CNS (Communication Navigation Surveillance)

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Abstract: Communication, Navigation and Surveillance (CNS) [ref2] are the three systems required for an aircraft to fly from a departure aerodrome to its destination in a safe and efficient manner. Air Traffic Control (ATC) [ref1] is a service provided by ground based controllers who direct the aircraft on the ground and in the air in its entire flight path. The primary purpose of both ATC and CNS systems is to organize and expedite the flow of air traffic, separate the aircrafts to prevent collisions, and provide information like weather, NOTAMs etc. to the pilots.

Keywords: RADAR, Remote Unit, target processor, multi sensor data processor

I. INTRODUCTION

Air Traffic flow is broadly divided into departures, arrivals, and over flights. As aircrafts move in and out of the terminal airspace, they are handed over to the next appropriate control facility (a control tower, an en-route control facility, or a bordering terminal or approach control). Terminal control is responsible for ensuring that aircraft are at an appropriate altitude when they are handed over, and that aircraft arrives at a suitable level for landing. This journal contain details of ASMGCS (Advanced Surface Movement Guidance and Control System), ILS (Instrument Landing System), SMR (Surface Movement Radar), Remote unit, reference transmitters, processors, display subsystem and interconnection of network.

II. ASMGCS

The A-SMGCS system provides air traffic controllers with a complete picture of the airport surface in all weather conditions. With the increasing demand for higher levels of aircraft movements, pressure is growing for airport systems to safely handle greater capacity in all weather conditions, improve traffic distribution and maximize use of existing infrastructure. It is used to reduce runway incursions; when two aircraft or an aircraft and a vehicle come too close to each other on an airport surface. It improves coordination between Air Traffic Control personnel. It correlates flight plan information with aircraft position on controller display. It eliminates blind spots and coverage gaps and increase situational awareness in all weather conditions. A-SMGCS utilizes multiple surveillance sources such as Primary Surveillance Radar (PSR), Secondary Surveillance Radar (SSR), Surface Movement Radar (SMR), a transponder multilateration system, an Automatic Dependent Surveillance - Broadcast (ADS-B) vehicle/aircraft tracking system and an advanced multi-sensor data processor to provide comprehensive surveillance picture of the airport surface. This surveillance data is presented to the controller on an integrated display.

The A-SMGCS system is composed of many subsystems.

1. The Surface Movement Radar (SMR) subsystem is primary radar used to detect surface targets, and report that information to other A-SMGCS subsystems for processing.
2. The Multilateration subsystem (MLAT) is secondary surveillance-like radar that provides position and identification of all transponder equipped aircraft and vehicles.
3. The Processor Subsystem combines (fuses) all sensor reports for a target, determines target position, tracks the target, and provides safety logic alerts.
4. The Tower Display Subsystem provides the data and CWP displays for Air Traffic

Controller and Airway Facility Technician use.

5. The Remote Monitoring System (RMS) provides the data and displays the Airway Facility Technician uses to monitor, troubleshoot, and manage A-SMGCS.

III. ILS (Instrument Landing System)

ILS is a radio aid to the final approach and is used only within a short distance from the airport. Its purpose is to help the pilot land the airplane. It is very helpful when visibility is limited and the pilot cannot see the airport and runway. ILS facilities are a highly accurate and dependable means of navigating to the runway in IFR conditions. The landing path in ILS is determined by intersection of two planes a vertical plane and a horizontal plane. Horizontal plane contains information of the Central Line of a runway and Vertical plane provides Glide Path angle.

IV. SMR (Surface Movement RADAR)

The Surface Movement Radar (SMR) subsystem is primary radar used to detect surface targets and report track data to the A-SMGCS Multi-Sensor Data Processor (MSDP) for fusion processing. SMR is a X-band radar that performs following functions:

1. Detects the presence of aircraft and surface vehicles on or approaching heliports, taxiways, and runways.
2. Generates plot data and processed digital video for tracking all targets of interest on the airport surface and in the approach corridors.
3. Assists in avoidance of ground traffic incidents by clarifying relative positions of aircraft and other vehicles under difficult viewing conditions.
4. The SMR subsystem's processed digital video and plot data outputs represent accurate, essentially clutter-free position information on all moving and stationary aircraft or vehicles located on all airport movement, holding areas under adverse weather conditions and under all visibility conditions.

MDS offers accurate surveillance and identification of all transponder equipped aircraft in the air as well as on an airport's surface. It provides highly reliable data for further processing at MSDP.

Multistatic – Multiple sensors for high accuracy

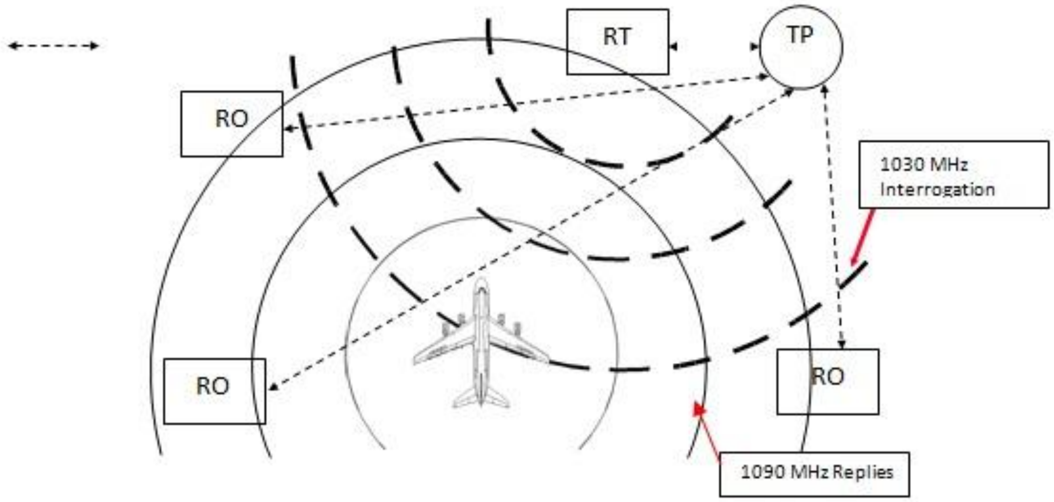
Dependent – Relies on transponders

Surveillance – Provides position and Identification

MDS, a transponder based multilateration system, uses multiple receivers to capture aircraft transponder pulses and calculate position and identification. Target must be within "line of sight" of a minimum three sensors at all time to be tracked. Each sensor receives, decodes, timestamps, and transmits the data to a Target Processor (TP). The TP compares the reports from multiple sensors to derive the target position based on the time of receipt of the signals at each sensor. MDS supports simultaneous reception of ADS-B long squitter messages with no equipment modification.Multilateration is the process of calculating a target location by performing Time Difference of Arrival (TDOA) processing (similar to triangulation) on RF signals received at multiple sensors.

A transponder transmits RF signals in omni-directional patterns. Multiple sensors receive this RF signal.

After detecting the RF signal, each sensor timestamps the signal with the Time of Arrival (TOA) at the sensor. Each sensor sends the time stamped signal to a target processor. For each pair of sensors, the target processor calculates the Time Difference of Arrival(TDOA) based on the differences in the TOA timestamps. Each TDOA can be represented as a hyperbolic solution arc between the pair of RUs. The intersection of multiple solution arcs provides an estimation of the transponder location and thereby the target location.



V. REMOTE UNIT

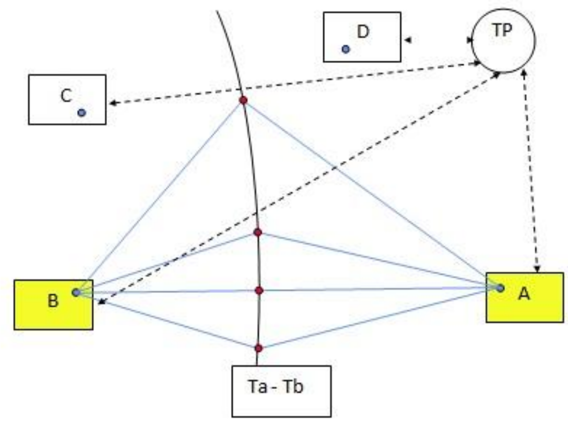
Remote units are the sensors used by A-SMGCS to detect transponder signals. These signals (ATCRBS & MODE S) are time stamped and passed to the target processor for multilateration.
There are two types of RUs:

1. Receive Only (RO) and Receive/Transmit (R/T).
2. The RO and R/T are based on a common architecture.

The RU elements are configurable by software and hardware to operate as either an RO unit or an R/T. To operate as an R/T, the unit requires the addition of a transmitter module. Target Processor performs TDOA calculations to generate hyperbolic solution arcs. Transponder must exist somewhere on the arc

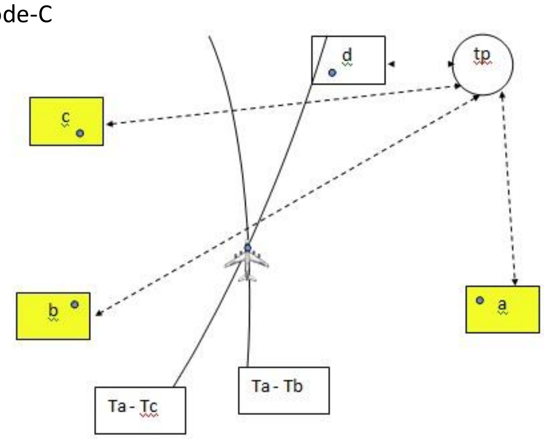
TDOA = (Time received at location a) - (Time received at location b) (1)

TDOA = Ta - Tb (2)



To get a two dimensional point, three RUs are required. 3 RUs develop intersecting hyperbola, 2D formula is used (no Z axis). 2d position is generated

- Gives range and azimuth
- Target height is unknown without more RUs or Mode-C



VI. REFERENCE TRANSMITTERS

RefTrans are used to calibrate the target processor's Time Difference of Arrival Function (TDOA). RefTrans perform this function by squitting Mode-S messages. These squitters are from a known location and the multilated position provides calibration. The RUs detect the RefTran squit as a Mode S message – it will be time stamped and provided to the TP. The TP uses these squits for RU Time Correction. Calibration is necessary for accurate multilateration and for redundancy, each RefTran has two transmitters. The number and placement of RUs and RefTrans is determined through site surveys and mathematical modeling of the coverage area.

VII. TARGET PROCESSOR

Target Processor is located in the Processor Cabinet; it is part of the multilateration subsystem. The TP is the processor that performs Time Difference of Arrival (TDOA) processing, better known as multilateration. The TP will perform TDOA processing on signals received at the Remote Units. The types of signals it will process include ATCRBS replies, Mode-S replies, Mode-S squitters and RefTran Mode-S squitters. The TP processes targets (received by the RUs) as track and identification data. The track information will be passed to the MSDP for fusion processing. There is one primary and one secondary TP. In the event the primary fails, there is an automatic switchover to the secondary TP.

VIII. MULTI SENSOR DATA PROCESSOR

The purpose of the Multi-Sensor Data Processor (MSDP) is to process all surveillance and target information sources and provide an integrated (fused) output to the Display subsystem. The MSDP is the heart of the A-SMGCS system. It processes data from all connected subsystems.

1. SMR plot and track data based on radar measured position.
2. Multilateration plot and track data (including identification) based on multilaterated position measurements from beacon-equipped targets.
3. GPS-based position measurements from ADS-B equipped targets.
4. Terminal radar plots.
5. Flight Plan information.(Note: If both MSDPs are reset, it may take up to one hour before information is available from FPDS for departing aircraft.)
6. Subsystem Status messages from each connected subsystem.
7. Safety Logic audible and visual alerts.

It provides integrated data (fused) to the Display subsystem to assist controller's in minimizing ground traffic incidents and clarifying relative positions of aircraft and other vehicles under all viewing conditions.

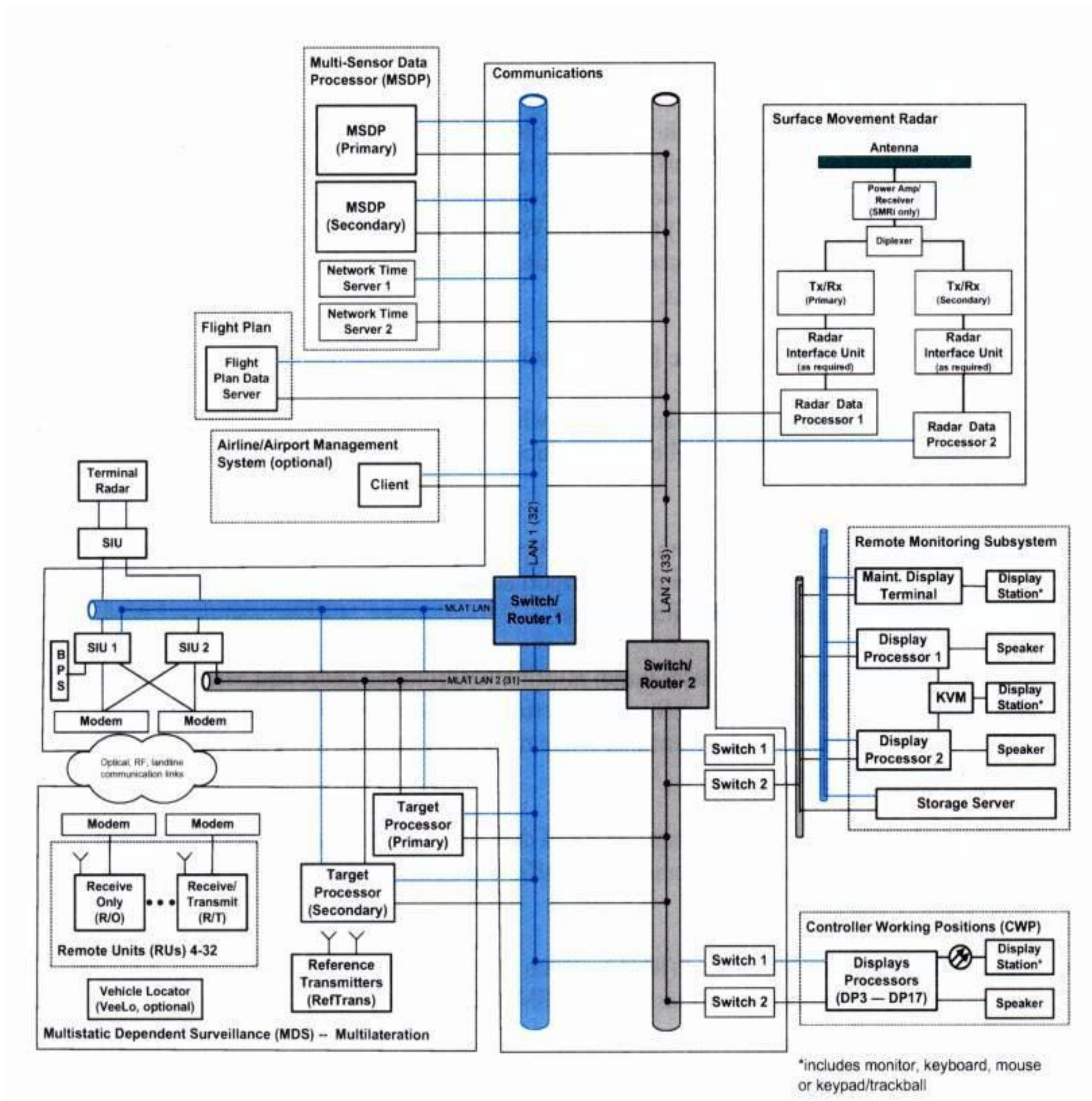
IX. DISPLAY SUBSYSTEM

The Display Subsystem provides the interface used by operators to view and manage A-SMGCS target and map information. The Display Subsystem contains:

1. Up to 15 KVM Extenders (Receiver/Transmitter pairs)
2. Up to 15 Display Processors (DPs)
3. Display Processors
4. One Tower Display (CWP) per DP
5. Two Ethernet Switches per rack

The purpose of the display processor is to convert the MSDP map and target data into a visual representation of the airport surface and targets in the coverage volume.

X. INTERCONNECTION OF SUBSYSTEMS



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