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Network Centric Operations Impact on Avionics

Ellis Hitt*
Battelle, Columbus, Ohio 43201-2693

NETWORK centric[1] operations involve networking together aircraft and ground systems through high bandwidth two-way communication links (air to air, air to satellite to ground, and ground to air). Civil aircraft use internationally approved communications links while military aircraft will make use of the Global Grid and Internet Protocol Version 6 (IPv6) as shown in Fig. 1.

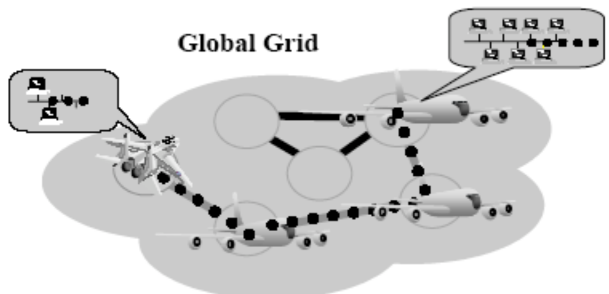

Fig. 1 Network centric operations using the global grid.

In network centric operations, avionics on an aircraft will be both a source and destination of information. The U.S. Department of Defense (DoD) has mandated capabilities required for transforming to network centric operations. These capabilities are called out in the Joint Technical Architecture (JTA) Version 6.0 (Ref. 2). The Weapon Systems Domain, Aviation Subdomain, identifies preferred interoperability standards for communications, data links, navigation/landing aids, and identification aids. Communications, navigation, and surveillance (CNS) avionics systems and functions impacted by the JTA include nearly all avionics hardware, software, and the human system interface.

Existing avionics architectures may require major changes for integration in network centric operations. A key question is whether these changes are affordable. The controller pilot data link communication (CPDLC) retrofit into existing commercial aircraft is expensive and many airlines are in bankruptcy or have a weak financial report. Most existing military aircraft have wiring installed during production, with few upgrades since the aircraft went into service. Aircraft still in the design phase will utilize a network centric architecture that will be upgradeable as technology advances provide new "plug and play" processors, displays, and sensors and the cost of new technology such as CPDLC will be built into the aircraft cost.

Architecture. Network centric operations[3] require integrated information from many avionics systems that were originally "stand alone" and implemented a function such as navigation, or had an output to the automatic flight control system. Many current avionics systems, both military and civilian, employ a federated architecture. The federated architectures are not highly integrated since they descend from stand-alone systems employed in analog avionics and first generation digital avionics. Current aircraft architectures and avionics compatibility with the capabilities required present interesting data flow challenges. Two key requirements that an architecture must provide are high bandwidth and low data latency.

Technologies. Keys to implementation of net centric capabilities are software programmable radios, Gigabit Ethernet, and "smart" displays. The Joint Tactical Radio System (JTRS) software programmable radio plans to provide up to eight channels which must connect with a multiband antenna. The Gigabit Ethernet can be fiber or

*Senior Marketing Manager, 505 King Avenue. JACIC Associate Editor. AIAA Member.

cable as long as it provides the needed bandwidth, minimum data latency, "plug and play" connectivity, and is affordable from a total life cycle. Smart displays will have a digital video interface to the Gigabit Ethernet.

Capabilities Assessment. Current aircraft data buses such as ARINC 429 and MIL-STD-1553 were never meant to carry video, which is important in network centric operations. An assessment of the capabilities of existing avionics architectures use for network centric operations should make sure there is adequate bandwidth for video and take note of the impact of data latency on the end users' decision processes. Careful attention should be given to the bandwidth of all devices in the signal path of video signals. Insufficient bandwidth will result in loss of detail in the video. For example, an SXGA display (1280 horizontal, 1024 vertical) needs a maximum signal bandwidth of 51.9 MHz.

Compatibility Assessment. Integrating network centric capability into an existing aircraft is not just a matter of installing the new high speed Local Area Network (LAN), displays, communications links, antennas, and software. The system must be shown to be compatible with the existing avionics, and other systems on the aircraft. Tests must be conducted to ensure there is no interference between the network centric system and the systems that are currently installed and will not be removed. Tests also need to be conducted to verify that flight critical and mission essential functions provide the required levels of performance and integrity.

Total Life Cycle Systems Cost. If the existing avionics does not provide the needed bandwidth, the challenge is to determine if technology that is affordable can be retrofit into the existing aircraft, whether this is economically viable considering the remaining airframe life and the impact on operating and support costs, and impact on revenue when the aircraft is out of service for the retrofit.

Implementing network centric capability may require changes to existing aircraft avionics starting with the removal of hardware that cannot be upgraded to the required capability, as well as many software changes in systems that can be retained. Wiring changes may be required to route the required information from the source to the destination. Software changes may be needed to generate the required information in the correct data format. New data packages including drawings and changes to maintenance manuals will be required. Training will be required to operate the new systems and aircraft simulators will require hardware and software updates. It is possible that new support equipment will be needed.

The decision makers should be concerned with the total life cycle systems cost which includes the upfront investment to develop, acquire, and install the new systems and dispose of the equipment that is removed, as well as the logistics support costs associated with the network centric systems. The logistics support (operation and maintenance) costs of the new system should consider different sustainment scenarios considering alternatives such as warranty offered and cost, supply chain management, supplier repaired vs third party repaired, or operator/owner maintained. If the equipment must be operable to fly the aircraft, downtime due to failed or unavailable parts reduces overall operational effectiveness.

Avionics suppliers, aircraft operators, and the aviation industry face many challenges to provide the avionics needed for network centric operations at an affordable cost.

References

[1]"Network Centric Warfare, Department of Defense Report to Congress," 31 July 2001, available online at http://www.dod.mil/nii/NCW/ (cited Aug. 2004).

[2]*Department of Defense Joint Technical Architecture, Volume I,* Version 6.0, 6 Oct. 2003, available online at http://jta.disa.mil/jta/jta-vol-I.pdf (cited Aug. 2004).

[3]Department of Defense Command and Control Research Program home page, http://www.dodccrp.org/research/ncw/ncw.htm (cited Aug. 2004).