REPRINT
SECOND QUARTER, 1965

GROUND SUPPORT EQUIPMENT

# GSE

THE MAGAZINE OF AIRCRAFT, MISSILE, SPACE VEHICLE, AND WEAPON SYSTEM SUPPORT

## SATS — short airfield for tactical support

# Marine Corps Develops First Portable Airfield for High Performance Planes

■ LARRY L. BOODA

Even though it weighs out at about 1,800 tons complete, the Short Airfield for Tactical Support (SATS) is truly air transportable. This includes planking, catapult, arresting gear, aircraft service equipment, vehicles and communications gear.

Yet it can handle the Mach 2 plus McDonnell F-4B Phantom II fighter and will be able to accept the oncoming General Dynamics F-111B in the future. It can also launch and retrieve the Douglas A-4E Skyhawk attack aircraft, Grumman A-6A Intruder and the Chance Vought Crusader F-8 series fighters.

Since the Marine Corps is an elite operating military organization, it is dependent on the Navy for some of its logistical services, including procurement of aviation equipment. So the development of the SATS system is under the Bureau of Naval Weapons. The SATS Project Office is located, oddly enough, under the Ships Installation Office, which in turn reports to the Assistant Chief of the Bureau for Research, Development, Test and Evaluation. The Project Officer there is Lt. Col. Steve Furimsky, USMC.

SATS has evolved over the years from Marine Corps requirements for expeditionary airfields aimed at operating the most advanced aircraft. It now appears that these limited war types of aircraft have reached their optimum size and will be frozen in weight so that the SATS requirements can be stabilized. They will remain so until true Vertical and Short Takeoff and Landing (V/STOL) aircraft are developed sometime in the indeterminate future. Only then will SATS become obsolete.

Although the SATS airfield is air transportable it would be in only the most urgent and unusual circumstances that all of the equipment would be carried by air. One aim of the concept is to have prepositioned equipment in forward areas where ships could deliver the heavier items in a matter of a few days.

Only under rare circumstances would it be necessary to start from scratch as in World War II, bulldozing jungle to make clearings for airstrips. Sufficient already cleared level land exists in most of the world to eliminate major grading operations.

Of all of the services, only the Marine Corps has insisted in the past 20 years on being able to operate all of its aircraft, even the hottest jets, from forward airfields. The Army and the Air Force let these requirements slip.

Not even the Korean conflict brought about developmental work to any extent. Methods used were of World War II, requiring long runways and heavy equipment. The Air Force, until 1961, concentrated on nuclear tactical weapon delivery rather than conventional armament, and Army aviation operated light weight aircraft.

Marines are here shown tightening sections of the M9M1 extruded aluminum planking used to surface SATS runways. It is watertight, flexible at the joints and can take the aircraft wheel and tail hook impact loads.

In 1956 the Commandant of the Marine Corps determined that SATS units of a temporary nature were needed. They had to be capable of rapid construction and teardown, able to accommodate one tactical squadron, be in operation in three to five days, 1,000 ft. long and 100 ft. wide and capable of sustained operations ashore for 30 days. By 1958 the advent of heavier jet aircraft upped the length requirements to 2,000 ft., but the width was reduced to 72 ft.

By 1961 authorization was granted to establish SATS sites at the Marine Corps Outlying Landing Field (MCOLF), Bogue Field, N.C. and the Marine Corps Air Station (MCAS), Quantico, Va.

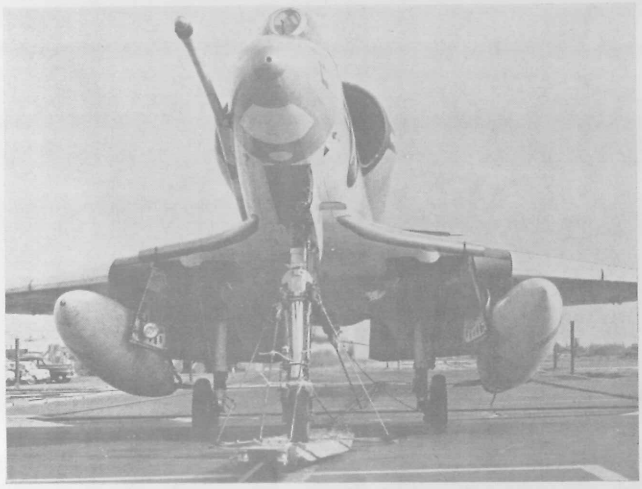
**Phased Buildup Written in Plans**

A SATS installation can be started as a minimum operation and gradually increased in size and capability. Phase I would include: an extreme minimum runway, 2,000 to 3,000 ft. long; a parallel taxiway; hotpad areas to accommodate 12 F-4 aircraft; a minimum amount of launch, recovery and support equipment. Operations would be limited to daylight Visual Flight Rules (VFR).

If the situation required, Phase II would go further in augmentation of equipment to take care of two squadrons of F-4 and/or A-4 aircraft — between 20 and 30 aircraft. Additions would be approach control facilities, air-field lighting and more launch, recovery and support equipment. Group level maintenance capabilities would be required.

If a further buildup were ordered — enough to accommodate a composite Marine aircraft group — construction of longer runways or additional runways would be in order. Lighting and navigation aids would permit 24 hr. operations. SATS would then have reached its complete combat capability.

In summarizing employment of SATS installations the guidelines publication DB No. 1-65 published by the Marine Corps Landing Force Development Activities, Marine Corps Schools, Quantico, says, "In addition to carrier operations, air support will be possible from SATS installations situated near force beachheads, offshore islands, or friendly land areas in close proximity to ground action. Operations conducted from the vicinity of force beachheads may warrant the establishment of a SATS installation as the initial field of operation until a conventional field becomes available. If a conventional field is available in or near the objective area, the SATS installation may be used as an alternate facility.



Douglas A-4E tactical attack aircraft sits poised for launching with its nose wheel on the wheeled dolly of the catapult system and the towing bridle attached to towing fittings on the aircraft.

"An existing airfield in the objective area constitutes the most desirable location for a SATS installation. Although existing airfield facilities may be badly damaged or deteriorated, such sites usually have cleared approach lanes, drained and level runway areas, and road networks. These factors influence the time required to establish a SATS installation."

**Main Components Are Matting, Catapult, Arresting Gear**

When a determined effort was mounted to find something better than the marston matting of World War II the lowered price of aluminum and its obvious weight advantages made it attractive as an airfield cover. But the search for suitable planking wasn't completed in one step of engineering technology.

What has finally evolved is what is called AM-2 standard matting. Each plank is an extrusion of high strength aluminum alloy. End connectors of the same alloy are welded to the matting to complete a water tight mat section. These connectors act as load transfer joints between planks. If planks are to be installed on soft earth, locking bars can be used to increase beam strength.

In testing matting several considerations had to be taken into account. Matting must be able to withstand the impact loads of all jet combat aircraft in the Marine Corps inventory at landing sink speeds as high as 20 ft. per second on tires pressurized to 400 psi and withstand an arresting hook impact of 14,000 lb.

The matting must be usable on a wide range of soil conditions. To measure soil resistance the California Bearing Ratio (CBR) is universally used in this country, not only for matting criteria but for measuring aircraft tire capabilities as well. In this instance, applied to matting, the CBR rating minimum is 4. As a measurement of soil resistance to penetration prior to reaching the ultimate shear value of the soil, the ratio is expressed as a percentage from 0 to 100. For comparison, the seeded top soil of a house lawn would have a CBR between 5 and 20.

The AM-2 matting was tested with single wheel loads ranging from 27,000 lb. to 39,000 lb. with a 30-7.7 tire inflated to 400 psi. The matting withstood 1,600 cycles with a 27,000 lb. load with a subgrade CBR rating of 6.3 or greater. At 39,000 lb. it withstood 1,600 cycles with a subgrade CRB rating of 7.4 or better.

Previous models of matting were the M9M-1 matting fabricated from standard M-9 pierced aluminum constructed by welding and riveting an aluminum plate to the top surface of M-9 plank. Threaded steel cap screws were used for end-to-end connections. This matting became obsolete with the introduction of F-4 and A-6 aircraft.

In the M9M-2 mod aluminum plates were welded on top and bottom of the M-9 core. This matting will carry the heavier traffic if laid on soil with a CBR of 11 or greater. It can operate on lower CBR subgrade but requires more maintenance. Although it is basically obsolete it can be used for SATS operations where a wheeled catapult dolly is not used.

AM-1 matting was an interim matting designed to take the heavier loads. Its characteristics are similar to AM-2 but it cannot take tail hook shock from the

## SATS PROCUREMENT ACCELERATION

**After simmering along at a leisurely rate since 1961 the Marine Corps Short Airfield for Tactical Support development and procurement program pot is boiling at a faster rate due to the intensified heat of activities in Southeast Asia.**

**The defense department admits to a $100 million program at present but there are indications that:**

- **Airfield aluminum extrusion matting buying will shoot up rapidly, mostly due to needs of the Air Force. It makes the construction of an airfield much simpler in lieu of pouring concrete runways, such as was done at Da Nang in the northern part of South Vietnam. Dow Chemical Corp. is presently producing the extrusions while the Washington Aluminum Co. is fabricating the planks. Harvey Aluminum Co. and the Aluminum Company of America are competing for an upcoming contract.**

- **Nine complete SATS units, which include catapults, matting, arresting gear and all support equipment, are scheduled for the Marines, which would make three per Air Wing. But it is known that plans are in the making for production of components in much greater numbers. Informed sources indicate that the Air Force, which is operating the McDonnell F-4C Phantom as a fighter-bomber, an aircraft very similar to the Navy-Marine Corps F-4B, will be told to plan to make use of most of the package.**

- **Those SATS units which were installed in the United States have disappeared to the Western Pacific, leaving a vacuum behind. Procurement will have to be accelerated to provide for training.**

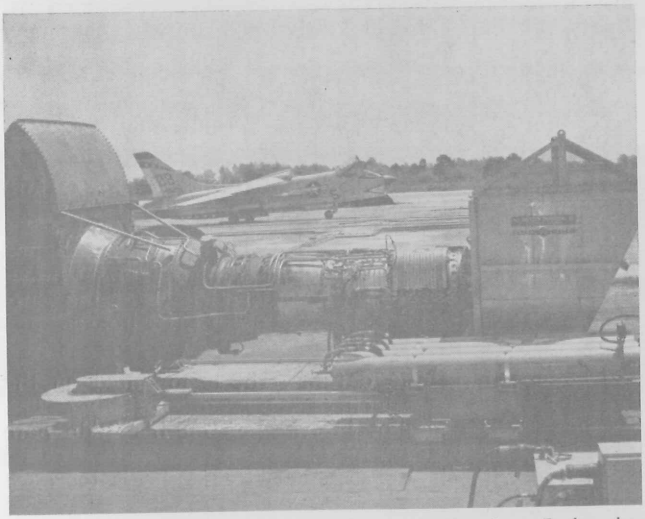
**Other major contractors for SATS include:**

- **All American Engineering Co., Wilmington, Del., for the CE-1 Mod. 3 launching system including a complete power plant and catapult. (See text) AAE developed a trackless model, greatly simplifying the system.**

- **Vortec Products Co., Torrance, Cal., a division of Douglas Aircraft Co., the M-21 arresting gear.**

- **Oxford Corp., Buffalo, N.Y., airfield lighting.**

- **Control Instruments Division, Burroughs Corp., Paoli, Pa., Fresnel lens, a visual glide-slope reference system to aid landings.**



Integral part of catapult system built by All American Engineering is the General Electric J-79-2 turbine engine which furnishes power for launch. Ready for catapulting in background is Chance Vought F-8.

F-4 and aircraft wheels rolling over the arresting gear cross deck pendant.

Each section of AM-2 weighs 144 lb.; is 12 ft. long and 2 ft. wide and 0.125 ft. thick. Weight per sq. ft. is 6 lb. Pallets for carrying the matting will hold 11 full length mats and two half length. Total pallet and load weight is 2,011 lb.

AM-2 can be repaired by welding broken parts or by replacing whole mats. If the matting is laid on mud a vinyl covered nylon material that is oil, chemical and grease resistant, combustion resistant and self-extinguishing and resistant to rob and mildew, can be placed underneath to prevent mud pumping action under and through matting sections.

**Explosive Earth Anchor designed**

The EAW-20 earth anchor, designed to hold equipments in place, features a short-cut method wherein no large holes have to be dug. A hollow post is driven into the soil, either by mechanical emplacement (sledge or machine driven) in softer earth, or in drilled holes in rocks. After it is in place an explosive charge is lowered to the bottom end and fired. This explosion deforms the tube extremity so that tines stick out and a cavity is formed in the soil.

Next, grout material, which can be a mixture of cement or other hardening agents, is poured down the tube to fill the cavity and envelope the tines. After it is set it is effectively the same as a post set in a dug hole surrounded by a concrete bolus, yet the job was done quickly.

Demand for matting is growing so great that multiple sources are being sought. At present Dow Chemical Corp. is producing the basic extrusions and other parts and the Washington Aluminum Co. is fabricating it. The Harvey Aluminum Co. and the Aluminum Company of America are competing for another contract. It is probable that a third source will be sought soon.

**Portable Catapult Developed**

As higher performance jet aircraft were developed, longer runways became necessary. Generally speaking, Navy-Marine Corps planes needed less distance for takeoff than those of the Air Force. Nevertheless, runways needed were still too long for beachhead installations.

In earlier attempts to reduce takeoff runs jettisonable JATO rocket bottles were used and drogue parachutes shortened landing rolls. Since the Marine Corps is Navy oriented (every attack and fighter pilot is aircraft carrier operations qualified), it was only natural that some adaptation of shipboard catapult and arresting gear techniques be tried for SATS.

The catapult contractor, All American Engineering Co., (AAE) Wilmington, Del., has specialized in the development of many kinds of different launch and retrieval systems for aircraft, cargo and humans. It began its career as part of what is now Allegheny Airlines but broke away as a separate enterprise after the Civil Aeronautics Act of 1938 forbade airlines from doing any kind of manufacturing.

The present catapult, the CE-1 Mod. 3, is an outgrowth of a requirement set by the Bureau of Naval Weapons (BuWeps) in 1961 for a develop a long stroke catapult powered by a commercially available turbine engine. Shipboard catapults, which progressed from compressed air, gunpowder and hydraulic power to steam, are all short stroke (about 250 ft.), and must be rigidly mounted.

As a relatively simple answer a cable tow system was prescribed, with the cable being driven by a capstan.

In December, 1961, BuWeps let a contract to AAE for development of the XCE-1 catapult, a launcher utilizing a track on the runway, similar to a shipboard installation, and two turbine gas generators driving a free turbine connected to the capstan. Dead load testing began at AAE's Georgetown, Del. facility in October, 1962. BuWeps directed the change of the system to a single engine and eliminated the track. The designation was changed to XCE-2. Testing began in November, 1962 and was completed the following March.

The following month the CE-2 was installed in three days at the Naval Air Test Facility, Lakehurst, N.J. and live aircraft launches begun. This catapult has been in use there since then, incorporating improvements leading to the present dual engine trackless production model.

**Endless Cable Used**

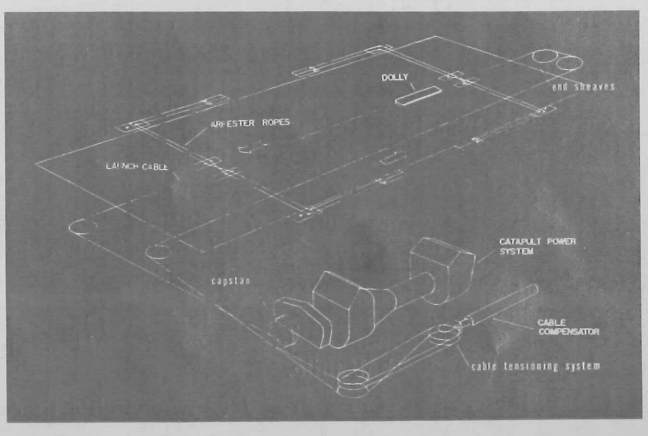
The CE-1 Mod. 3 is so arranged that it can be used to launch planes in either direction on an airstrip (see drawing). It can also be varied in length according to the size of the airstrip.

The endless (spliced) loop wire cable runs around sheaves at the ends of the runway, looped several times around the power capstan, and runs through a compensator which maintains the tension on the cable.

Power comes from two General Electric J-79-2 jet engines, only slightly modified from those used in aircraft such as the F-4. The free power turbine, the LM 1500, also made by General Electric, is driven by the hot engine gases. It transmits its drive through a 3.55:1 reduction gear box.

The power system delivers 34,800 hp., producing a tow force of 55,000 lb. It launches the F-4 in 1,485 ft. at a speed of 178 kt., the A-4 in 1,165 ft. and speed of 160 kt. and the F-8 in 1,010 ft. and speed of 162 kt.

Catapult system outline shows J-79 engine, cable tension system, and cable leading through sheaves to the SATS runway where it can launch an aircraft in either direction using wheeled dolly.



By comparison, the Air Force Lockheed F-104G Starfighter takes 1,950 ft. at a speed of 220 kt. due to its higher wing loading (smaller wings), an example of the difference in aircraft mentioned earlier in the introduction to the catapult system.

A control console alongside the runway permits an operator to monitor and control all operations.

Power from cable to aircraft is transmitted through a wheeled dolly on which the plane's nose wheel rests. A towing bridle similar to those used aboard ship is fastened to the dolly and is passed around the plane's towing hook. A holdback system keeps the plane in place until catapult power is applied.

The operating sequence is very similar to shipboard procedures. The catapult brakes are set, the catapult engines started, the dolly positioned, the aircraft taxis onto the dolly, the bridge and holdback breakaway link connected, the system tensioned, aircraft brought to full power, and on signal from the pilot, the brakes released, catapult engines advanced to full power and the aircraft is underway. The pilot rotates his plane for takeoff as in a normal takeoff. The engines automatically return to idle position and the dolly runs into an arrester and is returned to battery by a nylon rope dolly rebound system.

The launch cycle can take as little as 90 seconds.

The CE-1 Mod. 3 grosses to about 126,250 lb. for air shipment — enough to require four Lockheed C-130 Hercules aircraft.

Installation time is approximately 700 man hours. A crew of five men and one officer is required for operation.

**Liquid Energy Absorber Stops Planes**

When the Marine Corps first tried the idea of using arresting gear for short airfields it adapted the Mk5 Mod. 5 shipboard arresting engines, which are essentially hydraulic rams connected with the arresting wires The adaptation, called the M-2 MOREST, is rugged and reliable but its growth potential and capacity are less than optimum.

The system chosen is the M-21, developed by Vortec Products Co., Torrance, Cal., a division of Douglas Aircraft Co. It consists of a single cross deck pendant (wire) which the tail hook of the aircraft engages on touchdown. This wire is attached to nylon tapes on each side of the runway. These tapes are wound around reels, or capstans, on each side. The reels in turn are connected by shafts to vanes in a cavity filled with a mixture of water and ethylene glycol (antifreeze). When an aircraft engages the pendant the tapes pull out, turning the reels and vanes. The fluid mixture absorbs the energy from the vanes. Braking energy absorption capability is 44 million ft/lb., using 11 inch nylon tapes with a tape runout of approximately 600 ft. The pendant is brought back to its operating position by a diesel powered retract system.

In operation a carrier qualified landing signal officer is in positive control of landings. He must be prepared to bring in a pilot by means of "talk-down" if the Fresnel lens system is not operational for any reason. He is aided by a crew of nine men. An essential part of the operation is a communication system between crew members through line connected noise-proof headsets and by radio with pilots.

**Other SATS Components**

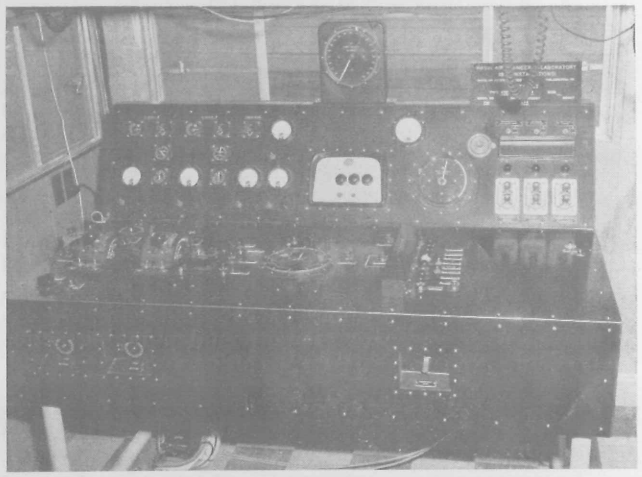
For nighttime operations an expeditionary airfield lighting system has been adopted including high intensity approach lights, steady and sequence flashing lights, and high intensity bidirectional runway lights, which, when used with navigational aids will permt operations to a minimum ceiling of 200 ft. and minimum visibility of one-half mile.

In addition to the approach and runway lights there are low intensity taxiway lights, circling guidance lights, runway threshold lights, runway centerline lights, airfield beacon, obstruction lights, lighted wind indicators, runway status lights, electrical cable and generators. Two 30 KW or one 60KW generators can be connected with 208V, Wye AC, 3 phase outlets. Total weight when boxed is 8,150 lb.

The contractor for airfield lighting is the Oxford Co., Buffalo, N.Y.

The Fresnel lens, or optical landing aid mentioned above, is a self contained source light system manufactured by the Control Instruments Division of the Burroughs Corp., Paoli, Pa. It produces a light image when projected out on the aircraft approach path.

A set of horizontal datum light is mounted on the sides of the lens, which is the source of light. The image provides a pilot information on his glide path (too high, too low or just right) but not whether he is in line with the runway or whether he is too slow or too fast.



One man control module for the All American Engineering CE type catault used in the SATS system is shown here in personnel shelter.

Expeditionary vans for SATS use provide a multitude of auxiliary equipments. Made of aluminum alloy for weight saving they are configured for aircraft engine shops, metal shops, hydraulic shops, meteorological office, avionics, pilot ready room, and medical.

A standard collapsible shelter which can be expanded by increments can be used for "D" and "E" level maintenance. Another serves as a ready service weapons shelter.

A continuous track crash, fire fighting and rescue vehicle, weighing 5,700 lb. can travel 35 mph on land and 5 mph in water. This is a tri-service vehicle and three prototypes have been procured by the U.S.M.C. A rough terrain crane weighing 20,700 lb. will be of help when crashes occur.

Other vehicles are fork lifts, tow tractors, passenger-cargo trucks, ambulances, fuel trucks, snow removal equipment, weapons loaders and trailers, rough terrain ordnance transporter-loader, and 6,000 lb. capacity crane.

A liquid oxygen-nitrogen generating plant weighing 14,000 lb. can produce two tons of cryogenics each 24 hour period.

Rounding out the equipment is a traffic control facility consisting of an AN/TPN-8 Ground Controlled Approach radar set and two helicopter transportable shelters with all of the communications gear needed. The shelters can be mated end-to-end. A portable control tower can be erected rapidly. A runway mobile control unit is compact and easily moved.

*Reprinted from Ground Support Equipment, Second Quarter 1965*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WILMINGTON, DELAWARE 19899

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255 CHAUSSEE DE VLEURGAT
BRUSSELS 5, BELGIUM

Printed in U.S.A.