands?

- **tangible experience with surprise** – precarious
- **human talent** – *initiative*: decentralized, coordinated
- **resources to *invest* toward graceful extensibility**
 - not only FBC pressure

build the capacity to handle **crunches** ahead
anticipatory signals shared,
modify readiness to respond,
proactive learning

= Capacity for Maneuver (CfM)

**Releasing the Adaptive Power of
Human Systems**



0930GMT 15 April 2010



1600GMT 16 April 2010



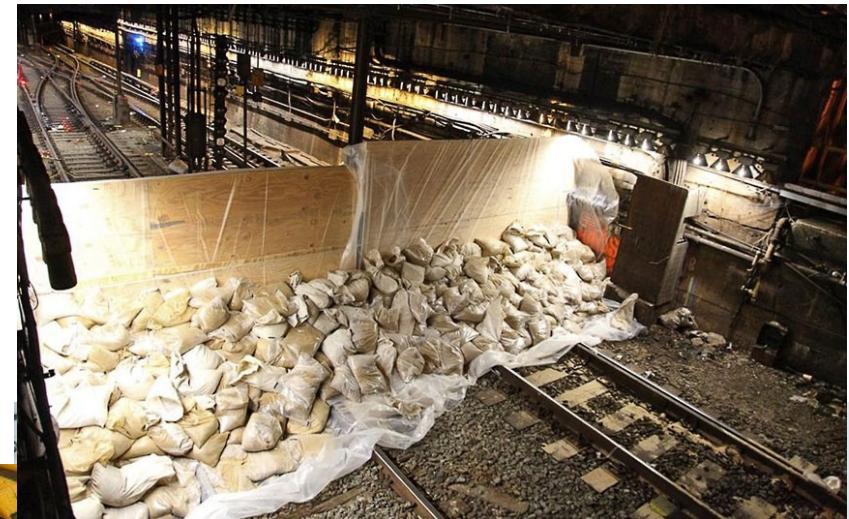
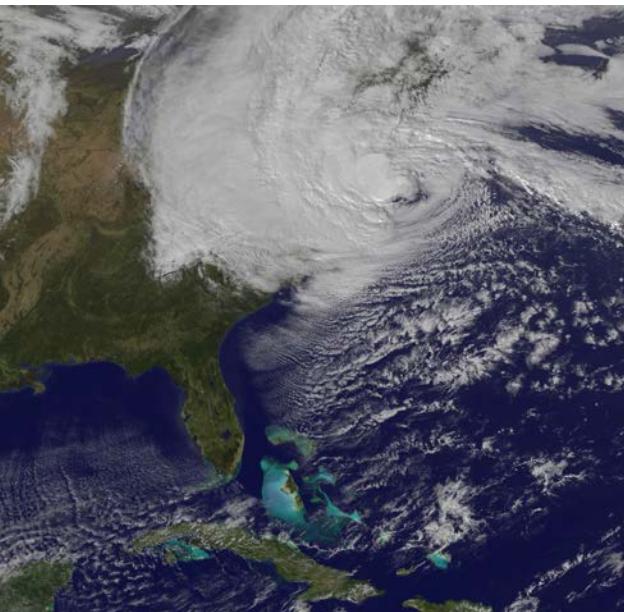
Resilience Engineering
Association



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Adapting to Hurricane Sandy

- Natural laboratory for observing resilience in face of cascades
- Highly adaptive transportation firm
- Hundreds of movements a day
- Short notice requests
- High schedule variability



Preparing
for surprises

Prior learning

Strategic tradeoffs

Explicit intent-plan link

Timely direction

Top down

Anticipate & Direct Potential Adaptations

Cross-Scale Flows

Awareness of priorities & intent

Supervisory buffers

Sensitivity to others' goals

Adapt in Pace to Events

Appropriate authority

Sense of urgency

Taking initiative

Premium on responsiveness

Reconfigurable communication

Bottom up

Competence Envelope

pursues optimality under FBC pressure

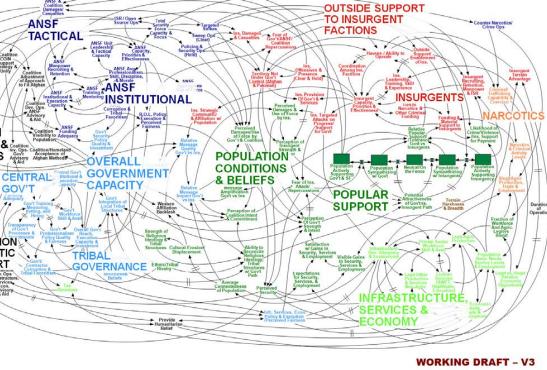
P/R ratio Managing Trade-off P/R ratio

gracefully extensible
by sustaining CfM

Borderlands



Balance 2 kinds of adaptive capacity



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we are all in the Adaptive Universe and subject to its rules
 linear simplifications are no longer sufficient
 how to provide an appropriate P/R for graceful extensibility
 as evidence of surprises changes?

Grace Extensibility in the face of Surprise ?

*to know what generates and what undermines it,
 to know how much is needed when*



“there will be dragons”