Matcals - Archived 10/96

Orientation

Description. The Marine Air Traffic Control And Landing System (MATCALS) mobile ATC system includes the E/F-band, 2D TPS-73 tactical radar, the I-band TPN-22 precision approach radar, and the TSQ-131 command and communications subsystem.

Sponsor

Space and Naval Warfare Systems Command

Washington, DC

Naval Air Systems Command

Washington, DC

(Joint program managers)

Contractors

Alenia SpA (formerly Selenia)

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(Integrated radar beacon/antenna, receiver/signal processor, radar/beacon correlator and beacon subsystem for ATCS, Argos-73)

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(ATCS design review analysis)

Raytheon Co.

Equipment Division

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(Modification kits)

Sierra Nevada Corp

Sparks, NV USA

(TPN-22 modulators)

Unisys Corp

Systems Development

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(Prime contractor)

Status. TSQ-131,TPN-22, and TPS-73 fielding completed.

Total Produced. Seventeen each TSQ-131s and TPN-22s (includes prototypes, two each), and eighteen TPS-73s.

Application. US Navy and Marine Corps airfields. The TPS-73 replaces the TSQ-107 radar. The Argos-73, a variant of the TPS-73, is a short and very short range air defense radar.

Price Range. Estimated US$3.5 million per installation for MATCALS. Argos-73 cost is estimated at US$1.5 million.

Technical Data

Design Specifications. MATCALS is a deployable, modular system, made up of three functional subsystems that provide enhanced airfield operation capabilities through the use of advanced sensors, data links, and operator consoles. The three functional subsystems are the Air Traffic Control Subsystem (ATCS), the All-Weather Landing Subsystem (ALS), and Control Communications Subsystem (CCS). The ATCS is designated the TPS-73 (replaces the TSQ-107), the ALS the TPN-22 and the CCS the TSQ-131.

TPS-73. The TPS-73 is a new E/F-band, 2D tactical radar with an integrated IFF antenna replacing the 1950s vintage TSQ-107. The TPS-73 is essentially off-the-shelf, with the exception of the solid state E/F-band transmitter. The hardware and software are based primarily on the ATCR-33 radar manufactured by Alenia SpA of Italy, with Unisys supplying the solid state transmitter. The use of the E/F-band presents several operational tradeoffs; i.e. longer pulses, for example, are needed to generate sufficient power. The longer pulses, however, lower the peak power requirement, resulting in both a reduction in vulnerability to anti-radiation missiles and smaller transmitter size. Pulse compression is used as compensation for the reduced range resolution normally associated with longer pulses. The use of E/F-band also permits use of a smaller antenna size.

The radar uses two primary radar-received beams to improve target reflection processing in the presence of ground clutter. The main beam, used for intercepting missile control signal transmission and long-range detection, is pointed 3^{o} above the horizon. The auxiliary beam, used for improved medium and short-range target detection in conditions of heavy ground clutter, is pointed 5^{o} above the horizon. The autotracker capacity is 600 tracks, plus 300 tentative tracks.

TPS-73 is accommodated in one ISO shelter (fully transportable) which includes the transmitter, autotracker, beacon equipment, radar electronics, power distribution unit and display console. The shelter also acts as the transport container for the antenna components. Ancillary support equipment includes two air conditioners and a motor generator set.

TPS-73 availability is an impressive 99.97 percent, which exceeds the required 99.60 percent. MTBF is estimated to be in excess of 5,000 hours, almost five times that required by the specification. This is supported by the fact that even if the transmitter should lose 28 out of its 60 modules, the radar will still be able to detect targets out to 45 miles, with only a 25 percent degradation in capability. The MTTR is 1.4 hours.

TSQ-131. Each CCS is made up of two 8x8x20 ft shelters butted together. Included are UHF, VHF, and HF radios, cryptos, a voice recorder, air conditioners, UYK-44 computers, UYQ-34 multimode displays, USH-26 tape units, and items of government-furnished equipment. Unisys (the prime contractor) also provides and installs contractor furnished equipment; i.e. shelters, racks, cables, communications control group, TADIL-C buffer, power distribution and control, printers and miscellaneous gear.

TPN-22. The I-band precision track-while-search radar operates in the 9-9.2 GHz frequency range, with a peak power of 120 kW. Range is approximately three miles, with a detection probability of 95 percent cumulative in the acquisition gate. The MTI capability includes search (2-pulse canceler) and track (3-pulse canceler). The antenna is a planar array.

Operational Characteristics. US Marine Corps expeditionary forces rely on continuous close air support which can sometimes be suspended due to inclement weather and visibility conditions. The integrated, automatic MATCALS landing and terminal system enables all-weather flight operations at Marine Corps expeditionary airfields and at the same time greatly improves the safe landing rate and air traffic control capacity at these airfields. MATCALS also provides the capability to control all aircraft landings by means of a fully automated ILS (Instrument Landing System) type cross pointer (Mode I) and/or GCA (Ground Controlled Approach) "talk-down" guidance. MATCALS is fully compatible with existing military and civil ATC systems and associated data links, and with the commercial aviation Microwave Landing System (MLS) development previously sponsored by the FAA.

TPS-73. The TPS-73 tracker is a major advance over the TSQ-107, with the TPS-73 being able to automatically track 900 targets. A more than 13 dB increase in the signal-to-clutter ratio is achieved with the dual-beam antenna. Additionally, the use of circular and linear polarization of the antenna also results in enhanced performance in rain and ECM environments. Range is 60 nautical miles. Operating capabilities include monopulse IFF, AKA beacon, and Adaptive Moving Target Indication (AMTD).

The set-up and take-down time of this mobile radar is less than two hours.

Mission capabilities of the TPS-73 include the following; air traffic control, electronic countermeasures, anti-radiation missile threat warning, coastal surveillance, and gap filling.

CCS. The Control Communication Subsystem performs the centralized data processing required for MATCALS operation using data received from ATC and ALS sensors, and also from the ALS program and external communications sources. The software is programmed in the US Navy CMS-2 high order

computer language. The following functions are provided by the CCS:

- Flight path conformance monitoring
- Detection and warning of potential hazard/conflicts between aircraft being tracked and ground proximity
- Accommodation of intra-facility hand-offs with MATCALS and inter-facility hand-offs with other Marine Air Command and Control Systems (MACCS)
- Acquisition and final approach control for up to six aircraft
- Computation of ground-derived landing control information (pitch and bank commands) for full automatic landing (Mode II)
- Calculation of ground-derived course deviation (altitude and lateral errors) information for voice landing control (Mode III)
- Monitoring of landing operations for automatic upgrading/downgrading and for safety hazards
- Interchange of tactical information on TADIL-B
- TADIL-C processing for aircraft remote control
- Generation of air situation and landing control displays on operator consoles for all targets detected by the MATCALS surveillance radar; points, and tracks reports received via TADIL-B
- Generation of simulated traffic on displays for training purposes

Variants/Upgrades

Present upgrade work appears to concentrate on software changes that become evident as the result of operational testing.

Argos-73. Selenia developed this radar which operates in the E/F-band (10 cm) based on the TPS-73. Key features include: three operating modes (burst-to-burst agility, fixed frequency, pulse-to-pulse agility); 10 kW peak power; 10, 12 and 15 rpm scan rates; fixed or staggered PRF; solid-state transmitter; and coverage of up to 120 kilometers in distance and 30,000 feet in altitude. This highly mobile radar is intended for low and very low level air defense. Its up-to-date capabilities are evident by its ability to detect and identify targets with diverse velocities, ranging from hovering helicopters to aircraft exceeding Mach 3, as well as the capacity to detect targets with very small cross-sections, even in conditions of clutter and jamming or saturation attacks with stand-off or "intelligent" weapons. The radar system includes a primary radar and a monopulse secondary surveillance radar.

A coastal defense version of the Argos-73 has also been developed which combines both air and surface surveillance capabilities. One important feature is its ability to vary transmitted output power according to operational requirements via the use of modular air-cooled, high-power transistor active arrays. This radar is well suited for high reliability applications such as unmanned sites since the active arrays provide high reliability and graceful degradation. Detection range is 112 kilometers for a small fighter aircraft.

Program Review

Background. MATCALS replaces what Unisys and the US Marine Corps describe as the "operationally inadequate and technologically obsolete" TSQ-18 air traffic control system with state-of-the-art equipment.

The TPS-73 ATCS was the last major element in MATCALS to be procured with deliveries completed in 1993. Fielding of the ITT Gilfillan TPN-22 and TSQ-131 equipments was completed some years ago.

Besides responsibility for CCS production, Unisys integrated the first article CCS with the ATCS, ALS, and Full Operational Capability (FOC) software. Unisys also had responsibility for qualification testing of the CCS after refurbishing CCS 1 and 2 to bring them up to production status.

MATCALS software was developed in two phases, with test-bed software being developed for safety-of-flight

testing, and operational software being developed for use in the field. On-going modifications are being made to the operational software to include deferred capabilities, enhancements and Mode I control of capable aircraft.

The first TPS-73 was delivered in July 1988 to the Marine Corps. The first of 17 Marine Corps MATCALS were installed at Cherry Point, NC; Camp Pendleton, CA; El Toro Marine Corps Air Station, CA; and with Navy/Marine forces in the Western Pacific.

As part of the Marine Corps buy, the USAF purchased one TPS-73 system with an option for up to 17 more. This unit was delivered in late 1998 and underwent comparative evaluation testing in parallel with a similarly purchased Siemens-Plessey Watchman radar. A subsequent complete/partial exercise of the USAF option has not been confirmed.

A detailed chronology of the resent years of the program is provided below.

In FY91, OPEVAL testing of software compatible with the TPS-73 radar was successfully completed. Work on software to provide the Tactical Digital Information Link (TADIL)-B/C capability was begun, as well as studies for Advanced Air Traffic Control (i.e. Automatic Landing System technology improvements and Flight Safety).

Scheduled work in FY92 saw continued development and testing of required operational capabilities, including tactical data links, TADIL-B certification by the Joint Tactical Interface Facility (JTIF), and continuation of the Advanced Air Traffic Control study. Versions J and K of the Operational Software were also fielded.

Accomplishments during FY93 included: development, testing, and certification of software and procedures for MODE I ALS capability to assure reliability and safety of flight; development, testing and initiation of certification of MATCALS Version K Operational Software which provides for the control and safety of aircraft in landing/take-off operations, including TADIL-B (ground-to-ground radio data link) with the TPS-73 radar configuration; and study of the effectiveness of model-following algorithms to ensure more accurate landing system performance.

The list of FY94 accomplishments includes: completion of certification and fielding of software for the MODE I ALS capability; development, testing, and completion of certification of TADIL-B/C Version L Operational Software; and the study of TPN-22 Modulator design changes and Communications system Remote Landing Site Tower (RLST) compatibility issues.

The agenda for FY95 consists of the following: development, testing and start of certification of Version M software for increased automation for MATCALS control of fleet air; analysis and evaluation of performance and safety improvements from the utilization of Differential GPS data; and development, testing and certification of TADIL-B/C software improvements to enhance flight safety and control of aircraft in tactical operations and Version M of the MATCALS Operational Software.

Plans for the next two year period include the development, test and certification of; 1) Version N Operational Software to accommodate new and/or modernized fleet aircraft and 2) a differential GPS approach and landing capability.

Funding

US FUNDING

	FY93		FY94		FY95		FY96 (Req)	
	QTY	AMT	QTY	AMT	QTY	AMT	QTY	AMT
RDT&E (US Navy)								
PE #0604504N								
Air Control								
Project X0718								
MATCALS	-	2.7	-	0.8	-	1.5	-	1.4
PROCUREMENT (US Navy)								
MATCALS	-	3.5	-	1.4	-	4.3	-	1.6
Total Funding	-	6.2	-	2.2	-	5.8	-	3.0

All US$ are in millions.

Analysis. MATCALS procurements under existing contracts have been completed and the prospects for additional US purchases of additional equipment of the same configuration in the current economic environment are very remote and are not being forecast.

Chances of MATCALS being exported are also rather slim at this time. This lack of potential foreign sales is mainly due to the system's specialized nature which is basically optimized for the Marine Corps needs. The TPS-73/Argos-73 also is unlikely to encounter much in the way of international orders as the radar market in this specific area is already dominated by powerhouses such as Thomson-CSF and Marconi. At the present time, foreign sales are not being forecast; however, the provision of TPS-73s via FMS orders remains the most likely prospect if any directly related sales do materialize.

Assuming that development funding continues to be provided and schedules maintained, we believe, however, that a strong market may develop for a GPS-based MATCALS technology derivative. (See **Background** section, above). This possibility is based on the fact that in 1994 the FAA terminated its troubled MLS development program for the next generation US ATC system in favor of a GPS based approach and landing system. While Canada followed suit, the rest of the ATC world did not and individual countries/ regions have been left to pursue their preferred technical approaches, many of which are MLS based.

This has several ramifications for MATCALS. First, in light of the facts that international armed forces interoperability is becoming an increasingly important issue and the line between military and civil ATC systems blurred, the existing MATCALS is not likely to become prematurely obsolete. This should assure a long and healthy life for support and maintenance activities. Secondly, if the FAA's badly tarnished previous program management track record is any indication, MATCALS could well develop and demonstrate the GPS based Category III approach and landing capability needed to support an all weather operational capability long before the FAA. Being first to demonstrate this vital capability would open a major market for future MATCALS derivatives.

Recent Contracts

Contractor	Award ($ millions)	Date/Description
Unisys	13.2	Dec 1987 - Modification to contract for 17 ATCSs (N00039-86-C-0452)
Unisys	4.2	Feb 1988 - Modification to contract for interim repair parts in support of TPS-73 (N0-0039-86-C-0452)
Unisys	5.6	Nov 1988 - Modification to contract for two ATCS (N00039-86-C-0452)
Unisys	0.05	Mar 1989 - Contract award for the repair of MATCALS equipment (N00104-86-G-A048, WQ7Z)
Unisys	0.03	Aug 1989 - Contract award for the repair of MATCALS equipment (N00104-86-G-A048, WQ8U)
Unisys	0.3	Mar 1990 - Contract award for the repair of MATCALS equipment (N00104-90-G-A046, WQ2G)
Unisys	0.04	Mar 1990 - Contract award for the repair of MATCALS equipment (N00104-90-G-A046, WQ2H)
Raytheon	7.9	Nov 1990 - FVI to an FFP for nine receiver/processor and transmitter kits for AN/GPN-22 and AN/TPN-25 precision approach radars and redundant transmitter for AN/TPN-22 precision approach radars (F04606-89-C-0932, P00005)
Raytheon	12.4	Sep 1991 - FVI to an FFP for 24 receiver modifications kits and 24 installation kits. This action provides for a redundant receiver/processor for AN/GPN-22 and AN/TPN-25 precession approach radars and redundant transmitter for AN/TPN-22 precision approach radar. (F04606-89-C-0932, P00008)
Unisys	0.3	Apr 1992 - Contract award for the repair of MATCALS equipment (N00104-90-G-A046/W2QH)
Unisys	0.04	Apr 1992 - Contract award for the repair of MATCALS equipment (N00104-90-G-A046/W2QH)
Sierra Nevada	5.1	Dec 1992 - FFP for the procurement of solid-state modulators for the TPN-22 Marine precision approach and landing radar set, with associated data and options for a training course and field engineering services (N00039-93-C-0096)

Timetable

	FY83	Design concept completed
	FY84	Operational software testing completed; Sperry awarded initial production contract
	FY85	Development of MATCALS software for control of other aircraft initiated
	FY86	Combined developmental/operational testing of MATCALS IOC completed safety of flight testing for F/A-18 Mode I capability conduced and development of other deferred required operational capabilities initiated
April	1986	First TSQ-131 CCS delivered
Aug	1986	Sperry/Selenia awarded $44.9 million multi-year contract for 17 ATCSs
	FY87	Development and testing of MATCALS DT/OT recommended changes initiated in FY86; additional MATCALS required operational capabilities developed
	FY88	Software to enhance Mode I capability developed and tested; Mode II safety-of-flight testing continued; GPS for MATCALS applications flight tested
Jul	1988	First TPS-73 ATCS delivered to Marine Corps
Oct	1988	TPS-73 delivered to Air Force for evaluation
	FY89	MATCALS operational capabilities/SW changes developed/tested; MATCALS Mode I safety-of-flight testing continued
Jun	1990	Successfully completed TPS-73 developmental testing
Aug	1990	Commenced TPS-73 OPEVAL

FY91	Commenced development of software for required TADIL-B/C/J capability; Commenced studies for Advanced Air Traffic Control
1991	Original completion date for TPS-73 deliveries to Marine Corps
1993	Revised completion date for TPS-73 deliveries to Marine Corps
1994	Completed certification of MODE I ALS
1995	Develop MATCALS Version M software
1997	Complete development of MATCALS Version N software and GPS approach and landing capability.

Worldwide Distribution

At the present time, the **US Navy/Marine Corps** are the only known users of the MATCALS.

Forecast Rationale

Current production was completed in 1993. In light of the commitment to downsize the US force structure, future US procurement is highly unlikely. Prospects for foreign sales have also not sufficiently developed to be included in the forecast period. If Foreign sales do materialize, Argos-73 will be the most likely candidate but it will be facing stiff competition from well established European suppliers such as Thomson CSF and Siemens-Plessey. We are, consequently, unable to identify new TPS-73/Argos-73 procurements in the ten year forecast period. Present contract delieveries have been anticipated. Contract activity during the forecast period will limited to the procurement of spares and maintenance actions required to maintain the operational status of the complement of existing equipment.

Ten-Year Outlook

Due to the maturity of the program, the forecast chart has been omitted.