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RTCA Special Committee 186, Working Group 5

UAT MOPS

Meeting #2

UAT GROUND INFRASTRUCTURE

(Presented by Ed Valovage)

SUMMARY

Draft #1 for the Appendix D of the UAT MOPS. The last page contains an outline of the appendix (for visual reference during group discussion) and a list of discussion topics.

D UAT Ground Infrastructure

As part of the Minimum Operational Performance Standard for the UAT, this appendix describes the working concept for a UAT ground infrastructure. This infrastructure supports the ground-air segment of the overall UAT network. This is not intended to be a specification or set of requirements for such a ground infrastructure, but rather a context in which to understand the intentions of the UAT data link.

D.1 General Description

The role of the ground infrastructure is twofold:

a. To receive ADS-B broadcasts and generate a summary of the air traffic in a given area, possibly fusing it with other surveillance data (e.g. radar or multilateration systems).

b. To transmit this traffic data along with other flight service information (weather, NOTAMS, differential GPS corrections) to the airborne traffic for use in the cockpit.

There is considerable flexibility in the deployment and functionality of the ground infrastructure. The receive and transmit functions may be physically separate and even have different providers, or they could be a single ground network of transceivers feeding an integrated system providing all the above functions. This will probably be decided more by economics than by engineering design. It will certainly not be decided by the time this document is released. Fortunately, this appendix need only describe enough of the system to allow understanding of the UAT data link and be reasonably sure that it will provide the necessary functionality.

D.2 Uplink: Broadcast

D.2.1 Geometric Coverage

Due to the limited range and geometry of a single ground station, a network of ground broadcast transmitting stations will be required. Each station will have associated with it two types of coverage. One is the *radio coverage* of the transmitted signal. This is the airspace which can be usefully reached by signal from the ground station. The other type of coverage is the *product coverage*. This is the geographic scope of responsibility the ground station assumes for each product (such as a weather map) broadcast.

D.2.1.1 Radio Coverage:

The UAT system uses time division multiplexing to allow multiple stations to operate on the same frequency. Each ground station is assigned one of 32 ground broadcast time slots. In addition, the UAT waveform has a high tolerance for self-interference. Thus a generous deployment of ground stations can assure good coverage of the airspace, possibly with enough overlap to assure redundancy (loss of an isolated station without loss of coverage continuity).

As a sample coverage scheme, a somewhat regular “cellular” pattern of ground stations with a nominal intersite spacing of 100 nmi would assure coverage everywhere down to about 3000 feet above ground level (AGL). (This is based on a 4/3 earth refraction

model a nominal antenna height, and ignores terrain effects.) This intersite spacing would require a minimum broadcasting range of about 70 nmi. A nominal coverage cell layout is shown in Figure 1.

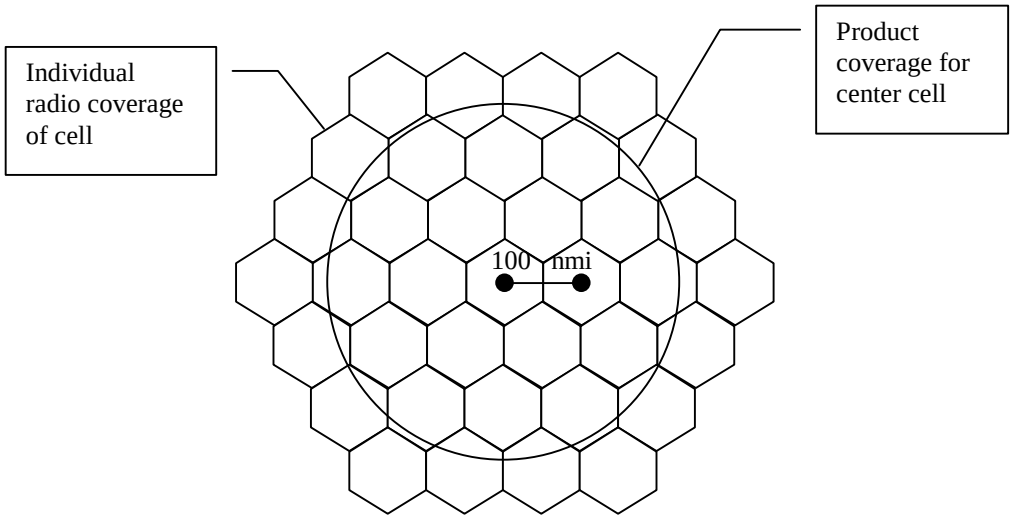

Figure 1 Nominal Coverage Cell Layout

D.2.1.2 Product Coverage:

The product coverage and update rate can be tailored to suit the characteristics of individual products. For example, products that are relatively small in terms of total data volume and that are updated infrequently such as Automated Terminal Information Service (ATIS) messages could have a relatively large product coverage such as 500 or 1000 nmi radius of the ground site with a relatively low update rate. A product such as real time traffic data may call for a relatively high update rate and a smaller coverage area – say within a 200 nmi radius of ground site – to keep data link bandwidth requirements at a reasonable level.

The product coverage should exceed the radio coverage to assure overlap between ground station boundaries. This will allow site transitions to appear seamless to the user. In addition, some data products require a context larger than one radio coverage cell to be meaningful (such as weather data).

When an aircraft receives uplinks from multiple ground stations, it has the task of fusing these data. This task can be minimized by having the ground infrastructure assure that redundant information from different ground stations is identical. For example, adjacent uplink stations reporting target position for a given aircraft should report exactly the same position in the same one-second frame. Then the avionics need only associate the reports by ID and choose either for displaying or automated processing. Note that this precludes autonomous ground stations, requiring a networking of all stations.

D.2.2 Data Source For Ground Broadcast

Contents of the ground broadcast messages can be put in the following categories:

1. Flight Information Services-Broadcast (FIS-B) – the broadcast distribution of weather and aeronautical information.

2. Traffic information from other surveillance sources (radar, multilateration) – this augments the ADS-B data received directly from the air-to-air link.

3. ADS-B data collected from non-UAT links.

4. Re-statement or condensation of UAT ADS-B data.

There are many possible configurations for the flow of information for the uplink stations. Not all stations need to be configured the same way. The communication links can take on many forms, such as satellite, land line (phone, fiber) or microwave or other dedicated RF link.

D.3 Downlink: Surveillance

ADS-B data being transmitted by aircraft will be received (in general) at multiple ground receiving stations. This redundancy is readily fused since all stations are receiving the same message contents. Because of the required frame synchronization of all UAT transmitters and receivers, there is ample accuracy in the time-of-arrival stamp on each message to readily associate them and merge them. No averaging or weighting need be done on the contents as they are all the same.

These downlinked data are destined for end-user systems on the ground or for fusing with other surveillance data and re-transmitting (via TIS-B) back to the aircraft. In addition, a rough range from the receiving station can be determined from the Transmission Epoch (MSO number) encoded in the Type 0 Long ADS-B message. A more accurate time stamp on arrival and a more accurate receiver synchronization would allow multilateration on ADS-B reports received at multiple ground stations. Either method of independent position verification can be used in a health monitoring check on the reports (a check of the on-board GPS equipment in the aircraft).

D.4 Summary of Infrastructure and Implications

Figure 2 shows a generalized diagram of the components and interconnnect of a ground infrastructure for the UAT data link. Many variations of this general structure are possible. Transmitters and receivers may or may not be co-located. Different sites may have different levels of service. This data link will have to support a transition period for a considerable time period before the fleet is fully equipped. Flexibility will be essential.

The characteristics of the UAT link required to support this general structure are in the areas of time stamps and predictable latency, one second frame synchronization, time division coordination of adjacent ground cells, and a waveform tolerant of self-interference.

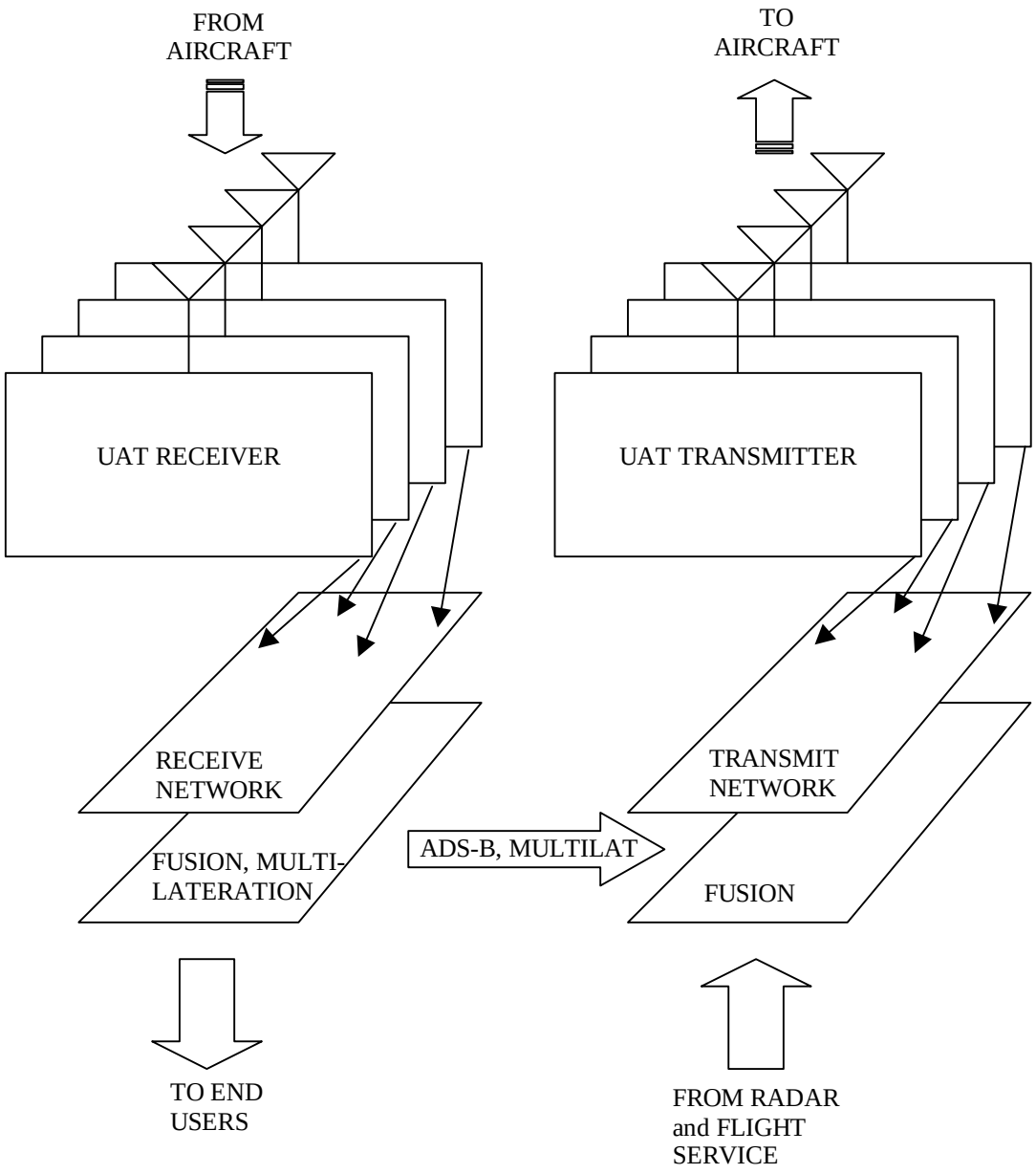

Figure 2 General Form of Ground Infrastructure

UAT Ground Infrastructure

- General Description
- Uplink: Broadcast
  - Geometric Coverage
    - Radio Coverage
    - Product Coverage
  - Data Source For Ground Broadcast
- Downlink: Surveillance
- Summary of Infrastructure and Implications

Additional topics for discussion:

- *health monitoring of ground and air equipment (message formats to support), notify when failure sensed*
- *always re-transmit ADS-B?*
- *data rate estimates*
- *more specific on overlap scheme?*