MARINE AIR TRAFFIC CONTROL AND LANDING SYSTEM – TACTICAL AIR TRAFFIC CONTROL USING A DISTRIBUTED SYSTEM ARCHITECTURE

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Practically everyone is familiar with the mechanics of a basic air traffic control (ATC) system, i.e., NAVAIDS, displays, surveillance sensor and landing systems. These capabilities are normally housed in fixed ATC installations of varying sizes. This paper describes an ATC system that has the additional requirement of tactical mobility. It must, if necessary, be capable of deployment anywhere in the world and must incorporate the further capability of rapid emplacement and displacement. The system that will be addressed here is the Marine Air Traffic Control and Landing System (MATCALS).

MATCALS is comprised of three basic subsystems:

- Air Traffic Control Subsystem (ATCS) which performs the surveillance radar function including identification of friend or foe.
- All Weather Landing Subsystem (ALS) which provides precision guidance for final approach.
- Control and Communications Subsystem (CCS) which integrates all sensor data. It is the operational center for MATCALS.

Additionally, MATCALS possesses the necessary TACAN, UHF beacon, portable control tower, etc. to provide full ATC services at an expeditionary airfield. MATCALS then, as with any command and control system must perform several basic functions:

- EXTERNAL INTERFACES. The system must have the capability to interface with various sensors and other system elements.
- DATA PROCESSING. The data processing functions include sensor data manipulation, management of data bases, selective display of tracks, track course predictions, interface and communication control and processing, and malfunction detection and reconfiguration.
- DISPLAY/OPERATOR ENTRY. Several operator and display station are required to provide the man-machine interface with the system, e.g., monitor the air traffic situation, select specific track data, and perform command actions based on observed information.
- COMMUNICATIONS. To extend the operational coverage of the local system, communications links are required to exchange digital and voice data with adjacent system. Encryption devices are used where secure transmissions are required.

As stated earlier, an effective, tactical ATC system must be designed to overcome the major requirements associated with its application in a deployed system. These requirements are:

- TRANSPORTABILITY. MATCALS must be transportable by aircraft, helicopter, ship, or truck. This dictates that space, weight, power, and environmental control factors must be carefully considered in all design aspect while maintaining the necessary ruggedness and high reliability features of all hardware items.

- SURVIVABILITY. Because of the requirement to operate in a hostile environment and the importance of continued real- time operations, survivability is a critical factor. To achieve maximum, practical survivability, redundancy and degraded modes of operation are important design features.

- FLEXIBILITY. Since MATCALS must deploy to any geographical area and considering transportability constraints, it is normal to plan judicious deployment configurations. However, since any tactical situation may change, the system must be readily capable of expansion of operator positions, communications equipment, etc. As well be seen later, the CCS design incorporates the required flexibility.

- MAINTAINABILITY. Space in a deployed shelter is always at a premium and any interruption of operations could be critical. Therefore, MATCALS is designed for high reliab1l1ty and maintainability to reduce frequency of repa1rs and to expedite restoration of any lost capability.

The CCS has been designed **as** the operational center “or hub” of the MATCALS system. It is a shelterized configuration that has been based upon careful evaluation of human factors, thermal electromagnetic interference, maintainability, and transportability concerns. All components of the CCS are contained in a single, specially designed 8'x8'x20' ISO shelter that constitutes a stand-alone subsystem. The shelter design includes a removable panel nine feet in length which, when removed, will allow two shelters to be butted together. When butted together, the configuration basically produces a “mini IFR” room.

Figure 1 is a diagram of two identical CCSs connected together. Each CCS shelter has four operator positions, each consisting of an AN/UYQ-34 Multi-Mode Display (MMD), communication control/selector panel, and access to numerous RADAR/NAVAID remote controls and indicators. Each position provides all the control necessary for voice and digital communication selection and manual entry of data and action commands to the computers. Each CCS has an assortment of thirteen HF, UHF, and VHF radio transceivers for ground-to-air and ground-to-ground transmissions. Associated with the radios are ten encryption devices for either radio or land line secure links. The selection of voice or digital radio and land line links and encryption units is initiated at the operator position by the controller. The action circuit connections are performed by an electronic switching unit called the Communication Control Sub-Group (CCSG).

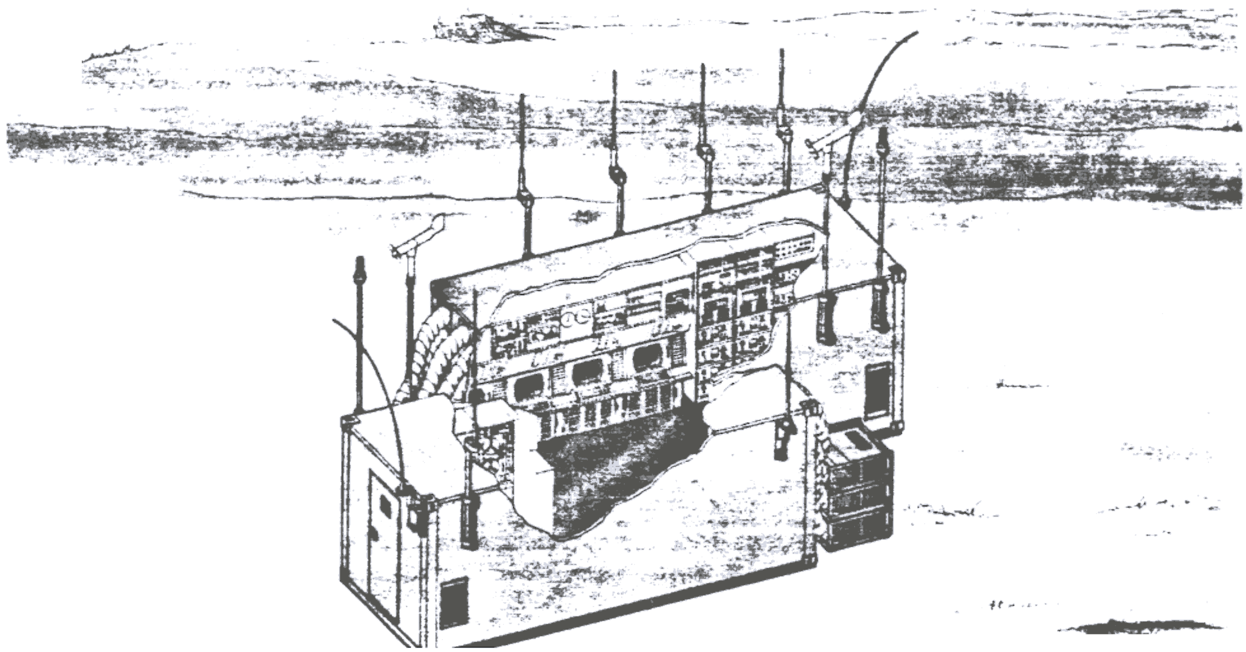

Figure 1. MATCALS Control and Communication Subsystems AN/TSQ-131

Figure 2 conceptually depicts a typical Marine Corps expeditionary airfield employing a MATCALS using a dual shelter CCS. As mentioned previously, the CCS is the operational center for MATCALS and can also operate in a single shelter mode. In either case, it functionally interfaces with other MATCALS subsystems, of which the major ones are briefly described below.

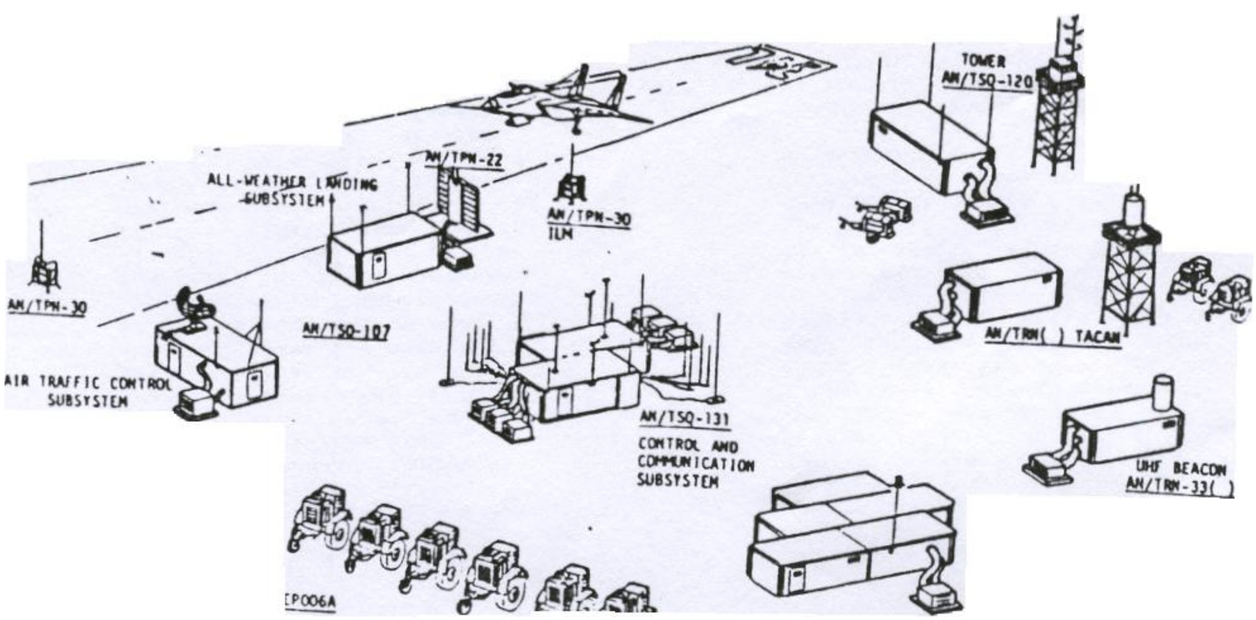

Figure 2. Tactical Marine Corps Expeditionary Airfield Employing MATCALS

- CCS/ALS. Through the use of the AN/TPN-22 Precision Approach Radar (PAR), and in conjunction with the AN/UYQ-34 display processor, the ALS provides automatic tracking of up to six aircraft on final approach while simultaneously searching its sector coverage. The ALS provides data to the CCS over a serial data bus for display, which enables the CCS operators to monitor and control aircraft within the landing area airspace. The ALS also has Independent Landing Monitor capabilities provided by the AN/TPN-30 aircraft approach transmitting sets which are remotely controlled from the CCS.

- CCS/ATCS. The ATCS consists of the AN/TSP-73 Radar Surveillance Control with Radar Digitizer/Tracker. (The initial radar subsystem that was developed was the AN/TSQ-107 as depicted in Figure 2). Data input to the CCS enables target display and track monitoring of up to sixty aircraft within a sixty nautical mile radius of the airfield. The CCS provides for remote control and status monitoring of the ATCS equipment.

- CCS/AIRCRAFT. The CCS has the capability of secure and non-secure HF, VHF, and UHF voice communications with aircraft. It also provides a Tactical Digital Information Link-C (TADIL-C). The TADIL-C function is a ground-to-air and air-to-ground data link which provides for fully automatic or semi-automatic control of appropriately equipped aircraft. Each single-shelter CCS is capable of providing two TADIL-C links for either approach/departure flight path command or final approach commands.

All subsystem digital processing and control operations are performed by the embedded AN/UYK-44 computers arranged in a distributed architecture. Within this architecture, each embedded display processor on the bus contains all operational software. Thus, each embedded display processor is functionally capable of controlling all traffic. To avoid timing problems, the number of tracks which can be started from a given processor is limited. If a processor becomes unusable, the system will automatically reconfigure. The AN/UYK-44 computers are compatible with the AN/UYK-20 computer currently in use in military applications. Each AN/UYK-44 will have 512K of RAM and 65K of PROM memory. A limited operational program can be installed in the PROM to be used immediately upon restoration after a failure or interruption of power. When system operations return to normal, the regular application programs can be reloaded from the magnetic tape units. The executive software that is used for overall program and external bus control is compatible to the U.S. Navy's SDEX software with additional features to perform local area network control of the Serial Data Bus interconnects. The AN/UYK-44 has extensive built-in-test programs that are used to test for failures and, upon detection, isolate the failure to the lowest replaceable module.

All digital interfacing between the major elements within the CCS is provided by the Serial Data Bus. For the MATCALs application, three channels of the bus are used. One is for bus control, another for data transfer, and the third is available as a spare in the event of a failure on either of the other two channels. While MATCALS utilizes three channels, the Serial Data Bus has the capability to provide an additional three spare or extra channels. Data can be exchanged at up to ten megabits per second rates and over distances up to three hundred meters on single conductor triaxial cables. An additional thirty meter maximum is allowed for each stub from the bus to an individual user. The stubs are transformer connected to the bus as passive devices and therefore cannot interrupt bus operations in the event of a failure at the connection. Besides providing internal CCS interfacings, the Serial Data Bus exits the shelter at a connector panel tor extension of use to other MATCALS elements located at distances up to 300 meters from the CCS.

While there are many facets involved in fielding a tactical ATC system, the basics have been highlighted. In summary, the primary thrust of MATCALS has been to:

- Provide as close to a state-of-the-art system as is practically realizable.
- Supply a system that performs the routine functions thereby allowing the operator to concentrate on control decisions.
- Design-in both redundancy and the capability to operate in a degraded mode while reconfiguring from a failure.
- Build a reliable, and most importantly, a maintainable, rugged system.

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