Unmanned Systems Autonomy Services: Use Cases

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Integrity ★ Service ★ Excellence

AFRL

Centralized

- A single instance of UxAS controls all vehicles
- Easiest use case to setup, configure, and simulate
    - Simple, consistent AMASE interaction
- Centralized examples:
    - Waterway Search
    - Assign Tasks
- Research applications
    - Play calling

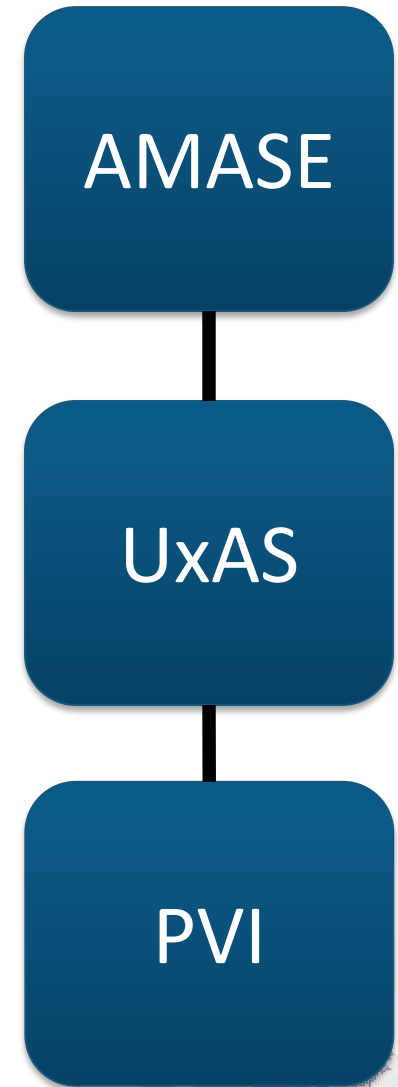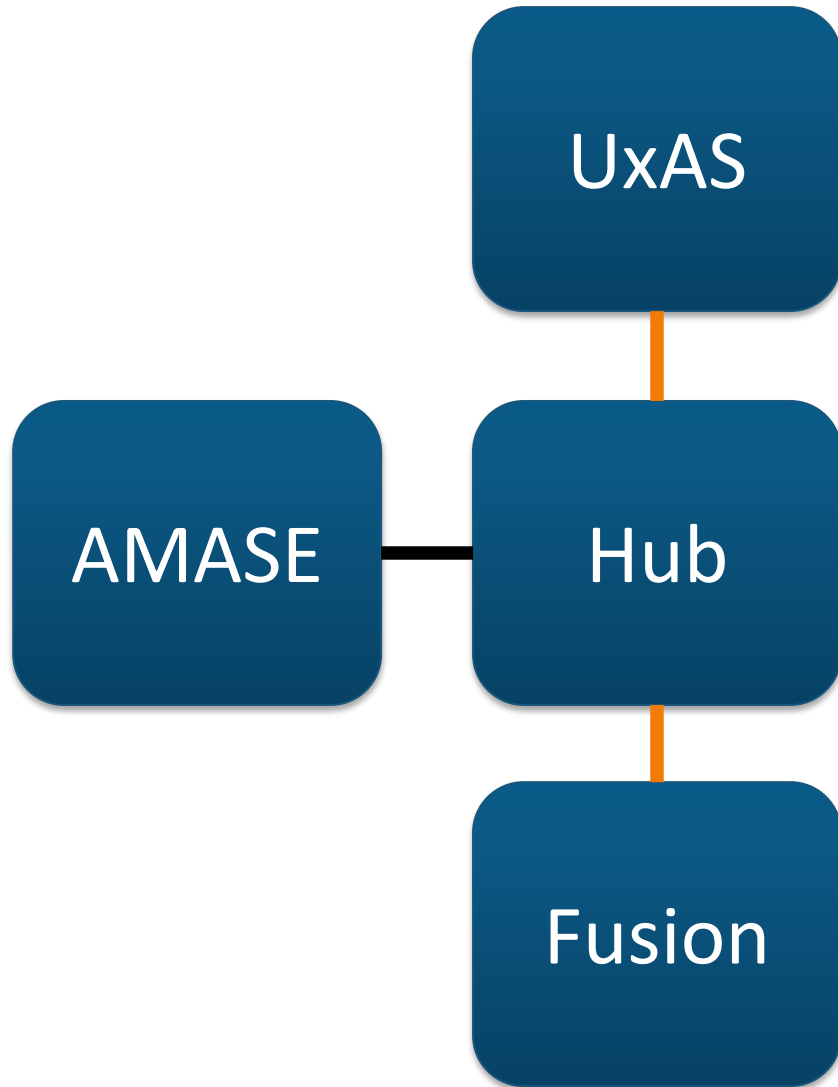# Human Operator Integration: Play Calling

- **Human-autonomy systems to maximize system agility**
- **Human as coach; manage teams of autonomous agents**
- **Tri-Service effort with shared Virtual Lab**
- **Explore increases in agility through:**
  - **Dynamic & adaptive task allocation**
  - **Joint human-automation problem solving**
  - **Task sharing to complete the mission**

Centralized

Centralized

Centralized

```
1   <?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
2 ▼ <UxAS EntityID="100" FormatVersion="1.0" EntityType="None">
3
4       <Service Type="HelloWorld" StringToSend="Hello from #1" SendPeriod_ms="1000"/>
5       <Service Type="HelloWorld" StringToSend="Hello from #2" SendPeriod_ms="5001"/>
6
7   </UxAS>
```
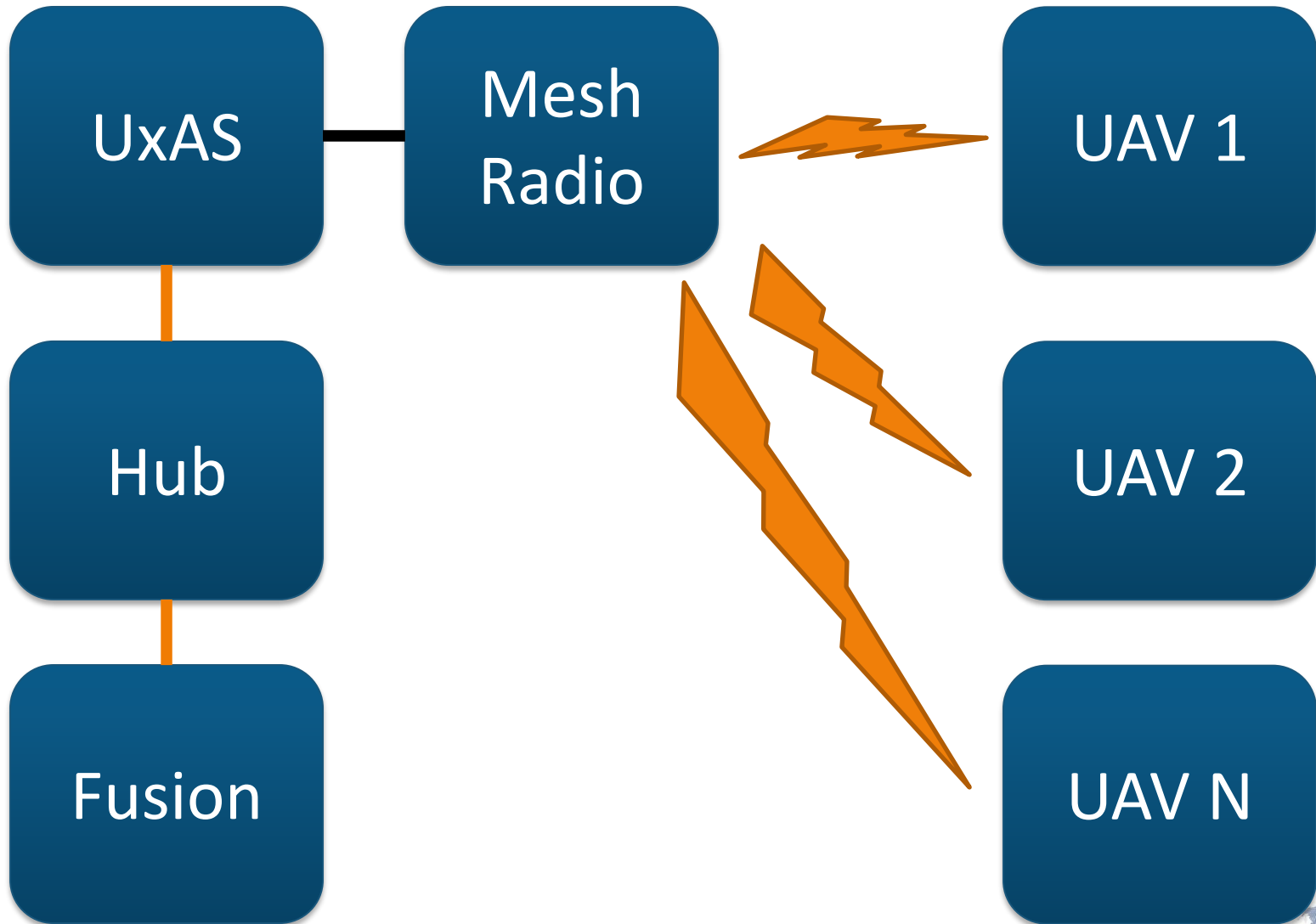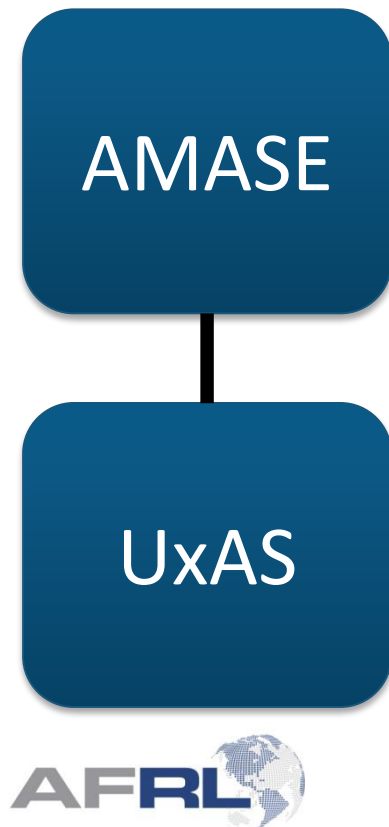
- **Configuration for 'Hello World'**
  - **Two copies of the same service**
  - **Single instance of UxAS**

```
*** RECEIVED:: Received Id[49] Sent Id[48] Message[Hello from #1] ***
*** RECEIVED:: Received Id[48] Sent Id[49] Message[Hello from #2] ***
*** RECEIVED:: Received Id[49] Sent Id[48] Message[Hello from #1] ***
*** RECEIVED:: Received Id[49] Sent Id[48] Message[Hello from #1] ***
*** RECEIVED:: Received Id[49] Sent Id[48] Message[Hello from #1] ***
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*** RECEIVED:: Received Id[49] Sent Id[48] Message[Hello from #1] ***
*** RECEIVED:: Received Id[48] Sent Id[49] Message[Hello from #2] ***
*** RECEIVED:: Received Id[49] Sent Id[48] Message[Hello from #1] ***
*** RECEIVED:: Received Id[49] Sent Id[48] Message[Hello from #1] ***
```

AMASE

UxAS

Centralized

- **Waterways example**
  - **Complete "task assignment pipeline"**
  - **Waypoint manager services for each vehicle**

```xml
<Bridge Type="LmcpObjectNetworkTcpBridge" TcpAddress="tcp://127.0.0.1:5555"
Server="FALSE">
    <SubscribeToMessage MessageType="afrl.cmasi.MissionCommand" />
    <SubscribeToMessage MessageType="afrl.cmasi.LineSearchTask" />
    <SubscribeToMessage MessageType="afrl.cmasi.VehicleActionCommand" />
</Bridge>

<Service Type="TaskManagerService"/>
<Service Type="AutomationRequestValidatorService"/>
<Service Type="RoutePlannerVisibilityService" />
<Service Type="RouteAggregatorService" />
<Service Type="AssignmentTreeBranchBoundService" CostFunction="MINMAX" />
<Service Type="PlanBuilderService"/>
<Service Type="AutomationDiagramDataService"/>

<Service Type="WaypointPlanManagerService" VehicleID="400" />
<Service Type="WaypointPlanManagerService" VehicleID="500" />

<Service Type="MessageLoggerDataService">
    <LogMessage MessageType="uxas" NumberMessagesToSkip="0"/>
    <LogMessage MessageType="afrl" NumberMessagesToSkip="0"/>
</Service>
```

AMASE Connection

Task Assignment Pipeline

Per Vehicle Waypoint

Data Logger

Distributed

- An instance of UxAS runs locally on each vehicle in the system; *assumes a connected network*
- Multiple instances run simultaneously
  - Careful configuration and network setup
  - Can be challenging to properly configure each to be compatible (i.e. changes in one need may need to be carried to the others)
  - Simulation is more complex: each needs to connect to its own simulated vehicle (AMASE supports this through EntityNetworkModule for specific vehicle IDs)
- Distributed examples:
  - Distributed Cooperation
- Research areas: first step toward decentralized

Distributed
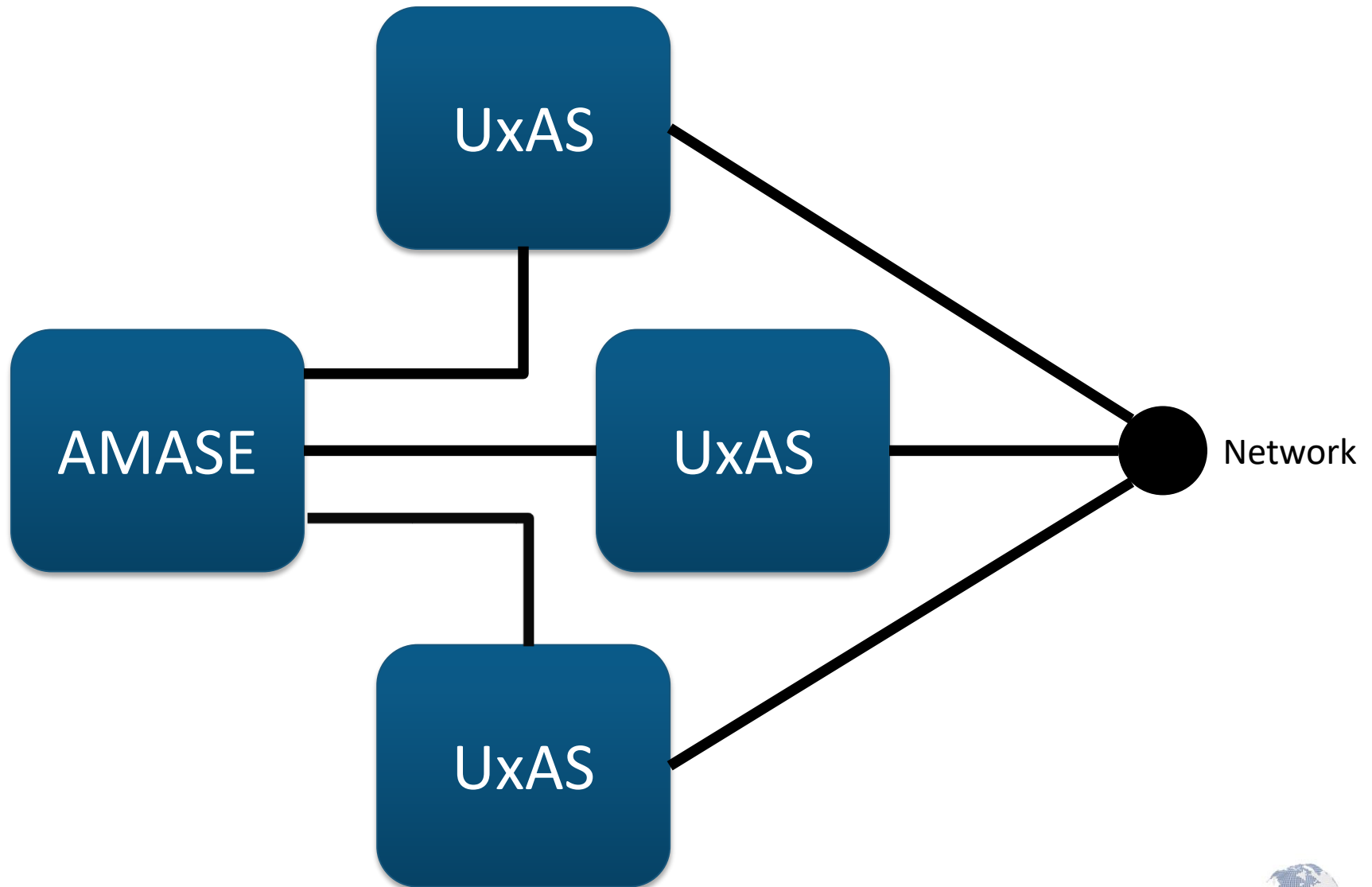
Distributed

- **AMASE: multiple vehicle setup: OpenAMASE/OpenAMASE/config/amase/EntityControl.xml**
  - **Note: an additional vehicle ID will require a specified "single vehicle" connection**

```xml
<Module Class="avtas.amase.entity.modules.EntityNetworkModule">
    <TcpConnection Id="100" Port="9100" />
    <TcpConnection Id="400" Port="9400" />
    <TcpConnection Id="500" Port="9500" />
    <TcpConnection Id="600" Port="9600" />
    <TcpConnection Id="700" Port="9700" />
    <TcpConnection Id="1000" Port="9800" />
    <TcpConnection Id="2000" Port="9900" />
    <TcpConnection Id="4208" Port="4208" />
    <TcpConnection Id="5140" Port="5140" />
    <TcpConnection Id="6050" Port="6050" />
    <TcpConnection Id="6051" Port="6051" />
</Module>
```

Distributed

Connection to UxAS instances on other vehicles (across network)

```xml
<Bridge Type="LmcpObjectNetworkZeroMqZyreBridge" NetworkDevice="en0">
    <SubscribeToExternalMessage MessageType="afrl.cmasi.AirVehicleState"/>
    <SubscribeToExternalMessage
    MessageType="uxas.messages.task.AssignmentCoordination"/>
</Bridge>

<!-- Connect to AMASE on a single vehicle port (see config folder in OpenAMASE) -->
<Bridge Type="LmcpObjectNetworkTcpBridge" TcpAddress="tcp://127.0.0.1:9800"
Server="FALSE" ConsiderSelfGenerated="TRUE">
    <SubscribeToMessage MessageType="afrl.cmasi.MissionCommand" />
    <SubscribeToMessage MessageType="afrl.cmasi.LineSearchTask" />
    <SubscribeToMessage MessageType="afrl.impact.ImpactLineSearchTask" />
    <SubscribeToMessage MessageType="afrl.impact.AngledAreaSearchTask" />
    <SubscribeToMessage MessageType="afrl.cmasi.AreaSearchTask" />
    <SubscribeToMessage MessageType="afrl.cmasi.VehicleActionCommand" />
    <SubscribeToMessage MessageType="afrl.cmasi.KeepInZone" />
    <SubscribeToMessage MessageType="afrl.cmasi.KeepOutZone" />
</Bridge>
```

Connection to AMASE

Distributed

```xml
<Service Type="Test_SimulationTime"/>
<Service Type="TaskManagerService"/>
<Service Type="AutomationRequestValidatorService"/>
<Service Type="SensorManagerService"/>
<Service Type="RouteAggregatorService"/>
<Service Type="RoutePlannerVisibilityService"/>
<Service Type="AssignmentTreeBranchBoundService" CostFunction="MINMAX" />
<Service Type="PlanBuilderService"/>
<Service Type="AutomationDiagramDataService"/>

<Service Type="WaypointPlanManagerService" VehicleID="1000"/>

<Service Type="MessageLoggerDataService">
    <LogMessage MessageType="uxas" NumberMessagesToSkip="0"/>
    <LogMessage MessageType="afrl" NumberMessagesToSkip="0"/>
</Service>
```
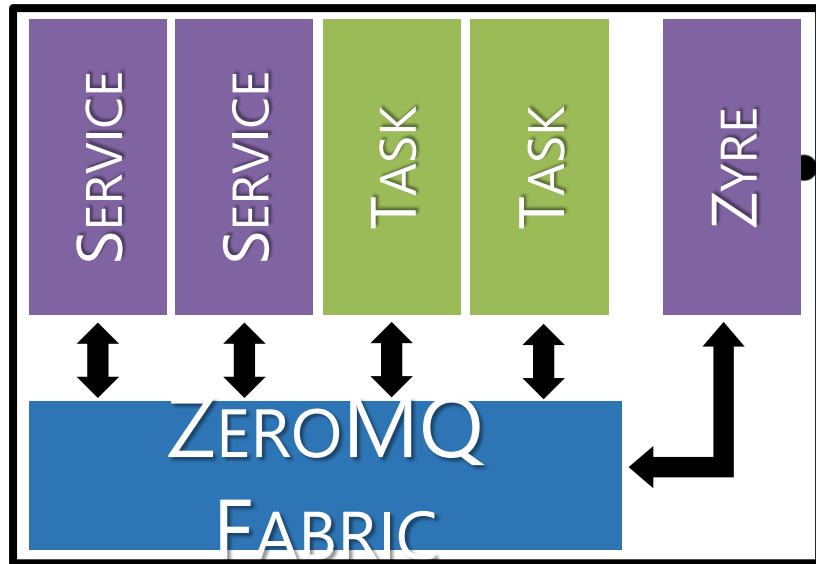
Decentralized

- **An instance of UxAS runs locally on each vehicle in the system;** *vehicles dynamically connect when able; vehicles must be able to operate completely independently*

- **Multiple instances run simultaneously**
  - **Careful configuration and connection setup**
  - **Can be challenging to properly configure each to be compatible (i.e. changes in one need may need to be carried to the others)**
  - **Simulation requires radio simulation (not supported in OpenAMASE)**

- **Decentralized example**
  - **Distributed Cooperation, see use of Zyre for connection**

- **Research areas**
  - **Cooperative control**
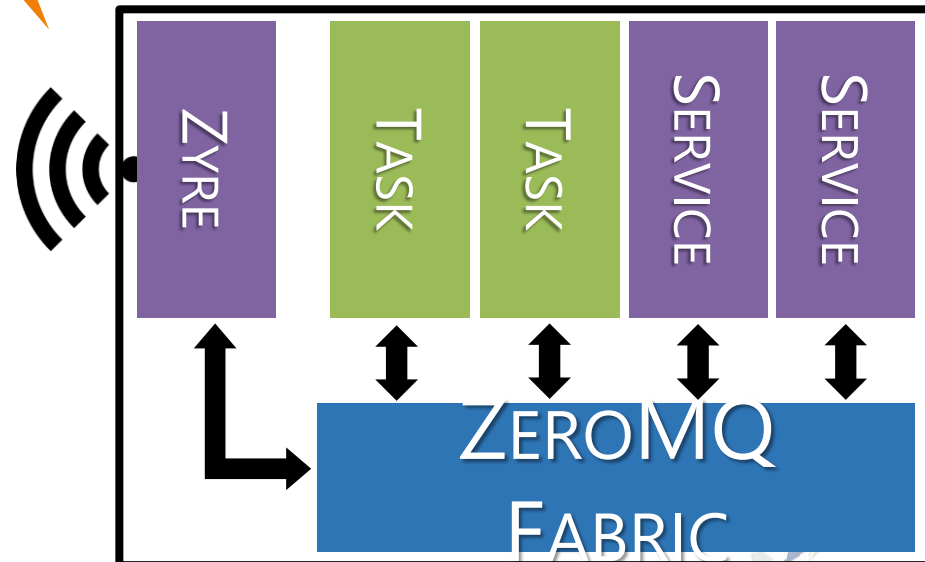
Multi-Vehicle Architecture

UAV 1

SERVICE	SERVICE	TASK	TASK	ZYRE

ZEROMQ FABRIC

Assumed lossy; 'joined' notification is a hint only.

UAV 2

ZYRE	TASK	TASK	SERVICE	SERVICE

ZEROMQ FABRIC

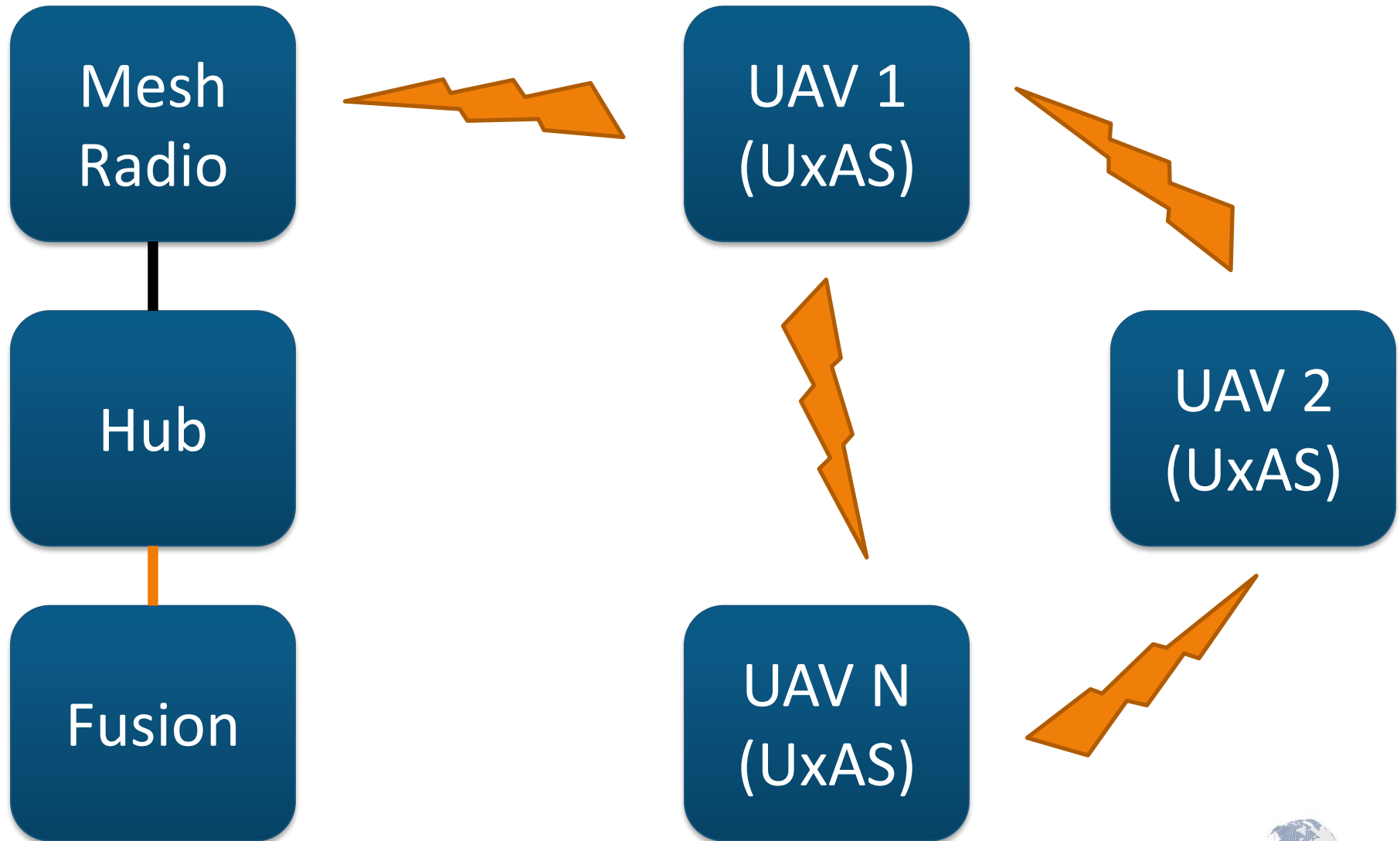Running on same computer or wired network. Assumed msg delivery and ordering.
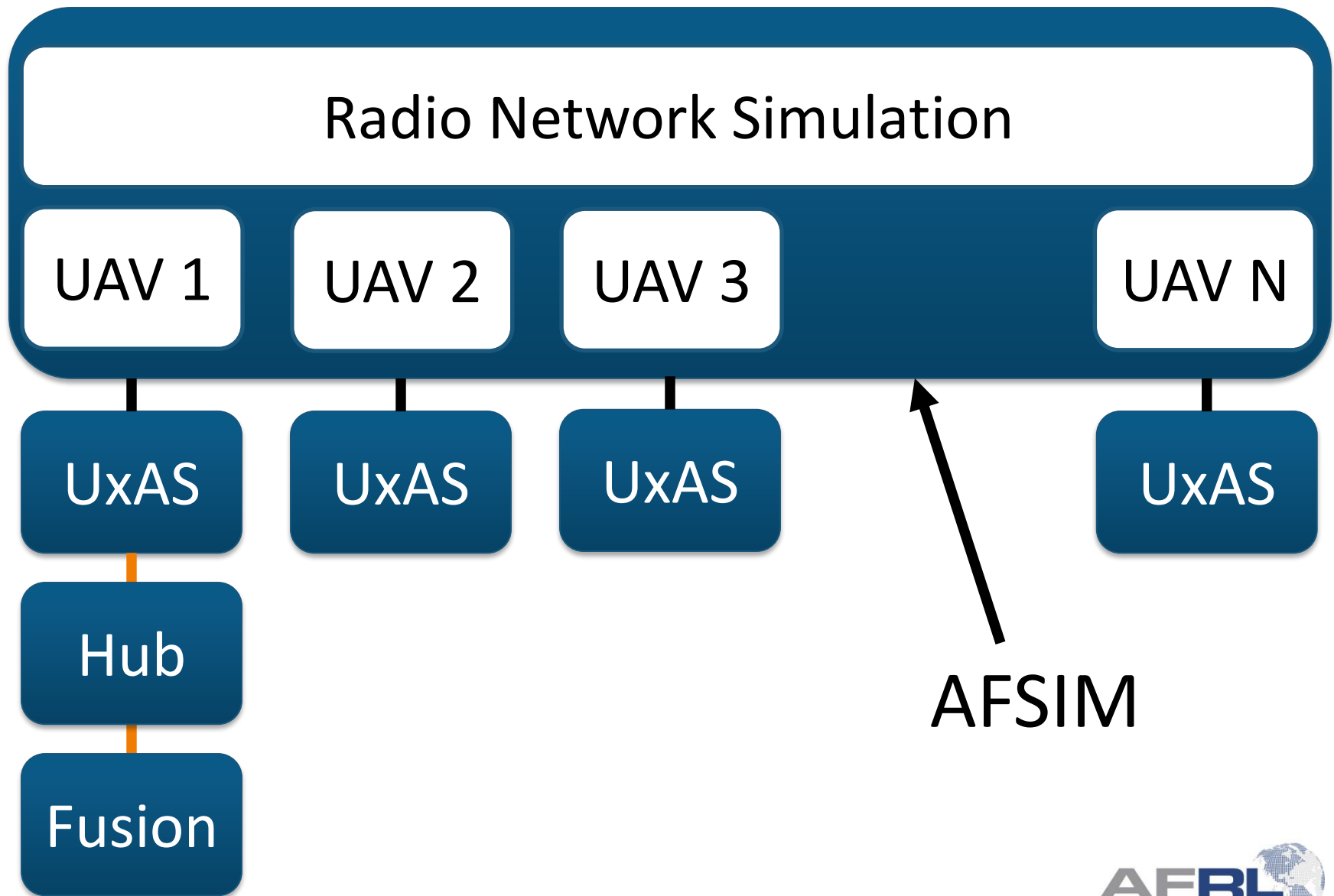
Decentralized

Decentralized

Talisman Sabre 2017

- **Joint US-AUS military training exercise conducted biennially in Australia**

- **Largest combined air, land and sea military training exercise regularly undertaken by the ADF/US forces**

- **Purpose is to improve combat training, readiness and interoperability**

- **Over 28,000 participants**

- **Opportunities for testing and demonstration of technologies relevant to the warfighter (white cell)**
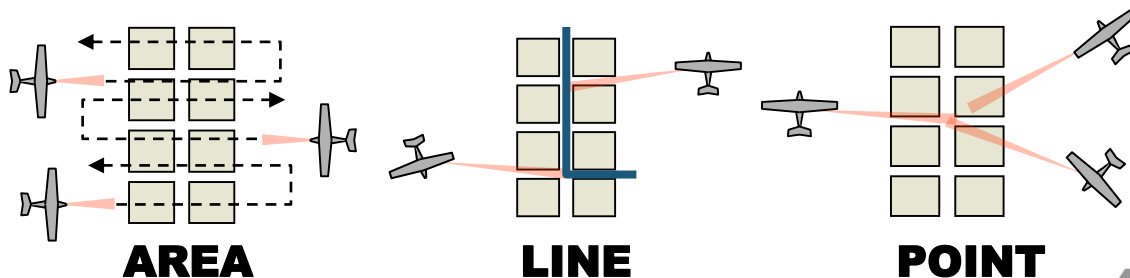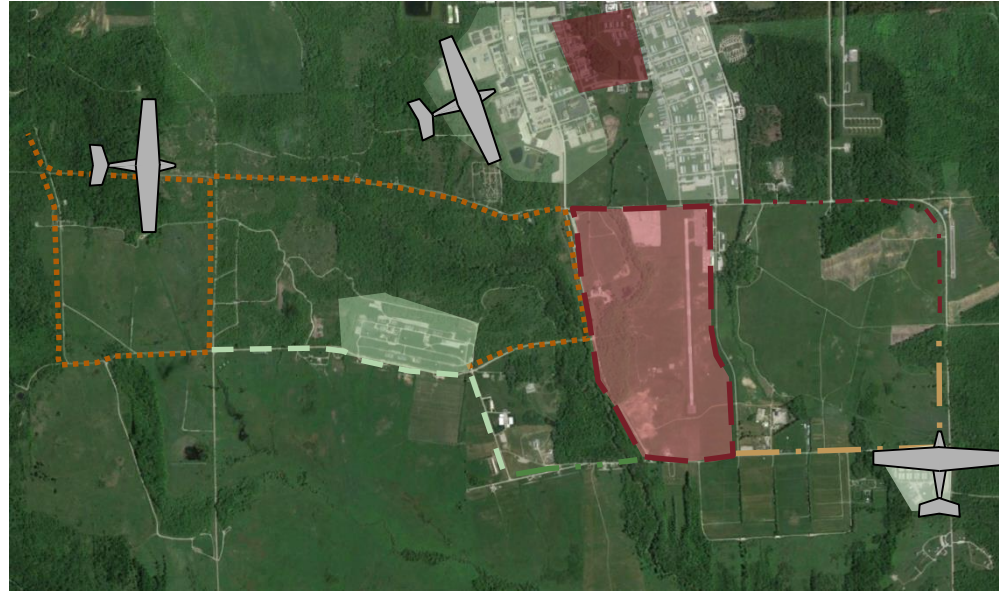
Algorithm Development for TS17: Persistent ISR

- **Collect ISR products using multiple aircraft when tasks are:**
  - **Arbitrary (from known sets)**
  - **Prioritized**
  - **Re-occurring**

  while adhering to ATO and in "near optimal" patterns
- **Deliver collected ISR (video, ground sensor traffic, etc) on demand or when necessary**
- **Tasks utilize database of environmental features to plan (e.g. roads)**
- **Automated interpretation of ISR data (e.g. density maps)**

AREA   **LINE**   **POINT**

Questions?