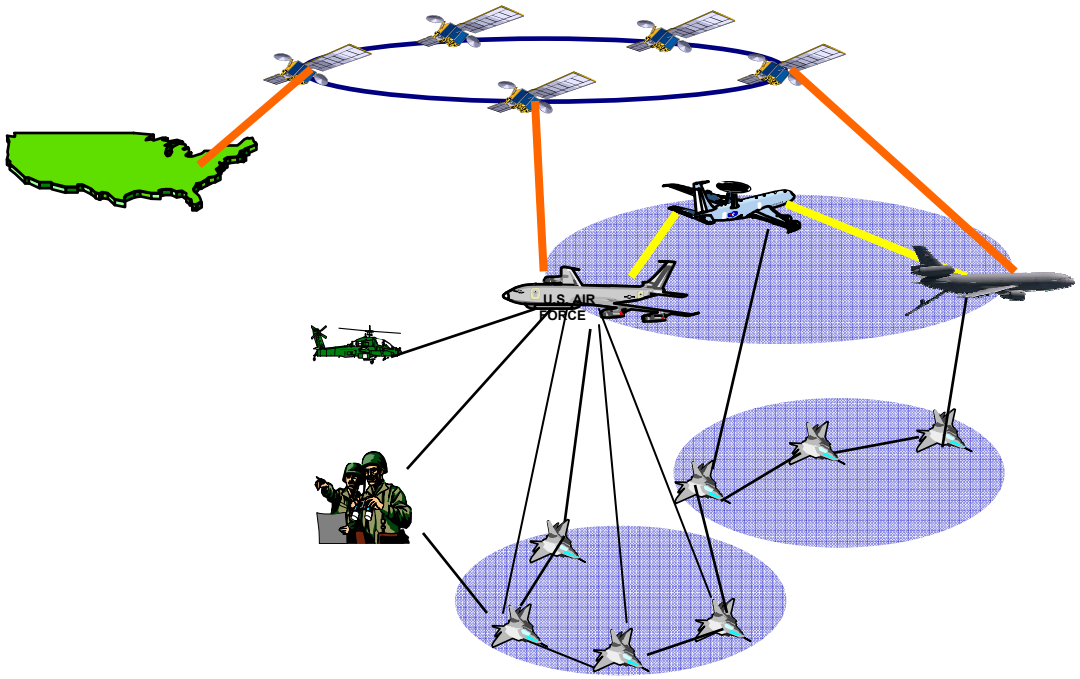
Integrity - Service - Excellence



Airborne Networking

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Purpose

- **Describe the context in which an Airborne Network will operate**
  - **Operational requirements span a huge range**
  - **Technical communications challenges are daunting**
- **Initiate a dialog on the impact of using XML in an Airborne Network**
  - **Network performance and transition issues are likely to constrain use of XML in the air**

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Overview

- Airborne Operations and Network Traffic Characteristics
- Airborne Network Architecture
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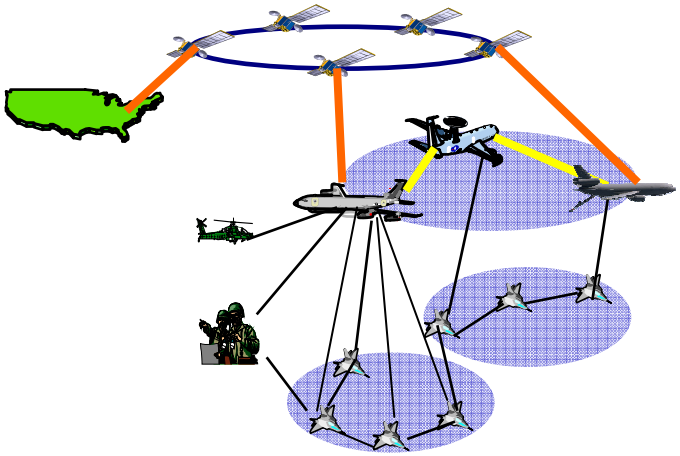
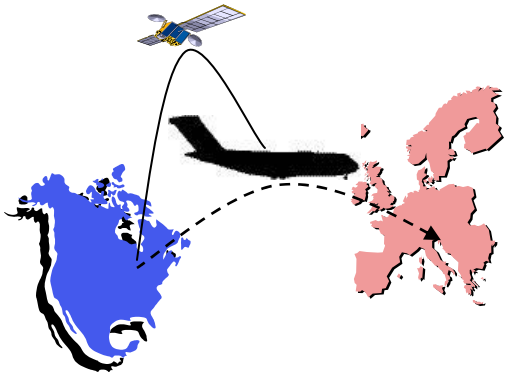
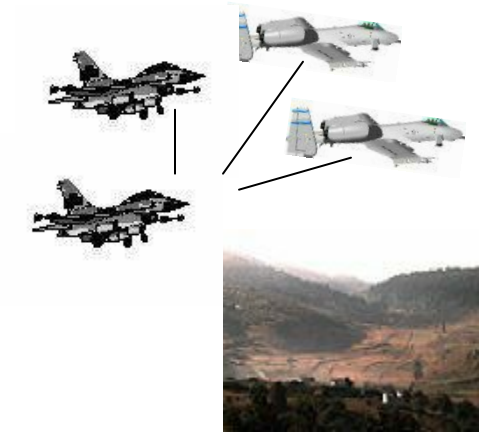
Airborne Operations and Network Traffic Characteristics

Airborne Mission Profiles







Command & Control (C2) Constellation Configuration

- Global Strike Task Force in Persistence Phase
- Theater Mission
- Line of Sight of Many Nodes

En-Route Configuration

- Airlift En-Route to Theater
- B-2 En-Route to Theater
- Global Mission
- Beyond Line of Sight of Surface Nodes

Strike Package Configuration

- Global Strike Task Force in Kick-Down-Door Phase
- Fighters, Attack, Bombers, Munitions
- Beyond Line of Sight of C2 Assets

Airborne Operations and Network Traffic Characteristics

Representative AN Traffic

Traffic Type	Information Unit Size or Type	Delivery Latency	Delivery Assurance	Range of Transmission	Examples
Low-latency Line of Sight	Very compact bit-oriented messages, e.g., <800bits	<100 msec	>99.9%	<300 nmi	Time-critical targeting, machine-to-machine tip-offs, UAV control
Command & Control	Bit-oriented messages and text messages	<1sec	>99.9%	<1000 nmi	Force Orders, Receipt/ compliance messages
Situational Awareness	Large bit-oriented messages, e.g., >65 Kbits	<1 sec	>99%	Mostly <1000 nmi, but can be routed beyond the AN	Continuous flow of moving target indicators, Blue Force Tracking information
Tactical Video, Voice, Imagery	Continuous or interrupted stream	<500 msec voice, <2 sec video and imagery	>95%	From anywhere to anywhere	Pre-strike imagery, surveillance video, tactical voice
Non-time-critical	Files, messages,	seconds	>95%	From anywhere to anywhere	Data base/library queries, file transfers, routine messaging, web services

Airborne Traffic Profile is Changing

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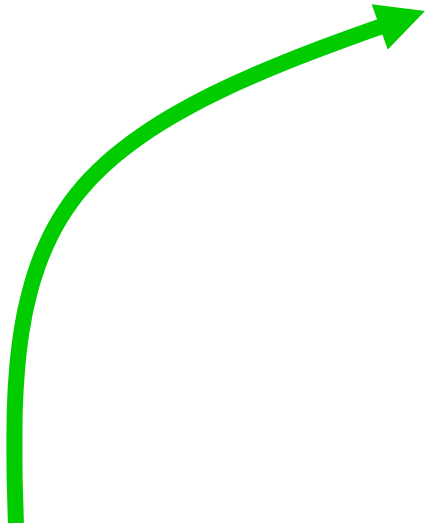

Future – Machine-to-machine

- Moving target updates to en-route weapon
- Pre-strike imagery returned from a weapon
- Sensor fusion data
- C2 collaboration data
- More ISR products
- Joint Unmanned Combat Aerial Vehicle (JUCAV) control
- Reachback queries for specific information

Now – Sensor-to-display

- Fixed target locations
- Moving target tracks
- Air and surface situational awareness data
- Target identification
- Radar data
- Voice

Airborne Network Platform Types


Command and Control


Intelligence, Surveillance, Reconnaissance


Logistics (Tankers, Airlift)


Strategic (Bombers)


Tactical Edge (Fighters, Attack)


Weapons (Dispensers, Munitions)

Airborne Connectivity is Changing

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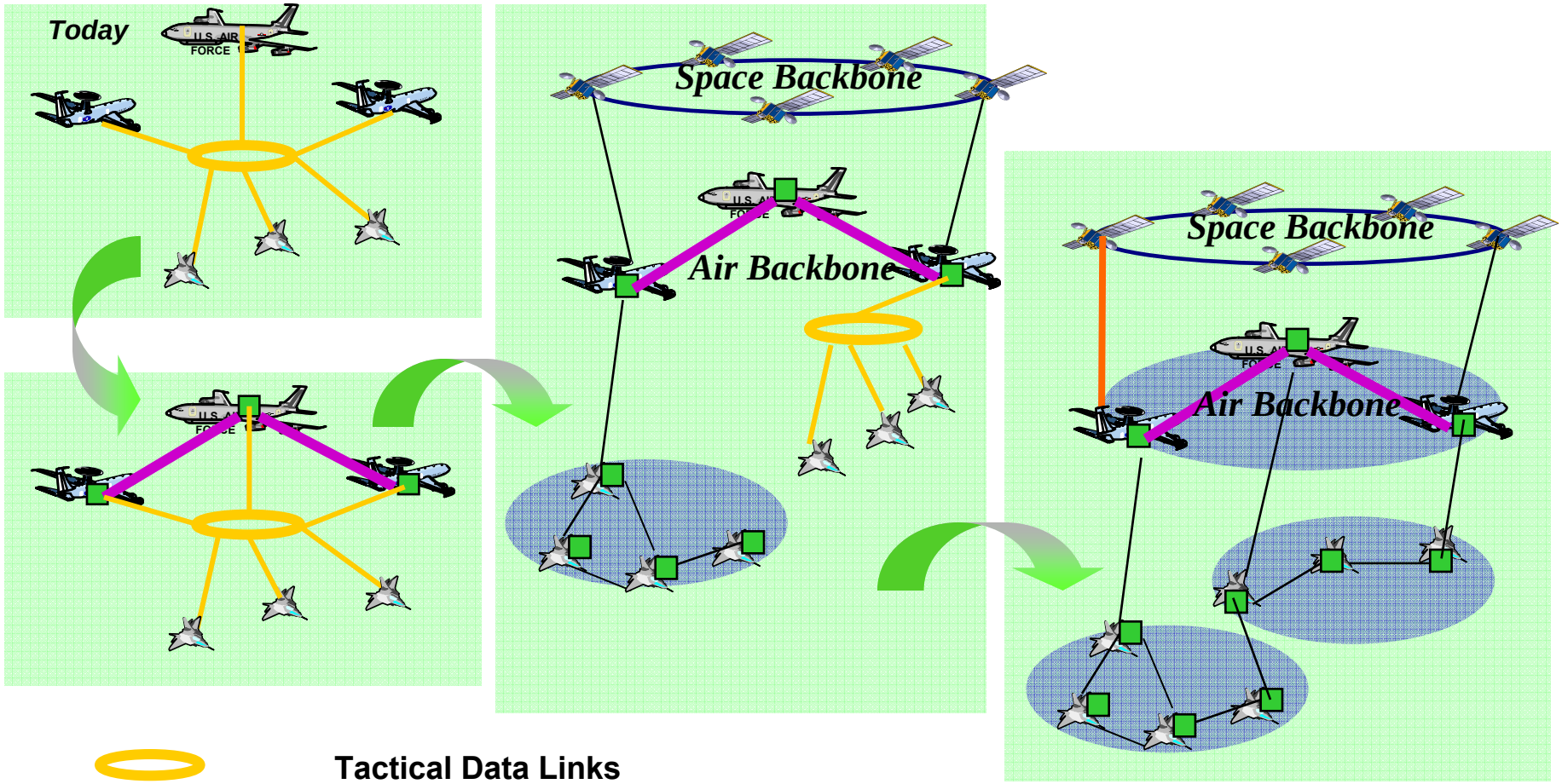

Tactical Data Links

Wideband air-air links

Ad-hoc networks using Joint Tactical Radio System (JTRS) Networking Services

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Broad range of technical requirements

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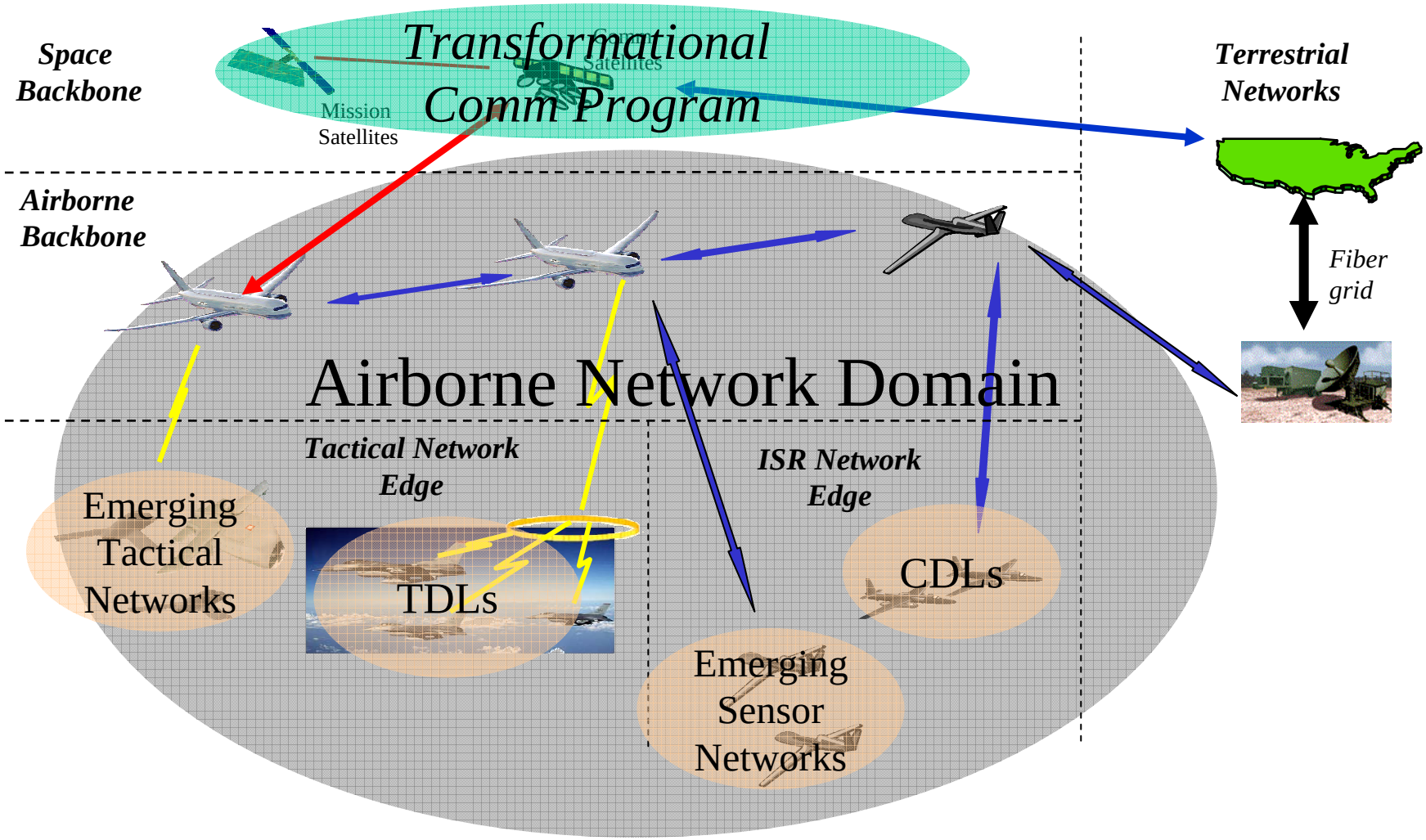
- **Network structure**
  - Self-forming, self-organizing, self-healing
  - Fast formation and organization - join, leave, reorganize quickly
- **Information Transport Performance**
  - Very short transport latency to normal latencies to best effort
  - Assured delivery of information – delivered correctly within expected time period
- **Special case - receive-only mode platforms**
- **Intra-network range**
  - Line-of-sight as well as beyond-line-of-sight intra-networking
- **Integration with the Global Information Grid (GIG)**
  - AN will provide airborne connectivity for USAF's ConstellationNet, Army's LandWarNet, and Navy's ForceNet
  - Requests for information can spawn reachback connection to other parts of the GIG
  - GIG mandates (i.e., IP, XML) apply to the AN

Airborne Objective Architecture



Implementing the AN on platforms

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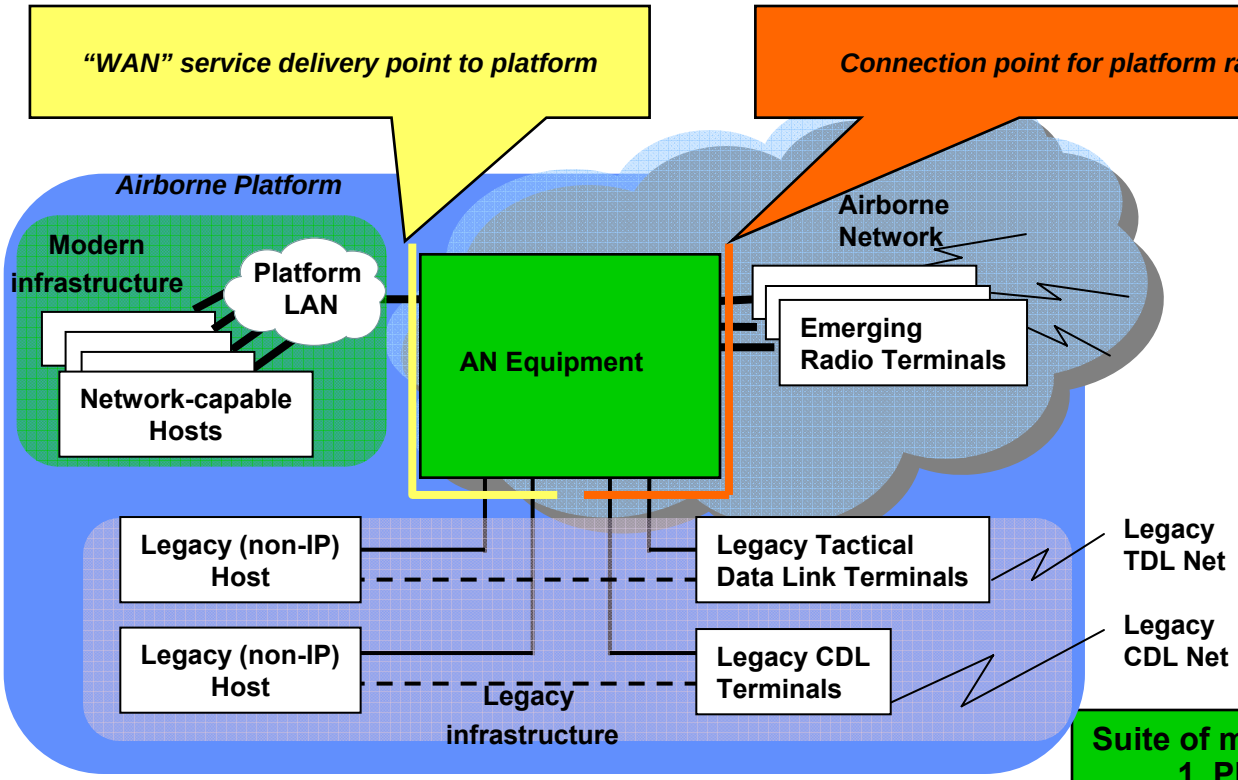

Suite of mission-selectable functions:

1. Platform Host Interface to the AN
2. Off-board Routing
3. Transit Routing
4. Legacy Data Link Interface to the AN
5. Security
6. Network Management
7. Link Management
8. Network Services

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Considerations in Architecting the AN

- **Expanded range of networking requirements**
  - **Concurrent line-of-sight and internetwork operational modes**
  - **Very low latency to best-effort latency**
  - **Assured delivery to best-effort delivery**
- **Cannot assume any connectivity exists to terrestrial systems**
- **AN will evolve over many years**
  - **Impact of legacy architectures**
    - **Legacy tactical data links designed for stovepipe use**
    - **Tactical data link communications channel is very aware of the information going through it**
  - **Impact on platforms**
    - **Computer, and other application changes**
    - **Radio changes**
  - **Mix of Service and coalition partners who are themselves evolving**

Invalidating Common Assumptions

- **Platforms must carry the AN infrastructure**
  - All routing nodes
  - Most (maybe all) network management, information assurance, DNSs and info directories
- **Use of less than perfect communications channels, e.g., compare**
  - Terrestrial Common Carrier
    - Very low error rate, relatively few outages, bidirectional, infinite bandwidth
  - Airborne Radio
    - High error rates, fading, susceptibility to jamming and unintentional interference
    - Intermittent link performance due to platform blockage of radiated signals
    - Links may be unidirectional
    - Limited electromagnetic spectrum in a region
- **Subscribers and infrastructure are in motion**
  - Platforms frequently joining and leaving
  - Network topology changes – frequent link closures, breaks, new end points
  - Routing
  - Addressing issues
  - Impact on scalability
    - Consequences of changes take time to propagate and incur overhead

Potential Opportunities

- **Content-based routing**
  - Reduces use of network through selective information dissemination
- **QoS**
  - Admission control restricts traffic during peak periods
  - Precedence-based forwarding to achieve latency goals
- **Policy-based Network Management**
  - Dynamically and quickly changes how network resources are applied as missions change
- **Multicasting**
  - Transmissions branching out over the network fabric to members of community of interest groups
- **Data link layer broadcasting**
  - Single transmission reaches all line-of-sight recipients

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Performance Issues

- **Predictability of the AN's communication transport services will be low at first, but can be expected to improve**
  - **What assumptions does use of XML make on the performance of communication transport services?**
- **Bandwidth constraints**
  - **Can XML compression maintain current message sizes?**
- **Perishable traffic in corrupted and dropped packets will not be retransmitted**
  - **Would XML require a current 1 packet message to expand to 2 or more packets, where the loss of either one makes the other unusable?**
  - **How can interdependence between content of sequential packets be minimized?**
- **Links will be made and broken frequently with network layer alt routing mitigating some of the effects, but not all**
  - **What is the impact on transport of XML-formatted information?**

Transition Issues

- **Long transition time to achieving the AN**
  - **Think decades!!**
  - **Thousands of operational platforms → significant acquisition and integration costs will slow transition**
- **Continued use of stovepiped data links**
  - **Communication functions tightly coupled to message format and even to the message content**
  - **Not candidates for transmission of XML-formatted information**
- **Interoperation with legacy airborne applications**
  - **Use of translating gateways not advised within tactical edge networks due to added latency**
  - **Transmitting multiple copies wastes scarce bandwidth**
  - **Intermediate solutions such as the Common Link Integration Processing (CLIP) software may help**

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Summary

- **The Airborne Network will operate in an extremely challenging communications environment**
  - **Link performance – high error rates, bandwidth constraints, instability**
  - **Increased overhead impacts due to mobility of its subscribers and infrastructure**
- **The Airborne Network must satisfy a wide range of operational requirements**
  - **Assured delivery with extremely low latency to best-effort delivery in many seconds**
  - **Very small compact messages to video streams**

Network performance and transition issues are likely to constrain the use of XML in the airborne domain