AVT-355 Research Workshop on Intelligent Solutions for Improved Mission Readiness of Military UxVs

Distributed Sensing and Resilient Datalinks for UAS/UxV

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Outline

- **Threats and Challenges**

- **Confluence of Enabling Technologies**

- **Persistent Airspace Control by Multiple Airborne Nodes (PACMAN) Architectural Vision**
  - Distributed Sensing
  - Resilient Communications
  - Variable & Collaborative Autonomy

- **Summary**

Threats and Challenges

- **Modern threats (e.g. multi-domain, hybrid, cyber and asymmetric) demand persistent awareness across threat spectrum**
- **Fading relevance of monolithic and vulnerable Cold War-era platforms**
  - ➢ Unable to provide the scalability or agility to counter adaptive adversaries
  - ➢ Costly to operate and maintain
  - ➢ Distributed, service-oriented architectures have supplanted need for centralized airborne Battle Management Command & Control (BMC2)
- **Information superiority requires connecting disparate systems with varied waveforms and protocols**
  - ➢ Legacy platforms must be interoperable with modern systems
  - ➢ No single waveform or protocol will "rule them all"
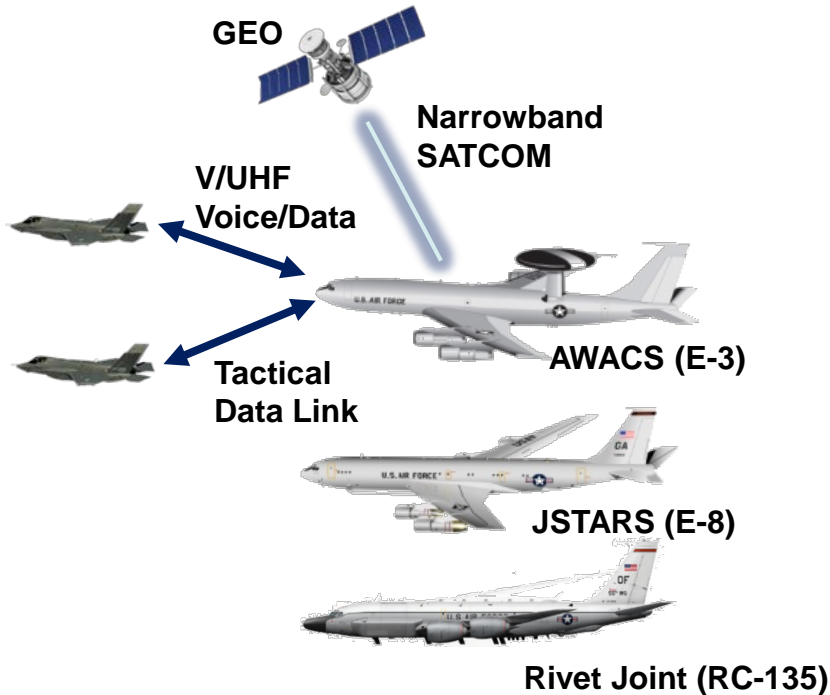
Modern threats drive operational needs that can't be met by aging monolithic solutions
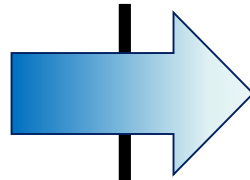
Confluence of Enabling Technologies

- **Persistent unmanned systems**
  - ➤ Increasingly automated to improve effectiveness and reduce manning
  - ➤ Ability to stay airborne for weeks with aerial refueling
- **Networked communications with enhanced performance and resilience**
  - ➤ Low latency, high-throughput, self-forming mesh networks
  - ➤ Low latency, Low Earth Orbital (LEO) satellites
  - ➤ High-throughput laser communications
- **Distributed sensing and cloud computing**
  - ➤ Software-defined, broadband multi-function apertures
  - ➤ Secure cloud services with high-performance computing & data analytics
- **Variable & collaborative autonomy**
  - ➤ Artificial Intelligence and Machine Learning

Advances in technologies enable new approaches to ISR&T that counter modern threats
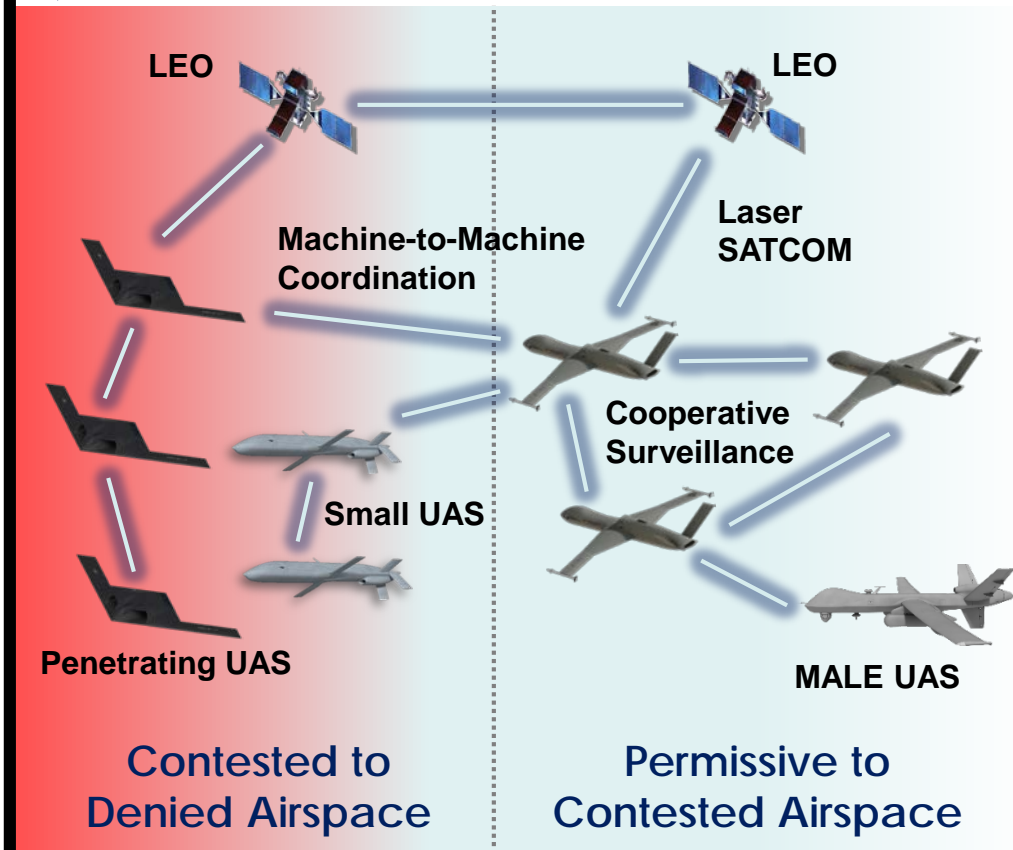
Persistent Airspace Control by Multiple Airborne Nodes (PACMAN) Architectural Vision

Remote Operation

GEO

Laser Comms

LEO

LEO

Multi-Domain Operations

Cloud Computing

Reconfigurable MALE UA

Interoperability

Manned-Unmanned Teaming (MUM-T)

Cooperative Broad Area Surveillance

Penetrating UAS

Secure Networked Communications

Small UAS

Aerial Refueling Receive Capability

Variable Collaborative Autonomy
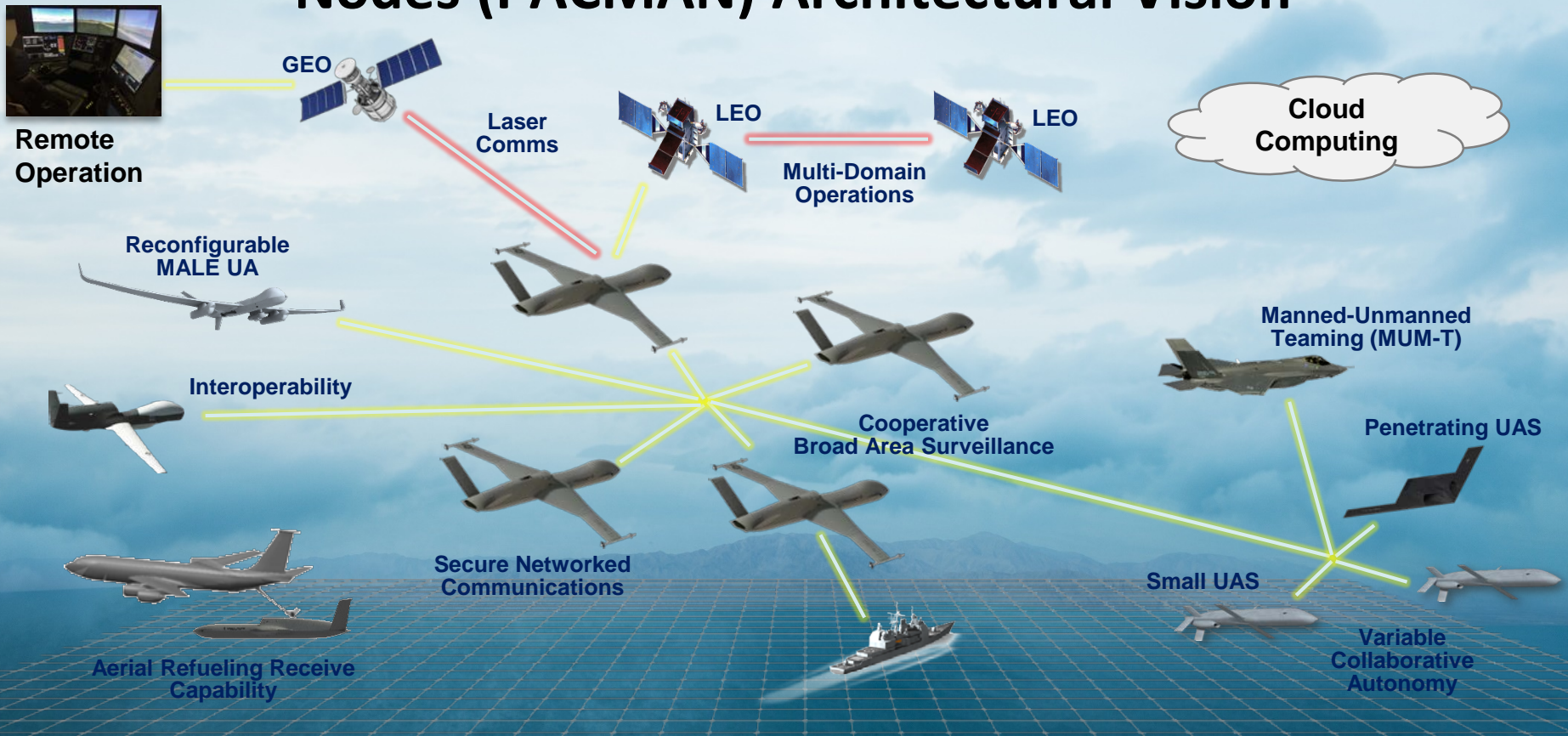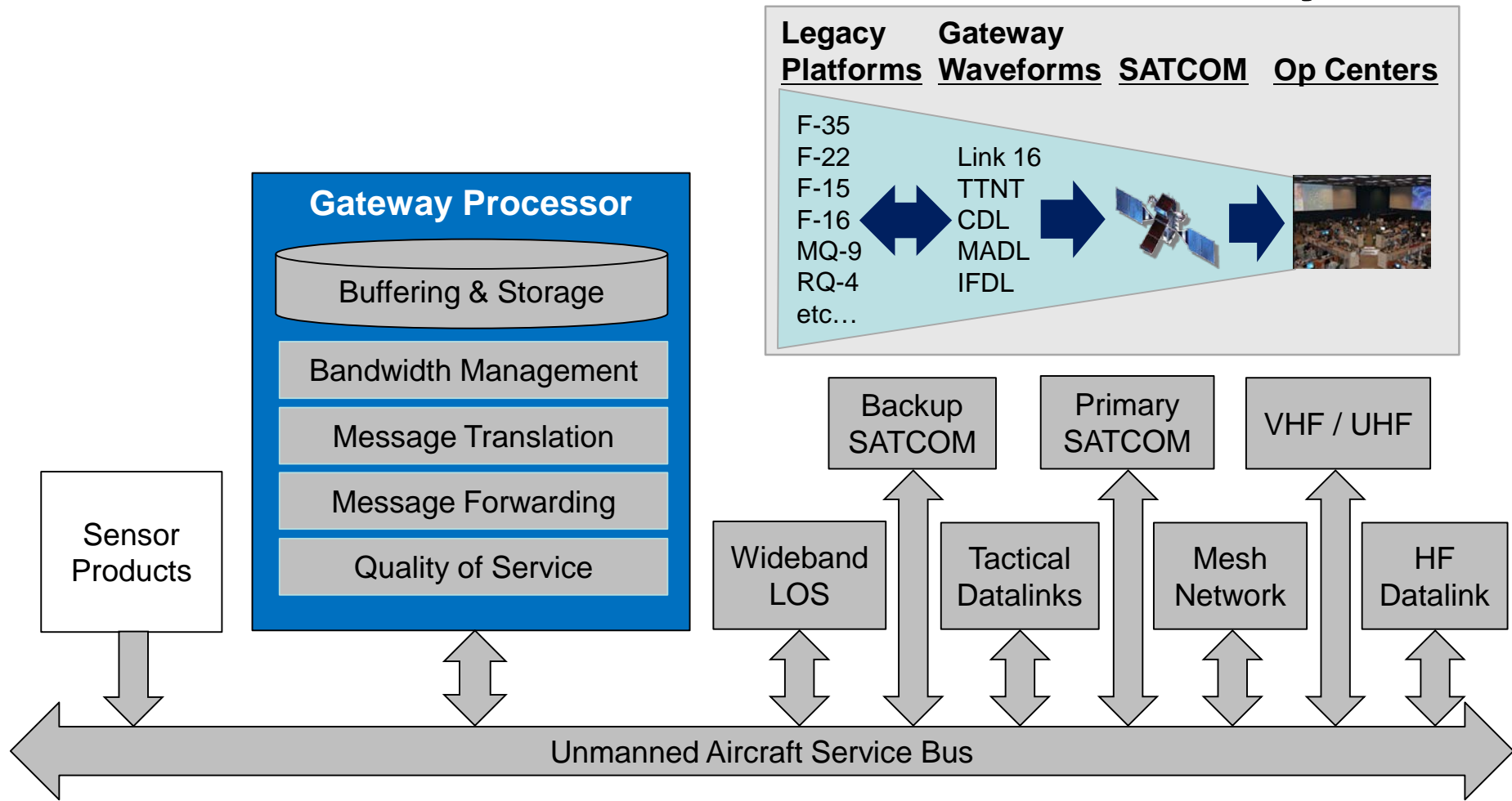
Multi-domain, multi-orbital surveillance and communications architecture that is more resilient, effective and affordable than traditional approaches

Resilient Communications

- **Redundant and diverse secure communications**
  - Primary and secondary SATCOM, providing spatial and spectral diversity
  - HF Beyond Line-of Sight (BLOS) data link for C2 without SATCOM
- **Technologies and concepts to mitigate possibility of signal detection and exploitation**
  - High Throughput Satellite (HTS) Spot-Beams improve protection from jammers outside of spot beam
  - Frequency-agile SATCOM to swap satellite frequencies in flight
  - Jam-resistant laser communications with LPI/LPD
- **Communication gateways to establish resilient Line-of-Sight (LOS) network without reliance on SATCOM**

Diverse protections against signal detection, jamming and cyber threats promote resilient communications
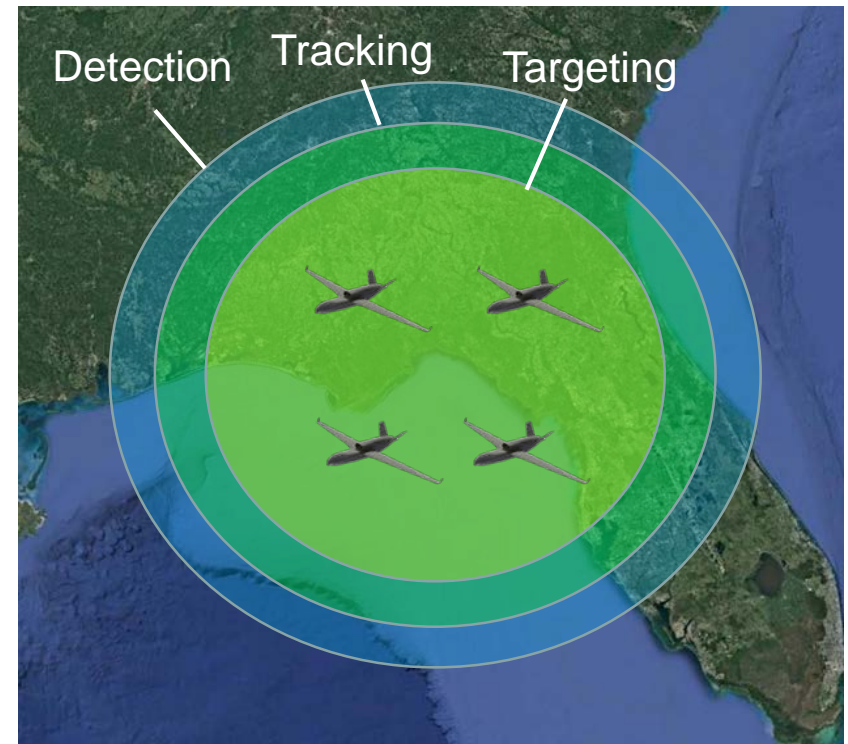
Airborne Communications Gateway

Legacy Platforms	Gateway Waveforms	SATCOM	Op Centers
F-35 F-22 F-15 F-16 MQ-9 RQ-4 etc…	Link 16 TTNT CDL MADL IFDL		

Gateway Processor

- Buffering & Storage
- Bandwidth Management
- Message Translation
- Message Forwarding
- Quality of Service

Sensor Products

Backup SATCOM

Primary SATCOM

VHF / UHF

Wideband LOS

Tactical Datalinks

Mesh Network

HF Datalink

Unmanned Aircraft Service Bus

Gateway translates, shapes and forwards data across disparate datalinks & networks

Disaggregated Sensing

- **Spatially distributed architecture of cooperative and interoperable UA**
- **Diverse set of complementary payloads**
  - ➤ High confidence target identification with multi-spectral sensors
- **Flexible broad area coverage**
- **Improved target location accuracies**
- **Robust to loss of a single platform**
- **Scalable and adaptable**
- **Overwhelms adversary by complicating their targeting and jamming**

Detection   Tracking   Targeting

Disaggregated sensing enables flexible broad area surveillance and targeting

NATO
OTAN

NORTH ATLANTIC TREATY ORGANIZATION
SCIENCE AND TECHNOLOGY ORGANIZATION

S&T
organization

Variable & Collaborative Autonomy

- **With collaborative autonomy, UA Team works together to accomplish an objective**

- **Each team member can have its own "personality" in heterogeneous swarm**

- **Autonomous modes include Formation Flight, Dynamic Routing, Attrition Compensation, and Sensor Management**

- **Variable autonomy sets autonomy level according to mission and risk acceptance**
  - ➤ Higher autonomy levels selected for contested operations to limit or eliminate RF emissions

SIGINT

Mesh
Network

Radar

EW

EO/IR

Mission continues
with combat loss
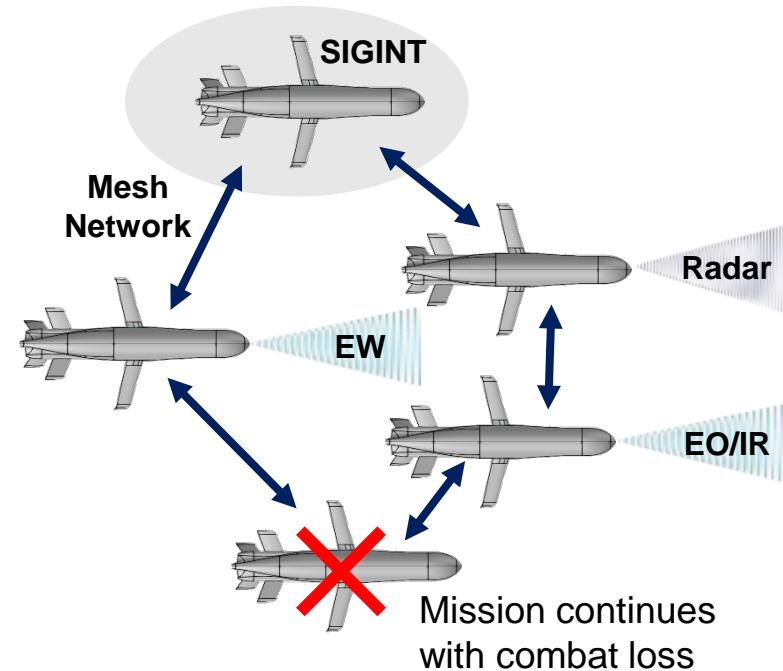
Heterogeneous Swarm With Multi-Ship Collaboration

Variable and collaborative autonomy enhances survivability and mission assurance

PACMAN Features and Benefits

Features	Benefits
Distributed and Networked Sensors	• Resiliency against modern threats • Operable across the threat spectrum from Phase 0 to Denied Operations • Accurate and timely target identification • Fast and highly-precise multi-platform targeting • Diverse sensors for enhanced situational awareness • Scalable and reconfigurable architecture
Airborne Communications Gateway	• Message translation and cross-banding capabilities connecting modern and legacy systems • Backhaul of high-bandwidth data through laser SATCOM or line-of-sight datalinks • Serve disadvantaged users and dynamically shape data to fit available resources
Open System Architecture	• Interoperability • Rapidly upgradeable capabilities • Obsolescence avoidance • Reduced life-cycle cost
Redundant, Diverse and Secure Data Links	• Assured (rapid, reliable and resilient) communications in all threat environments, including SATCOM-denied
Variable Collaborative Autonomy	• Sustain operations across threat spectrum with greater autonomy in contested environments to minimize required bandwidth and enhance survivability
Cloud Computing & Data Analytics	• Leverages external high-performance computing and vast databases for secure and scalable processing to acquire knowledge from all-source intelligence

Summary

- **Modern threats require more scalable & resilient architectures to counter them**

- **Enabled by recent advances in technology, GA-ASI's PACMAN architecture promotes wide area sensing and interoperability across threat spectrum**

- **Based on a heterogeneous mesh of unmanned systems, our multi-domain PACMAN architecture supports ISR&T and connectivity functions that are:**
  - ➢ Agile and adaptive to changing threats and priorities
  - ➢ Resilient to adversary jamming, detection, and interception
  - ➢ Scalable to complexity of threats and size of AOR
  - ➢ More affordable than traditional approaches