Slyusar Vadym, DSc, Prof.
MOD of Ukraine

The networked distributed engine control system of future air vehicles

The future distributed engine control system (DECS) of air vehicle should be built on the base of networking principle as the part of an integrated, hierarchical, multidimensional and multiple networks system on the air vehicle board.

As the prototype of the DECS can be used NATO Generic Vehicle architecture (NGVA, STANAG 4754), which is used in combat vehicles, and the similar approach - in the GVA Standard of UK or VICTORY Architecture of combat vehicles in USA. But DECS should combine of multiple networks such as control network, diagnostic and maintenance network to transfer sensors data and video streams from different high resolution cameras in the space around of engines and has a full integration with firefighting network, thus such network use the same sensors and control object as DECS.

In this regard for the transfer of control and feedback data inside the DECS the current trend is the use of Real-time Data Distribution Service (DDS) over a wireless IP network (also used in NGVA) based on ROS-2 (Robotic Operating System) or a similar version of ROS-M. As the dissemination protocol of data can also use combination of DDS with MQTT-SN, which is a publish/subscribe messaging transport that was designed for vehicle-to-vehicle telemetry, sensors networks and is now a major protocol of IoT. To reduce jitter and latency of engine control networks can be used the integration of DDS with Time-Sensitive Networking (DDS-TSN), which will have the jitter on a level not more as few microseconds.

To the building of EMP-tolerant and fault-tolerant engine control networks and high temperature-compatible communications need use fiber-optic engine control networks. In this context the best solution is use few SOSA single board computer units and SOSA Input-Output modules with fiber-optic connectors. Such connectors have maximum transfer speed 22 Gbod and all SOSA units are full ruggedized. Worth saying, that on this time the SOSA standard is shared only for USA citizen, but in the future it will be expand to other countries. Each network inside DECS (control network, diagnostic and maintenance network, firefighting network) need have one or few distributed SOSA single board computer units with gateway between such networks inside DECS and gateway to other networks of air vehicle beyond DECS. For better compatibility networks on board air vehicle need expand general principles building of DECS (common DDS-TSN Data model etc.) to all hierarchy of such networks.

Because Artificial Intelligence (AI) is the basis of future control networks, the implementation of AI is an important trend in the development of the future DECS. AI is useful in particular with respect to making heterogeneous control systems work together; to improve data exchange to working with fewer resources of data; to making coordination of sensors, actuators, and controllers onboard air vehicles, threat detection and identification. AI can also perform inside DECS the following functions: warnings about the possibility of a critical situation, determining a safe mode of an engine working, detecting suddenly emerging threats that impede engine functionality, visual warning for marking areas requiring special attention, the analysis of hyper spectral images of the local zones of the engine to identify changes in its surface, which is a sign of possible destruction, identification against the backdrop of natural wear. AI is a means of improving timeliness (fast threat, pop up, numerous threats), derivation of intents, situational awareness and evaluation. On the other hand, as a communication bridge and feedback mechanism from AI to a Human for the support of decisions making should be used Augmented Reality (AR) technologies. For this task can be used the cloud or multi-network cooperative AI algorithms, which is distributed between several networks and systems of air vehicle and can design joint three-dimensional outlines AR visions for the common situation awareness picture.

In this regards, it is about the need for interoperability between the format (model) of data that is generated at an engine networks and the software of AR symbols playback devices, which must identify the type of data, and send it to the display (visual data), speakers (acoustic symbols) or tactile elements (gloves, belts, etc.). In some cases, engine data can be transformed into AR data (and back) in the DECS. But in most general case, there is a need to exchange AR-specific data or AR data blocks, because not all AR data is the engine feedback information. For an example of such a context is AR 3D virtual models of engine for testing engine systems before mission, anime, avatars, shell symbols of sensors or actuators, which was recognized by AI on the point cloud and video streams, also some elements of synthetic environment, etc. All these tasks can be decided by standardization of an AR data transfer protocol (structure and size of a typical data block). On the other hand, cross-networks transparent AR data traffic needs to be transmitted by using cyber and jamming protected communication. In the future, block chain technology can be used, but the big issue today is limited by performance of on board communication links. In this context current data transfer standards via fiber-optics have to be updated on the base of new waveforms and technologies. One new idea suggests the spread spectrum with not-orthogonal frequency discrete multiplexing (N-OFDM) of signals. It can increase data performance by better spectral efficiency.

On board cross-networks sharing of AR data will radically update the learning and training process for crews on the frameworks of virtually missions. As noted by other researchers, AR data can be used as virtual combination of live and synthetic environment elements as well.

The current situation is that existing standards in this area is not fully developed, i.e. there are several gaps. Moreover, there is no overall and long-term plan for establishing a set of standards that consider the aspects of interoperability. Some initiatives and technology trends that are believed to help on the current situation is under discussion.

The key means to ensure the interoperability of DECS subsystems is thus to develop DECS standards as a System of Systems of Standards (S3). DECS S3 should represent interoperability, and it is defined in an integrated, hierarchical, multidimensional and multifunctional system of normative documents.