



# 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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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?







# SLOWPOKE

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Surprising reverberations in tangled layered network

Adaptive Behavior Consumes Success





## Unintended Consequences Offset Gains





**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

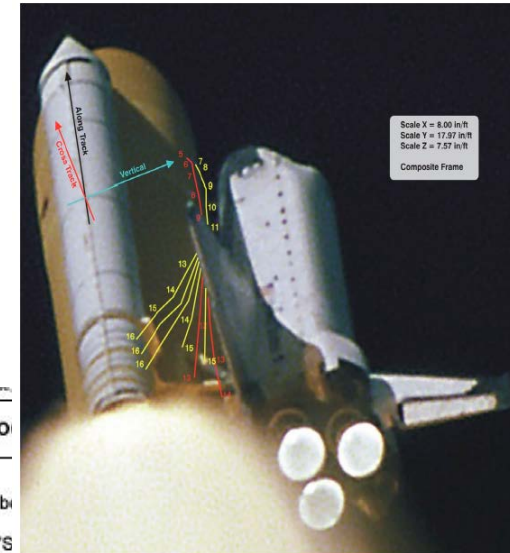
2003: Run up to Columbia  
accident

## 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 completed
  - 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



# NASA failure history captures cumulative complexity circa 2000



## *Creating Safety Under Pressure*

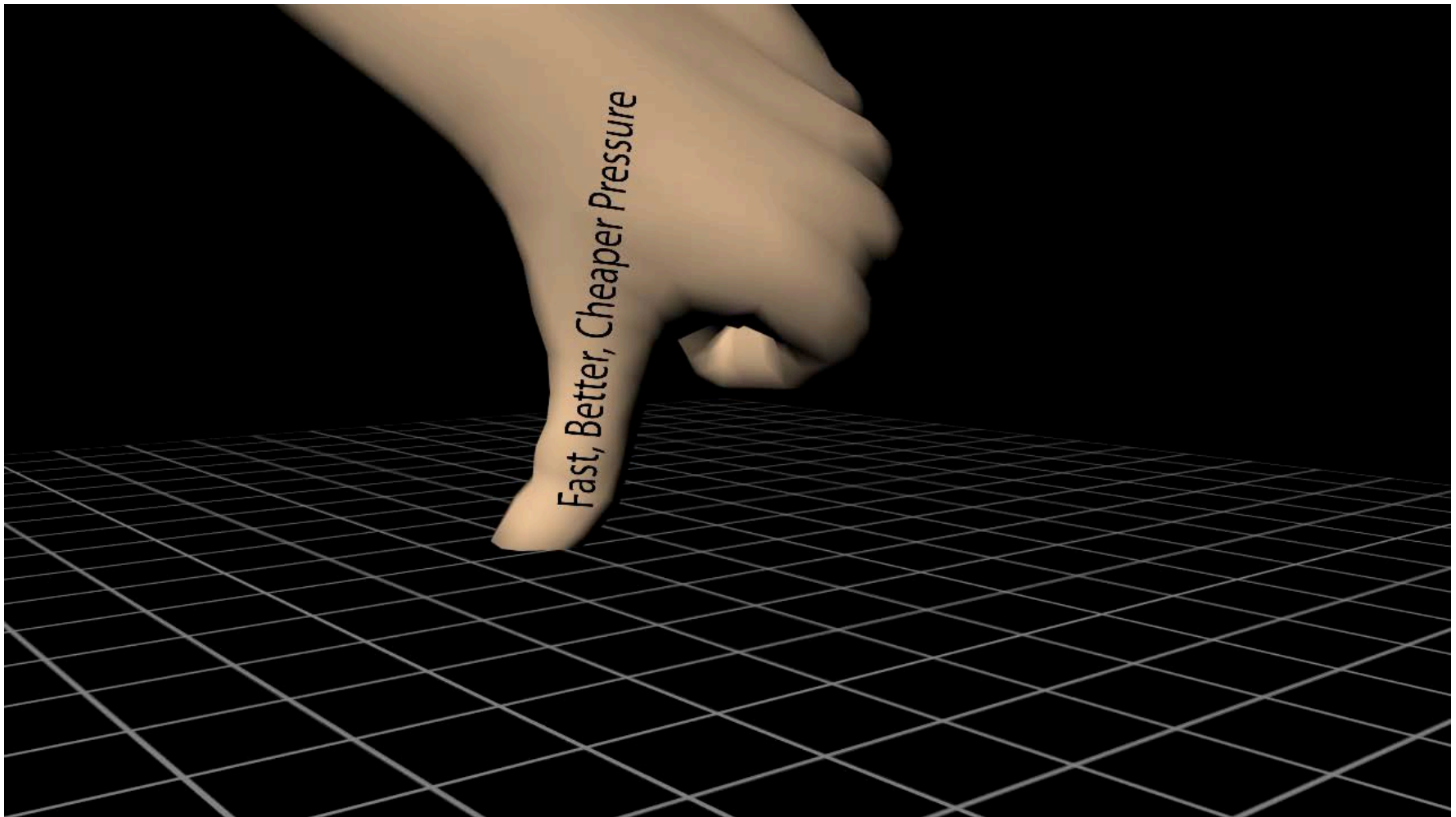


NASA in a changing environment under performance demands and resource pressures:

- 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**



# 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**



Resilience Engineering  
Association



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- **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

## Multiple Senses of 'Resilience'





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**

Trade off

***P/R* ratio near boundary**  
***Graceful Extensibility***

Borderlands



Cascades, Friction, changing Tempos

**Surprise at boundaries**



# Borderlands



## What adaptations produce Graceful Extensibility?

(descriptive) **Brittleness**



## 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**

## Graceful Extensibility



Competence (Base) Envelope  
***P/R*** ratio far from boundary

Trade off

***P/R*** ratio near boundary  
***Graceful Extensibility***

Borderlands



**Surprise at boundaries**

# Competence Envelope

Perspective 1:  
Work to rule/role

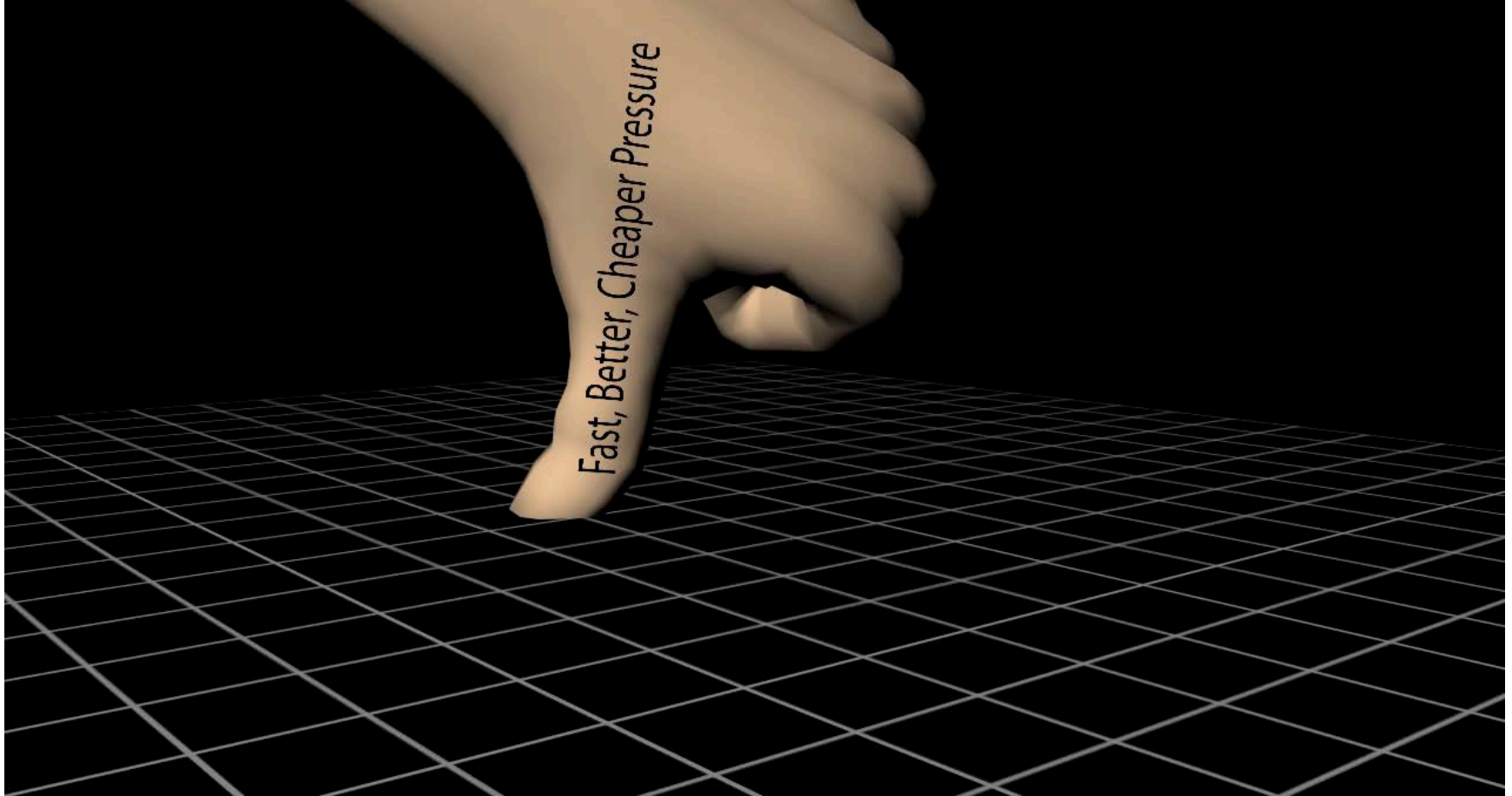
## Borderlands



Perspective 2:  
Handling Surprises  
Regularly

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

## Fluency Law



**FBC: faster, better, cheaper pressure**



# Competence Envelope

## Borderlands



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**

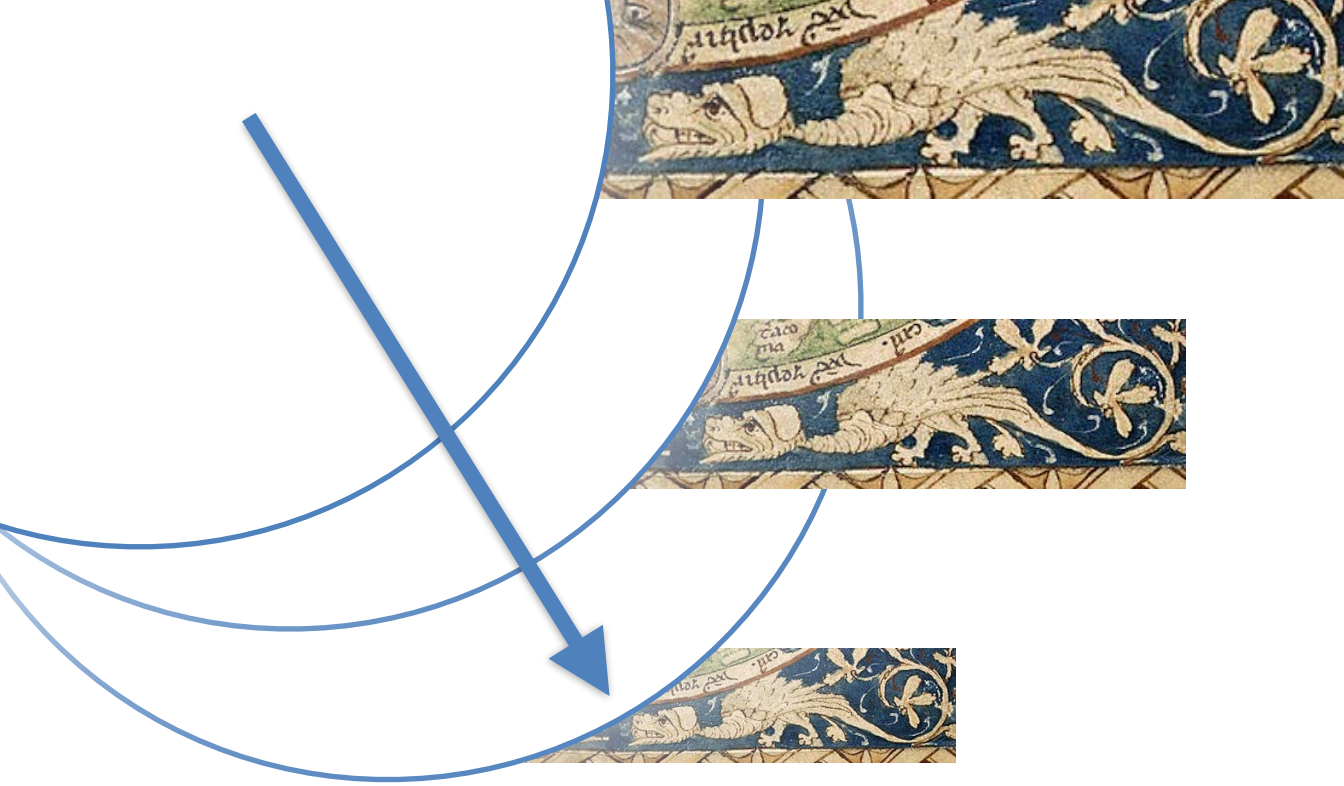


Distant Perspective?  
normal

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

## Hobble Adaptive Power



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

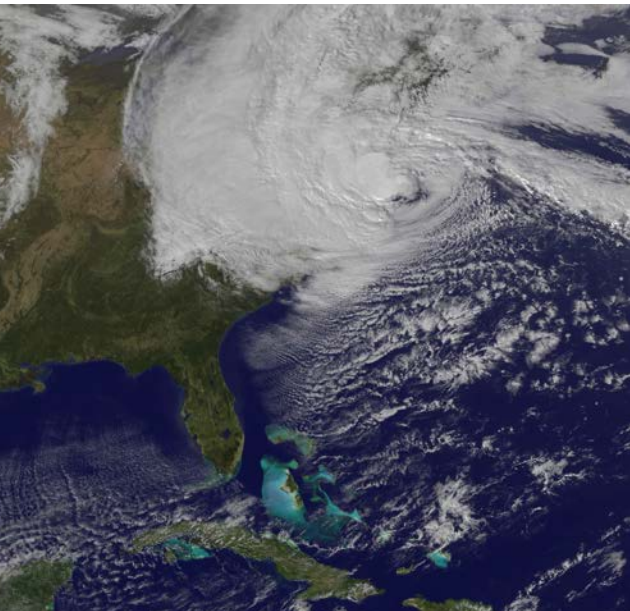


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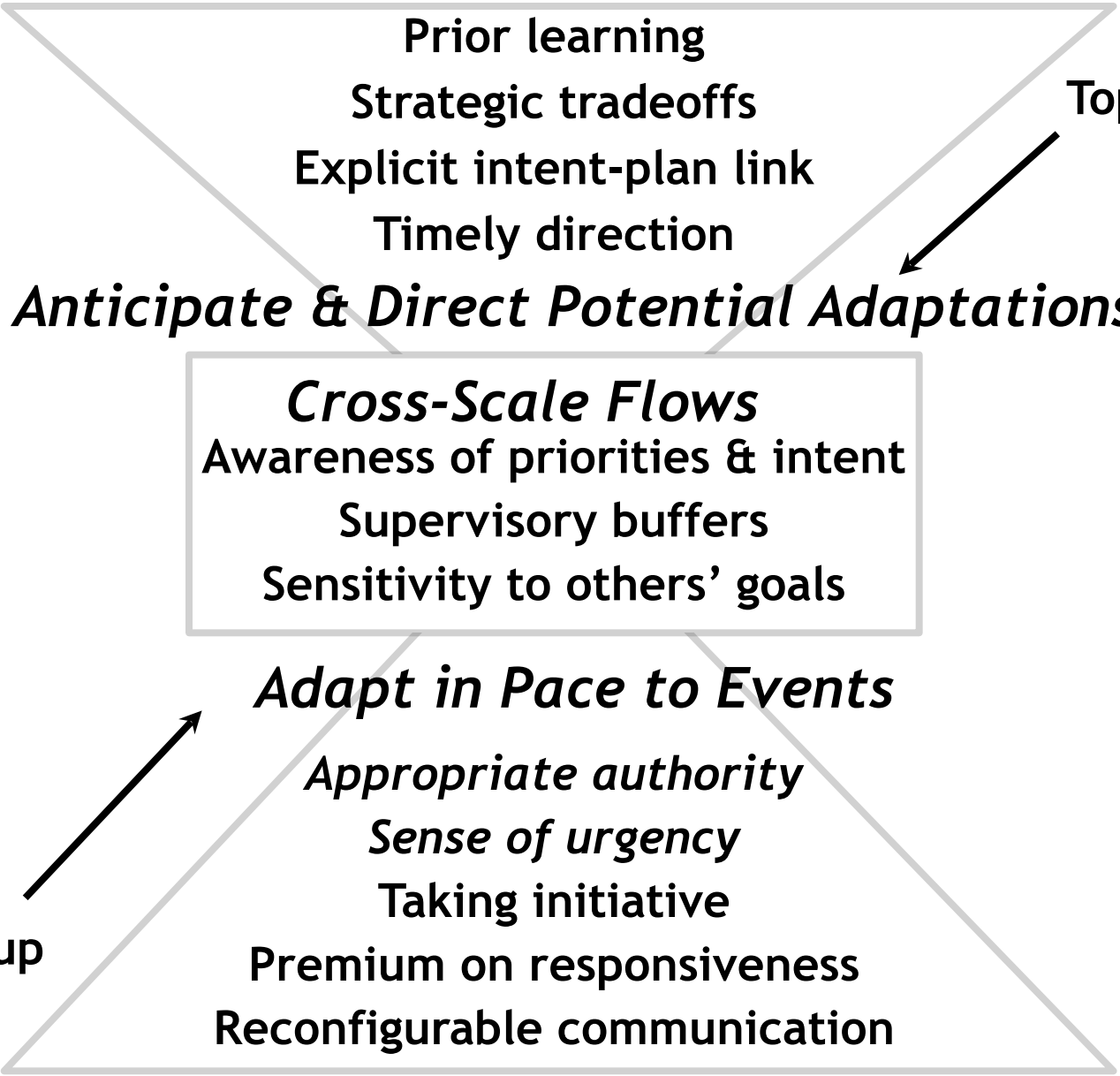
# Adapting to Hurricane Sandy

- 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**



**Top down**

**Bottom up**



# Competence Envelope

pursues optimality under FBC pressure

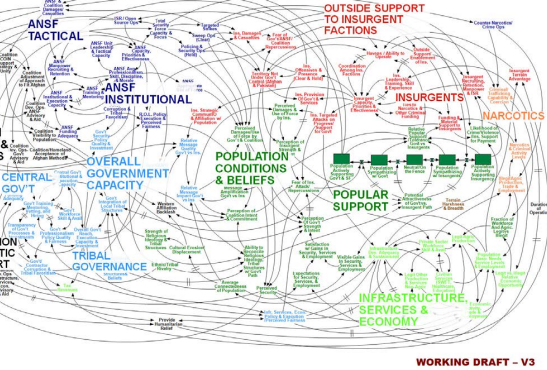
gracefully extensible  
by sustaining *CfM*

## Borderlands



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

## Balance 2 kinds of adaptive capacity



Page 22



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”**