Captain Vern Lochausen, USN (Retired)

Strategic Nuclear Deterrence

With Mutually Assured Destruction (MAD) as the defacto balance of power during the Cold War, the United States and the Union of Soviet Socialist Republics, each executed a varied of strategic and tactical programs, all with the intent off proving to the other that the first use of nuclear weapons would result in such a massive retaliation as to make nuclear war unthinkable. Every day they maintained bomber, submarine, missile and command and control forces on high alert and operating as close to the real engagement as possible in peacetime. Having over 2,500 nuclear warheads in each of their respective arsenals, the assumption was that nothing would be left of either side should an all out nuclear exchange occur. This prospect formed the quid pro quo mechanism for maintaining the balance of strategic nuclear power. The variety in types of delivery methods, bombs, intercontinental ballistic missiles, and submarine launched missiles, was matched by a variety of means of communicating with the airman and sailors that were charged with controlling those weapons. The national leadership of each nuclear power underwrote the effectiveness of its strategy by maintain robust and sure command and control communications of nuclear forces. Such was the mission of TACAMO.

TACAMO Mission



De Triad waarop de Amerikaanse nucleire afschrikking was gebaseerd. V.l.n.r. De Minuteman, de B-52 en de Polaris.

TACAMO was the name of system and the forces that operated that system. The name is an acronym coined in 1962 by RADM Roeder, then director of Naval Communications. With the success of the Navy's nuclear powered submarine force and its ability to carry nuclear armed missiles, a completely reliable system of communications was needed to reach a submerged nuclear submarine patrolling with nuclear missiles aboard. The admiral assigned the development of the system to a young naval officer named Jerry Tuttle who was told to 'take charge and move out' on the project. The admiral scribbled the word TACAMO on his notepad and the name was assigned.

De 151891 bla bla testvlucht.

The TACAMO operating forces flew EC-130Q Hercules aircraft manufactured by Lockheed of Marietta, Georgia and specially modified by Rockwell Collins Radio in Dallas, Texas. The TACAMO communications system enabled the mission crew to receive and transmit vital nuclear command and control messages via nearly every radio frequency band and using several different modes includes continuous wave (Morse code), voice, teletype, and computer-generated text. The part of the system that made it most valuable to the nuclear submarine forces was the very low frequency transmit system. With the EC-130Q flying in a continuous circle, trailing wire antennas were extended from the bottom and tail of the aircraft. The circular flight path, called an orbit, resulted in a spiraling dipole antenna that was about 70% vertically-oriented. Very low frequency radio waves emitted from this system penetrated the oceans and reached submerged submarines thousands of miles away.

The TACAMO forces maintained a high alert status and for many years to meet the mission of continuous airborne alert over appropriate ocean patrol areas within range of the nuclear submarine forces. The TACAMO forces were forward deployed and scheduled for overlapping takeoff and landing times to ensure effective coverage of the patrol area (Around Guma and the Iceland-UK gap). Other aircraft and crews were sequestered and kept ready to fly either in the event of war order or to replace an airborne alert aircraft.

The EC-130Q Hercules aircraft was a modified version of cargo transporting aircraft used by Air Force, Marine, and Navy squadrons. The TACAMO communications system added so much weight to the basic aircraft that it had to be structurally reinforced and external fuel tanks added to give it sufficient range to cross the oceans. It was this overweight condition and the constant high operational tempo to maintain airborne coverage that led to the replacement of the EC-130Q by a much larger, more capable, and more reliable E-6 Mercury aircraft. This aircraft, first introduced in 1989, was based on the Boeing 707-

De 151889 Tacamo IV Hoog boven de Atlantische Oceaan op weg naar het operatie gebied in 1975.

320B intercontinental model with high bypass turbo fan engines. With the E-6 came greatly improved power, thrust to weight ratios, crew comforts, safety of flight, and navigation and communications equipment.

For the EC-130Q Hercules operations which covered most of the Cold War era until 1991, a crew flying across the Atlantic or Pacific had to carefully plan their fuel load and route of flight to ensure they could reach their destination while still completing the orbit maneuver. Each mission made more challenging by the Herc's service ceiling being no higher than most of the severe weather enroute, turbulence, icing, and strong winds as well as its range being limited to about 2,700 nautical miles. Too much icing, too much headwind, or too much maneuvering around thunderstorms, put the ability to orbit and the destination at risk because of the limited fuel reserves. Further complications resulted from the then lack of long range navigation systems and mission as well as long range safety of flight communications. The challenges then were weather, fuel, navigation and communications.

Weather forecasting was without satellite imagery common today. Crews were briefed before flights on the potential for severe weather and strong winds. Only after they started on their route did they know for sure what was really out there to impact their mission. The oceans were partially covered by Long Range Navigation (LORAN) radio signals that the navigator could use to develop an approximate position for fix, if the signals were strong enough. Most often a LORAN line was combined with a celestial line of position developed by

De 15171/TC van VQ-3 in de landing op Dallas in de jaren zeventig

observing a star or the sun or moon for a two minute period using an averaging periscoptic sextant. Using pre-calculated tables for the azimuth and altitude of the celestial body, the navigator used the sextant to record the actual readings and then plotted them on a navigational chart. Other lines of position could be available by use of aerial direction finding of broadcast radio stations, radar contacts with land masses, and into the mid-1970s there were Ocean Station ships of the US Coast Guard in nearly fixed positions at sea that provided bearings for passing aircraft and ships.

When the navigator updated the aircraft position, he or she consulted with the flight engineer and developed a progress check on fuel used versus distance to go as well as provided a written form for the pilots to advise ground controllers of the position and progress of the aircraft enroute. Fuel management charts called HOWGOZITs were developed by the navigator for each specific missions conditions. Two or more status checks that showed fuel use above the planned consumption rate for that enroute position were cause for re-evaluation by the crew of their mission, destination, and route of flight. Options were to divert to a closer destination, modify the mission to consume less fuel, or alter the route of flight or altitude to consume less fuel per hour and make more progress toward a landfall.
During an orbit period, the TACAMO crew conducted exercises of the communications system and frequently responded as part of a larger exercise of the entire communications network supporting strategic nuclear forces. Messages received via a number of circuits or paths were processed and appropriately transmitted to operating forces via several communications frequencies and modulation schemes. Among them was the use of Morse Code transmissions of coded numbers and letters, effected by a simple on/off key that triggered

De machines van VQ-3 op Guam 1977.

shifts in the transmitter over brief periods of time, resulting in Morse Code 'dots and dashes' corresponding to number and letter combinations. Skilled radiomen in the TACAMO aircraft as well as aboard submarines and land stations listened to and decoded these Morse Code transmissions and passed the messages to appropriate officers who made decisions and took actions on them as part of the exercise.
The very low frequency (VLF) transmit system was the true heart of the TACAMO mission. Powered by four engine-driven 60/90 KVA electrical generators dedicated solely to its power requirement for 250,000 volts, it produced a radio signal of 200,000 watts that penetrated the sea water to submarine patrol depth for thousands of miles from the transmit location. Collins Radio, later Rockwell Collins, of Dallas, Texas produced an evolution of VLF transmitters that began at 25,000 watts in early models up to the current solid state power amplifier that produces 200,000 watts.

Orbit Maneuver

The VLF transmission range was increased as the verticality of the trailing wire antennas increased in the orbit maneuver. In the Hercules aircraft, the pilots continually adjusted nose attitude and angle of bank to maintain a 'tight' orbit, characterized by relatively stable trailing wire antenna tension, measured along the antenna and displayed on the pilot and antenna system operator's instrument panels. At the end of the trailing wire antennas were weight cones called drogues that provided a degree of aerodynamic stability during flight. The array of an orbiting antenna between the drogue at the bottom and the aircraft at the top resembled a helical coil. This made the TACAMO aircraft with trailing wires extended an obvious hazard to other aircraft flying around or below it. Federal Aviation Administration and equivalent international airspace management agencies provided separation of air traffic and most orbit areas were well off the most common transit lanes.

EC-130 TACAMO starting its orbit maneuver (US Navy)

While in a reserved airspace cylinder of 100 NM radius and altitudes from

Een EC-130Q van VQ-4 in de landing.

5,500 feet to 25,000 feet, an EC-130Q crew would position the aircraft as far upwind as possible and in clear air before extending the dual trailing wire antennas and starting the orbit. The angle of bank was gradually increased to 30 degrees, delivering a standard rate turn and an orbit circle of 2 minutes duration, the distance being a function of ground speed. The length of antenna varied with the VLF frequency used but nominally was about 20,000 feet for the long trailing wire and 2,000 feet for the short trailing wire. The initial orbit altitude was chosen based on winds, fuel status, wire length and weather present.

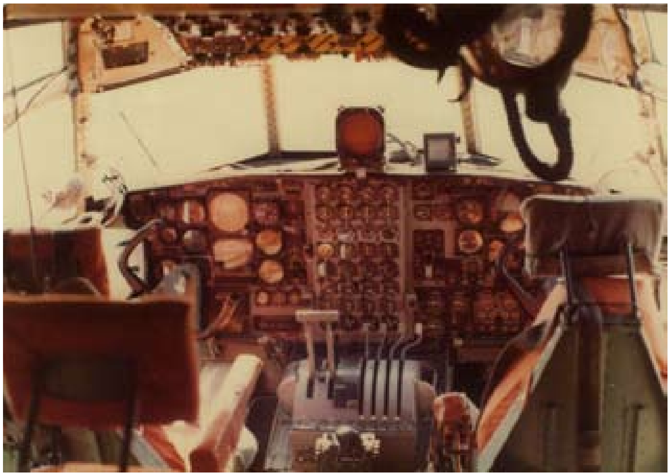
Because the heart of the mission was to be able to transmit VLF on very short notice if required and because fuel use was more efficient at higher altitudes, missions were not generally flown below 18,000 feet. On an average, 30 degrees of bank was nominal starting point. Depending on amount of wind shear, it would be varied + or - 5 degrees. Good orbits were always flown approximately 5 knots above stall speed which was determined by weight of the aircraft and angle of bank. This created about 1.15 to 1.2 Gs on the aircraft and crew. Orbits could be maintained for several hours and averaged between 1 and 3 hours. Not every mission featured an orbit, due to either operational scheduling, weather, or maintenance diverts. With the advent of the E-6 Mercury in 1989, TACAMO crews learned to orbit a heavy, swept-wing jet and achieved successful VLF signal propagation using the same equipment and similar antenna wire exit locations and orbit procedures. Boeing engineers modeling the procedures and developed the Orbit Improvement System which entered fleet use in 1996. OIS uses a computer executing the orbit algorithm coupled to the autopilot to fly a tighter orbit and the resultant antenna stability increased VLF signal propagation range.

Mission Communications Suite

Starting with a single VLF trailing wire antenna and roll on/roll off mission communications suite, the TACAMO system evolved from TACAMO I through TACAMO IVB. Improvements brought additional communications modes, increased reliability and maintainability, and the application of digital processing. Wing tip pods were added with the IVB systems and contain satellite communications equipment. The second VLF trailing wire antenna was also added in this version.

Crew Composition

Mission Commander: The designation of Mission Commander is reserved for select individuals who by their extensive knowledge of aircraft systems and mission requirements have been designated by the Commanding Officer as the person ultimately responsible for the conduct of the VQ mission. Both Naval Aviators (AC designation) and Flight Officers (ACO designation) are eligible to undertake the responsibilities of being a Mission Commander. The Mission Commander briefs the crew prior to each flight and, once airborne, a complete understanding of complex aircraft systems as well as superior ability to direct the crew effort enable the Mission Commander to complete the mission.



Cockpit van een EC-130Q in de jaren zeventig.

Aircraft Commander: The Aircraft Commander (AC) is a pilot with a high degree of maturity, experience, and flying skill. He or she is in command of the aircraft and is responsible for the safe and orderly conduct of the flight. The AC is thoroughly familiar with aircraft systems, squadron manuals and directives, and all other directives from higher authority. The AC has authority to delay or discontinue a flight when, in his opinion, conditions are unsafe or pose a threat to the safety of the crew. The AC works closely with the entire crew to coordinate activities while airborne in order to complete the mission in an efficient and effective manner. The AC must have at least 1,000 total flying hours and have successfully completed the AC training syllabus to quality for this designation.

Airborne Communications Officer: The Airborne Communications Officer (ACO) organizes and supervises the Communications phase of the mission. Information from current Communications operations orders, messages, publications, and crypto material are used by the ACO to plan and successfully fulfill mission requirements. The ACO is responsible for procuring and safeguarding all crypto material, equipment, and other registered publications necessary for execution of the mission. The ACO provides other crewmembers with pertinent

Mission crew at work.

information regarding communications effectiveness and ensures the completion of all assigned communication logs and a report of mission effectiveness. An ACO is dual qualified as a Navigator.

Navigator: The Navigator is an integral member of the mission crew. He or she obtains tactical information on the mission, weather conditions under which it must be performed, and plans the navigational phase of flight. To qualify as a Navigator requires a complete understanding of the several different navigational systems installed in the aircraft. The Navigator furnishes other crewmembers with information on headings to be flown, estimated times of arrival, current positions, and ground speed. Navigational instruments and data such as maps, charts, and flight publications are the tools the Navigator uses to position the aircraft to successfully accomplish the mission.

TACAMO Navigator Station

Flight Engineers: The Flight Engineers hold a highly valuable position and are responsible to the AC for the mechanical condition and operation of the aircraft. They are experts on aircraft systems, and perform and supervise all maintenance activities when the crew is deployed. The Engineers are usually the first crewmembers at the aircraft, the last ones to leave, and are responsible for all aircraft servicing, inspections, and aircraft records.

Navigatorstation

Airborne Communications Supervisor: The Airborne Communications Supervisor (ACS) is a designated airborne communicator qualified to coordinate and supervise the communications phase of the flight. He is responsible to the ACO and assists him in performing all duties pertinent to the mission. He directs in-flight training of airborne communicators and coordinates troubleshooting procedures and in-flight maintenance of the special communications equipment with the flight technician. He is also responsible to the ACO for security of the aircraft, crypto materials and equipment, and communications procedures.

Airborne Communicator: The Airborne Communicator (ACOM) is a qualified Morse Code operator who operates the special communications equipment in support of the communications phase of the mission. The ACOM assists in the preflight inspection of the special communications equipment and completes all assigned communication logs and reports of mission effectiveness.

In Flight Technicians: The In-Flight Technicians are aviation electronics technicians who are responsible to the Mission Commander for overall troubleshooting and maintenance of all communications, navigation, and avionics equipment installed on the aircraft. He supervises the inventory of all electronic spares and publications and coordinates electronic maintenance actions with the flight engineer and airborne communications supervisor both in flight and at deployed bases.

Inflight Tech preflight VLF-system VQ-4 ca. 1976

Reel Operator: The Reel Operators are directly responsible to the ACO and AC tor the extension, retraction, and maintenance of the dual trailing wire antenna system. Reel Operators are additionally responsible for preparation of crew meals while airborne.

Crew Factors

The TACAMO missions were long and often tedious. Aside from the challenges of the oceanic crossings, the crews faced sub-zero floors, inadequate cabin heating, constant vibration and high noise levels, and primitive lavatories. With scheduled missions 8 to 11 hours in length, various 'records' were set at 13 to 15 hours. As continuous airborne coverage was required, a crew nearing the end of its mission might find itself extended because of aircraft, crew or weather problems with the crew scheduled to relieve them. This frequently led to the longest missions and at times the launch of a backup crew from a standby status. With 18 to 22 being the normal crew size, qualified operators and trainees rotated through appropriate crew positions and rested briefly. For a morale boost, some crew members organized and prepared at least on hot meal during the flight, as well a snack or cake. Crew members pooled private funds and the money was used to shop at military base or commercial markets for enough food for an each flight. Holiday turkeys and hams were cooked in a small convection oven and other meals were heated in

Inflight Tech preflight of the SATCOM system VQ-4 ca. 1976

Reel operators

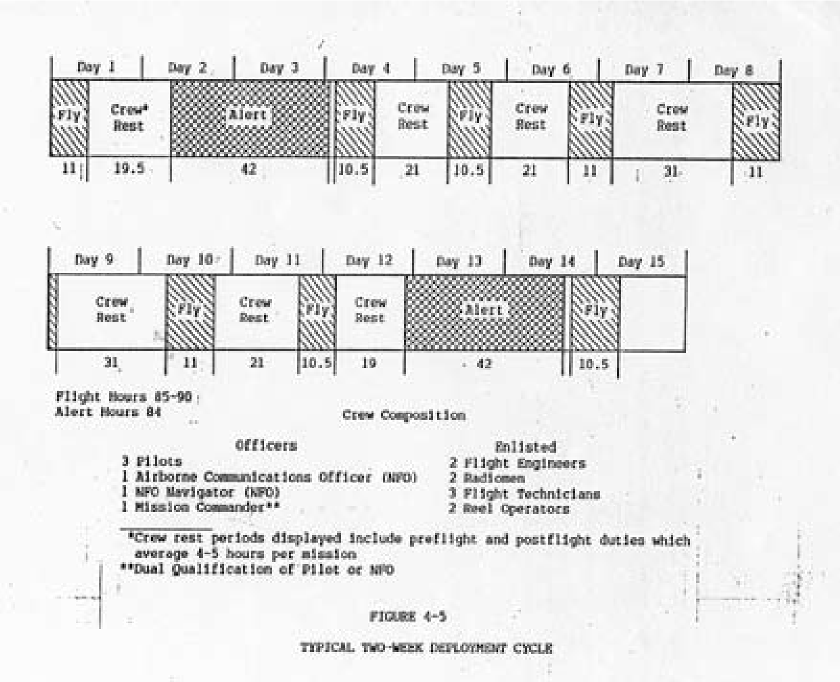
electric skillets. Some crews cooked a cake upon notice of being extended on a mission because of a delay in the takeoff of the relieving crew. The extended mission caused airspace management issues as the crew had to extend its flight and not commit to a landing as scheduled. Some crews were meal challenged and purchased individual cold meals from their departure base messing facility. One labeled 'their' box and they were stacked around the small galley until consumed. Other crew members would sometimes add comments to another's box, a congrats or a good natured jib, or a comment on the quality of the food inside.

TACAMO Crew Rest / Galley Station

Alert duties, with the aircraft 'cocked and locked' were performed at many sites including 'permanent sites' at NAS Patuxent River, Naval Station Bermuda, British West Indies, NAS Agana, Guam, Travis AFB, California, Tinker AFB, Oklahoma, and for a time NAS Barbers Point, Hawaii and NAS Moffett Field, California. Crews were launched on short notice and quartered close to their aircraft. The quality of creature comforts varied widely among the alert sites, included food variance from self-cooked meals to box lunches and buildings from mobile home complexes to purpose-built facilities with soundproofing and a cafeteria.

The crew rotation schedule created a continual challenge for squadron leadership and the maintenance of morale and communications. With one third to one half of the crews deployed away from the home station at nearly all times, standardization of procedures, proficiency training, advancement exams, and the other recurring, routine squadron events had to be repeated to reach all the crews. Most Naval Aviation squadrons operate as entire group, deploy to-

Crew restroom and galley (left)



Typical crew schedule.

gether, and return to home station together to a stand down period. TACAMO squadrons never experienced this type of operations and never had a stand down from the mission requirements, even during periods of aircraft out for modifications and the transition to the E-6.

Women in TACAMO

The TACAMO mission became an officially recognized warfare specialty in Naval Aviation in 1978. About this same time the first women were assigned to aircrew and maintenance roles, beyond the earlier assignment of women to administrative roles. Women naval aviators and naval flight officers have both worked their way through the officer ranks to command TACAMO squadrons and the TACAMO wing. Two active duty TACAMO women have been selected for admiral and two from the Naval Reserves preceded them to flag rank.

VQ-3 was chosen to receive this new airplane first, starting in August 1989 and completing in September 1990. VQ-4 deliveries were completed between in 1991 and 1992. TACAMO operations never stopped during this long transition to the new aircraft and new ways of operating. The E-6 contained mission avionics systems that were transplanted from the EC-130Q aircraft. The TACAMO IVB system was removed from a EC-130Q and reinstalled in the E-6,using a human-factors engineered layout that increased crew operating efficiency. In 1998, the E-6B was introduced with improved mission systems, the VLF power amplifier was upgraded to a solid state system and a third or utility trailing wire antenna was added. Also included was the addition of equipment and crew

156174/74 van VQ-4 tijdens een fuellstop op Upper Heyford in Groot-Britanie, 21 juli 1980. (Arie van Groen)

stations that enabled the E-6B to assume duties as the Strategic Command Airborne Command Post, being based as a detachment at Offutt AFB, NE. In this new role, the TACAMO aircraft support all nuclear forces, submarines, bombers, and missiles that are controlled by US Strategic Command.

TACAMO Unit Relocations

With the advent of the E-6 and its airframe commonality with the E-3 AWACS

Change of command, first E-6 arrival ceremonie in August 1986.

161223 of VQ-3 final departure 1989.

aircraft, the decision was made to co-locate the TACAMO squadrons at Tinker Air Force Base, Oklahoma City, OK. Facilities were constructed there on 80 acres purchased by the Navy that was added to Tinker, between 1991 and 1993. A TACAMO Wing, Strategic Communications Wing ONE, was established in 1992 and received the two TACAMO squadrons, the training units, and the communications and other support organizations there between 1992 and 1995. The TACAMO wing commander or 'commodore' is selected from post-TACAMO operational command commanders. The Wing Commander is also the Commander, Task Force 124, which is the designation for the TACAMO operational units that are assigned administratively to Commander, Naval Air Forces. The integration of the TACAMO wing at Tinker Air Force Base is a success story of inter-service cooperation vice competition. The concept of 'TEAM TINKER' was formulated between the first TACAMO Wing Commander and his Air Force counterpart who commanded the air base in 1993.

Mishaps

156176 / 4280 / Crew Four - The TACAMO forces lost one aircraft and crew during the Cold War. It was the Pacific squadron (VQ-3) TACAMO Pacific Crew Four. They crashed into one of the deepest parts of the Pacific Ocean off Wake Island, just after takeoff. From early 1975 to 1977, VQ-3 was down to a single aircraft for most of the period and it was being shared by all the crews. The EC-130s were being upgraded to a new TACAMO IVB mission suite during this time. Some crews were sent to VQ-4 to gain some experience by augmenting VQ-4 crews on deployments. Proficiency for VQ-3 was at an all time low. Following the loss of Crew Four, an additional EC-130Q was assigned along with a KC-130F on loan from the US Marines.

The 156171 was lost with the whole crew on 21 June 1977.

BuNo 156176 (c/n 4280)

151890 / 3871- Another TACAMO aircraft, this one from the TACAMO Atlantic squadron, VQ-4. A wing fire developed after takeoff from NAS Patuxent River, MD and the crew was forced to ditch in a farmer's field in Delaware. There were no serious injuries. The aircraft was disassembled and the mission communications system was reassembled as the first crew and maintenance system trainer alongside the VQ-4 operating site.

1986 - Given the mission tasking, rarely if ever where all of the squadron aircraft and crews together at their home base at the same time. This photo is one of those rare moments when one aircraft and crew was away and the others were formed up for a photo opportunity. Within a few hours, several aircraft and crews had departed for missions.