Resilience is a Verb

Chapter · November 2018

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Keywords Resilience engineering, adaptive capacities, graceful extensibility, adaptation

Introduction: Poised to adapt

The title of this paper appears to violate grammar rules. But the violation runs in the opposite direction — much too often we see resilience as a state to be achieved — something a system has, when it refers to a set of capabilities for action, actually future action when conditions, challenges, opportunities change. As Erik Hollnagel has said repeatedly since Resilience Engineering began (Hollnagel & Woods, 2006), resilience is about what a system can do — including its capacity:

- to anticipate — seeing developing signs of trouble ahead to begin to adapt early and reduce the risk of decompensation
- to synchronize — adjusting how different roles at different levels coordinate their activities to keep pace with tempo of events and reduce the risk of working at cross purposes
- to be ready to respond — developing deployable and mobilizable response capabilities in advance of surprises and reduce the risk of brittleness
- for proactive learning — learning about brittleness and sources of resilient performance before major collapses or accidents occur by studying how surprises are caught and resolved

Resilience concerns the capabilities a system needs to respond to inevitable surprises. 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. Systems possess varieties of adaptive capacity, and Resilience Engineering seeks to understand how these are built, sustained, degraded, and lost.

Adaptive capacity means a system is *poised to adapt*, it has some readiness or potential to change how it currently works— its models, plans, processes, behaviors (Woods, 2015; 2018). Adaptation is not about always changing the plan, model, or previous approaches, but about the potential to modify plans to continue to fit changing situations. Space mission control is a positive case study for this capability, especially how space shuttle mission control developed its skill of handling anomalies, even as they expected that the next anomaly to be handled would not match any of the ones they had planned and practiced for (Watts-Perotti & Woods, 2009). Studies of how successful military organizations adapted to handle surprises provide another rich set of contrasting cases (Finkel, 2011).

Adaptive capacity does not mean a system is constantly changing what it has planned or does so *all the time*, but rather that the system has some ability to recognize when it's adequate to continue the plan, to continue to work in the usual way, and when it is not adequate to continue on, given the demands, changes and context ongoing or upcoming. Adaptation can mean *continuing to work to*

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Suggested citation: Woods, D. D. (2018). Resilience is a verb. In Trump, B. D., Florin, M.-V., & Linkov, I. (Eds.). *IRGC resource guide on resilience (vol. 2): Domains of resilience for complex interconnected systems.* Lausanne, CH: EPFL International Risk Governance Center. Available on irgc.epfl.ch and irgc.org.

plan, but, and this is a very important *but*, with the continuing ability to re-assess whether the plan fits the situation confronted—even as evidence about the nature of the situation changes and evidence from the effects of interventions changes. The ability to recognize and to stretch, extend, or change what you're doing/what you have planned has to be there in advance of adapting. This capability can be extended or constricted as challenges arise, expanded or degraded over cycles of change, and redirected or become stuck as conditions evolve into new configurations. Extensibility is fundamental to adaptive capacities that support resilient performance when future challenges arise (Woods, 2015; 2018).

Systems are messy

All systems are developed and operate given finite resources and live in a changing environment. As a result, plans, procedures, automation, agents and roles are inherently limited and unable to completely cover the complexity of activities, events, demands. All systems operate under pressures and in degraded modes (Cook, 1998). People and operations adapt to meet the inevitable challenges, pressures, trade-offs, resources scarcity, and surprises. To summarize the point vividly, Cook and Woods (2016) use a coinage from the American soldier in WWII: SNAFU is the normal state of systems—where SNAFU stands for Situation Normal All 'Fouled' Up. With SNAFU normal, SNAFU Catching is essential— resilient performance depends on the ability to adapt outside of the standard plans as these inevitably break down. SNAFU Catching, however technologically facilitated, is a fundamentally human capability essential for viability in a world of change and surprise (Woods, 2017). Some people in some roles provide the essential adaptive capacity for SNAFU Catching, though this may be local, underground, and invisible to distant perspectives (Perry & Wears, 2012).

All organizations are adaptive systems, consist of a network of adaptive systems, and exist in a web of adaptive systems. The pace of change is accelerated by past successes, as growth stimulates more adaptation by more players in a more interconnected system. Growing technological and productivity capabilities also grow interdependencies and scales of operation that invoke complexity penalties and require trade-offs to cope with finite resources. The complexity penalties occur in the form of changing patterns of conflict, congestion, cascade and surprise. Regardless of the advance, SNAFU will re-emerge.

Improvements drive a pattern in adaptive cycles: effective leaders take advantage of improvements to drive systems to do more, do it faster, and in more complicated ways. Growth creates opportunities for others to hijack new capabilities as they pursue their goals. Success drives increasing scale complexity which leads to the emergence of new forms of SNAFU and SNAFU Catching, as systems become messy again. This can be observed in the rise of high frequency trading in financial markets, in ransomware, and the influence of internet bots in elections, among others.

SNAFU Catching is essential for the viability of adaptive systems in complex worlds. But organizations rationalize this core finding away on grounds of rarity, prevention, compliance. The first claim is: SNAFUs occur rarely given the organization's design thus investing in SNAFU Catching is a narrow issue of low priority. The second claim is: there is a record of improvement that reduces the likelihood/severity/difficulty of SNAFUs. Third, when SNAFUs occur, poor response is due to people who fail to work to the rules for their role within the organization's design.

These rationalizations are wrong empirically, technically, and theoretically. As organizations focus on making systems work faster, better, and cheaper, they develop new plans embodied in procedures, automation, policies, and forcing functions. These plans are seen as effective since they represent improvements relative to how the system worked previously. When surprising results occur, the organization interprets the surprises as deviations—erratic people were unable to work to plan, to work to their role within the plan, and to work to the rules prescribed for their role. The countermeasures become more stringent pressures to work-to-plan, work-to-role and work-to-rule (Dekker, 2018). The compliance pressure undermines the adaptive capacities needed for SNAFU Catching (such as initiative), creates double binds that drive adaptations to make the system work 'underground,' and generates role retreat that undermines coordinated activities.

In every risky world, improvements continue, yet we also continue to experience major failures that puzzle organizations, industries, and stakeholders. SNAFU recurs visibly—in June 2018 IT failures stopped online financial trading (TSB in the UK and Canadian Stock exchanges). Befuddlement arises from a background of continued improvement on some indicators, coupled with surprising sudden performance collapses.

This combination IS the signature of adaptive systems in complex environments. The *scale complexity* that arises from changes to increase optimality comes at the cost of increased brittleness leading to systems "which are robust to perturbations they were designed to handle, yet fragile to unexpected perturbations and design flaws" (Carlson & Doyle, 2000, p. 2529). As scale and interdependencies increase, a system's performance on average increases, but there is also an increase in the proportion of large collapses/failures.

Given that pursuit of optimality increases brittleness, why don't failures occur more often?—SNAFU Catching. Adapting to handle the regular occurrence of SNAFUs makes the work of SNAFU Catching almost invisible (Woods, 2017). The fluency law states: *well adapted activity occurs with a facility that belies the difficulty of the demands resolved and the dilemmas balanced* (Woods, 2018). Systems that continue to adapt to changing environments, stakeholders, demands, contexts, and constraints are poised to adapt through enabling SNAFU Catching (Cook & Woods, 2016).

Continuous adaptability

How can organizations flourish despite complexity penalties? Answers to this question have emerged from research on resilient performance of human adaptive systems. For organizations to flourish they need to build and sustain the ability to *continuously adapt*. Today this paradigm exists in web engineering and operations because it was necessary to keep pace with the accelerating consequences of change as new kinds of services arose from internet fueled capabilities (Allspaw, 2015). Web-based companies live or die by the ability to scale their infrastructure to accommodate increasing demand as their services provide value. Planning for such growth requires organizations to be fluent at change and poised to adapt. Because these organizations recognize that they operate at some velocity, they know they will experience anomalies that threaten those services.

Web engineering and operations has served as one natural laboratory for studying resilience-in-action (emergency medicine and space mission management are other examples). Outages and near outages are common even at the best-in-class providers. Past success fuels the pace of change. Systems work at increasing scale in a constantly changing environment of opportunity and risk. Web engineering and operations is important also because all organizations are or are becoming digital service organizations. For example, recently multiple airlines have suffered major economic losses when IT service outages led to the collapse of the airlines ability to manage flights. Results from this natural laboratory help reveal fundamental constraints on how human adaptive systems function.

Organizational systems succeed despite the basic limits of automata and plans in a complex, interdependent and changing environment because responsible people adapt to make the system work despite its design—SNAFU Catching.

Four capabilities provide the basis for continuous adaptation. *Initiative* is essential for adaptation to conflicting pressures, constant risk of overload, and inevitable surprises (Woods, 2018). Organizations need to guide the *expression of initiative* to ensure synchronization across roles tailored to changing situations. This requires pushing initiative down to units of action (Finkel, 2011). Initiative can run too wide when undirected leading to fragmentation, working at cross-purposes, and mis-synchronization across roles. However, initiative is reduced or eliminated by pressure to work-to-rule/work-to-plan, especially by threats of sanctions should adaptations prove ineffective or erroneous in hindsight. Emphasis on work-to-rule/work-to-plan compliance cultures limits adaptive capacity when events occur that do not meet assumptions in the plan, impasses block progress, or when opportunities arise.

Resilience engineering is then left with the task of specifying which system architecture balances the expression of initiative as the potential for surprise waxes and wanes. The pressures generated by other interdependent units either energizes or reduces initiative and therefore the capacity to adapt. These pressures also change how initiative is synchronized across roles and levels. The pressures constrain and direct how the expression of initiative *prioritizes* some goals and *sacrifices* other goals when conflicts across goals intensify.

Effective organizations build *reciprocity* across roles and levels (Ostrom, 2003). Reciprocity in collaborative work is commitment to mutual assistance. With reciprocity, one unit donates from their limited resources now to help another in their role, so both achieve benefits for overarching goals, and trusts that when the roles are reversed, the other unit will come to its aid.

Each unit operates under limited resources in terms of energy, workload, time, attention for carrying out each role. Diverting some of these resources to assist creates opportunity costs and workload management costs for the donating unit. Units can ignore other interdependent roles and focus their resources on meeting just the performance standards set for their role *alone*. Pressures for compliance undermine the willingness to reach across roles and coordinate when anomalies and surprises occur. This increases brittleness and undermines coordinated activity. Reciprocity overcomes this tendency to act selfishly and narrowly. Interdependent units in a network should show a willingness to invest energy to accommodate other units, specifically when the other units' performance is at risk.

Third, a key lesson from studies of resilience is that tangible experiences of surprise are powerful drivers for learning how to guide adaptability. Tangible experience with surprises helps organizations see SNAFU concretely and to see how people adapt as difficulties and challenges grow over time. Episodes of surprise provide the opportunity to see when and how people re-prioritize across multiple goals when operating in the midst of uncertainties, changing tempos and pressures.

Fourth, proactive learning from well-handled surprises contributes to re-calibration and model updating (Woods, 2017). This starts with careful study of sets of incidents that reveal SNAFU Catching (Allspaw, 2015). What constitutes an 'interesting' incident changes. Organizations usually reserve limited resources to study events that threatened or resulted in significant economic loss or harm to people. But this is inherently reactive and many factors narrow the learning possible. To be proactive in learning about resilience shifts the focus: study how systems work well usually despite difficulties, limited resources, trade-offs, and surprises—SNAFU Catching. In addition, effective learning requires organizations to develop lightweight mechanisms to foster the spread of learning about SNAFU Catching across roles and levels.

Resilience is a verb that refers to capabilities that build and sustain the potential for continuous adaptability. Only few organizations can 'do' resilience, but these systems provide the 'proofs' of concept that can guide all organizations to develop the adaptive capacities needed to flourish in an increasingly interdependent world as the velocity of change accelerates.

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