Training Capabilities
"The Facility Part of the Equation"

By

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ABSTRACT

The theme of increased readiness through training has an inherent assumption that adequate facilities either exist, can be modified, or can be built to house computerized training devices. Too often adequate facilities do not exist or require long lead times to acquire. Training capabilities can become a myth to the realities of not having an adequate facility or of having modern training equipment fail because of facility deficiencies such as high temperatures and power spikes. But what are adequate facilities for computerized training devices, and how do we acquire them? This paper will review the time phasing and types of funding available within the Department of Defense for construction projects, design concepts of a flexible modular training building including security and environmental considerations. Without understanding the time phasing for acquisition of training facilities, the effectiveness of training devices can be reduced to zero.

1. ACQUISITION OF NEW FACILITIES VIA THE MILITARY CONSTRUCTION PROGRAM (MCP)

Agencies within the Department of Defense acquire new facilities via the MCP (3300) appropriation and in the Air Force in accordance with AFR 86-1. The lead time for a project greater than one million dollars is usually five years from planning to completion of construction. Thus in early 1983 the planning must be done for a Fiscal Year (FY) 86 funded facility to be completed in 1987. The following are illustrative FY 86 MCP MILESTONES shown on Figure 1:

- In 1983 the user identifies a requirement, receives approval to proceed with detail studies, prepares a Military Construction Data Sheet DD Form 1391, starts a design criteria study/project book;

- The Major Command (MAJCOM) includes the project in the 1985-89 submission in July 1983. It is mandatory the facility project be 35% designed by Sept 84 for an FY86 MCP. To obtain this milestone the project must be included in the 1985-89 plan so design can be started in early 1984;

- Major Command (MAJCOM) 1986-1990 Budget Review Jul 84;

- Air Force and Office of the Secretary of Defense (OSD) Review Sept-Dec 84;

- Congressional Review and Approval - Jan-Sept 85;

- FY86 Appropriation becomes Law on 1 Oct 85.

- Other MILESTONES would reflect a minimum 60-day period to select and hire an architect-engineer to design the facility, and a minimum 60-day period to award a construction contract for a one to two-year construction effort.

Congressional approval and MAJCOM review dates do vary but the chart reflects the milestone sequences.

Minor Construction Projects. Construction projects for a single undertaking which cost less than one million dollars, and provide complete and useable facilities or improvement to an existing facility are Minor Construction Projects.(1) They are called specified minor construction if identified in the annual Congressional submittal. These require the same lead time as the MCP described above. A minor construction project considered exigent (or urgent) can be submitted for approval at the time the requirement is defined. Upon approval of the Major Command and HQ USAF/LEE the facility design can be started and upon completion of the design, funds can be requested for construction. This is often a one year cycle. The difference between the specified and exigent minor construction is: 1) the approval level, 2) the time required for approval, and 3) the intense competition for the limited funds in the exigent category. Figure 2 shows the approval levels for an Air Force Human Resources Laboratory/Operations Training Division (AFHRL/OT) MCP, Minor Construction and Equipment Installation Project.

For all MCP projects the DD Form 1391 must show: a well defined requirement reflecting program funds and manpower; funds and schedules for equipment and construction completion; detail construction costs; location at a specific base or site; size and the environmental impact of the new building. A design criteria study for R&D facilities and a project book for MCP will provide most of this information. After the project is submitted to Congress, to the House and Senate Authorization and Appropriation Committees, the location, size and cost cannot be changed.

Another method of obtaining an adequate R&D Training or Simulator capability is to modify an existing building in accord with the criteria of

SCHEDULE FOR FY86 MCP

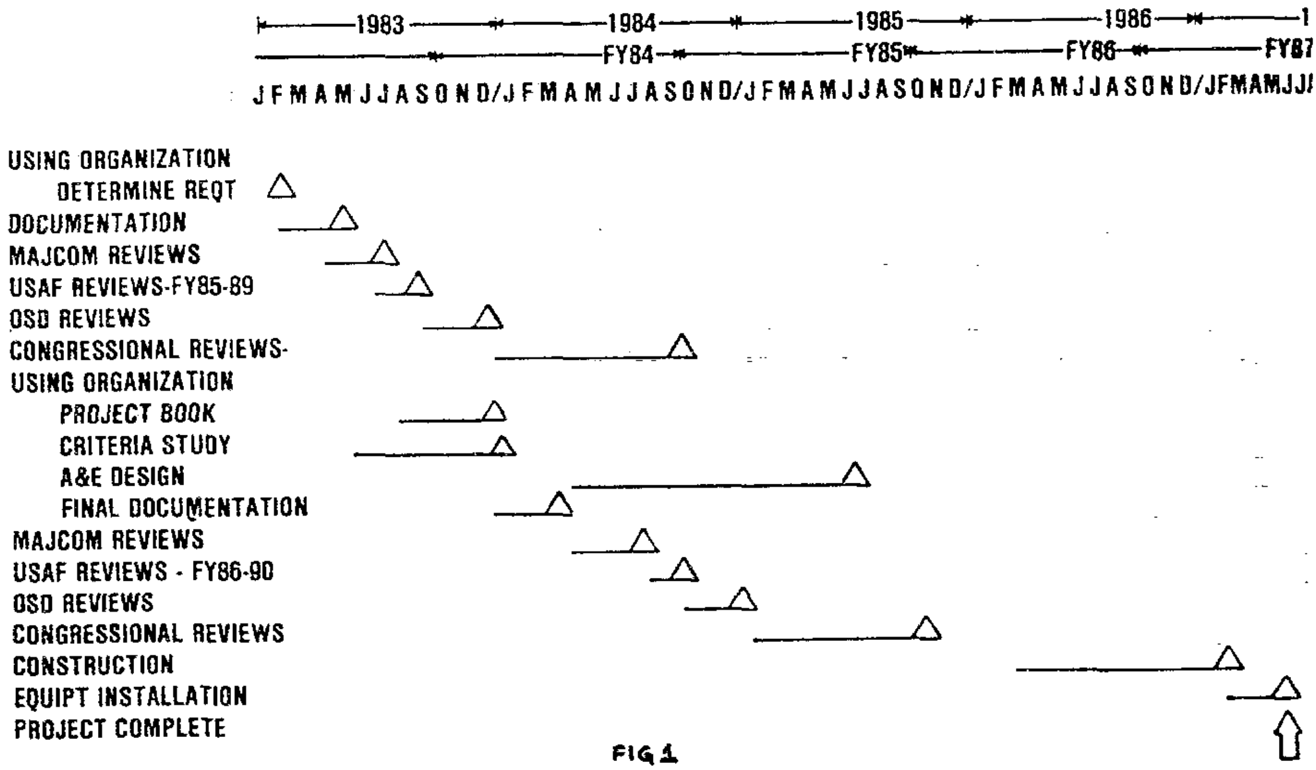

FIG 1

APPROVAL LEVELS FIG 2

MILITARY CONSTRUCTION PROGRAM (MCP) (AFR 86-1)

PROJECT COST		HRL	AMD	AFSC	AF	SAF	OSD	CONGRESS
MCP	OVER $1.0 MILLION	X	X	X	X	X	X	X(S&C)
Minor Construction	$.5 - 1.0 MILLION	X	X	X	X	X	X	X(S)
(P-341)	$.2 - .5 MILLION	X	X	X	X	X	-	-
(1)	0 - $200,000	X	X	.	-	-	-	-
	0 - $75,000	X	.					

NOTE: (1) $200K LIMIT PER BUILDING/YEAR

(.) APPROVAL LEVEL REDELEGATED (S) STAFF REVIEW (C) COMMITTEE REVIEW

EQUIPT INSTALLATION (AFR 80-22)

	HRL	AMD	AFSC	AF	SAF	OSD	CONGRESS
ANNUAL CONGRESSIONAL NOTIFICATION (RD-4)	X	X	X	X	X	X	X
OVER $300,000	X	X	X	X			
75-$200,000(2)	X	X	X	(3)			
0-$75,000(2)	X						
TO $300,000 (APPROVAL PRIOR TO RD-4	X	X	X	X			
SUBMISSION)			75	200	200	300	

NOTE: (2) NEW EQUIPMENT PURCHASED & INSTALLATION COST UP TO TOTAL COST OF $1.0 MILLION

(3) NEW EQUIPMENT PURCHASED & INSTALLATION COST EXCEED $1.0 MILLION TOTAL IS AF APPROVAL

AFR 80-22 Par 3, "Installing R&D Equipment." False floors, shielding, special foundations, secondary utility work, air conditioning and mechanical ventilation are included in an R&D equipment installation project.(2) These modifications are accomplished with R&D funds. Another method is to use maintenance funds to modify an existing structure but this is limited to $200,000.

2. FACILITY CONSIDERATIONS

A training simulation facility usually consists of four areas: Computer area; Simulation or Training area; Office area; and Support area (Figure 3). The COMPUTER AREA should contain features such as: tight-fitting raised floors with static-free sectional carpeting; air conditioning and humidity control in accordance with the equipment manufacturer's specifications; an electrical system with dedicated electrical circuits and circuit breakers for the computers, a separate circuit for lighting and receptacles and other building power, and a grounding system; an AC power protection system for the entire electrical system; fire protection system with detection alarms for smoke and heat and a Halon (1301) protection system(3); safety items such as battery operated emergency lights and electrical cutoff switches.The Halon system provides a non combustable gas. There must be enough Halon avaiable to fill the room and deprive a flame of oxygen. The system release points should be located close to expensive as well as combustable materials in the training area ie., hydraulic fluids, petrochemicals, cockpits, crew stations, and the computers. Halon is used for fire protection instead of water and avoids the possibility of water damage to computer equipment and electrical shocks to people in the event of an emergency. Of course the room with Halon must be evacuated in the event of any emergency. For new buildings the computer area can have a 18 inches sunken floor with the raised computer floor on the same level as the corridors and other rooms. This avoids the need for ramps and steps. The 18 inches space under the floor serves as an air conditioning plenum to provide cold air into the bottom of the computers and as an electrical trough for all the interconnecting cables and wires. The need for a tight-fitting floor with static-free carpeting is to retain the cold air in the plenum for air conditioning purposes but also to prevent the computer room from becoming a refrigerator: A comfort zone temperature is $72^{\circ}\pm2^{\circ}$ but computer cooling temperature requirements may be as low $55^{\circ}\pm2^{\circ}$. One solution for having comfortable work areas in computer rooms is to have terminals and work space on the concrete floor level rather than the raised floor level. The floor to ceiling height in a computer room should be a minimum of eight feet. Separate circuits, grounding system and AC power protection systems are considered essential to establishing and maintaining electrical integrity for computer operations.

The Simulator or Training Areas should contain such features as: 1) air conditioning and humidity control in accord with the equipment manufacturer's specifications and this is often not as cold as the computer area; 2) sufficient space from the bottom of the simulator or other training equipment and the floor. This is for maintenance purposes and for accessibility to cables; 3) the same electrical, fire protection and safety considerations as noted for computer areas.

The Office and Support Areas require similar electrical services noted for computer areas. To have both areas as flexible as possible, the use of electrical equipment such as desk top computers, CRT Terminals, word processors and printers should be considered in the location of receptacles and distribution of power loads. The interior decoration of the office areas should reflect a pleasing environment with proper lighting (see section on lights) furniture, colors, use of paneling and rugs. Studies at TRW Inc. indicated a high increase in programmer productivity when working in a pleasant environment and more comfortable offices.(4) The institutional green, gray or white cinderblock walls(5) and gray office furniture next to the radiator is not recommended. It does not stimulate productivity, longevity, or employee morale. The Air Force Standard of 130 square feet per person in office areas is encouraged. The use of modular office funiture with sound-absorbing fabric-covered partitions could reduce this to 100 square feet per person.

Before reviewing Design Concepts, the relationship between the User and the Architect - Engineer (A-E) should be explained. The A-E will take the Users requirements (routine and mission necessary) and develop a layout and plan for a facility to accomplish the mission. Too often the User thinks, "I'll wait for the A-E to tell me what I need." The design criteria type of study will define what is needed. The User should specify his mission requirements which include the technical, administrative, support, health, welfare and morale aspects of work and training areas for people to effectively use for 8 to 10 hours a day. From the very beginning the User should work closely with the A-E and the Base Civil Engineer to obtain a facility that enhances the training mission.

Design concepts should include the following:

a) Flexible and Expandable Areas. The four areas discussed should be designed as separate rectangular or square sections with each section having expansion capabilities both interior and exterior to the building. No one section should be totally surrounded by another section. There should be at least two exterior areas for external expansion for each section. Figure 3 reflects this concept in a two-story, four-section simulator/training building. The computer, simulator, and training areas are located on the below ground level floor to use the earth to contain electromagnetic radiations and emissions from the equipment as well as for physical security and environmental control. Another configuration would be the U-shape building that can be expanded into a square.

b) Environmental Considerations. Lighting-Electromagnetic Radiation and its Psychophysiological Impact.

Extensive clinical and laboratory data indicate that profound psychological and physiological effects can be routinely induced in humans, animals and plants by exposing them to the radiation emissions of conventional "Cool White" fluorescent lamps, in contrast to fluorescent lamps which simulate the electromagnetic spectra of terrestrial solar radiation in both the ultraviolet (UV) and visible wavelengths.(6)(7)8)(9) Ordinary window glass reflects or absorbs much of the "biologically active" spectra of natural outdoor sunlight. Having closed windows and rooms without windows has sealed-off these spectra. The psychophysiological manifestations of spectral deficiencies include: increased stress and fatigue, increased levels of depression, increased blood pressure and serum cholesterol levels, and Vitamin D deficiency.

Solar radiation can be specifically defined and it is rather stable in the proportion of radiation emitted in the near ultraviolet (320-380 nanometer-nm) and visible (380-750nm) regions, whereas the middle ultraviolet (290-320nm) region varies with the angle of the sun. The specification of artificial light sources for the simulation of the full visible and invisible balanced ultraviolet spectra of terrestrial solar global radiation (i.e., sun + sky) for use in general indoor illumination are as follows (10):

Correlated Color Temperature: 5500 to 6500K
Color Rendering Index: 90 or greater

Near Ultraviolet Radiation: (UVA, 320 to 380 nm) 220±60 microwatts/lumen

Middle Ultraviolet Radiation: (UVB, 290 to 320nm) 15± microwatts/lumen

Fluorescent lamps which simulate natural outdoor sunlight in both the visible and ultraviolet spectra are highly recommended. At AFHRL/OT we are testing the "Vita lite" of the Duro-Test Corporation. If obstacles to learning such as fatigue, headaches and eyestrain can be minimized by optimizing the indoor electro-magnetic environment with daylight simulating lamps, the cost benefit trade-offs will be very significant.

The building exterior such as the terrain, trees, shrubs should be utilized to take advantage of the existing environment rather than treat it as an enemy to be overcome with bulldozers and extra air conditioning. Reprocessed water can be considered for use exterior to the building for such items as watering lawns or other esthetic features. In the southern part of the county the use of solar and geothermal energy devices should also be considered.

c) Energy and conservation. The energy conservation initiatives are driven by actions involving energy system optimization.(11) There will be changes in the design practice with "life-cycle costing and sensitivity analysis becoming very important."(12) Computer-Aided Engineering and Architectural Design System (CAEADS) as developed by the US Army Corps of Engineers will have far-reaching benefits.(13) Consideration should be given to siting the building with few windows along the southern or western side of the building in order to reduce heating and air conditioning costs. The offices and support areas where sunlight may be desired should be located in the NE and NW side of a building with windows on the North and East sides of the building. High bays with no windows should be located on the west side of buildings and in a two-building complex one building should be located to provide shade to the other one. The Naval Facility Engineering Command has a five-step plan to save energy which includes use of outside air instead of return air on an air conditioning system when conditioning outside air requires less energy than using the return air. (14) The AFHRL/OT Laboratory Annex includes this feature. Cost trade-off studies between using commercially available power with a low investment cost versus generating power are recommended. The Air Force has done both. Power line problems consist of blackouts, brownouts, fluctuating voltage and noise or transients superimposed on the line. The first problems can be solved with Uninterruptible Power Systems (UPS). All Air Force UPS are centrally procured through Air Force Logistics Command (AFLC) channels from the Chesapeake Division, Naval Facilities Engineering Command under a fixed price, indefinite quantity contract for the following KVA sizes: 50, 100, 200, 250, 400 and 500.(15) Too frequently the noise or transient problem is overlooked. For training facilities with a high reliance on computers it is essential to have an AC power protection system. The degrading effects of short duration transient voltages on solid-state semi-conductors and integrated circuits are of prime concern to the users of electronic computers and equipment. The effects can inflict immediate and extensive damage to vital circuitry to on-line equipment and can result in equipment failures. The associated costs for replacement equipment and delayed training or the research missions can be prevented with an AC Power Protection System with the technical features and Electrical Specifications covered in Report-AFHRL-TP-82-38 by Mr Weldon M. Dube'. The desired features are:

1) Automatic status and monitoring capabilities
2) Resettable digital counter for transient readout with 36 to 48 hours ride-through if power is absent
3) Remote control panel with fully independent operating controls, status indicator and digital readout
4) Field repairable "downtime" of less than one hour so that on-hand replacement modules can be rapidly installed.
5) Protection available 100% of the time even if the utilities are blacked out and no power is available to the facility.

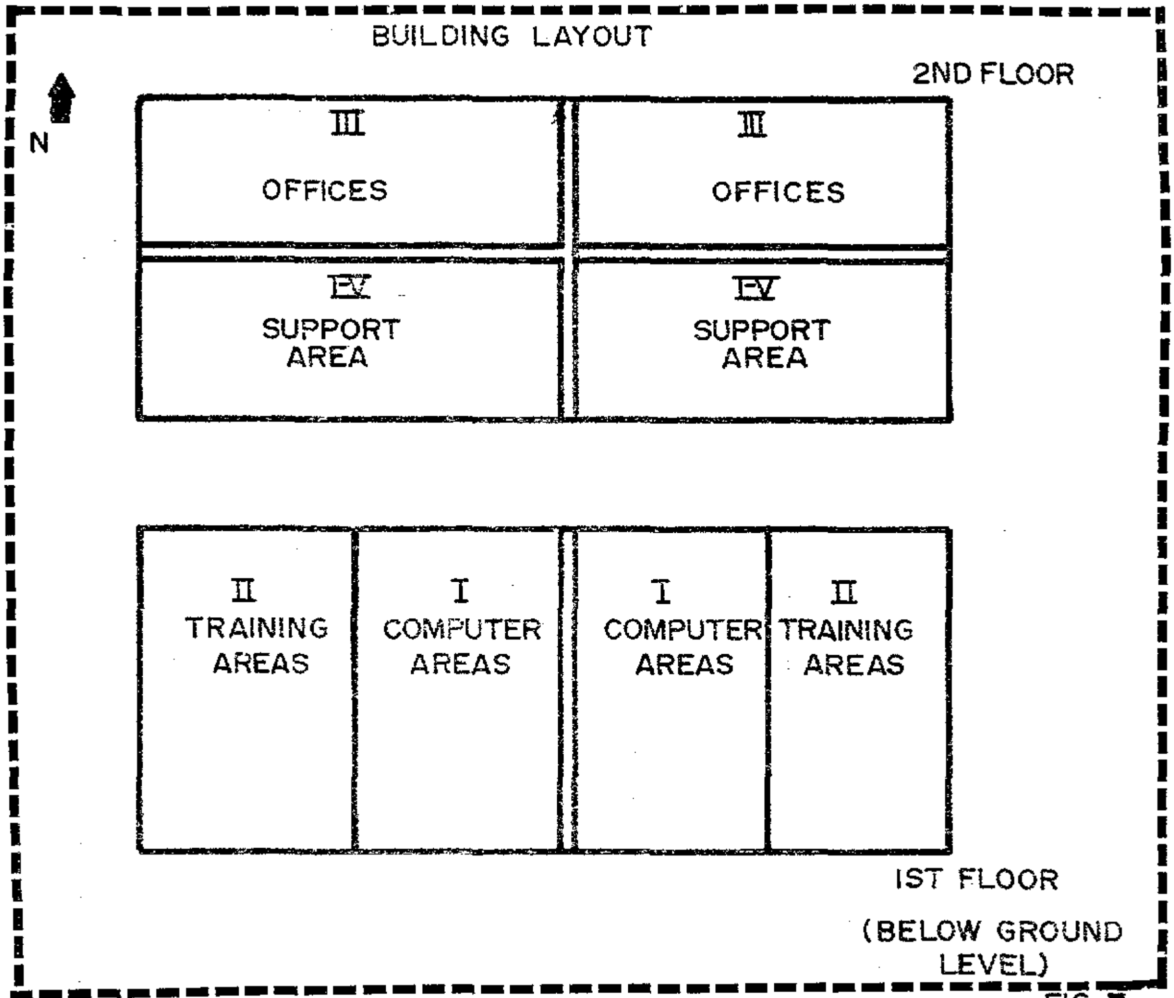

FIG 3

TABLE 1—EMI REQUIREMENTS FOR CLASS A (INDUSTRIAL) EQUIPMENT

RADIATION LIMITS:

FREQUENCY (MHz)	DISTANCE (m)	FIELD STRENGTH (μV/m)
30 88	30	30
88 216	30	50
216 1000	30	70

NOTE CLASS A MEASUREMENTS CAN BE MADE AT ANY DISTANCE BETWEEN 3 AND 30m IF THE TEST RESULTS ARE SCALED INVERSELY WITH THE DISTANCE FOR EXAMPLE AT 3m THE ALLOWABLE FIELD STRENGTH IN THE FREQUENCY RANGE 30 TO 88 MHz IS 300 μV/m

CONDUCTED (POWER LINE) LIMITS.

FREQUENCY (MHz)	MAXIMUM VOLTAGE (μV)
0 45 1 6	1000
1 6 30	3000

TABLE 2—EMI REQUIREMENTS FOR CLASS B (MASS-MARKET) EQUIPMENT

RADIATION LIMITS:

FREQUENCY (MHz)	DISTANCE (m)	FIELD STRENGTH (μV/m)
30 88	3	100
88 216	3	150
216 1000	3	200

CONDUCTED LIMITS

FROM 0 45 TO 30 MHz THE MAXIMUM VOLTAGE FED BACK TO THE LINE AT ANY FREQUENCY MUST BE LESS THAN 250 μV

FIG 4

There are signal line protectors expressly designed to protect signal/data/telephone lines from transport over-voltages caused by lighting, heavy machinery, electric motors, generators, etc.(16)The small investment of 5 to 25,000 dollars in AC power protection systems is considered essential when you relate the impact of a power or equipment failure to the training mission i.e., lost time and additional costs to repeat the training if schedules permit; completing training without repeating the "lost" portions because the training schedules can not be slipped; the time and cost to replace damaged equipment could mean a major rescheduling of several classes; and the increased potential for accidents in darkened training areas.

To maintain desired temperature control in the buildings, it is important to have the thermostat control accessible only to facility engineer/maintenance personnel and not in public areas where anyone can make changes. Most Air Force bases use an Energy Monitoring Control System. Other energy conservation techniques includes turning lights off in all areas that are to be vacant for more than several minutes; i.e., offices, conference rooms, support areas, and even restrooms in the evening. A trade-off study between fluorescent lamp replacement and electric costs has shown that any time a room is to be vacated for more than a couple of minutes, the fluorescent light should be turned off.(17) A free hot water making machine can reduce or eliminate the number of individual coffee making machines and mini-kitchens in offices.

d) Security. The two major systems for security are physical and electronic. The type of problem or threat must be identified when selecting protection devices. Is it an external enemy or is it an internal problem? Physical Compromise is a compromise of information by loss, theft, capture, unauthorized viewing or photography, recovery by salvage or physical means. Physical security protection involves techniques as 1) key locks, 2) electronic card keys with photo identification which give immediate printed reports. Equipment failures of key locks are more probable than intrusion tampering. 3) security guards which require three shifts for 24-hour protection plus replacements for lunch, rest periods, vacations and illness. 4) closed circuit TV or other detection devices to monitor intrusion into a building as well as for rooms with high value equipment or classified data. Designs for high security locking systems and secure window barriers will be published in the Naval Facilities Engineering Command Physical Design Manual (DM-13).(18) Electronic Security is concerned with preventing the loss of or compromising classified data via electronic emanations. A compromising emanation is an unintentional data related or intelligence bearing signal which, if intercepted and analyzed, discloses the classified information transmitted, received, handled or otherwise processed by any information-processing equipment. We should note there is a National Policy on Control of Compromising Emanations.

To appreciate the problems of electronic security, the following is a brief review of definitions, regulations, possible solutions and assistance. Definitions: The Physical Control Zone (PCZ) is the space surrounding equipment processing classified information which is under sufficient physical and technical control to preclude a successful or hostile intercept of any classified information from within this space. The Controlled Access Area (CAA) is the complete building or facility area under direct physical control which can include one or more limited Exclusion Areas (a secured room for RED information-processing systems equipment and wirelines), and controlled BLACK Equipment Areas or any combination thereof. Spaces within a facility which are not under direct physical control but to which access is controlled (administrative office, halls, restrooms) are not a part of the actual CAA but are considered as a part of the overall Physical Control Zone. RED/BLACK is a concept that electrical and electronic circuits, components, equipments and systems which handle classified plain language information in electronic signal form (RED) must be separated from those which handle encrypted or unclassified information (BLACK). Under this concept, RED and BLACK terminology is used to clarify specific criteria relating to and differentiating between such circuits, components, equipments and systems and the areas in which they are contained. Equipment TEMPEST Radiation Zone (ETRZ) is a zone established as a result of TEMPEST equipment radiation characteristics. The zone includes all space within which a successful hostile intercept of compromising emanations is considered possible. The Air Force (AFR 100-45), the Defense Communications Agency and the National Security Agency have regulations covering all phases of Electronic Security.

For additional information, Government employees can obtain 80 hours of training at the TEMPEST Officer Course L30ZR3016-006, PDS Code QVJ conducted at the USAF Technical Training School, Lackland Air Force Base, Texas. Industry and Government personnel with security clearances can also attend a 40 hour course titled "TEMPEST Design, Control and Testing" presented by Don White Consultants Inc, of Gainsville, VA. Firms have TEMPEST/EMI Departments which also provide consulting services. The Air Force Cryptological Support Center, San Antonio Texas is another source of information.

The Federal Communication Commission (FCC) regulations on Electromagnetic Interference provides some unclassified emanation data (Figure 4). An understanding of the problem can be obtained by looking at the EMI test methods used by the FCC. A description of how they satisfy their test requirements from 30MHz to 1000MHz is covered in an article by Glen Dash.(19) He notes that, "Most radiated emissions arising from computer equipment stem from attached I/O cables. When the equipment under test (EUT's) digital logic changes state, RF current pulses cause radiation from pc board traces and wires. Because the attached I/O cables are long wires they are the most efficient radiators below 100 MHz." He also notes that "FCC rules, as now interpeted, permit computer manufacturers to test without attached cables but require peripheral manufacturers to test with attached cables. And all I/O cables must be driven by an active source, such as a computer. To remedy this situation, the FCC Office of Science and Technology is considering new regulations. These regulations will require the Computer equipment be tested with attached cables and that the cables be moved during radiation detection." It is important to note that the FCC is concerned with EMI emissions and has established peak level emanations (Figure 4) whereas TEMPEST concern is with data related emanations.

The National Security Agency has an Industrial TEMPEST Program. The Subcommittee on Compromising Emanations (SCOCE) has a TEMPEST Qualifications Special Committee (TQSC) which issues a Preferred Products List. Accreditation is given to those products that have fully complied with all applicable TEMPEST requirements.

Solutions to satisfy the training/simulator/computer facility emanations problem involves modifications to either the equipment or the facility. It is important to identify the emanation db and frequency level before a solution is proposed. The equipment mods could be as simple as using aluminum or lead enclosures or tapes. It could be a design change which does not significantly increase the transport delay time in equipment performance. As noted above the SCOCE has a Preferred Products List of equipment which have been tested. Security for ADP equipment must be part of a facility plan. Possible solutions for new or existing facilities include armor shielded walls or very thick concrete walls, locating the computers and other equipment in the below grade basement with an RF shielded basement ceiling, fenced enclosures several hundred yards away from the building, separate power filters for the RED & BLack electrical power lines, signal filters and telephone filters, plastic coupling of all water pipe lines going into classified work areas, and a common ground for all pipes. If the classified work area is small, an RF shield room can be obtained. At AFHRL/OT Williams AFB we developed a specification for an 8 ft x 12 ft x 8 ft high modular RF shield room which included communication and power filters, assembly, electrical connections and a test to NSA 65-6 and MIL-STD285. On competitive bid we obtained this room for approximately $15,000 from Lectro Magnetics Inc of Los Angeles, CA.

e) Other Design Features. This includes: Uninterruptable Power Supply (UPS) which should not be confused with an AC Power Protection System; accommodations for the handicapped (20) in restrooms, dining areas, elevators, at special water fountains and with ramps at entrance points which will enable the handicapped to better use facility services. Safety features in accord with AFR 88-15 (CG) Section 1-38, "Air Force Occupational Safety and Health (AFOSH) Program." Student or crew lounges should be planned rather than to have these functions in an unused or office area. Secretary or typing areas should include sound absorption material such as acoustical tile, rugs, curtains or other fabric on partitions. Conference rooms should be designed with projection booths, speaker equipment, light dimmers, acoustical materials, microphone and telephone outlets for telephone conference meetings. If protected information is to be discussed in telephone conferences, then secure voice and video processing equipment with associated filters should be used. Parking lots should be designed with a light sensor controlled night lighting and special spaces for bicycles, motorcycles, small cars and vans.

3. CONCLUSIONS

A training or simulator facility is a technical complex that requires coordination and integration of all resources if it is to be acquired when needed. Good planning and design before it is built or modified will provide a building that enhances the opportunities to optimize the training mission. By working with the Base Civil Engineer and MAJCOM Civil Engineer, the major MILESTONES of the 3-year cycle for processing and approval of the DD Form 1391 through the Military Construction Program review to Congress can be identified and achieved. Success results from: 1) having accurate and meaningful information on the DD Form 1391; 2) working closely from the start with the Base Civil Engineer and the Architect Engineer; 3) defining, integrating and funding the MCP, manpower, and equipment requirements to accomplish the training mission; 4) planning a modular facility that provides necessary space for today's mission; 5) having flexible and reliable electrical service via AC Power Protection System and UPS to handle electrical abnormalities such as spikes, lightning strikes, blackouts or brownouts; 6) designing air conditioning for computer areas to meet manufacturer's specifications with controlled comfort zones for employees; 7) providing for physical and electronic security, and 8) having a pleasant office and healthy environment which includes color, fabrics, rugs and daylight simulating lights. The above suggestions are based on many years of combined facility engineering experience but should not be considered an inclusive list. Following these suggestions will result in the timely acquisition of a facility that enhances the effectiveness of the training mission.

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