Global Grid for Large C^2/ISR Aircraft with Joint STARS Example*

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ABSTRACT

As an aid in describing the Air Force Global Grid and how it can be integrated into present and future systems the MITRE Corporation Global Grid Project has undertaken studies of various projects/systems/platforms, as they would be impacted by the Global Grid. In this paper the author reviews the basic Global Grid Tenets, extends them to C^2/ISR airborne platforms and applies them to Joint STARS showing how Joint STARS can evolve to the Global Grid.

BACKGROUND

With the exception of voice radios and some communications utilities, e.g. AFNET, the U.S. Air Force has not in the past procured communications systems. Rather, it procures information delivery systems. That is, systems designed to pass information between users, which in part include communications. For example, Link 16 is designed to convey information among tactical users in the battle theater; Sacdin was designed to connect Strategic Air Command Headquarters processors to processors at the bomber bases and in the missile fields; and US Space Command has a system to connect sensors to it's command center at Cheyenne, Mountain, CO.

Each of these systems and many others were designed independently to serve their mission. If the mission required an interface to another mission it was designed in, if there was no requirement it was not. This led to a large number of Air Force systems each designed to satisfy the requirements of it's own mission. Each system has, internal to it, the communications that it needs. These communications only interoperate where there was a defined mission interface. A depiction of the collected system is shown in figure 1.

These systems are commonly called stove-pipes. They are systems that were designed separately with little or no consideration for interoperation.

Figure 1. Today's Reality – Mission Specific, "Stove-pipe" Communications

As the world has grown smaller, the types of information have expanded and the needs for the Air Force elements to intercommunicate have grown it has become evident that needs exist beyond the old requirements. Information must be passed between systems and operators of different systems. This has led to a US Air Force conclusion that it needs a global communications system, called the Global Grid, which provides communications to all and serves the needs of all, maximizing the potential for interoperations without requiring users to identify their interoperation requirements in advance.

The MITRE Corporation is working in support of the Air Force Electronic Systems Center to define and describe the needed technology of the Global Grid and to demonstrate to various users how they can gain advantage from use of the Global Grid. Figure 2 is a depiction of the Global Grid. The vertical and horizontal bars are meant to indicate that every user, plane, command center which can communicate with the Global Grid can

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communicate with every other user. For example, ground terminals might intercommunicate via Ethernet as is common with today's Internet. An aircraft can communicate to a ground entry point, hence the network, hence any other aircraft. The aircraft would have a network-centric radio and by communicating through the ground network could have his messages passed to any ground station or any other aircraft via uplink from a ground entry point. Communications via satellite can be handled in the same way.

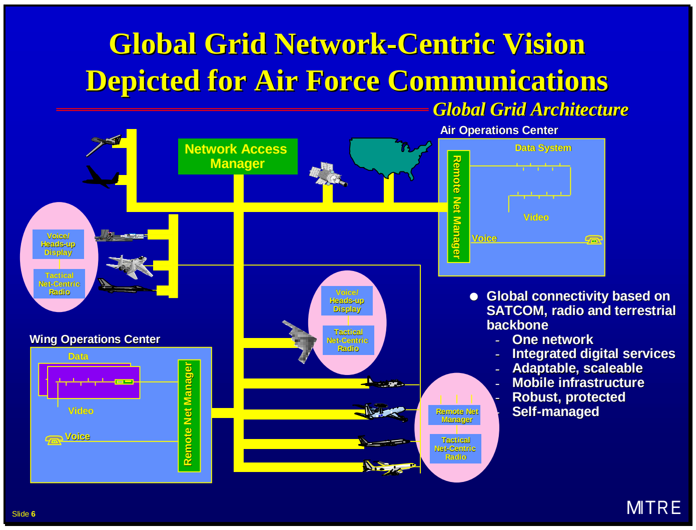

Figure 2. Global Grid Network-Centric Vision Depicted for Air Force Communications

This means that if any aircraft wanted to connect to any other aircraft and the connection were via the network the aircraft would only need a single network-centric radio and that radio would not have to be the same type as the radio on the destination aircraft. Via the network, voice, data, and imagery could be distributed.

Potential byproducts of Global Grid interconnectivity with operational impact are: 1) The more timely distribution of critical sensor information to additional war fighters and battlefield commanders; 2) The provision of common communication services that need not be generated separately by each application; 3) More robust communication links against all jamming and spoofing threats; 4) Improved survivability e.g., if network nodes are destroyed or disappear, the network is likely to recover by finding alternative communication paths; and 5) The possibility for distributed data processing to provide commanders with only the information they need.

TENETS of the GLOBAL GRID

The first tenet of the Global Grid is network-centricity. By that, we mean a global network of networks connecting all centers and platforms with common Internet protocol (IP), where each user has a unique address. All information, e.g., voice, messaging, video, imagery, and graphics applications, is transported as digital data. The network is extensible. That is, it is scalable so users can be added without bound like the internet; re-configurable to meet changing missions and war-fighting conditions, and evolutionary to enable rapid technology insertion. Second, there is as much capacity as can be afforded. The network is affordability-driven, not requirements-driven. Networks and communication links adapt to capacities available. Protected communications are provided and include integrated security and information assurance, and jam-resistant, anti-spoof, low-probability-of-intercept links, as necessary. Communications and networking support to mobile nodes and hosts provides improved capabilities for spacecraft, aircraft and ground vehicles. Suitable mobile routing protocols for timely and reliable communications under rapidly changing network topologies are also provided. Finally control is autonomously configured and managed and there is a reduction in the level of required human intervention and numbers of trained network operators.

THE C^2/ISR AIRCRAFT

The C^2/ISR (command and control/information, surveillance and reconnaissance) aircraft is a large aircraft like an AWACS, Joint STARS, Rivet Joint, etc., as opposed to a small one or two seat aircraft. It is distinguished by separate flight crew and staff work areas and by a more benign environment in the work area allowing for the installation of ground type equipment. As opposed to the smaller aircraft the availability of power, space, and weight carrying capacity is greater. There also exists within the Air Force ground based C^2/ISR nodes. The aircraft nodes are like an "office in the sky". Similarly any airborne battle staff member that is connected to the network via a workstation should experience the same network services as a ground-based counterpart. Any form of incoming communications directed to other users can be routed onward. Users within the aircraft should be interconnected by a single on-board network with a common network protocol. Large military aircraft should also take advantage of Global Air Traffic Management (GATM) and passenger communication technology being developed for civil aviation.

Joint STARS

The Joint STARS is an example of a C^2/ISR aircraft. We shall for the sake of discussion divide it into two compartments, the flight deck and the mission crew. The mission crew should be connected to the Global Grid. The flight deck may need access to the Global Grid but also needs access to commercial air traffic control communications. It is important that mission traffic and air control traffic be separated.

How will the Joint STARS benefit from evolving to Global Grid? There are operational and infrastructure advantages.

OPERATIONAL

- Vastly more adaptive network architecture for changes in
  - Threats
  - Missions
  - Performance
- Easier insertion of new technologies
- Connected to the network
  - More customers for Joint STARS products
  - More sources of combat information

INFRASTRUCTURE

- More efficient use of scarce resources (wireless bandwidth)
  - Eventual reduction in number of distinct communications components onboard
- Evolution away from stove-pipes toward network centricity
- Possibilities for
  - Hybrid CDMA/TDMA networks
- Queuing network radios to ease onboard cosite problems associated with many separate radio systems

Operationally, the fundamental benefit of the Global Grid is the enhanced connectivity among war fighters and decision makers that can lead to the significantly greater availability of situational awareness information. This will help respond to a trend towards distributed C^2, where more users need the basic data to make decisions. In addition, communications needs of new or improved missions that would be essentially impossible, or at least impractical, with today's communications systems, may be satisfied by the Global Grid. Options are needed to satisfy new or improved missions. One possibility is to develop a new higher capacity data link, perhaps an addition to the Common Data Link (CDL) family. Alternatively, from the infrastructure point of view, the Global Grid offers the possibility of sharing several network-centric data links dynamically to ease the communications workload of a single data link that might experience performance difficulties because of interference conditions. The Global Grid data links could be designed to be adaptive in real-time to utilize the available bandwidth more efficiently. With all radios designed to interface with a common network, fewer radios would be required compared to the present situation, where a separate radio system is needed to communicate with each set of users. The fewer number of radios, and the automatic management of the most effective employment of those radios, including the dynamic queuing of transmissions over the various antennas, should also ease the onboard cosite problem. Figure 3 shows the connectivity of the Joint STARS Block 20 aircraft.

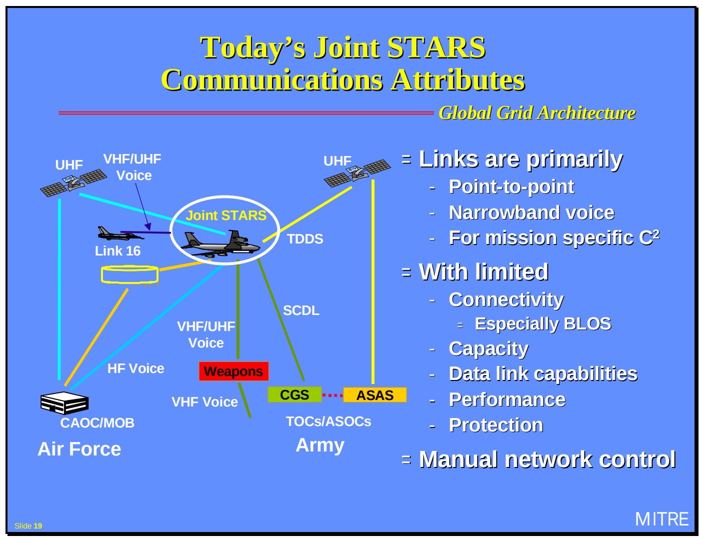

Figure 3. Today's Joint STARS Communications Attributes

If Joint STARS needs to communicate with another set of users, and they use a different radio from those already aboard Joint STARS, a new radio system would need to be added to the Joint STARS platform. Currently, Joint STARS has 22 radios (or SATCOM terminals). Most of these radio systems are only capable of analog voice. Joint STARS employs two data links, the Link 16 system used for tactical C^2, and the Surveillance and Control Data Link (SCDL) for communicating with the Army's Common Ground Station (CGS).

The busses and data links an Joint STARS Block 20 are identified as follows.

- E8C data/voice bus structure
    - Two data busses
        - JTIDS data (MIL-STD-1553)
            - Data I/O to bus from/to JTIDS processor to/from Link 16 Terminal
        - Digital data (MIL-STD-1553)
            - Data I/O to bus from/to SCDL processor to/from radio equipment
    - One digital audio bus
        - Voice to the input/output to voice radios (military C^2 and flight deck) is placed on this bus
- Other busses
    - Radar subsystem bus
    - Flight management bus
    - SCSI (small computer systems interface) bus
    - OWS (workstation to computer) LAN
    - RASP (Radar Airport Signal Processor) LAN
- Data/Voice links
    - (1) Link 16 data system (plus 1 spare)
    - (1) SCDL
    - (2) UHF SATCOM data and voice
    - (2) Constant Source data, receive only
    - (17) Voice Links
        - (12) UHF/AJ,
        - (3) VHF AM/FM,
        - (2) HF

Figure 4 depicts Joint STARS connectivity once it is integrated into the Global Grid.

By adopting a network-centric communications architecture with a common network protocol, Joint STARS becomes a node of the Global Grid network. This Global Grid network is shown as an amorphous “cloud” that is intended to impinge on all the links shown. From the point of view of a Joint STARS aircraft, the external network looks homogeneous in the sense that communication can be conducted with any other node of the network.

In addition to greater connectivity, a network-centric Joint STARS will have greater capacity, in part through the more efficient use of on board communications resources. Larger bandwidth pipes, e.g., associated with commercial SATCOM may be available for certain applications.

We can contrast Joint STARS’ Block 20 with the Global Grid Objectives by recognizing that:

- Joint STARS’ Block 20
    - Has multiple, separate local area networks (LANs) for voice, data, radar, processors, etc., and separate radios for different data links
    - Under the current architecture, if a new communication system with which to interface is identified, and that system employs a particular radio, then Joint STARS must employ that same radio
- Under the Global Grid
    - The network provides connectivity
        - There is no need for separate radios for each communication system
    - With voice over IP there is no need for multiple voice radios
    - The benefits of migrating towards the Global Grid include
        - Enhanced support for the ground moving target indicator (GMTI) multi-mission, system-of-systems concept
        - Increased connectivity between information sources and sinks over a greater variety of communication paths, and a reduction in specialized onboard communication assets

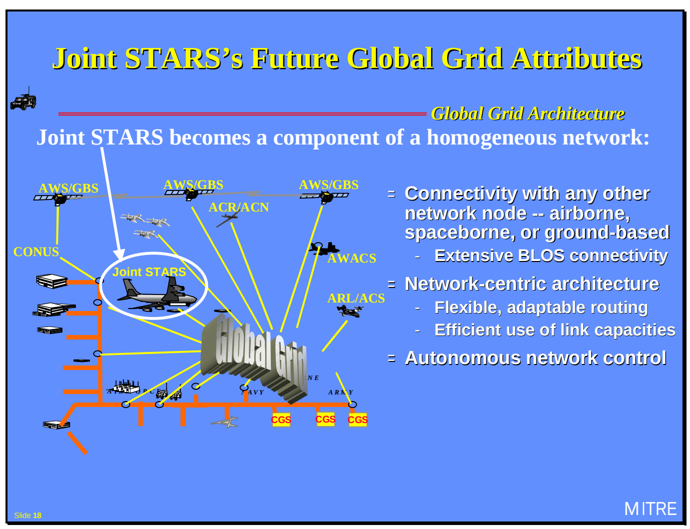

Figure 4. Joint STARS’s Future Global Grid Attributes

RECOMMENDATION

Short term and long term modifications to Joint STARS can be identified. In the short term Joint STARS can evolve toward a single, onboard communications network that functions like the terrestrial internet, transition to an IP LAN to serve as the backbone communications bus treating all information as data-centric, e.g., adopting voice over IP, make this aircraft LAN part of Global Grid network, connect all information appliances to this LAN, upgrade and supplant the existing data and voice busses by this LAN, and transition to a server/switch/router combination with distributed and automatic network management. Gateways can be included in the transition strategy to connect to existing systems like Link 16; Network appliqué's can be added to UHF/VHF voice radios. In the short run a network terminal can be placed on the flight deck without interconnecting air traffic control communications to the Global Grid. The Air Mobility Command (AMC) is seeking ways to take advantage of the communication capabilities of Global Air Traffic Management (GATM) avionics that are being installed on transport aircraft to become compliant with worldwide civil aviation standards. AMC would like to use the GATM data link for C^2 applications to keep track of its aircraft and cargo. Civilian airlines do this now with the Aeronautical Operational Control (AOC) data links. In the military, of course, one must be concerned about message security and not interfering with the Air Traffic Control (ATC) system. Once these are demonstrated, the cockpit can be fully connected to the Global Grid. Figure 5 is a depiction summarizing these short-term recommendations.

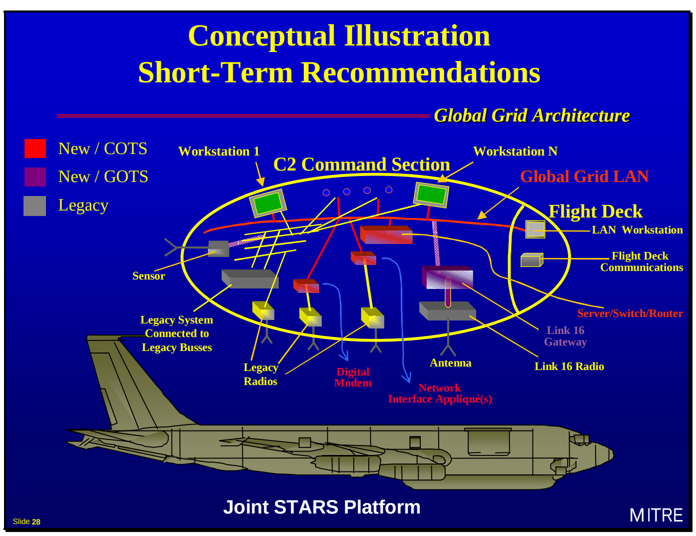

Figure 5. Conceptual Illustration Short-Term Recommendations

The basic additions are a LAN compatible with the Global Grid and an associated server/switch/router. Legacy systems and busses are still present, although interface appliqué(s) and/or devices are introduced to accommodate the connection of legacy radios to the LAN. In addition, a Link 16 gateway is shown. Note that a LAN workstation has been added to the cockpit or flight deck suite of equipment that already includes communications avionics. This may be a little presumptuous because putting things into the flight deck is primarily the domain of civil aviation authorities and commercial vendors.

Long term recommendations are to connect all* information appliances and wireless communications devices to the LAN, sensors and processors (workstations) connect directly, procure** new radios and data terminals as, network-centric capable, network efficient, network controllable and configurable (automated), using nonproprietary, standardized interfaces. Figure 6 is a depiction of the long-term recommendations

The main observation is that now there is only one onboard network. By now, legacy systems and busses are gone. Note that an appliqué may still be present to interface any radios that are not yet network-centric. In this pictorial, the somewhat optimistic assumption has been made implicitly that Link 16 has become network-centric.

Also, note that flight deck communications have been connected to the LAN. This implies that security and safety of flight concerns have been solved.

In addition, radio control functions have collapsed from a control head for each legacy radio to converged control through the LAN. The same trend has occurred implicitly for displays, glass cockpit features, etc.

NEEDED TECHNOLOGIES

All of the technologies that are needed to achieve the Global Grid and to convey to Joint STARS the advantages of it are not here today. Figure 7a and 7b present a list of these technologies and indicate where we are in the timeline to achieving them.

* Caveat: In some cases, this may not be possible because critical timelines or other performance criteria would not be met.

** As current equipment becomes obsolete and funds permit

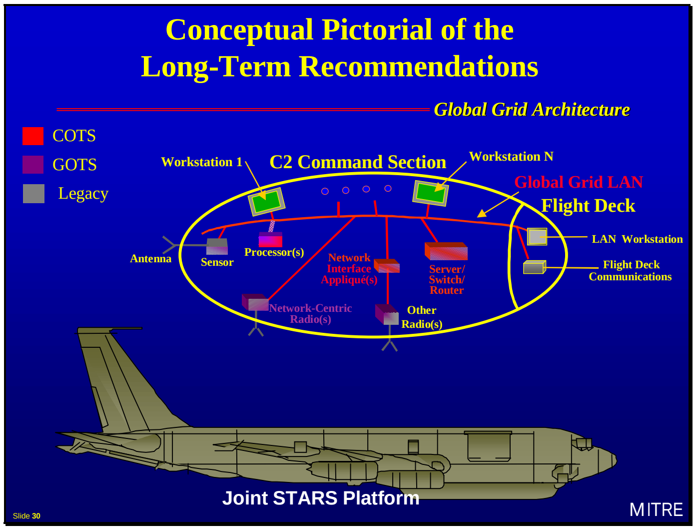

Figure 6. Conceptual Pictorial of the Long-Term Recommendations

Many of these areas such as dynamic protocols, mobile routing and network management are being researched only in the university environment with no input from potential users. A recent series of e-mails in the Internet Engineering Task Force (IETF) showed that researchers were leaning toward flood routing because it eventually delivers all messages. These researchers are not interested in bandwidth efficiency or speed of message delivery.

Unless the users get involved in sponsoring research, it is not clear that the technology will be there when it is needed.

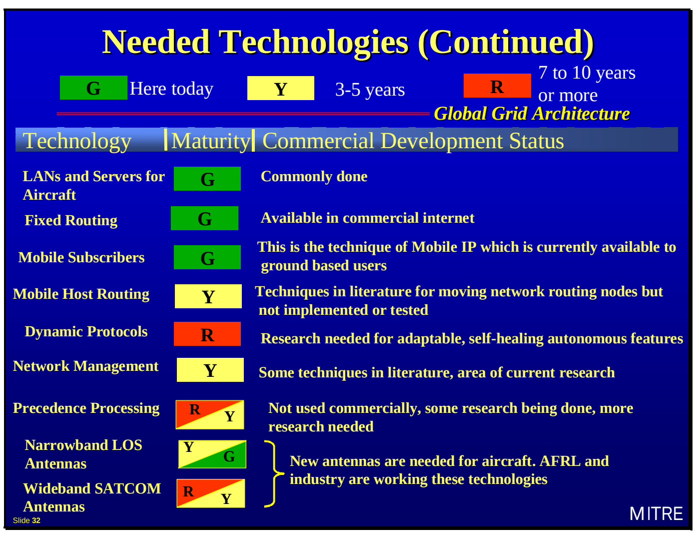

Figure 7a. Needed Technologies

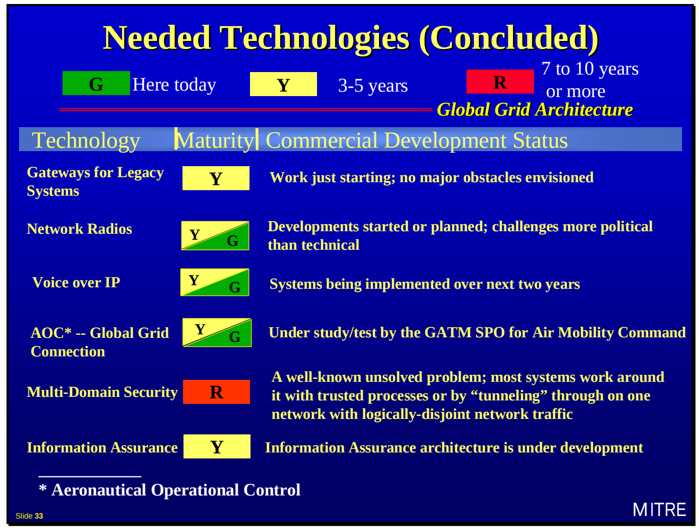

Figure 7b. Needed Technologies

SUMMARY AND CONCLUSIONS

C^2/ISR aircraft should 1) transition to IP LAN and server/switch/router, interface existing busses to the LAN in the near-term, and supplant existing busses with the LAN in the far-term, 2) progressively connect wireless communications to the Global Grid network, employ short-term migration aids, transition with gateways, e.g., for Link 16, utilize a network interface card and, if necessary, a digital modem, and procure network-centric capable radios, 3) work for higher-capacity.

Airborne C^2/ISR platforms including Joint STARS would benefit significantly by adopting the Global Grid's architecture and potential capabilities, a vastly more adaptive capability to facilitate future missions, more customers for data, more sources of information, no need for a large number of separate interfaces, e.g., fewer radios, a more efficient use of resources, and an easier and less costly insertion of technological innovation.

Evolution to the Global Grid can be implemented gradually, integration can be performed on a link by link (or bus by bus) basis, hardware and software procurement costs are reasonable, given the availability of commercial components, many changes would be commercially based and standardized, but some gateways or mobile protocols will require military developments.

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