REEVALUATING THE HIDER-FINDER PROBLEM

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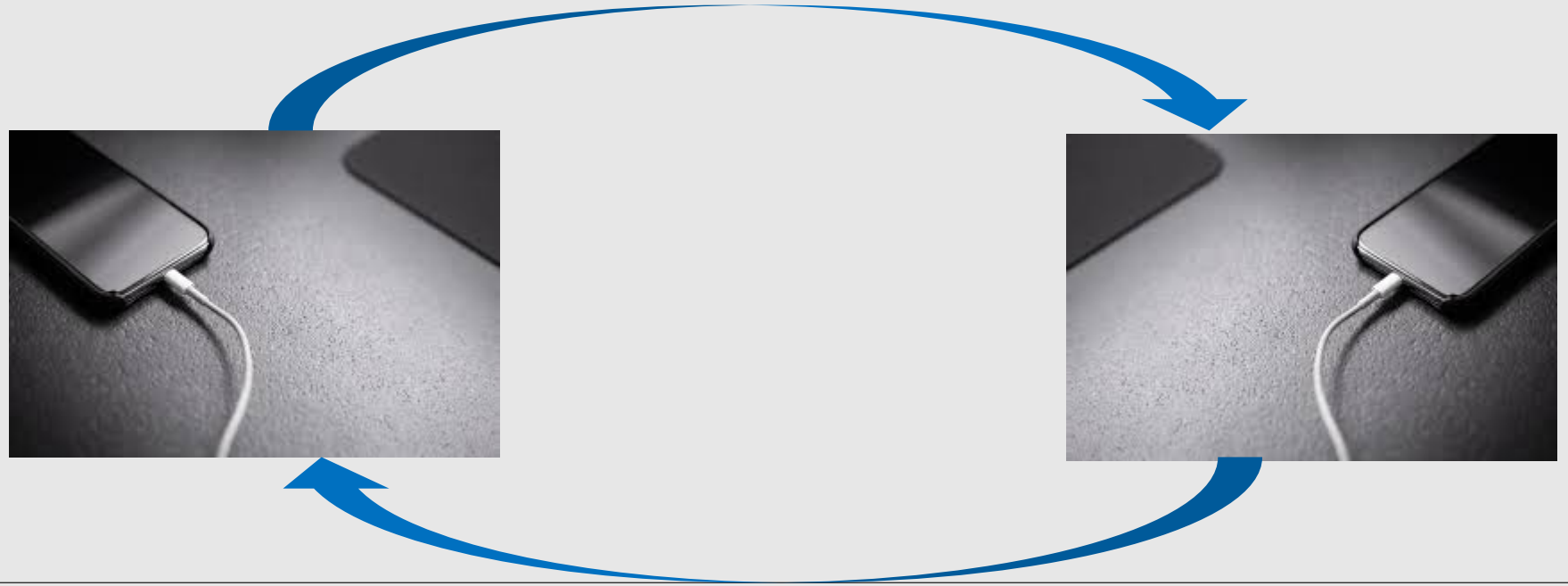
Overview and Problem Statement

- The growth and proliferation of unmanned systems broadly is cause to reevaluate some of our previous thinking on the topic
- There are many dimensions to this problem to consider, we wish to highlight one; that a fleet of remotely operating systems are subject to **two** types of failures:
  - Due to mechanical wear and tear, which we call *Unscheduled Maintenance*
  - Due to an intelligent adversary deliberately removing systems from the fleet, which we call *Adversary Action*.
- The key tension of our exposition is that the blue force commander will not be able to immediately tell the difference between systems lost due to maintenance vs. those lost to adversary action
- This situation is further complicated by the notion that when first deployed, the true maintenance performance of the fleet is *estimated*, but not *known*

A parallel problem

- This problem is practically identical to a set of cell phones placed in remote locations with renewable power supplies. While the end-user can interrogate the phones periodically, doing so drains their batteries and shortens their operational life. While the phones can have software updates pushed to them, it is impractical to physically inspect the phones. Therefore:
  - Updates on the phone's health is sporadic
  - Failures due to breakage / weather are indistinguishable from failures due to theft



The Changing Operational Context

- Better battery technology for USVs and UUVs leading to longer deployment time
- Forward-deployed unmanned systems used as an alternative to manned ISR forces
- Longer deployments mean unmanned assets are vulnerable for a longer period of time
  - Becomes difficult to distinguish between unscheduled failures and attrition from adversary interference

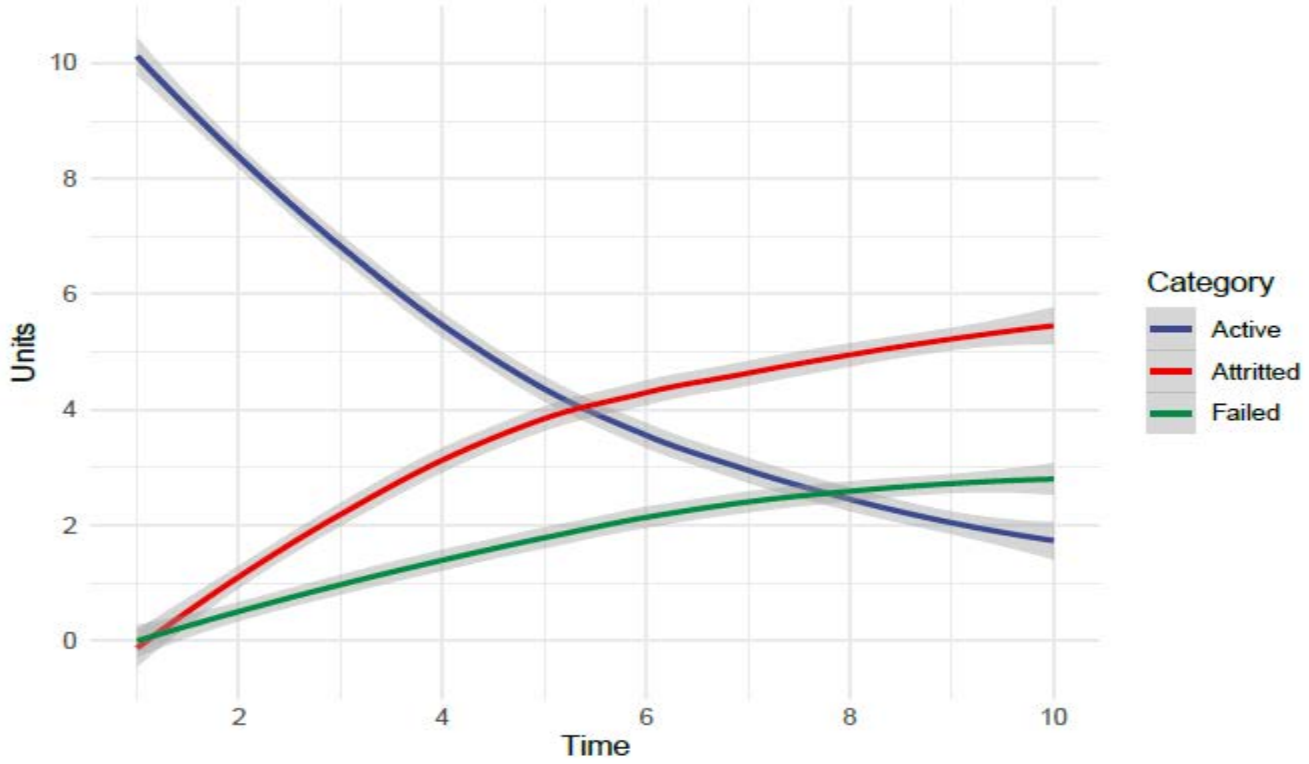
Image Credit: SailDrone

Central Question: What amount of attrition should be expected, and is there a definitive point where adversary interference becomes obvious?

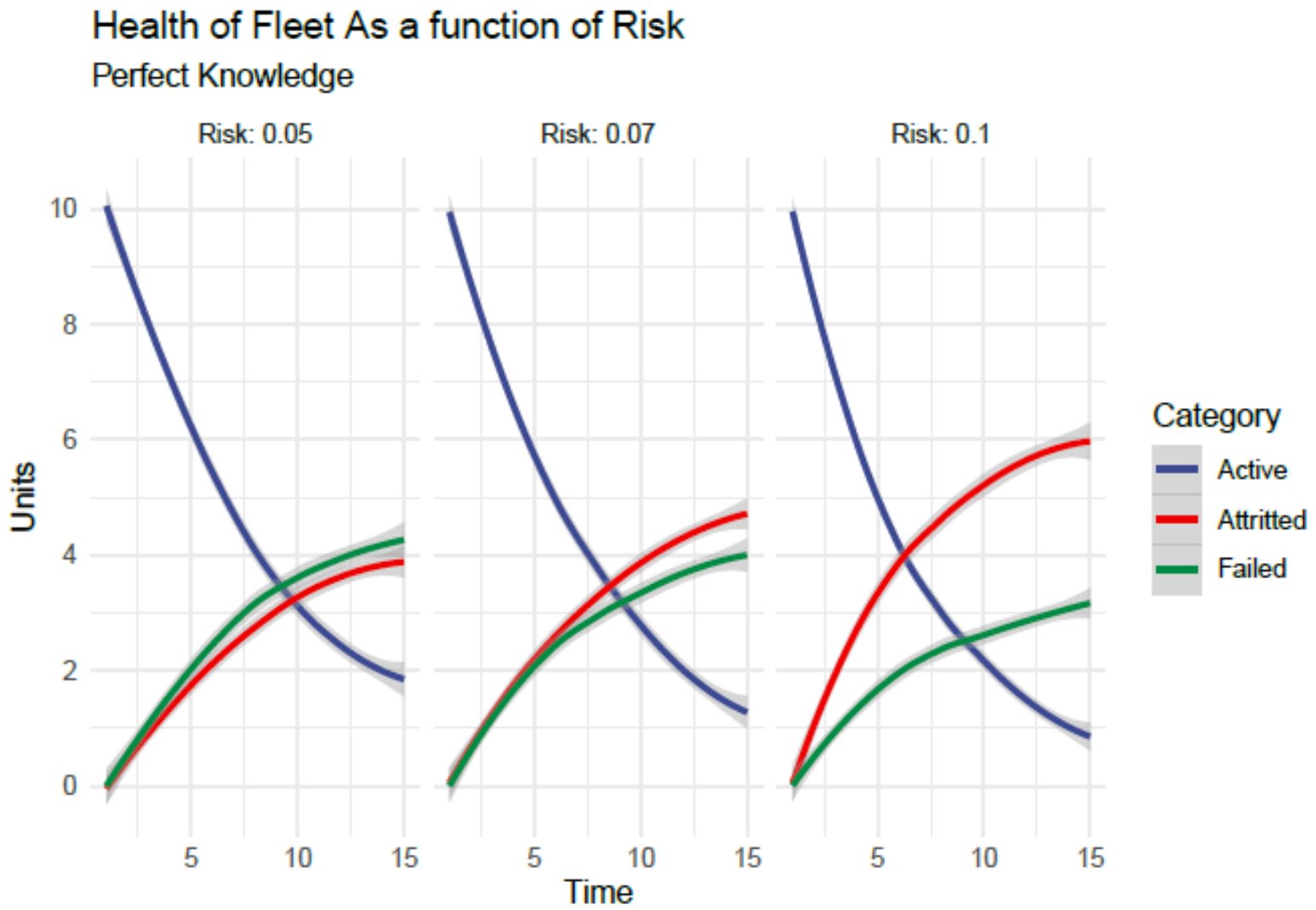
Analytic Approaches (for nerds)

- This process is modeled as a Discrete Time Markov Chain (DTMC), where the state space is the *true* status of the entities (Operating, inop. Due to maintenance, inop. Due to adversary)
- Use of Poisson Process
  - We treat the Hazard function as locally stationary
- Presumption of stationarity
  - Hazard experienced by remote, autonomous entity is a function of degree of exposure to the hazard it experiences

“Ground Truth” Of USV/UUV Attrition



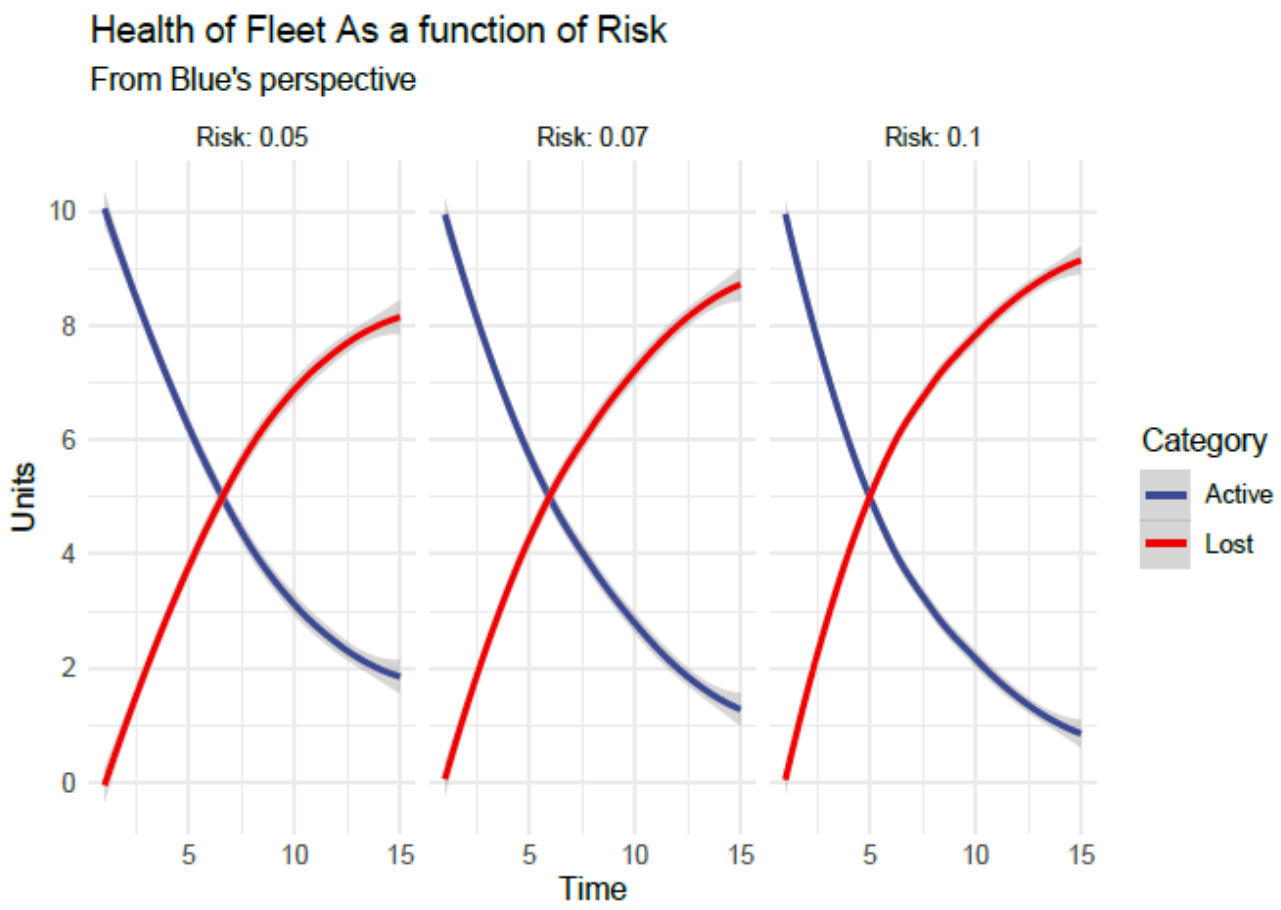
- In this example, a set of systems is exposed to hazard from both the environment and adversary action. Blue is unaware of the rate of loss due to adversary action (red) is ~2x that of mechanical failure (green)
- Without additional information, *Blue might presume that the losses are a disconnect between theoretical and field failure rates*.



- In this set of graphics, the per-month / per unit risk to each unit is varied; with consequent increased losses to Blue. Red's question is: How much attrition can they impose without arousing Blue's suspicions?

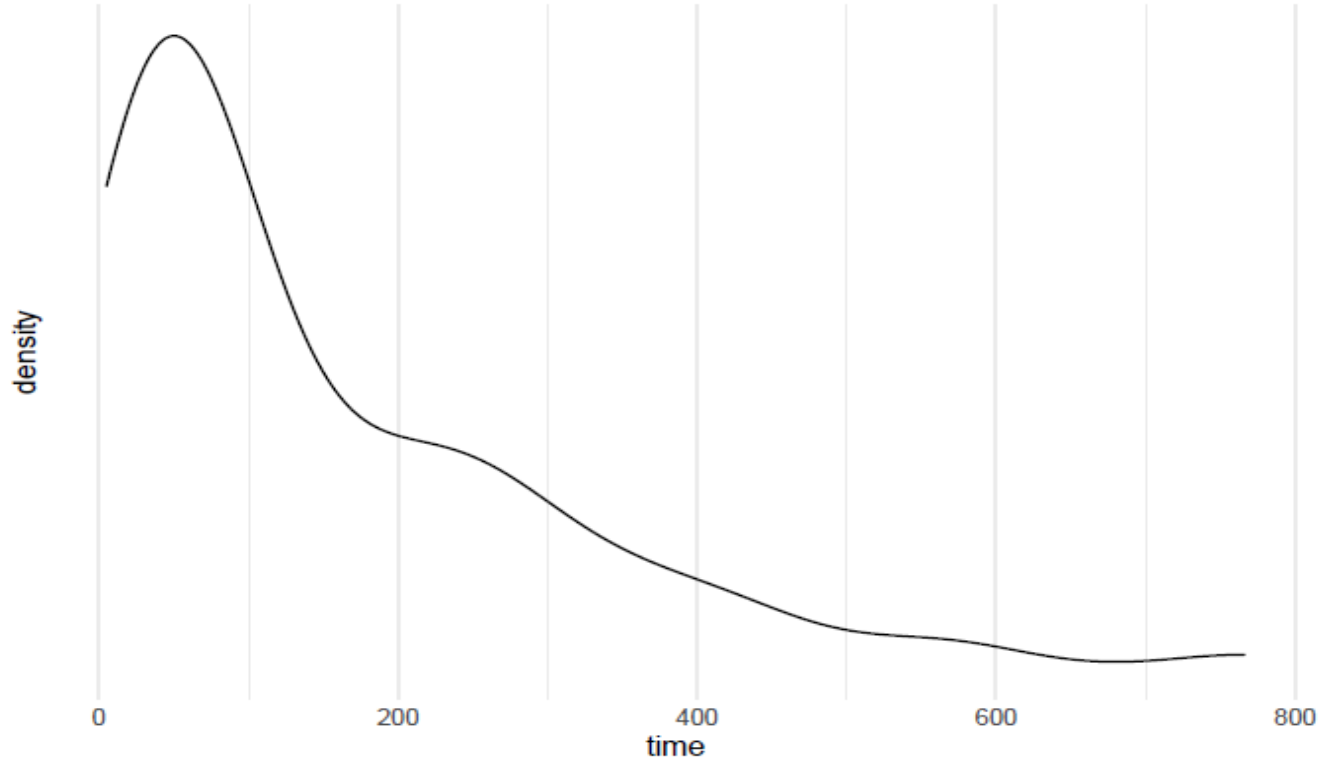
Unmanned Operations With Perfect Information

Blue’s View Of Attrition



- These graphs show Blue’s view of the attrition, showing that Red can ‘get away’ with a fair amount of attrition in what Blue deems low-risk operating areas without arousing Blue’s suspicions

Red opportunity to engage in a random search



- We might be interested to consider how long it will take a Red random searcher to find it's first Blue target in a large field with random (i.e. Brownian) motion. In the result of our simulation (above) we show that while the first encounter in a large field occurs relatively quickly, there are cases where Red is unsuccessful at finding a blue target for indefinite periods of time.

Insights

- Distinguishing between unscheduled failures and attrition from Blue’s perspective will likely not be obvious
- Minimizing players (Red) have agency within this scenario, allowing them to decide on a so-called “strike time”
- Taking advantage of the discrepancy between reported and expected reliability for Red
- Strategic tradeoff between minimizing risk of attrition through limiting UXS deployments and maximizing capability

Conclusion

- The proliferation of remote / autonomous systems leads to a renewed interest in considering the strategic implications of hider / finder competitions
- Understanding this problem from both the Blue *and Red* perspectives will increase the capability and effectiveness of these systems in the future

Authors

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Discussion