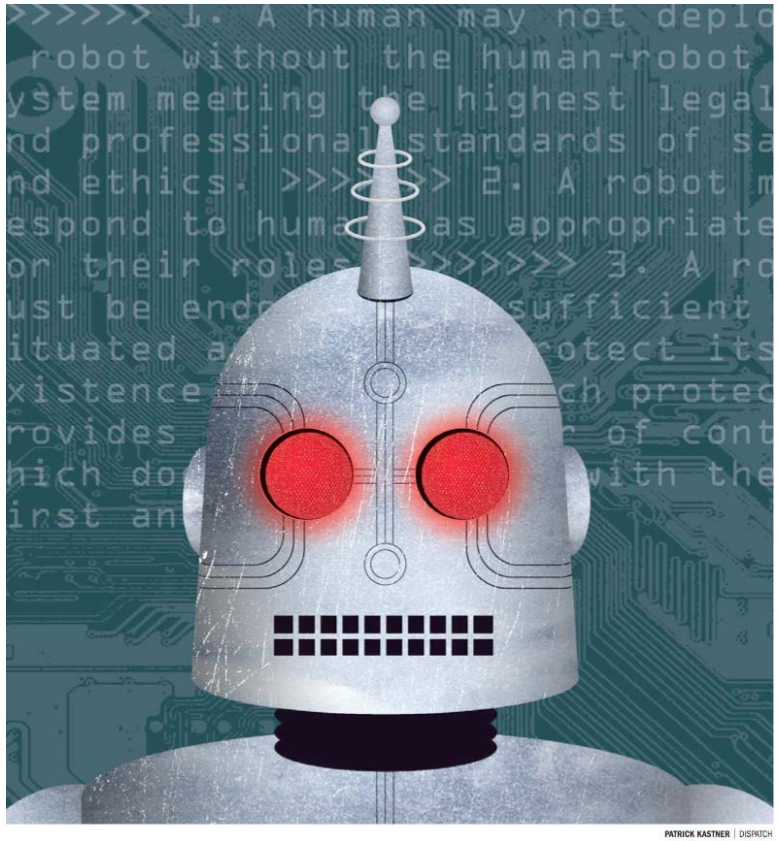
Autonomy and Resilience



David Woods

Ohio State University

People seeking *advantage*

Deploy increasingly autonomous capabilities

New missions, connections, risks, variations, pressures

inevitably, gaps, anomalies, surprises appear

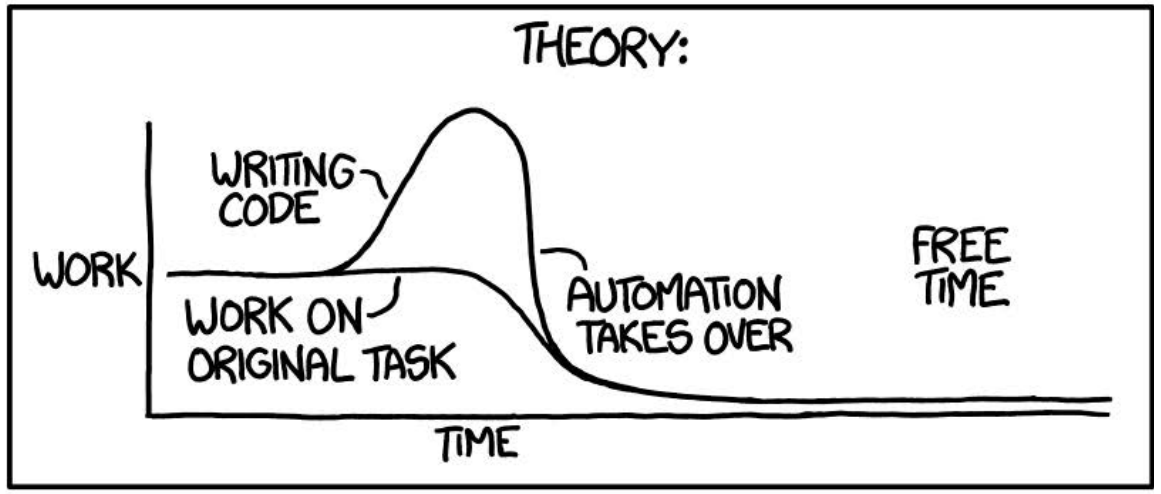
People adapt to produce resilient performance

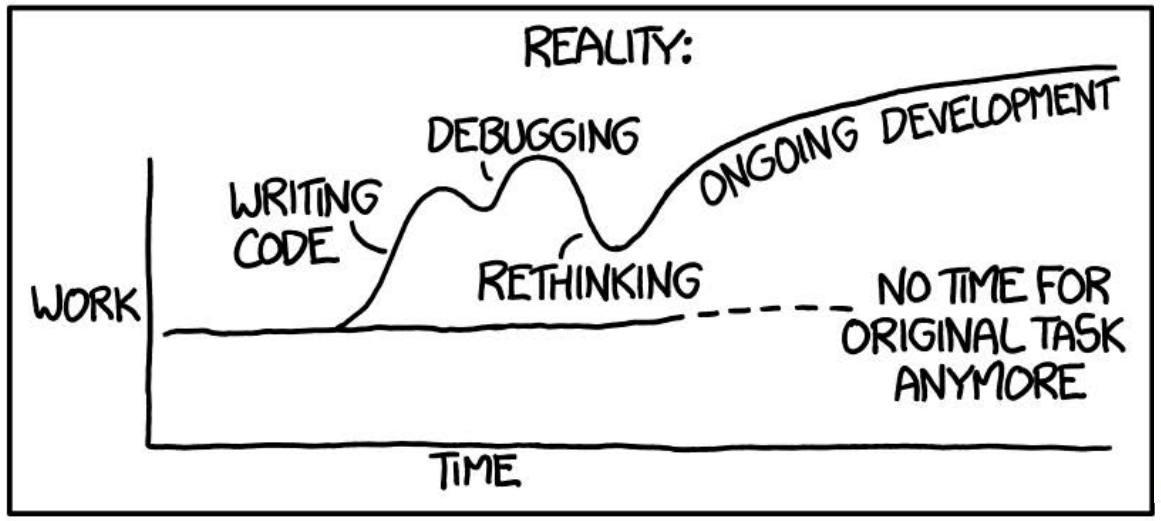
Deploying Autonomous capabilities:

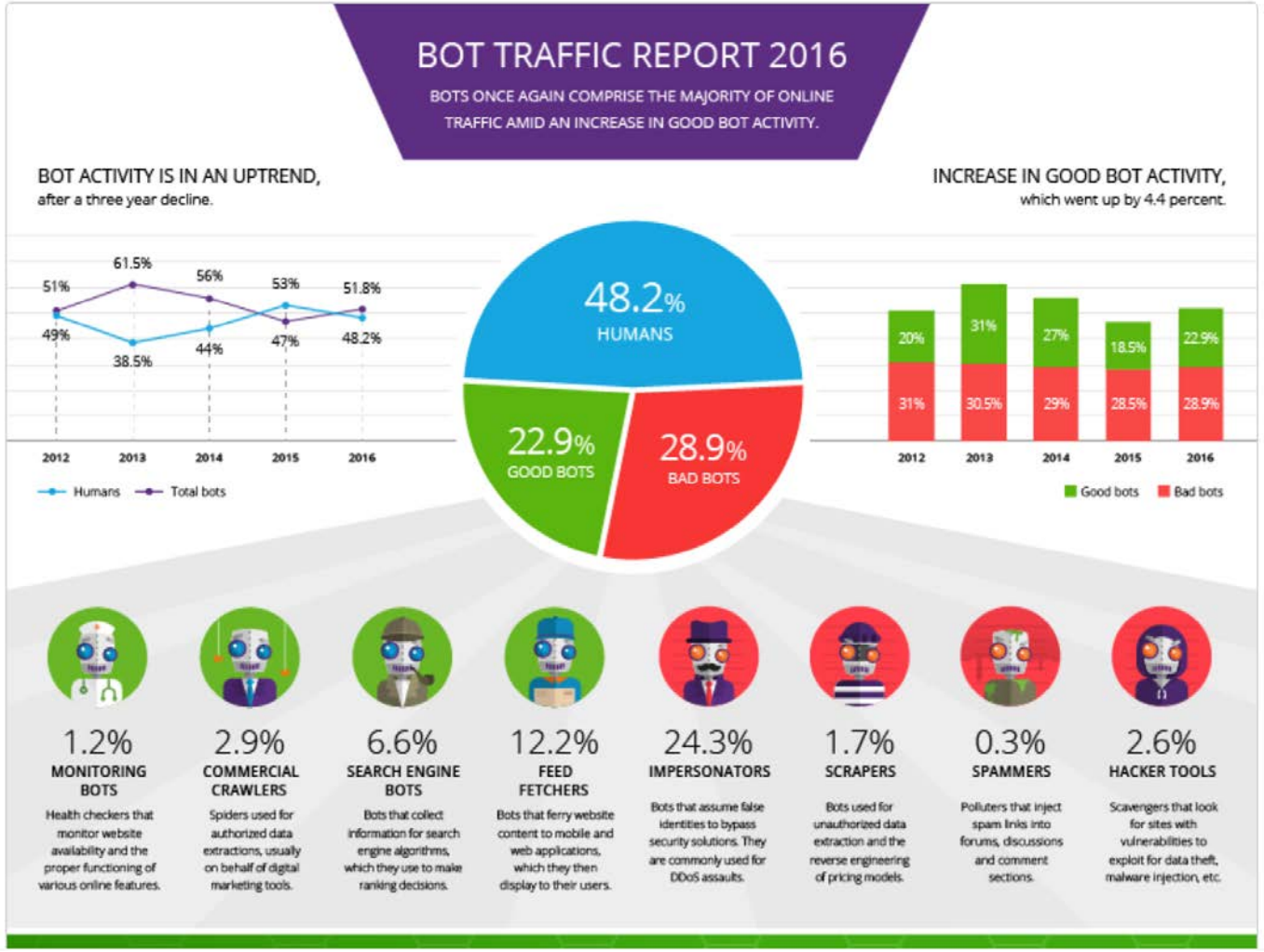
stories of technology change describe or envision
the *congestion, cascades & conflicts* that arise
when apparent benefits get hijacked

SNAFU CATCHERS

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

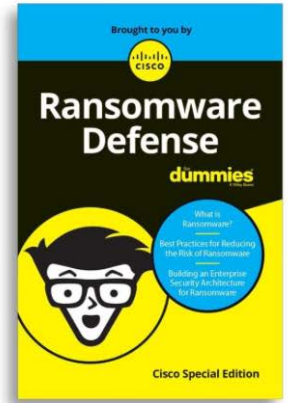






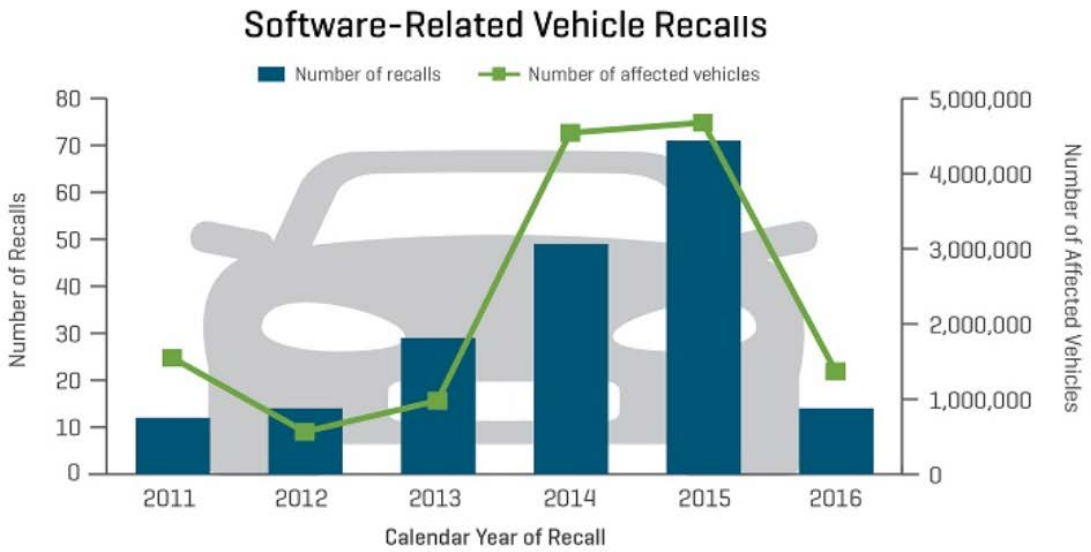
Adaptive Behavior Hijacks Success

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

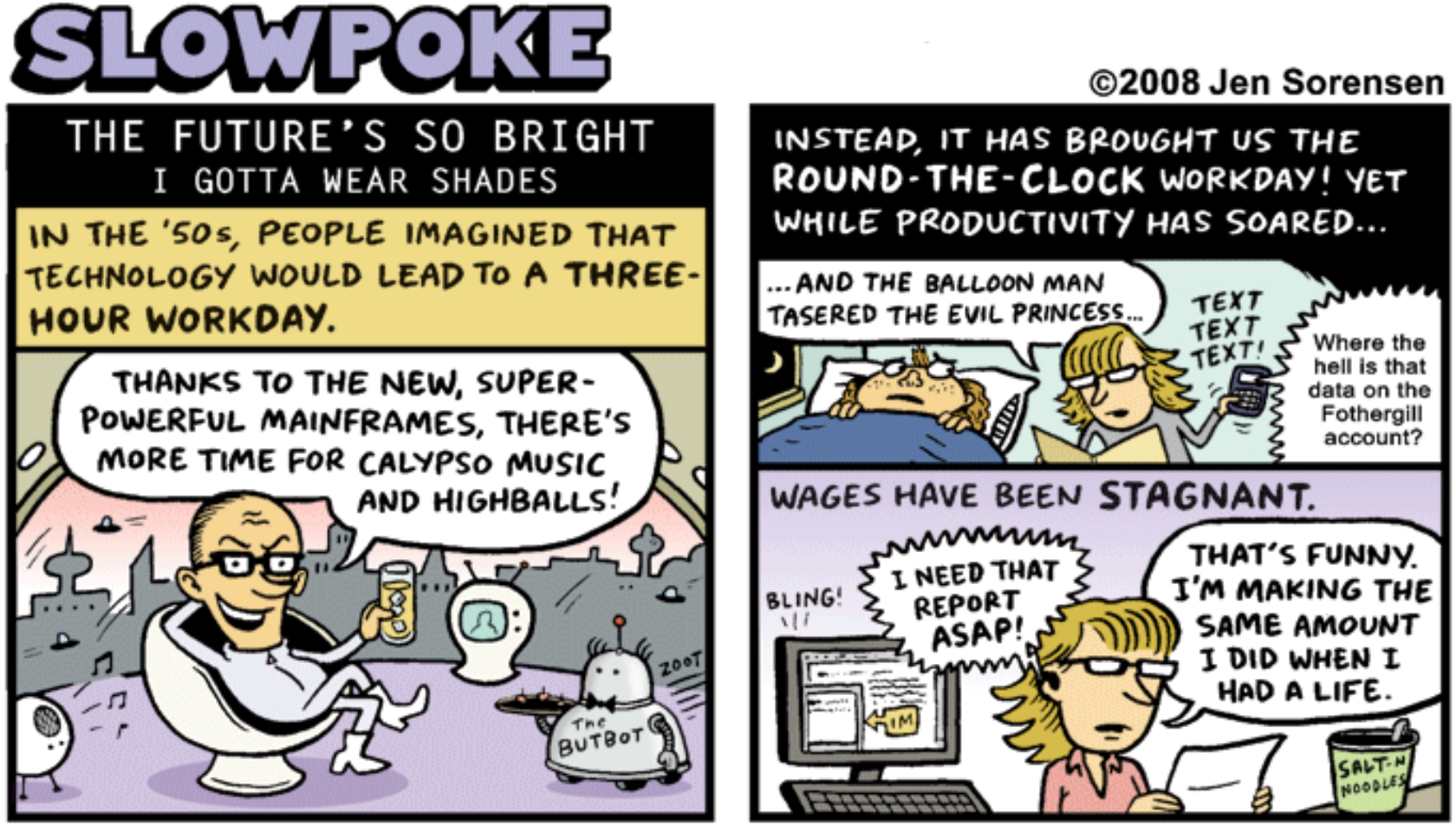
Milena Tsvetkova[1], Ruth García-Gavilanes[1], Luciano Floridi[1,2], Taha Yasseri[1,2]*

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

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

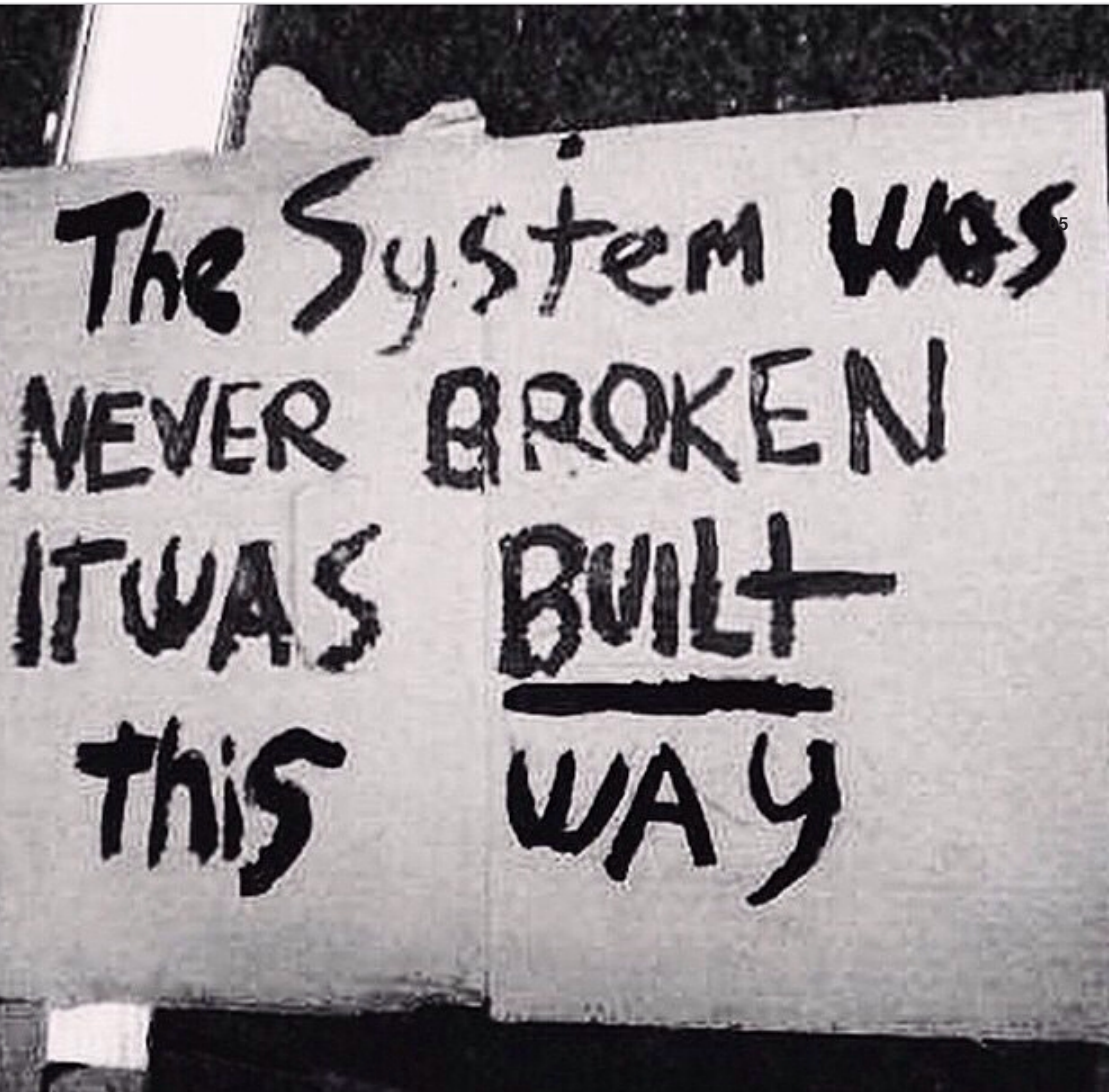
In 2015, three new software-related categories reported data for the first time:

- **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**



Surprising reverberations in tangled layered networks

find resilience in how systems succeed despite their design



Finite Resources / Change

Pressures

SNAFU is normal

Poised to Adapt

SNAFU CATCHERS


PLAN


PLAN

SNAFU Catching is Normal

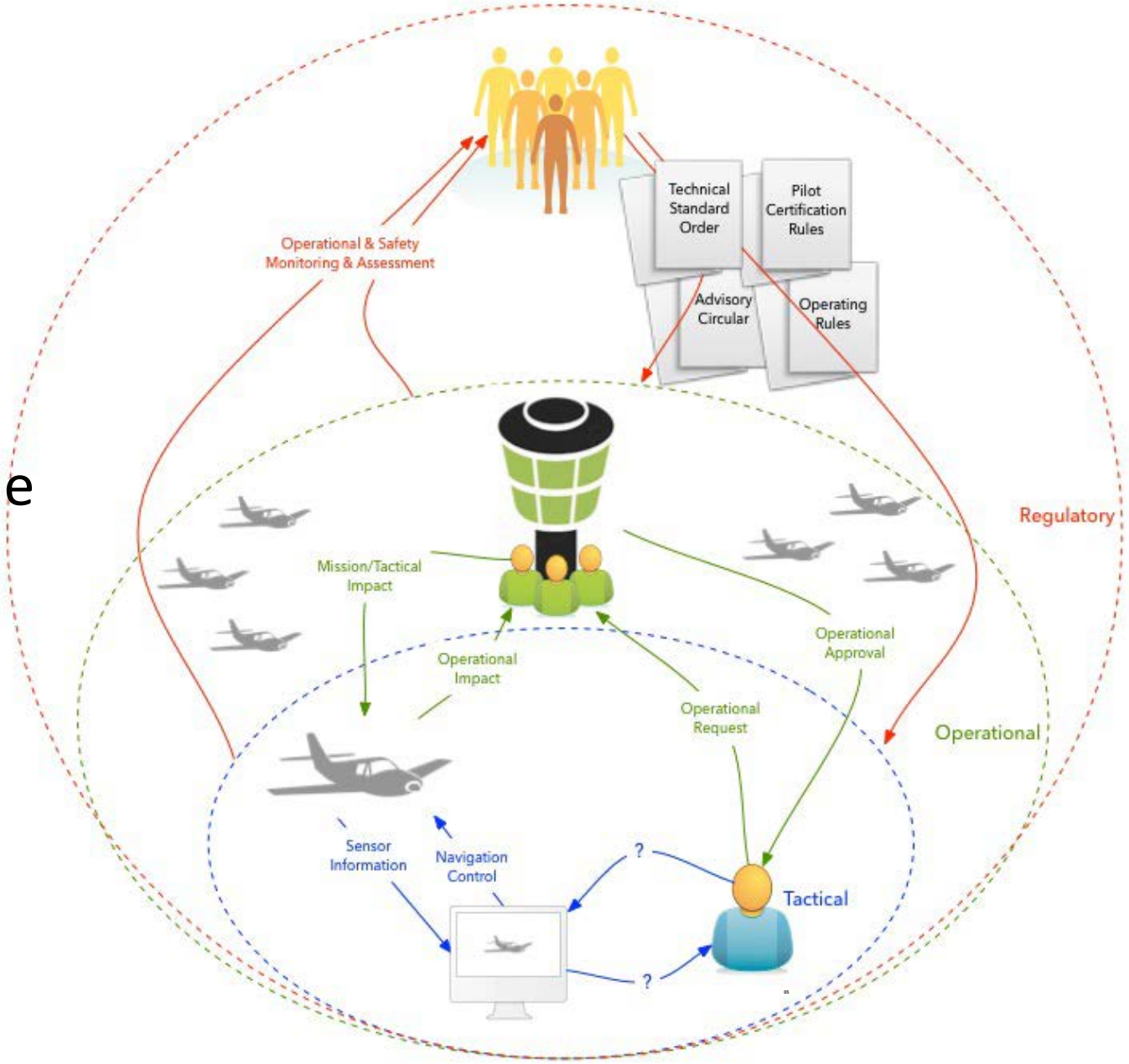
As change continues and pressures intensify, risk of brittleness increases.

How do people adapt to produce resilient performance?

What produces resilient performance at the edges?

Drones in Controlled Airspace

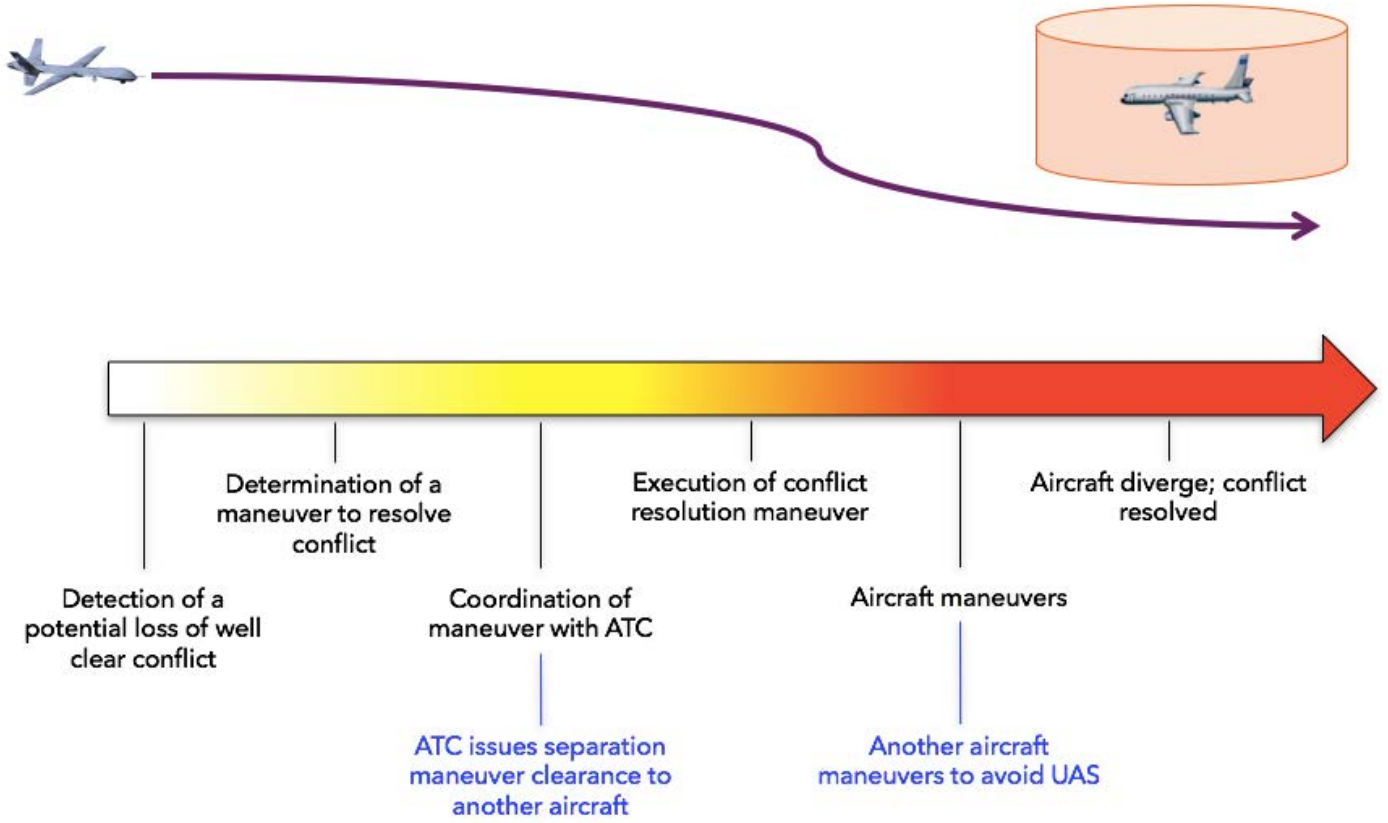
Multiple human and machine roles interact across different levels;
Roles and interplay change over time



Lisa Fern (OSU/NASA), Jay Shively (NASA), Conrad Rorie (NASA)

Detect and Avoid (DAA) Self-Separation (SS) displays and algorithms

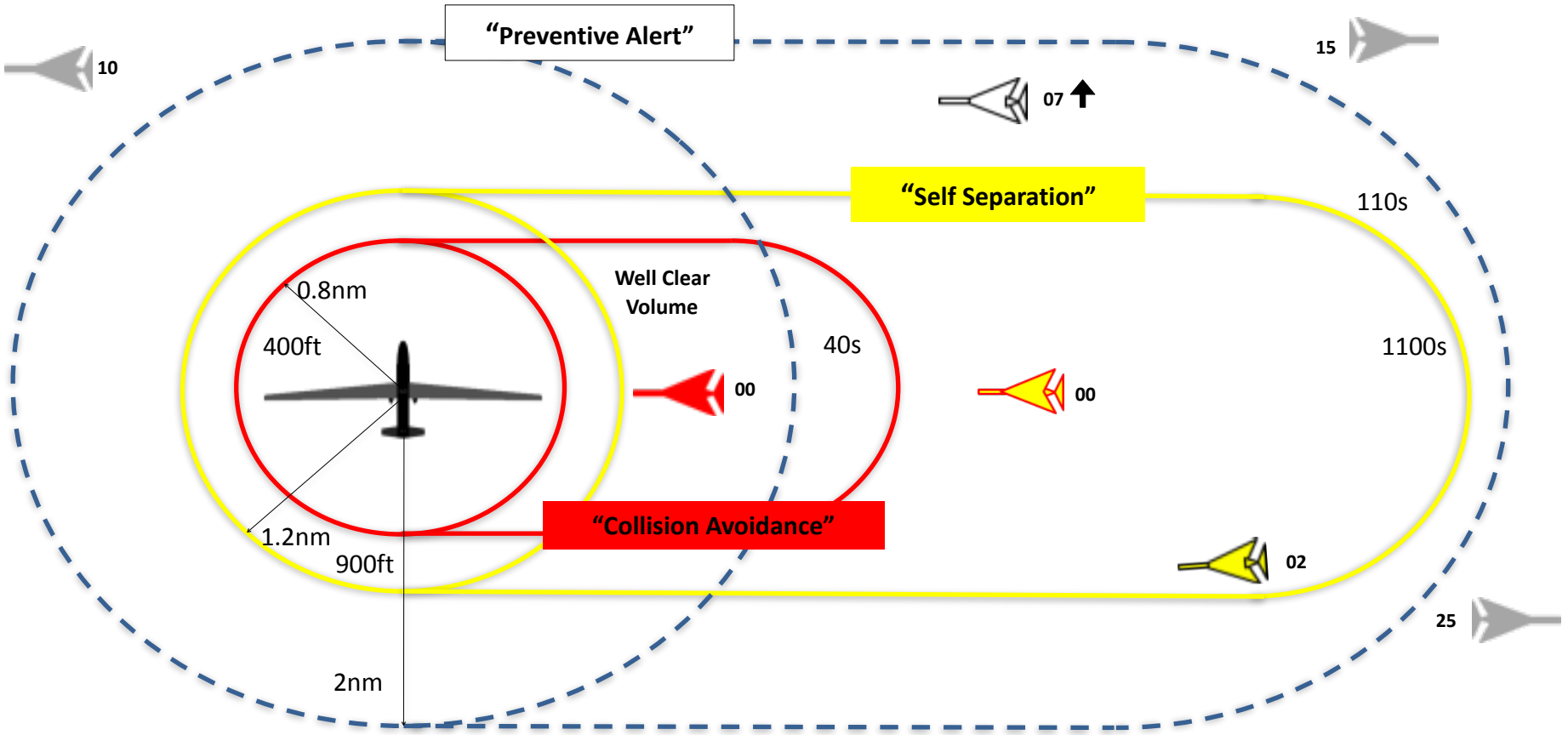
- What are the appropriate alerting thresholds for self separation and collision avoidance?
- What are the minimum information requirements for SAA displays?
- Is there a performance difference between integrated and standalone displays?
- What advanced display features improve accuracy and expediency in determining, negotiating and executing traffic avoidance maneuvers?



Alerting Logic

- Vigilant Spirit is capable of displaying surrounding traffic and alerting to potential well clear violations (WCVs)
  - Sensor range depends on equipage of nearby aircraft:
    - ADS-B-equipped aircraft:
      - Range = 80nm & +/- 5000ft
    - Non transponder-equipped aircraft
      - Range = 6nm
      - Azimuth = +/- 110deg (from nose)
      - Elevation = +/- 20deg (from horizontal)

DAA Alerting Logic



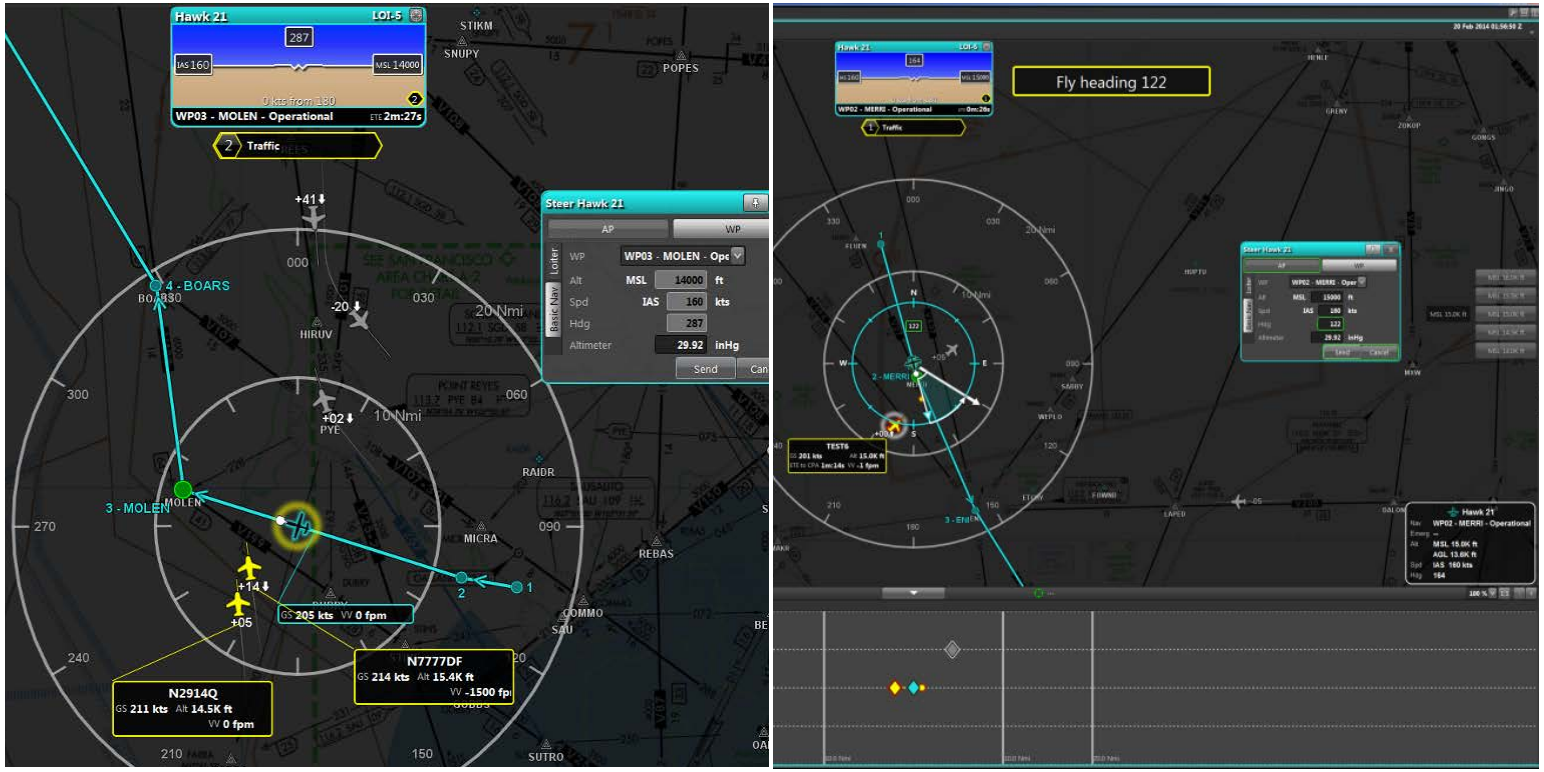
Auto Resolver

- *Auto Resolver* is a separation assurance algorithm designed to detect, evaluate and resolve threats to well clear
  - When a Self-Separation threat is detected, Auto Resolver automatically presents a maneuver that best resolves the conflict
    - *Best* = selects maneuver that *minimizes deviation* to prevent Collision Avoidance alert
    - If Auto Resolver is unable to find a threat-free maneuver, the solution with the greatest horizontal separation is provided
  - Auto Resolver also pre-loads the recommended maneuver into the steering window

Basic

Advanced

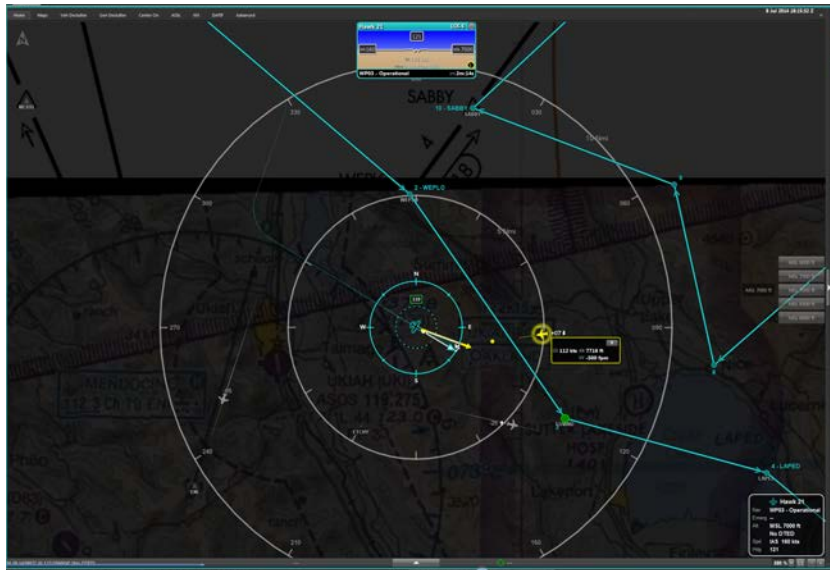
Integrated (VSCS)



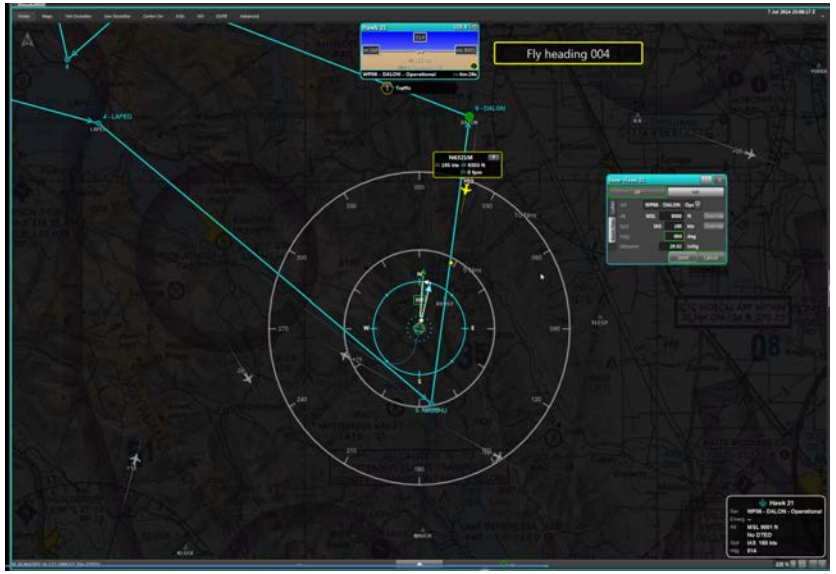
Display Conditions

D1

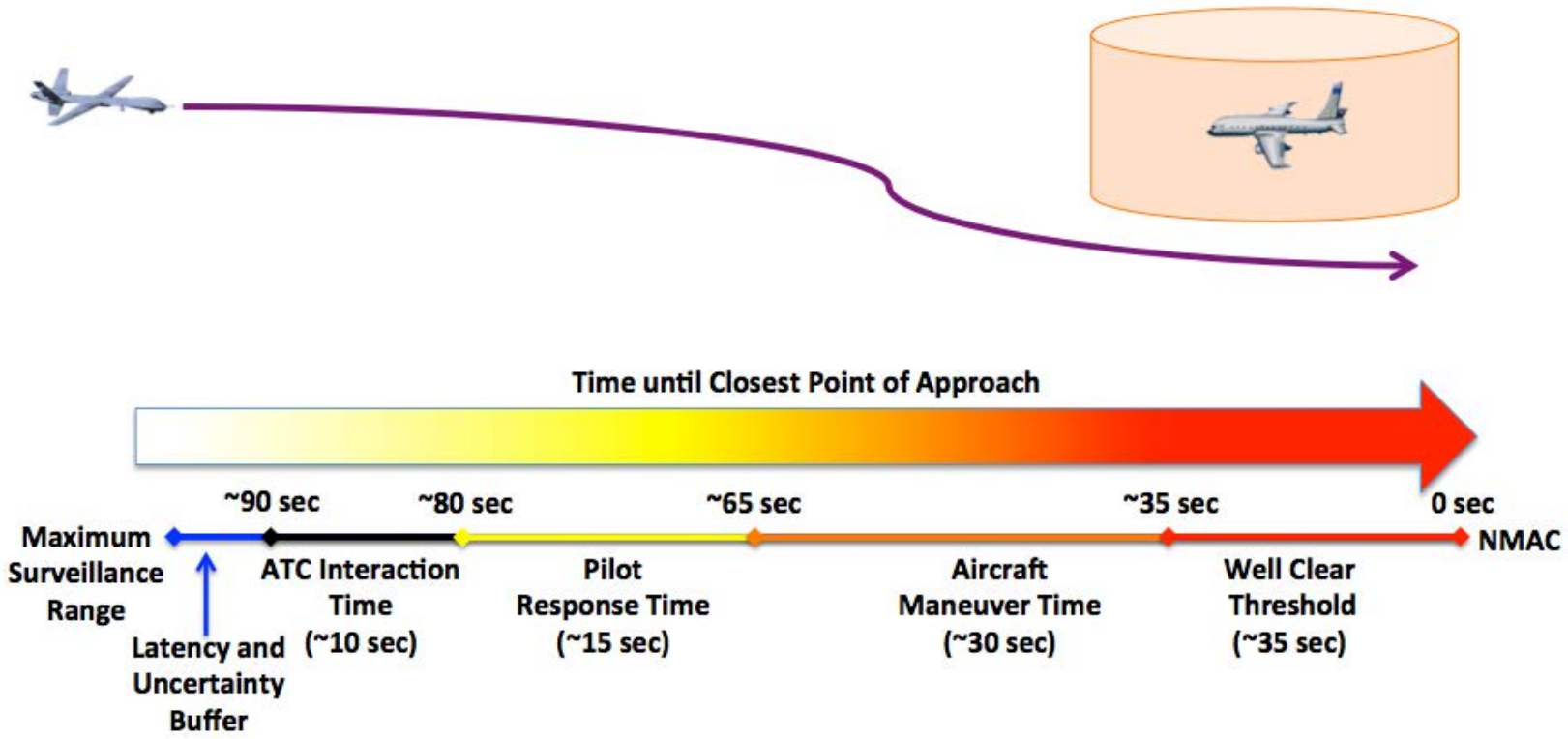
D2

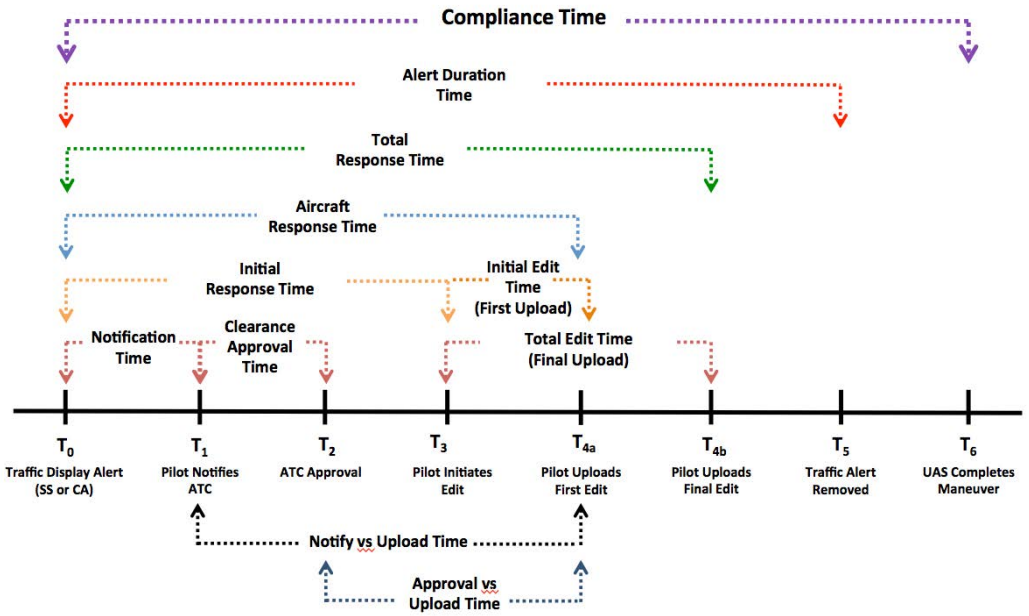


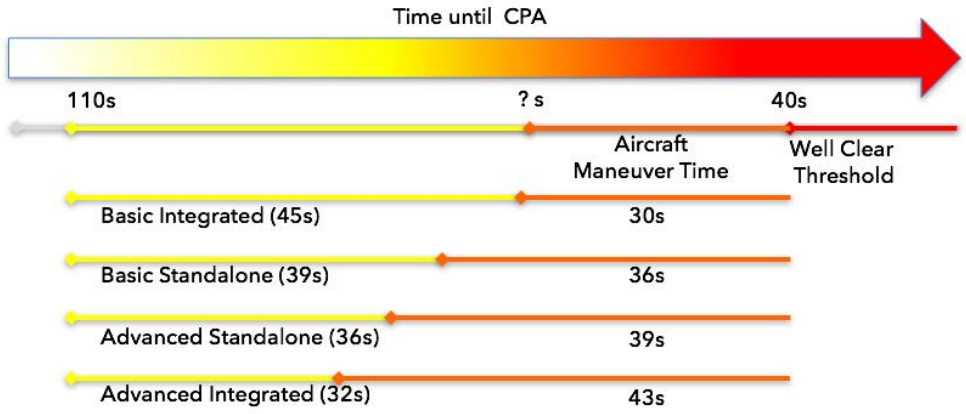
D3

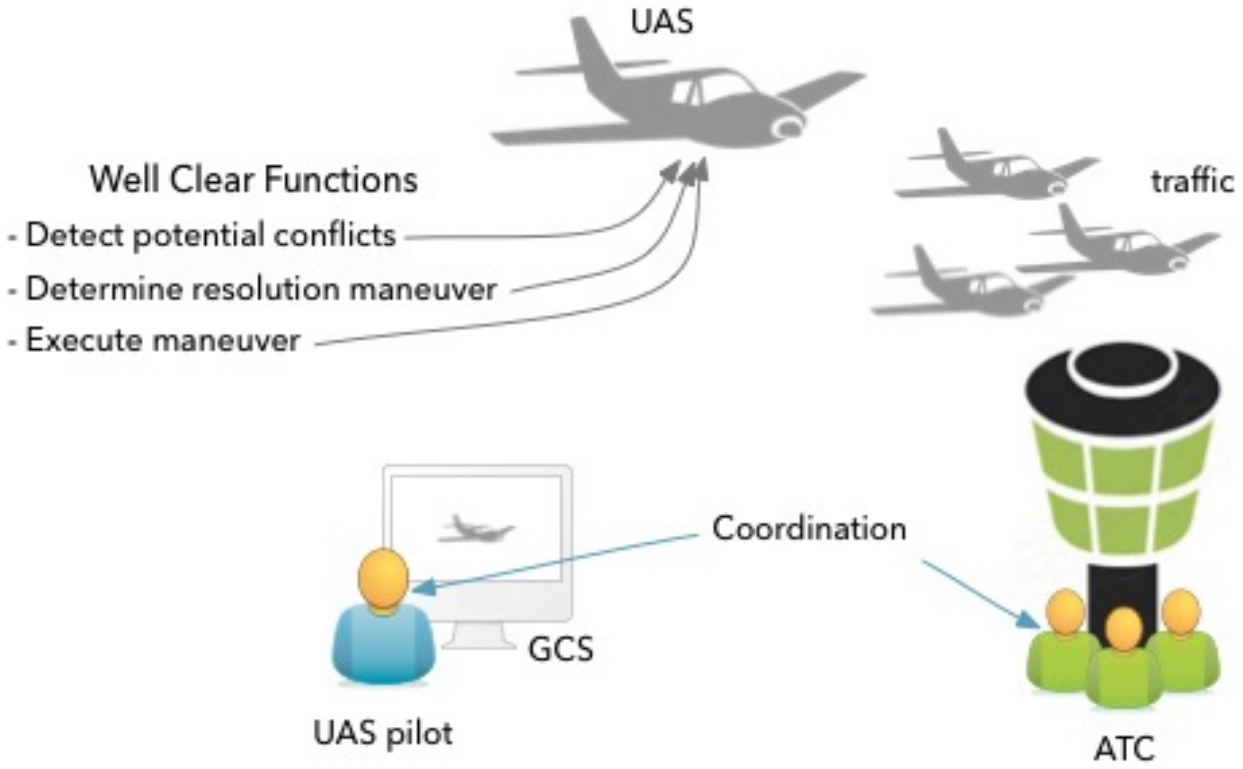


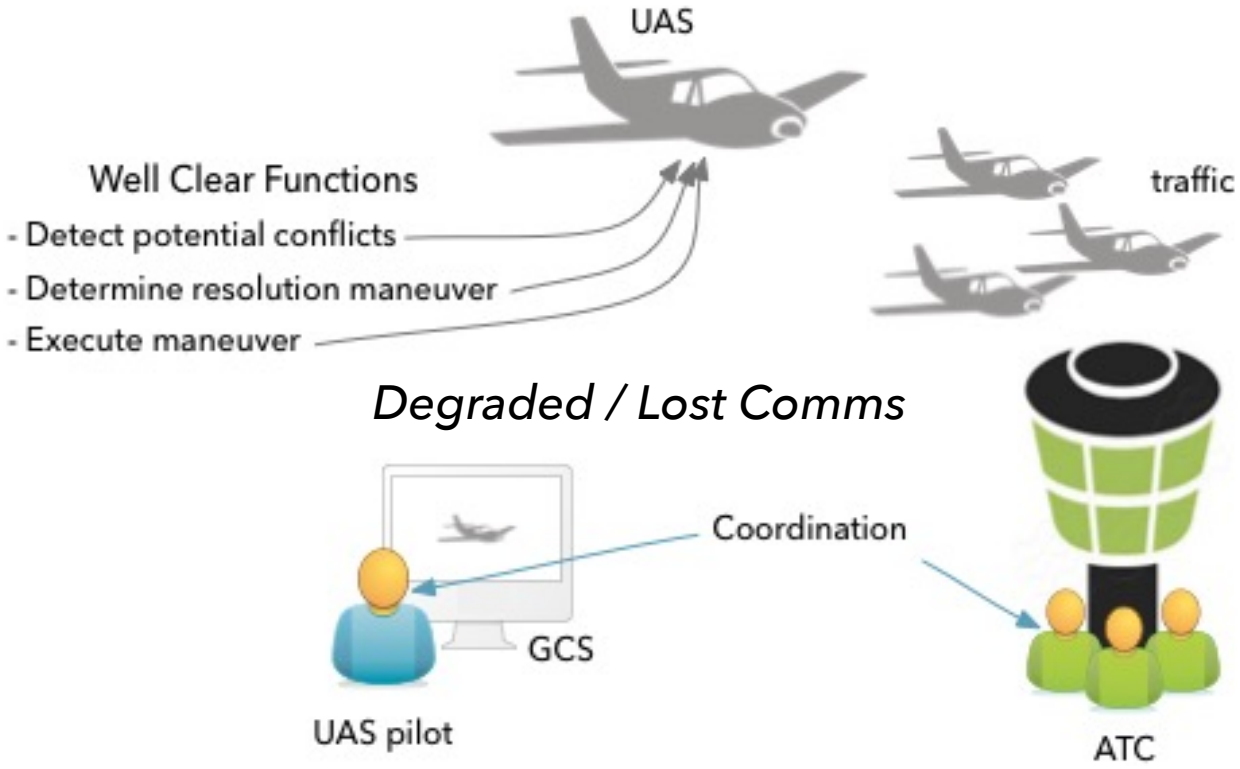
D4


Time until Closest Point of Approach
~90 sec
~80 sec
~65 sec
~35 sec
0 sec
Maximum Surveillance Range
NMAC
Latency and Uncertainty Buffer
ATC Interaction Time (~10 sec)
Pilot Response Time (~15 sec)
Aircraft Maneuver Time (~30 sec)
Well Clear Threshold (~35 sec)


Compliance Time
Alert Duration Time
Total Response Time
Aircraft Response Time
Initial Response Time
Initial Edit Time (First Upload)
Notification Time
Clearance Approval Time
Total Edit Time (Final Upload)
T0 Traffic Display Alert (SS or CA)
T1 Pilot Notifies ATC
T2 ATC Approval
T3 Pilot Initiates Edit
T4a Pilot Uploads First Edit
T4b Pilot Uploads Final Edit
T5 Traffic Alert Removed
T6 UAS Completes Maneuver
Notify vs Upload Time
Approval vs Upload Time

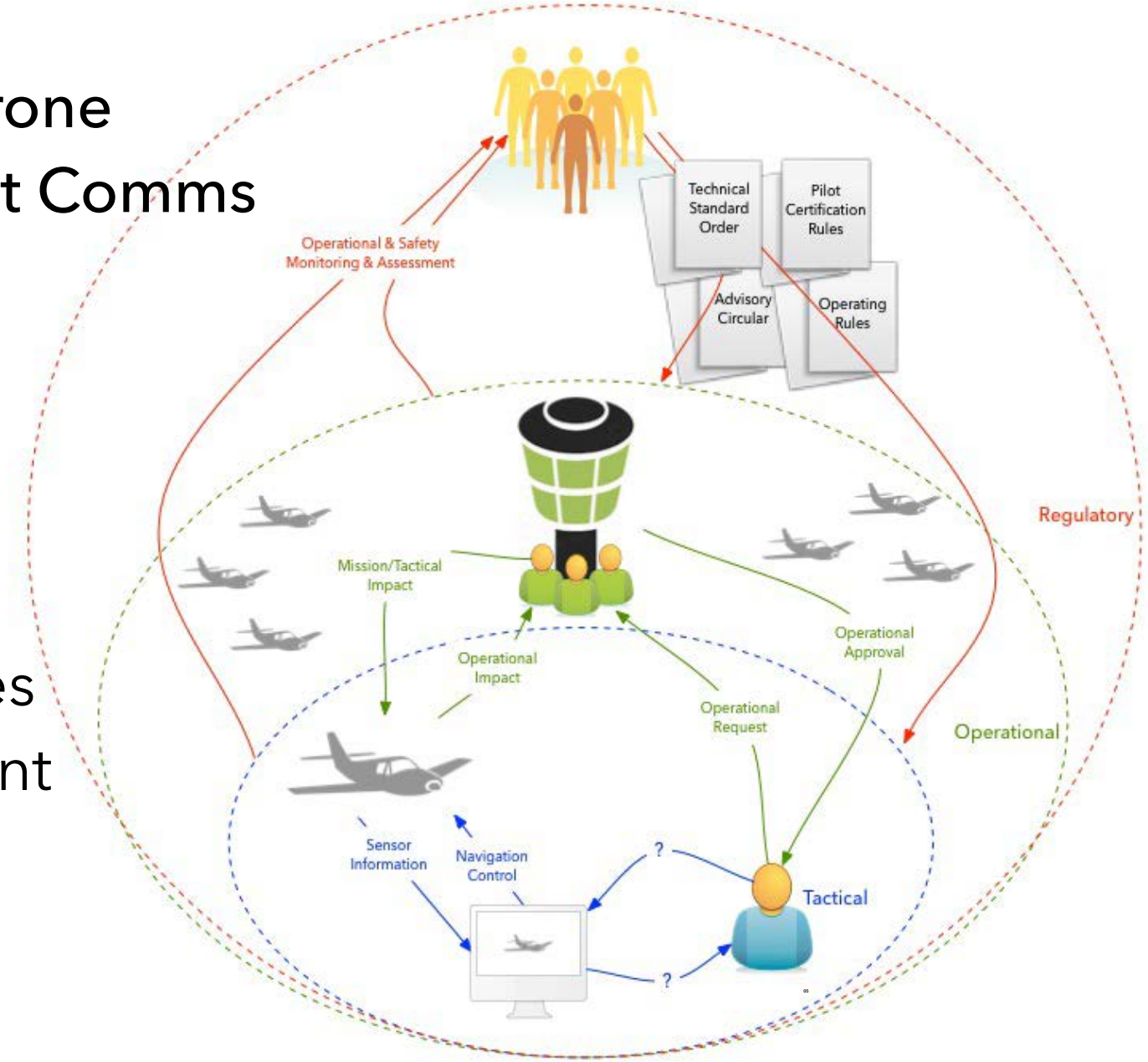

Time until CPA
110s
? s
40s
Aircraft Maneuver Time
Well Clear Threshold
Basic Integrated (45s)
30s
Basic Standalone (39s)
36s
Advanced Standalone (36s)
39s
Advanced Integrated (32s)
43s

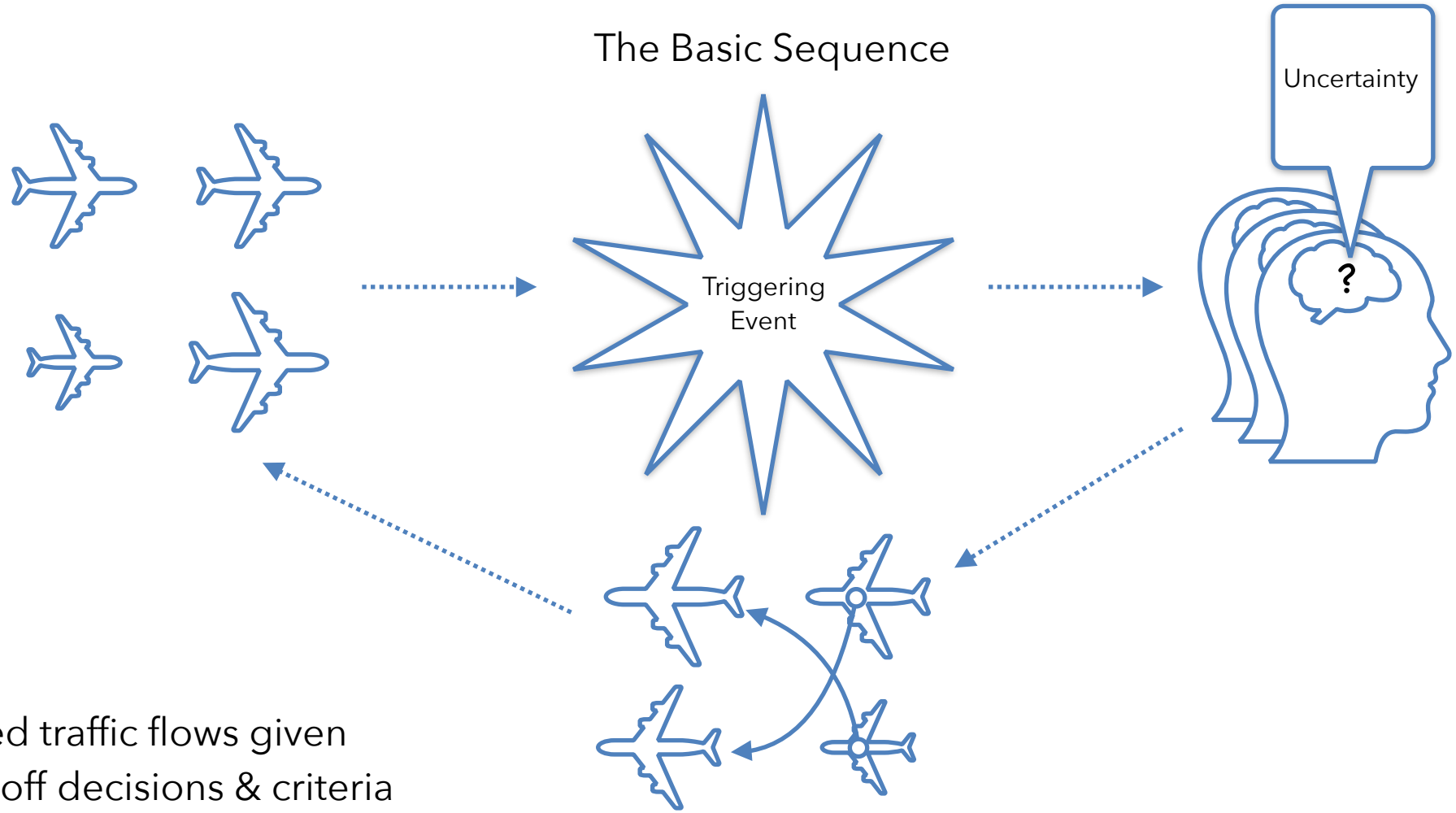

UAS
Well Clear Functions
- Detect potential conflicts
- Determine resolution maneuver
- Execute maneuver
traffic
Coordination
GCS
UAS pilot
ATC


UAS
Well Clear Functions
- Detect potential conflicts
- Determine resolution maneuver
- Execute maneuver
traffic
Degraded / Lost Comms
Coordination
GCS
UAS pilot
ATC

Delegate DAA Autonomy to Drone especially when Degraded/Lost Comms

How will people in different roles adapt to produce/ensure resilient performance?





The basic form:

1) Well-structured traffic flows given previous trade-off decisions & criteria
2) Triggering event,
3) Surprise
4) Adjustment/reconfiguration,
5) Return to structured flow

How to be a cooperative agent in a shared airspace when disruptions occur and standard comm channels are compromised?

A Simple Story

1. Typical traffic flows are moving through well-structured airspace;
2. Having completing its pipeline survey mission, UAS climbing to a higher altitude;
3. While climbing, UAS encounters extreme wake turbulence and is unable to maintain level flight or proper orientation;

—> *intermittent satcom loss due fuselage masking*

4. While losing altitude, UAS violates well-clear volumes **and** intended flight paths of other sector aircraft;
5. UAS maneuvers to stay well-clear
6. ATC manages other aircraft in the sector given UAS
7. ATC begins to re-establish traffic flow given performance goals.

Example : ambiguity, cascading effects, sector performance losses

Synchronization Challenges
Scenarios

Double Decker (3 variations)

Wake Turbulence and Cascade (5 variations)

Overtake on climb (5 variations)

Push from the rear (2 variations)

Transit of structured airspace due to in-flight route change of operator org priorities (2 variations)

Intermittent loss of data-link while crossing sector (3 variations)

Loss of UAS/ATC Communications (3 variations)

Loss of GCS/UAS comm-link post tactical direction (3 variations)

Loss of pilot/UAS data link mid-GCS hand-off (3 variations)

Prologue 1: Past Results on Human-Autonomy Teaming

Beyond Asimov: The Three Laws of Responsible Robotics

Robin R. Murphy, *Texas A&M University*
David D. Woods, *Ohio State University*

Seven Cardinal Virtues of Human-Machine Teamwork: Examples from the DARPA Robotic Challenge

Matthew Johnson, Jeffrey M. Bradshaw, Robert R. Hoffman, Paul J. Feltovich, and David D. Woods

Ten Challenges for Making Automation a "Team Player" in Joint Human-Agent Activity

Gary Klein, *Klein Associates*
David D. Woods, *Cognitive Systems Engineering Laboratory*
Jeffrey M. Bradshaw, Robert R. Hoffman, and Paul J. Feltovich,
Institute for Human and Machine Cognition

Team Play with a Powerful and Independent Agent: Operational Experiences and Automation Surprises on the Airbus A-320

The Design of Joint Human–Machine Cognitive Systems

AI Magazine Volume 6 Number 4 (1985)

How in the World Did We Ever Get into That Mode? Mode Error and Awareness in Supervisory Control

Nadine B. Sarter and David D. Woods

Human Factors: The Journal of the Human Factors and Ergonomics Society 1995 37: 5

Prologue 1: Increases in autonomy require more sophisticated coordination / synchronization

***(Robin)* Murphy's Law**: Any deployment of robotic systems will fall short of the target level of autonomy, creating or exacerbating a shortfall in mechanisms for coordination with human stakeholders.

As robotic system developers strive to achieve a certain level of autonomy, in general, they underestimate the need for coordination with human stakeholders. Deployment into a field and context will leave the robotic system short of the design target level of autonomy, without sufficient provision for human stakeholders' involvement in handling the situation with or through the robotic system.

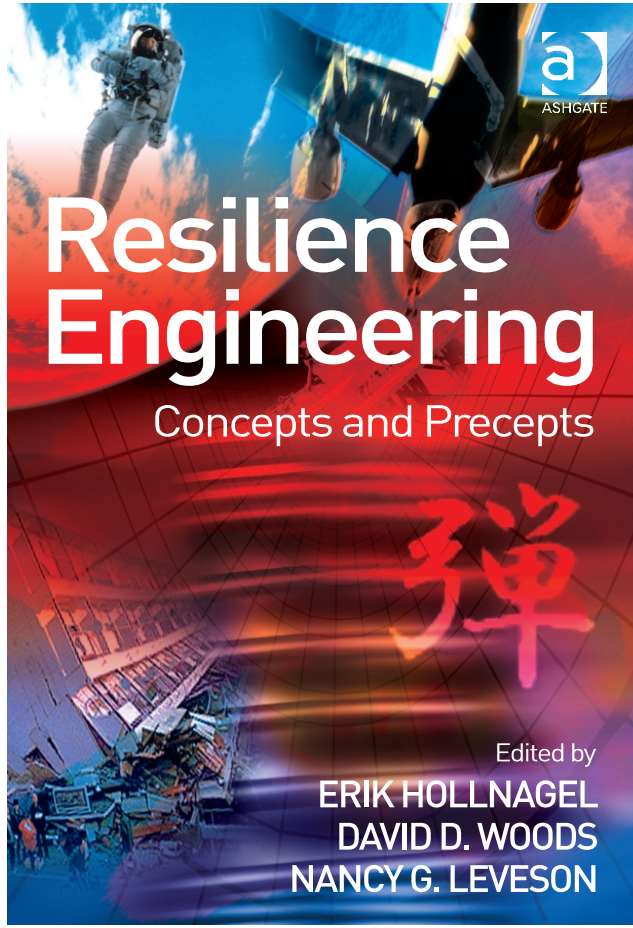
Prologue 2:

Resilience Engineering to overcome brittleness in complex systems

Anticipation (risk of Decompensation)

Synchronize over roles (risk of Working at Cross Purposes)

Proactive Learning (risk of being Stuck in Stale Models)



Resilience Engineering Association

7th REA Symposium 26th - 29th June 2017

'Poised to adapt: Enacting resilience potential through design, governance and organization.'

Resiliency Trade-Spaces

FOR

COMPLEX ADAPTIVE SYSTEMS

WITH DEPLOYMENTS OF INCREASED AUTONOMY

COMPETENCIES	POTENTIAL FOR RESILIENCY	CONSEQUENCE OF BREAKDOWN

Trade-Spaces

Specify
Competency Envelope

Capabilities for
Resilient Performance

Scenarios

Disruptions which challenge synchronization across roles and require anticipation of crunches ahead.

Trade-Spaces

Specify
Competency Envelope

Capabilities for
Resilient Performance

Add Robustness ?

Add Resilience ?

Scenarios

Disruptions which challenge synchronization across roles and require anticipation of couches ahead.

Initial Results

trigger/disruption + degraded SatCom –> ***uncertainty*** about UAS intent and future behavior

–> tactical rerouting of other aircraft: increase separation away from UAS with degraded comms (easier to maneuver everything else)

–> reduce sector capacity

–> reduce efforts to optimize network capacity and efficiency and meet other constraints

–> cascading effects including cross sector transitions and handoff difficulties

–> sudden workload increases for other roles

Uncertainty –> System Performance Sacrifices

The future is already here & it's not as advertised

- increases in autonomy are a capability not an integrated solution.
- people utilize new capability to operate at new scales and expectations,
- deploying autonomy –> new forms of synchronization across roles/levels
- integrated solutions invest in building resilient performance
- new challenges require new architectures for human and automated roles

As new tech capabilities ↑ & are deployed,
congestion, cascades & conflicts will grow faster than the tech

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

SNAFU CATCHERS