

117-264-D CCA, MMA, Hybrid Fleet and GUDIYA

A thought exercise by Stability Engineering Institute

The United States Air Force is building two distinct classes of uncrewed airpower.

- Collaborative Combat Aircraft are intended to operate as semi-autonomous combat teammates.
- Massed Modular Aircraft are intended to provide affordable, modular capacity in numbers large enough to accept attrition.

When these fleets meet in one theater, their interaction creates a third engineering object: the hybrid cognitive fleet.

Research note

This chapter is a conceptual Stability Engineering analysis based on publicly available program descriptions as of 14 September 2026. It does not describe classified capabilities, current rules of engagement, or an approved Department of the Air Force architecture. Its purpose is to identify the dynamic stability questions that arise when autonomous and semi-autonomous aircraft operate at scale.

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The central finding

CCA and MMA represent different theories of uncrewed airpower. CCA concentrates capability in a combat teammate that must coordinate closely with crewed aircraft. MMA distributes useful payloads across a larger population of lower-cost aircraft whose losses are expected and tolerated. A hybrid fleet combines these theories, but it also combines their failure modes. The result cannot be governed safely by treating every aircraft as an independent platform.

The hybrid fleet is a machine-speed Complex Adaptive System. Its behavior emerges from changing relationships among aircraft, pilots, autonomy software, sensors, weapons, communications networks, mission authorities, maintenance systems and adversary actions. Each component can perform within specification while the fleet as a whole drifts into an unstable state. Stability must therefore be engineered at the level of the interaction, the mission group and the theater, not only inside the airframe.

GUDIYA supplies the missing external reference and supervisory stability layer. It would not replace flight control, mission autonomy, command and control, or human authority. It would observe and manage the dynamic couplings among them. Its job would be to keep the hybrid fleet inside an approved Cognitive Envelope while preserving the ability to decompose safely when communications, membership or mission conditions change.

Two programs and three engineering objects

Public discussion usually presents CCA and MMA as two acquisition portfolios. Stability Engineering sees three objects that require separate treatment: the CCA fleet, the MMA fleet and the combined hybrid fleet. The third object does not appear on a procurement line. It emerges operationally whenever the two populations share missions, data, airspace, targets, spectrum, weapons authority or logistics.

Engineering object	Primary organizing principle	Dominant stability problem	Failure tendency
CCA fleet	Close collaboration with crewed and uncrewed combat aircraft	Precise rendezvous under high cognition velocity	Tightly coupled errors propagate quickly
MMA fleet	Affordable modular capacity deployed in large numbers	Population control under attrition and reconfiguration	Local actions accumulate into theater effects
Hybrid fleet	Mission-dependent composition of unlike aircraft	Coupling across different roles, tempos and authority models	Cross-fleet feedback creates unanticipated behavior

Collaborative Combat Aircraft

The Air Force describes CCA as combat-ready semi-autonomous systems intended to extend the reach, awareness and survivability of American airpower in contested environments. In September 2026 it named the General Atomics FQ-42 Vengeance and Anduril FQ-44 Fury and stated an intent to have 500 CCA by 2032, within a longer-range objective of roughly 1,000 aircraft. Earlier Air Force briefings described CCA as an extension of aircraft such as the F-22, F-35 and E-7, providing additional weapons, sensors and the ability to assume risks that would be unacceptable for a crewed aircraft. [1][2]

The defining word is collaborative. A CCA is valuable because it can participate in a tightly coordinated combat relationship. It may fly ahead of a crewed aircraft, carry weapons, sense threats, create geometry, support electronic attack or act as another decision-capable node. Its performance depends on timely and correct interpretation of intent across the team.

This makes CCA a rendezvous-intensive actant. The physical formation is only one form of rendezvous. The aircraft must also rendezvous in time, mission state, threat interpretation, communications state, authority and weapons logic. A CCA can be physically close to its human mission commander yet cognitively out of formation. A delayed track, stale intent, mismatched target identity or divergent autonomy state can create the equivalent of spatial disorientation even when every aircraft remains aerodynamically stable.



Figure 1: CCA Aircraft

Massed Modular Aircraft

MMA follows a different force-design logic. The public solicitation describes lower-cost, theater-range uncrewed aircraft that can carry interchangeable payloads and perform missions associated with the MQ-9A, including intelligence collection, weapons employment, electronic warfare and communications relay. The concept accepts that numerous aircraft may be lost while the larger force continues to create pressure and deliver useful capacity. [3][4]

The defining words are massed and modular. Massed does not automatically mean swarm. A force can employ many aircraft as scheduled waves, distributed cells, persistent orbits or independent mission packages without using one decentralized swarm algorithm. Modular means that the meaning of an airframe can change with its payload and software. The same fleet may contain sensor carriers, weapon carriers, electronic attack nodes and communications relays at the same time.

MMA therefore produces a population stability problem. The loss of one aircraft may be tactically acceptable, but the loss can change network topology, sensor coverage, communications capacity, strike sequencing and the workload placed on survivors. Attrition is not merely subtraction. It is a structural event that changes the remaining system. Every loss can induce reassignment, rerouting and recomposition, and each response can create new couplings faster than a human staff can inspect them.

CCA and MMA comparison

Dimension	CCA	MMA	Stability consequence
Operational identity	Combat teammate	Modular mission carrier	The Grid must distinguish relationship from payload role
Primary value	Coordinated combat effect	Distributed affordable capacity	Success metrics differ across the fleets
Typical coupling	Tight and tactically immediate	Broad and mission dependent	One control cadence cannot serve every interaction
Attrition assumption	Risk tolerant but capability significant	Losses expected within force design	Membership changes must be absorbed without cascade
Human interface	Close mission command relationship	Tasking across groups and packages	Human cognitive load appears in different places
Modularity	Mission systems and autonomy evolve by increment	Payload identity can change across sorties	Configuration must remain visible to the whole system
Principal hazard	Fast propagation of a shared error	Emergent behavior from density and reallocation	Hybrid operation contains both hazards

The hybrid fleet

A future mission may combine crewed fighters, CCA escorts, MMA sensor carriers, MMA weapons carriers, airborne command and control, tankers, space-derived sensing and ground-based decision systems. The mission group will not remain fixed. Aircraft will join, leave, fail, lose connectivity, exhaust weapons,

change payload relevance or inherit unfinished work. The operational unit is therefore a changing Intent Group rather than a static formation.

This is where the two fleet concepts become one stability problem. CCA may depend on an MMA relay for connectivity. An MMA weapon carrier may depend on tracks refined by a CCA. A crewed aircraft may redirect one group, which changes bandwidth and sensor coverage for another. An apparently local decision can move through indirect dependencies and return as a delayed effect. The hybrid fleet contains feedback loops, state persistence, asymmetric cognition velocities and repeated rendezvous. Time becomes a first-class engineering variable.

Five coupling layers

1. Physical coupling includes shared airspace, flight paths, fuel states, weapons envelopes and collision risk.
2. Information coupling includes tracks, sensor quality, data age, confidence, provenance and communications capacity.
3. Cognitive coupling includes interpretation of intent, threat prioritization, planning assumptions and autonomy state.
4. Authority coupling includes who may assign, redirect, approve, inhibit or terminate an action under each communications condition.
5. Logistics coupling includes launch capacity, recovery slots, maintenance, payload availability, software configuration and reconstitution time.

A fleet can be stable at four layers and unstable at the fifth. For example, aircraft may remain safely separated, share accurate tracks and agree on the threat while relying on conflicting assumptions about weapons authority. Conventional verification tends to examine components and interfaces. Hybrid-fleet stability also requires continuous observation of the relationships that form across these layers.

The new failure surface

The hybrid fleet expands capability by allowing machines to coordinate at a rate humans cannot reproduce. The same feature expands the failure surface. More cognition can be generated in response to uncertainty, and each new plan, reassignment or message injects additional cognitive energy into the system. If the system responds to instability by generating still more uncoordinated cognition, it can amplify the condition it is trying to solve.

Instability mode	Illustrative mechanism	Observable symptom	Required response
Velocity mismatch	One actant updates faster than another can observe or reconstruct	Oscillation between plans or repeated correction	Rate shaping and synchronized state exchange
Stale intent	Tasking survives after its operational premise changes	An aircraft continues valid execution of an obsolete objective	Intent expiry and authoritative revalidation
Authority divergence	Disconnected groups infer different permission boundaries	Conflicting actions after communications return	Predefined degraded-mode envelopes and reconciliation

Attrition cascade	Losses trigger repeated reassignment and overload survivors	Coverage gaps and rising coordination burden	Topology-aware shedding and controlled recomposition
Configuration drift	Payload, software or autonomy version is misidentified	Mission assignment exceeds actual capability	Continuous identity, lineage and configuration verification
Feedback amplification	Sensor reports and reactions reinforce one another	Threat confidence rises without independent evidence	Diversity checks, damping and external reference
Dark cognition	Local planning occurs outside fleet observability	Unexplained state changes or surprise rendezvous	Sealed cognition veil and recorded lineage
Recovery shock	Disconnected groups rejoin with incompatible histories	Duplicate work, contradictory tracks or authority collision	State comparison before reintegration

GUDIYA as the external stability reference

GUDIYA would treat every crewed aircraft, CCA, MMA, autonomy service, payload, command node and relevant human role as an actant attached to a Cognitive Stability Grid. Attachment would establish identity, capability, authority, configuration, lineage and current stability obligations. The Grid would then observe the relationships among actants through the mission lifecycle.

The Grid would remain orthogonal to platform origin. General Atomics, Anduril and future vendors could use different autonomy stacks. MMA payloads could come from many suppliers. GUDIYA would not require one model or one vendor to own the fleet. It would require each actant to expose a standardized stability interface that allows the Grid to establish an external reference across otherwise heterogeneous systems.

Grid functions for the hybrid fleet

GUDIYA construct	Hybrid fleet function
KYA and ACS	Know Your Actant establishes authorized identity. The Actant Cognitive Signature exposes the expected cognitive and interaction characteristics of the current configuration.
Gudiya cookie and GESR	A persistent record connects mission state, lineage, configuration changes, unfinished work and stability history across launch, disconnection, recovery and reassignment.
Cognitive Coordinate System	Supplies the external reference needed to describe an actant position, motion and relationship within the Cognitive Field.
Rendezvous Management	Controls the formation, timing, permissions and dissolution of explicit and implicit interactions among actants.

Cognitive Flight Plan	Represents the approved intent, participants, roles, authority, expected couplings and stability limits for an Intent Group.
Cognitive Envelope	Defines the permissible operating region for cognition velocity, autonomy, authority, recursion, coordination burden and degraded-mode behavior.
GCR and GRE	The Grid Cognitive Regulator and Grid Runtime Environment observe, shape, quarantine, degrade or terminate unstable interactions according to approved policy.
Cognitive SCRAM	Provides an authenticated emergency instruction that can force a safe state when ordinary coordination is no longer trustworthy.

The hybrid Cognitive Flight Plan

Traditional mission planning assigns aircraft, routes, weapons, timing and authorities. A hybrid Cognitive Flight Plan must also describe how cognition is expected to move through the group. It should identify which actants may create plans, which may modify them, which observations can trigger reassignment, how long intent remains valid and how the group must behave when its external reference degrades.

The plan should be approved for a defined composition rather than for an abstract fleet. A CCA configured for sensing and an MMA carrying a communications relay create a different stability object from the same airframes carrying different payloads. The approval must bind mission purpose to actual actant identity, software lineage, payload state and authority. If one of those elements changes, the Grid should determine whether the existing plan remains stable-worthy or requires reapproval.

Mission lifecycle under the Grid

1. Attach and verify each actant, payload and autonomy configuration through KYA and ACS.
2. Approve the Intent Group and its Cognitive Flight Plan, including expected couplings and degraded-mode boundaries.
3. Monitor rendezvous formation as aircraft launch, join the mission and assume assigned roles.
4. Measure stability margins during execution, including cognition rate, delay, disagreement, authority state and coordination burden.
5. Recompute the group envelope after attrition, payload exhaustion, software change, communications loss or mission redirection.
6. Decompose the group deliberately when the mission ends or stability margin falls below the approved threshold.
7. Reconcile returning actants before their accumulated state is admitted into another mission group.

Graceful decomposition under degraded communications

A hybrid fleet cannot assume continuous connectivity. Jamming, distance, terrain, damage and congestion will partition the system. The engineering goal should not be uninterrupted central control. It should be bounded autonomy with predictable decomposition. Each sub-group needs a preapproved envelope that defines what it may continue, what it must freeze, what it must abandon and when it must return or enter a safe state.

The danger appears when a partitioned group continues to learn, infer and replan while the rest of the fleet builds a different history. When communication returns, both histories may be locally coherent and mutually incompatible. Immediate reconnection can inject a discontinuity into the larger system. GUDIYA

would treat reconnection as a controlled rendezvous: compare state, resolve unfinished work, reconcile authority and only then restore full participation.

Stability observability

Platform health metrics remain necessary, but they are insufficient. The Grid must measure the changing relations among actants. These measures should be collected at the actant, Intent Group and theater levels so that a stable local condition cannot conceal a deteriorating system condition.

Metric family	Examples	Question answered
Identity and lineage	ACS match, payload identity, autonomy version, unfinished-objective continuity	Is this the actant the mission believes it is
Time and rate	Observation age, decision latency, update frequency, rate ratio, synchronization error	Can interacting actants reconstruct one another accurately
Rendezvous	Join and leave rate, coupling duration, failed handoffs, implicit dependency count	How quickly is mission topology changing
Agreement	Track divergence, intent divergence, authority disagreement, confidence dispersion	Where is shared mission state separating
Coordination burden	Messages, replans, approvals, task migrations and dependency depth per unit time	Is the system spending growing effort to remain coherent
Stability margin	Distance to envelope boundary, damping, recovery time, oscillation amplitude	Can the group absorb the next disturbance
Population condition	Loss rate, role concentration, survivor load and redundancy by function	Is attrition creating structural fragility
Human condition	Intervention rate, alert density, unresolved ambiguity and command workload	Is human stabilization capacity being exhausted

A representative instability sequence

Consider a mission in which CCA aircraft escort crewed fighters while MMA aircraft provide sensing, communications relay and standoff weapons.

- An adversary disables one relay.
- Routing software shifts traffic to the remaining relay, which increases latency.
- One CCA receives track updates more slowly than its peers.
- Its autonomy interprets the growing disagreement as uncertainty and requests additional sensing.
- Several MMA sensors retask, reducing coverage elsewhere.
- Another mission group detects the coverage loss and launches its own replanning cycle.
- No component has necessarily failed beyond specification, yet the theater begins to oscillate between competing allocations.

A conventional system may record each event in a separate log: relay loss, route change, stale track, sensor retask and coverage request. GUDIYA would reconstruct the loop as one dynamic event. It would see rising latency, disagreement and coordination burden before the aircraft converge on unsafe or tactically wasteful behavior. The Grid could damp the loop by rate-limiting replans, preserving minimum sensor coverage, separating the affected Intent Groups or assigning an authoritative state reference.

This scenario illustrates why hybrid-fleet stability is different from cybersecurity. An attacker may have caused the relay loss, but the subsequent instability can emerge without further malicious action. Securing every message would not resolve the rate mismatch or allocation feedback. Cyber defense protects the system from hostile manipulation. Stability engineering protects it from dangerous behavior produced by valid components interacting under stress.

Implications for acquisition and certification

Airframes and autonomy packages will still require conventional verification, validation, safety analysis and mission testing. The hybrid fleet adds a second certification problem: whether a proposed composition is stable-worthy under its expected density, communications conditions, attrition rate and authority model. Certification must extend from the product to the interaction pattern.

- Require a Universal Cognitive Standard Interface for every actant and payload that joins the fleet.
- Test mixed-vendor and mixed-version populations, including asymmetric update rates and partial failures.
- Certify degraded-mode behavior and reintegration, not only nominal connected operation.
- Evaluate dynamic stability at increasing population density before fielding at operational scale.
- Separate permission to fly from permission to enter a particular Intent Group and Cognitive Envelope.
- Treat autonomy updates as changes to fleet dynamics even when airframe and payload remain unchanged.
- Maintain a shadow hybrid fleet environment for replay, counterfactual testing and algorithm improvement.

Implications for command and operations

Human command must remain authoritative without requiring humans to manually supervise every machine-speed interaction. That distinction is essential. Human-on-the-loop cannot mean that a commander receives an unmanageable stream of alerts after the system has already changed state. The Grid should convert continuous dynamic behavior into a small number of operationally meaningful stability indicators and intervention choices.

Commanders need to know whether the fleet is oriented, how much stability margin remains and what capability will be lost if the Grid sheds a coupling or decomposes a group. This resembles instrument flight more than remote piloting. The commander does not need every raw waveform. The commander needs trustworthy external reference, clear authority state and an artificial horizon for the cognitive fleet.

The SEI research agenda

The Stability Engineering Institute should treat the emerging CCA and MMA portfolios as an unusually clear laboratory for machine-speed HCAS. Public information is sufficient to frame the science even though many operational details remain classified. The immediate research questions are structural.

1. What variables define the Cognitive Envelope of a mixed CCA and MMA Intent Group

2. How should cognition velocity and observation-rate compatibility be measured across unlike actants
3. Which hybrid-fleet topologies remain stable as density and attrition increase
4. How much state divergence can a partitioned group accumulate before reintegration becomes unsafe
5. Which stability functions must be local to the aircraft and which require theater-level reference
6. How should the Grid distinguish acceptable tactical surprise from early evidence of emergence
7. What stability battery capacity is required to absorb a sudden theater-wide cascade
8. How should stable-worthiness be certified across vendors, payloads, autonomy versions and mission authorities

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Conclusion

CCA and MMA solve different military problems. CCA extends the combat power of crewed aircraft through close collaboration. MMA distributes modular capability across an affordable, attrition-tolerant population. Their combination promises reach, resilience and mass, but it also creates a new dynamic object whose behavior cannot be inferred from either fleet alone.

The operational architecture must therefore do more than launch, recover, sustain and task aircraft. It must manage the formation and dissolution of cognitive relationships across the theater. It must preserve intent, authority, identity and stability as groups change faster than human organizations can redraw them.

GUDIYA offers a coherent response:

- attach every actant,
- provide a common external reference,
- approve each hybrid Cognitive Flight Plan,
- manage every rendezvous,
- measure stability margin and
- force graceful decomposition when the fleet approaches its envelope.

In this thought exercise, the hybrid fleet is the airpower case that makes the need for a Cognitive Stability Grid visible.

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