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National Aeronautics and
Space Administration

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CRUSTAL DYNAMICS PROJECT
SITE SELECTION CRITERIA

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This document supercedes previous Crustal Dynamics Project site selection criteria publications, and it will be changed or revised as required. Comments and/or questions concerning the contents should be directed to:

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CRUSTAL DYNAMICS PROJECT
CONSIDERATIONS FOR THE SELECTION OF GEODYNAMICS
SITE LOCATIONS

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CONSIDERATIONS FOR THE SELECTION OF GEODYNAMIC SITE LOCATIONS

1.0 PURPOSE

This paper primarily covers:

- Criteria for selecting a site location.
- Observing equipment requirements for site implementation.
- Gross system characteristics (size, shape, weight, power requirements, etc.).

2.0 INTRODUCTION

The National Geodetic Survey (NGS), U. S. Geological Survey (USGS), and National Aeronautics and Space Administration (NASA) are establishing worldwide geodynamic sites for the following transportable systems listed in order of descending site requirements:

2.1 Movable Systems

- MOBLAS: Mobile Laser System (GSFC)
- MV-1: Mobile VLBI system with a 9-meter antenna and accompanying electronics van (ARIES-9) (JPL/NGS)

2.2 Highly Mobile Systems

- MV-2: Mobile VLBI system with a 4-meter antenna and accompanying electronics van (ARIES-4) (JPL/NGS)
- MV-3: Mobile VLBI system with a 5-meter antenna and accompanying electronics van (ORION) (JPL/NGS)
- TLRS-1: Transportable Laser Ranging System (U. of Texas)
- TLRS-2: Transportable Laser Ranging System (GSFC)
- TLRS-3: Under construction. Upgrade of TLRS-2 (GSFC)
- TLRS-4: Under construction. Upgrade of TLRS-2 (GSFC)
- SERIES: Satellite Emission Range Inferred Earth Surveying utilizing radio signals from the Global Positioning System (GPS) (JPL)

In some cases several of the above systems will, at different times, occupy the same site. Therefore, each site should be permitted and the pad designed for occupancy of the most demanding system planned for that site. With the exception of the minor system specific requirements, such as power, the smaller systems can be accommodated on the same site.

This document defines those site selection considerations that are important from an operations point of view. The perfect location would meet all considerations but it is understood that compromises usually must be made. If the majority of criteria are met, the operations would most likely be successful with minimum impact on the surrounding community. The criteria are divided into eight sections, beginning with MOBILAS requirements and ending with SERIES requirements.

3.0 MISSION

Very Long Baseline Interferometry (VLBI) and Satellite Laser Ranging Systems (SLR) are being deployed worldwide in support of the GSFC Crustal Dynamics Project. The laser systems determine the range to orbital satellites by precise measurements of the time intervals between transmissions of a laser light pulse and the receipt of the light pulse reflected from the designated satellite. This time interval, telescope position information, and other parameters are recorded on magnetic tape and forwarded to Goddard Space Flight Center, Greenbelt, Maryland. At Goddard, this data is scientifically analyzed, yielding geophysical information important to the study of regional deformation, plate motion, plate deformation, and earth-rotational dynamics.

The VLBI systems, while obtaining essentially the same scientific results, employ a passive technique utilizing celestial radio sources to locate accurately two radio telescopes separated by distances of up to thousands of kilometers. The energy sources, usually extragalactic quasars, are recorded at both sites and cross-correlated at a later date. The time delay of the cross-correlation is dependent on the position of the quasar relative to the two antennas and the distance between them. The SERIES systems substitute GPS satellites for quasars as a noise source.

4.0 RESPONSIBILITIES

4.1 Inter-Agency Participation

NASA is developing these systems for use by operating agencies which include the National Geodetic Survey (NGS), the U.S. Geological Survey (USGS), the National Science Foundation (NSF), and the Defense Mapping Agency (DMA).

A part of these agreements specify that NASA will develop and demonstrate the mobile VLBI systems and transfer these systems to NOAA, which will carry out operational measurements in the United States to meet the needs of the NASA Crustal Dynamics Project (CDP) and to fulfill the requirements of NOAA for a National Crustal Motion Network (NCMN).

4.2 Generalized Site Selection

Candidate site locations are generated by the GSFC Crustal Dynamics Project based on inputs from the inter-agency participants, outside scientific groups and approved Principal Investigators (PIs).

4.3 Specific Site Locations

Specific site locations are identified after a field reconnaissance and are based on the criteria discussed in this paper. With the exception of MOBLAS sites, which are Goddard's responsibility, NGS is responsible for specific site locations in the U.S.

4.4 Site Implementation

With the exception of MOBLAS, NGS is responsible for permitting and implementing the U.S. sites.

4.5 System Development and Operation

Operation of the MV systems will eventually be assumed by NGS. In the interim, operational responsibilities are as follows:

MOBLAS	GSFC
MV-1	Jet Propulsion Laboratory (NGS in 1/1/85)
MV-2	Jet Propulsion Laboratory (NGS in 1/1/85)

MV-3	Jet Propulsion Laboratory (NGS in 1/1/84)
TLRS-1	GSFC (University of Texas)
TLRS-2	GSFC
TLRS-3	GSFC
TLRS-4	GSFC
SERIES	Jet Propulsion Laboratory

5.0 GENERAL SITE INFORMATION

Compromises are involved in locating all sites, but in the best of all worlds, sites should be selected on the following criteria:

5.1 Regional Tectonics

Locations should be on stable crustal blocks removed, as far as possible, from active faults. In areas where this might be difficult, like southern California, the surface patterns and activities from nearby faults should be known and active faults should not cut through the site.

5.2 Surface Stability

Site should be on firm, stable material, preferably basement outcrop; certainly not on soil that might slump, slide, heave or vary in elevation because of variations in ground water levels.

5.3 Ownership

In order to ease permitting and access problems, government or state owned land is preferable. Next in desirability is land owned by universities or large industries. Least desirable is small, privately owned land. Criteria also applies to access roads to the site.

5.4 Environmental Impact

Environmentalists are very touchy in some areas. For example, all construction within one and one-half miles of California coast must be approved by the California Coastal Commission. All of Marin County has similar restrictions. Environmental impact may also be a problem in popular National Parks. Typical problems involve disharmony of equipment

(Monument Peak MOBLAS trailers were required to be repainted "forest" green), noise and odor of motor generators (motor generators must have certified U.S. Forestry approved exhaust system spark arresters), or extended hours of crew operation.

5.5 Cultural Stability

Rapidly developing areas could pose a problem. It would be a blow to have a new shopping center built over an established site.

5.6 Proximity of Civilization

Crew living quarters and sources of supplies and fuel should be reasonably near the site. It is also cost effective to be near telephone and power lines.

5.7 Access to Site

- Off-highway access roads must be capable of handling the observing vehicles in normal weather conditions. As a guideline, the TLRS-1 can go on any road that is negotiable by a 2-wheel drive passenger car while TLRS-2, 3, and 4 are transported on 4-wheel drive pick-up trucks. In addition, the MV systems need a road wide enough with curves gentle enough to accommodate up to a 40-foot van towed by a 25-foot trailer. It is also vital that the access road be maintained over the lifetime of the project. We have had to abandon several sites because of poor or no maintenance on the access road.

- During initial contacts the permitter (NGS) should negotiate either a key, to gates with a single lock, or permission to add a NASA lock if the gate is secured with a "daisy chain" of locks. This will save arriving crews much time and effort.

- After a site is leased, it is the responsibility of the crew to notify the site owner one to two weeks prior to each site occupation. NGS is responsible for fulfilling any formal pre-occupation requirements such as notifying an owner in writing a specified number of days before an occupation.

5.8 Pad Construction and Design

The Moblas and MV-1 systems require the construction of a cement pad. The

other systems can, and do, observe from any flat, cleared area provided the soil is hard enough to support the vehicles (i.e. bedrock, adobe etc.). From the point of view of equipment cleanliness, crew comfort, and vehicle stability, existing paved sites such as old cement foundations or paved parking lots (if the tar will not soften under summer heat) are preferable. In most cases, of course, the observing monument will be isolated from the surrounding surface soil or pad and extend as deep into the subsurface as possible to obtain maximum stability.

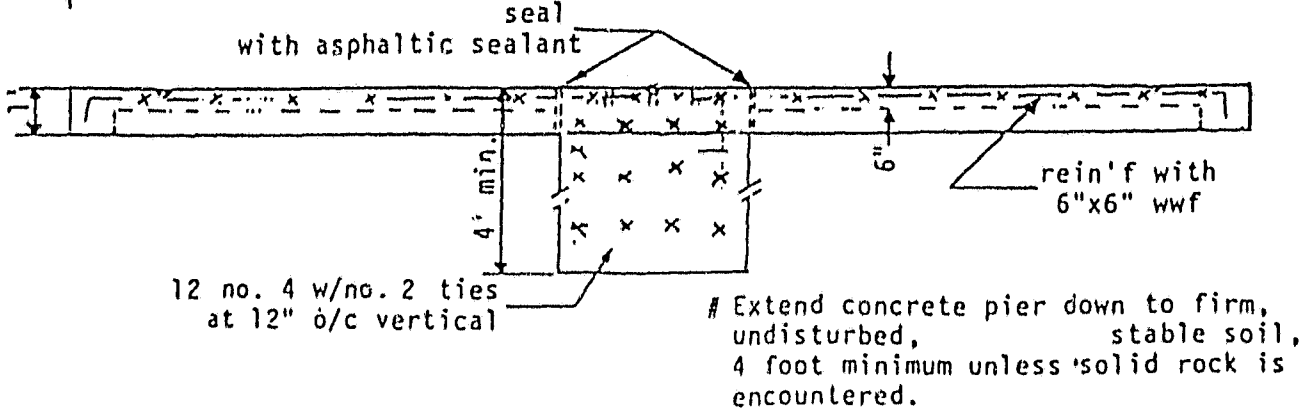
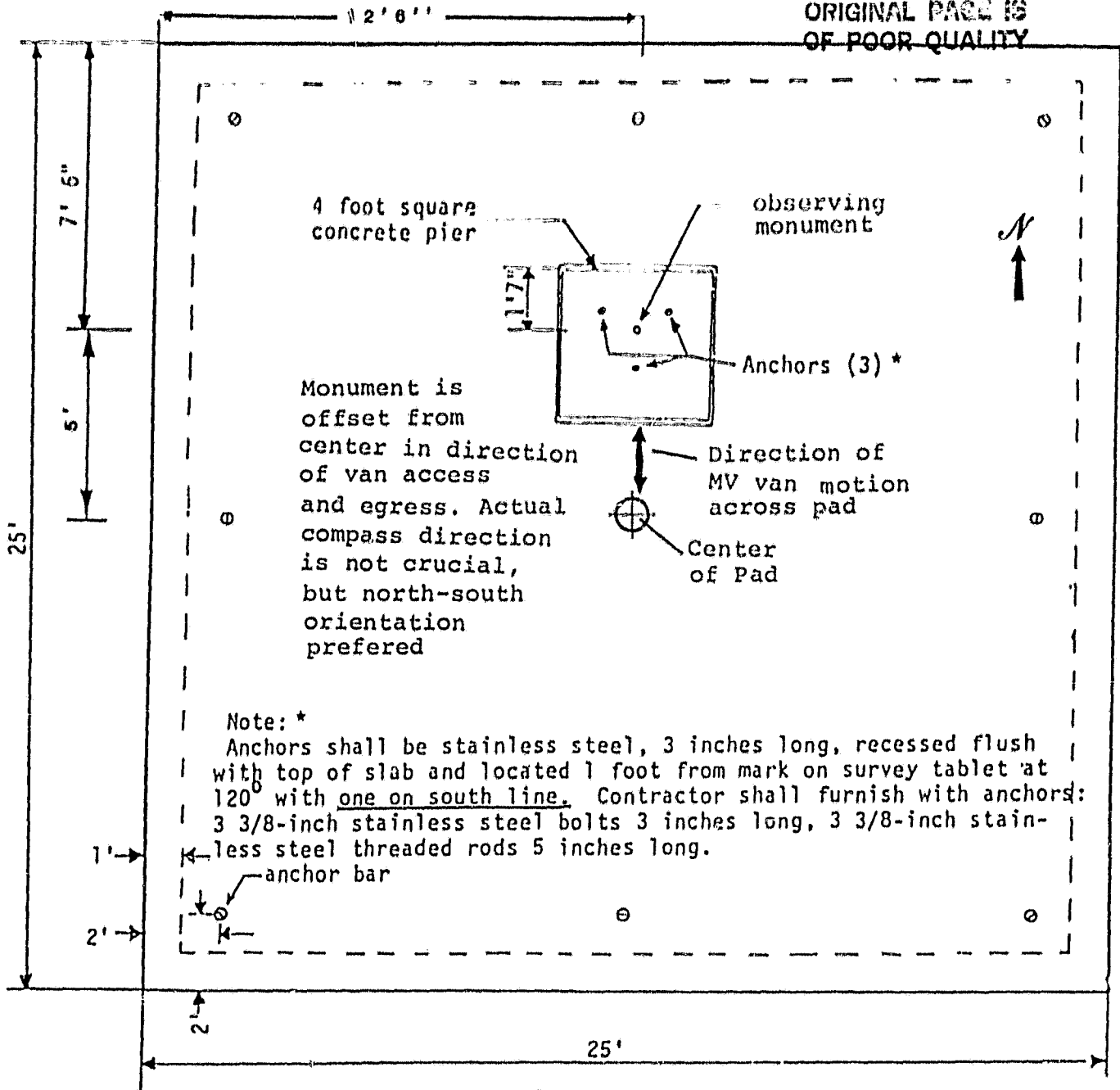
Figure 1 is designed to accommodate all the highly mobile systems and will be used for future sites on soft ground in the U.S. and Mexico that might be occupied by both laser and VLBI systems. The eight tie downs around the edge of the pad are to stabilize the MV-2 and MV-3 antennas in case of storm conditions. The 3 anchor holes one foot from the survey tablet (center hole in monument disk) are threaded to accept tie-down bolts for the TLRS-2, 3 and 4 optical mount. One of these holes must lie true south from the center of the survey tablet. While the physical directional orientation of the MV antennas is not important (the antennas are not directionally sensitive), it is preferable that the pad be North-South oriented (i.e. the entrance and exit are North-South), so that when possible the observing monument should be offset five feet north or south from the center of the pad. Figure 2 shows the MV-2 and 3 "footprints" on the pad. Further details are given in the sections on the individual systems.

5.9 Geodetic Monumenting

NGS is responsible for all U.S. monumenting except at the MOBILAS sites where NASA contractors perform the surveying. Three levels of monumentation and geodetic surveying may be employed:

1. At the site a central, observing monument is installed. Stability of this monument is insured by three reference monuments around the observing monument. The desired configuration of the reference monuments is an equilateral triangle having line of site between all monuments with legs = $N \times 25$ meters where N is any whole number, preferably even. It

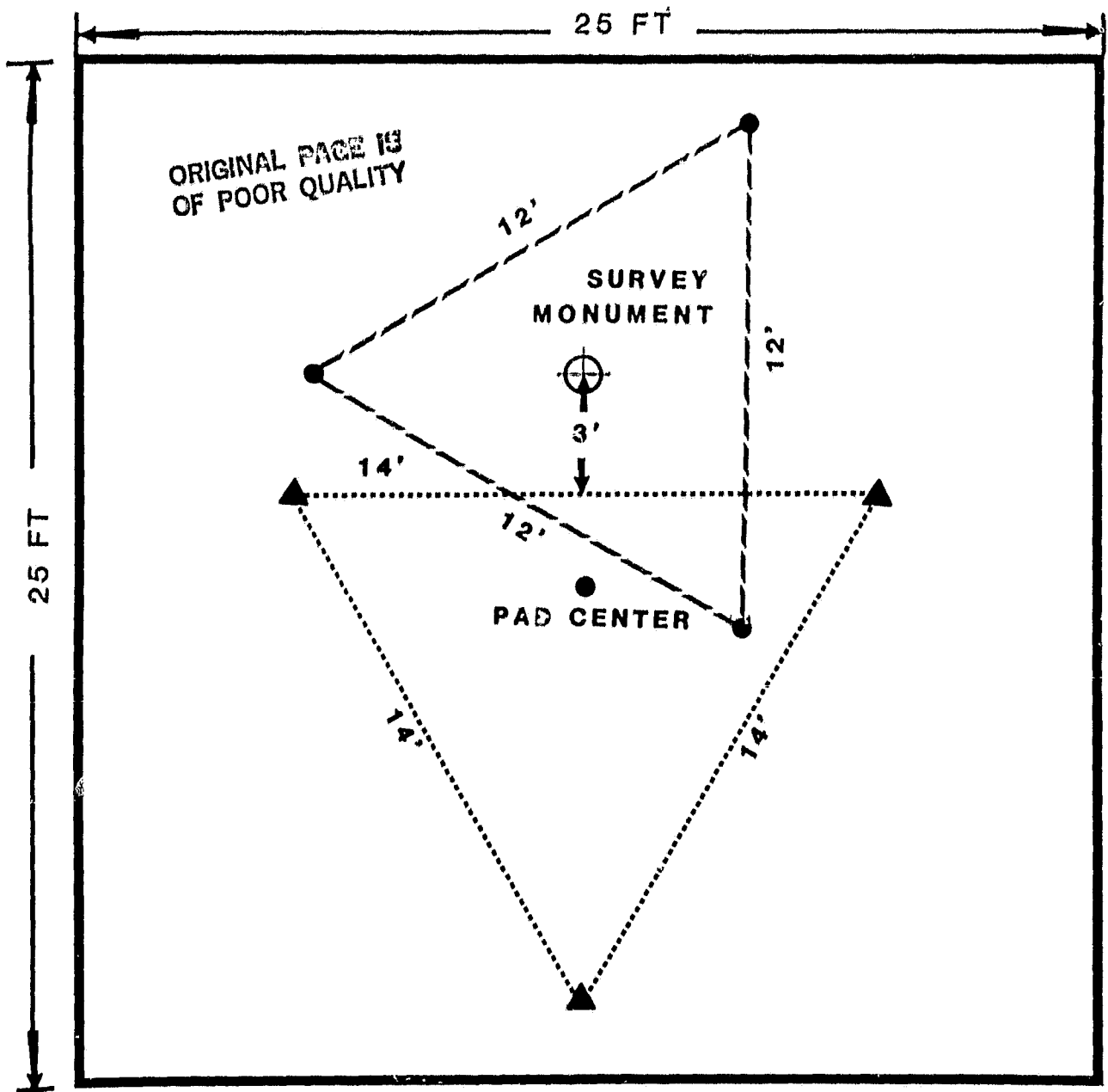
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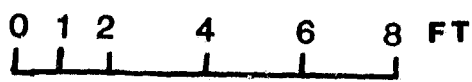
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FIGURE 1 for HIGHLY MOBILE SYSTEMS



FRONT

- MV-2 FOOTPRINT
- ▲..... MV-3 FOOTPRINT



SCALE

1 Inch equals 4 feet



MV-2 Trailer extends 15 feet from survey marker in this direction

MV-3 Trailer extends 46 feet from survey marker in this direction

FIGURE 2: MV-2 and MV-3 FOOTPRINTS

is most unlikely that this exact configuration would be obtainable due to the local terrain irregularities, therefore an alternative configuration must be accepted as close to the desired as possible. A single azimuth marker is installed at least 400 meters from the observing monument. While the outlying monuments have minimum impact on the property, the owner should be informed of the monument requirements during permitting.

2. Occasionally, if there is a possibility of the site moving as a unit, one to 10 km line-of-site baselines will be established using a geodometer.

3. All sites must be tied into existing national geodetic grids, although this can be done after the site has been occupied. Nearness of first order survey control monuments will save time and money. In order to facilitate data reduction, the approximate location (to about 10-20 meters) of a site must be known before the first occupation. This data is furnished by NGS (Dr. William Strange, 301/443-2520).

6.0 MOBILAS SITE LOCATION CRITERIA

6.1 General

The MOBILAS system consists of the following four truck transportable vans:

- Mobile Optical Mount (45 ft. x 8 ft. x 13 ft. 4 in.). Contains tracking telescope, laser, mount servo system, and control console.
- Instrument Van (40 ft. x 8 ft. x 13 ft. 4 in.). Contains high precision timing system, computer system, and communications equipment.
- Support Van (40 ft. x 8 ft. x 12 ft. 4 in.). For crew support at remote locations.
- Diesel Generator Van (approx. 35 ft. long). Optional for locations without reliable power.

6.2 Operational

- Elevation — As the MOBILAS systems transmit and receive light pulses, atmospheric attenuation greatly reduces the system loop gain. The most desirable locations would be at high elevations, but below where human function is impaired due to the rarefied atmosphere.

- Light interference -- The site location should be isolated from sources of light interference. The MOBBLAS system is a light detecting system. Sources of light other than the reflection of the laser light from the satellites are detected as noise and can seriously hamper the data gathering process. The ideal location would be away from traffic bearing roads, towns, shopping centers, etc. Contrariwise, the laser beam might interfere with nearby astronomical optical telescopes.

- Obscurations -- Ideally, there should be no obstructions that are above a twenty degree elevation angle from the selected station as satellite ranging operations are conducted in this area. Angles are computed from the horizontal axis of the telescope which is about 10 feet above ground level. Obstructions above the 20 degree elevation can be tolerated, but will result in a loss of tracking capability.

- Climate (environment) -- Poor weather conditions cause the largest percentage of data loss by the MOBBLAS systems. As the systems must detect low level light returns from the satellites, even mild cloud cover or haze is detrimental to successful operation. It is understood that geophysical priorities may override this consideration in the regional selection of stations; however, weather conditions may vary greatly within a region. Localized conditions such as fogs emitted from ponds or lakes and smog or clouds that lie predominantly on one side of a mountain should be avoided.

The MOBBLAS system equipment is also somewhat sensitive to environmental extremes. Continued operation outside of ambient temperatures of approximately 0-100°F. cause increased system failures. Dust, sandstorms, salt water spray or other corrosive elements or conditions can cause rapid deterioration of MOBBLAS systems optical and electronic equipments. These environmental extremes should be avoided.

- Survey Monument -- Must be located under the vertical axis of the telescope and isolated from the rest of the concrete pad. This monument, in turn, should be tied into three outer markers surrounding the pad at a distance of 25 to 100 meters. This grid is then tied into existing first order geodetic baselines.

- Services – MOBBLAS operations are enhanced if a variety of services are available in the general vicinity. Freight, medical, fire, and police, machine shop, document reproduction and electronic parts supply services are required periodically by the MOBBLAS system.

- For safety reasons, laser must shut down when aircraft are flying in the vicinity. Therefore, site should be located away from busy airports or flight paths.

6.3 Facilities

- The selected site must be capable of accommodating the facilities documented in NASA Drawing "MOBBLAS System for MOBBLAS 1-8, MLRS, TLRs, and ARIES System, Typical Site Layout and Details" (NASA Drawing SK-853-MOB-3). A general guideline is a cleared area 300 x 300 feet containing a 34 x 34 foot concrete pad.

- It is highly desirable that the site be provided with commercial power. The MOBBLAS system can function with diesel power generated locally; however, this should be considered as a last resort because of the high cost, environmental impact, operational inconvenience and the inefficient use of fossil fuels. The station requires two feeders of 75 KVA, 208 volt, 3 phase power supplied by a Y wound secondary transformer. In order to minimize voltage surges when air conditioning and other electric motors in the system start and stop, the power is split into an electronic equipment feeder and a utility feeder. Thus, two transformers are required. The selected location should be near existing commercial power to minimize installation costs.

- Telephone and teletype services are required at all locations. The selected site location should be near existing telephone lines to minimize installation costs.

- The station must be accessible by a safe road capable of MOBBLAS system transport. Clearances and turning radius for the largest system component, a tractor towed trailer measuring 45' x 8' x 13'4", are required.

- The site selected should have a generally level area capable of accommodating five trailers with a maximum length of 45'.

- It is convenient to MOBBLAS operation if a source of water is available.

● Calibration Board. A location for a calibration board must be available at a distance of from 1 to 5 KM from the selected station location. The calibration board line of sight must be unobstructed at the 10 foot high level of the telescope axis. The laser beam is transmitted to the calibration target at eye safe levels; however, in the interest of safety, the line of sight should be elevated by at least nine feet above any structure that could be occupied. The laser transmitter is elevated a minimum of ten feet for all systems. The calibration location should be vehicle accessible within approximately 1 kilometer.

● The concrete pad detailed in NASA Drawing SK-853-MOB-3 must be oriented to allow viewing of the calibration board by any MOBBLAS system.

● The preferred calibration board location would be to the north of the selected site. South is second best. The east and west should be avoided as the rising and setting of the sun would interfere with calibration of the system and cause of loss of data.

● If commercial power is not available, a reliable source of diesel fuel should be located in the general area.

6.4 Environmental Impact

● MOBBLAS stations sometimes operate 5 days/week, 16 hours/day. The specific times and days vary according to satellite and mission priorities. The system is normally comprised of four trailer type vans of an averaging 40 feet in length. During operation of the system, a warning horn is sounded at approximately one second intervals and a red light is flashed. MOBBLAS 4-8 produce a green beam of laser light, one per second which is visible over an approximate 1 kilometer radius. MOBBLAS 1-3 produce a red laser light that is at the edge of the visible region of the light spectrum and would not be visible off station. Any of these items may be annoying to nearby residents. The ideal location would be at least 1 kilometer from any area occupied by the general public. Such an area would also have a reduced likelihood of vandalism.

- MOBILAS personnel work at odd hours. A determination should be made whether vehicular traffic is of concern to the general public on the access road.

- If commercial power is not available, a diesel generator trailer would accompany the system. This produces noise and smoke 24 hours/day, 7 days/week, and should be located at least 200 feet from the other trailers. Special safety precautions are also required in high risk fire areas. In this case, the ideal location would be at least two kilometers from any area occupied by the general public.

- MOBILAS sites are occupied on a semi-permanent basis anywhere from 3 months/year to continually for several years. Other systems may occasionally occupy the site during its absence.

6.5 Safety

- As the laser radiates light that is potentially an eye hazard to persons intercepting the laser beam, constraints are placed on the MOBILAS operation. The laser is only radiated full power at elevation angles greater than 20 degrees. Below 20° the laser is radiated at specific targets at eye safe levels. If an aircraft approaches the hazardous area, the laser transmission is terminated until it is determined the aircraft has left the area. For these reasons, the ideal location should be outside normal air corridors and away from airports and areas used by the general public.

- The station access road should be safe for transit by MOBILAS personnel under varied weather conditions.

- Areas subject to fires should be avoided. At a minimum, a reasonable fire break area should exist around the site.

6.6 Personnel

- Reasonable living and eating accommodations for ten persons on semi-permanent (approx. 3-12 months) assignment should be available within a 45 minute driving radius.

7.0 MV-1 SITE LOCATION CRITERIA

7.1 General

The MV-1 system consists of the following vehicles:

- Electronics Van (approx. 32 ft. long)
- Generator Trailer (approx. 30 ft. long)

Contains generator, outrigger legs for antenna and cable reels. This generator is for set up only. It is not a power source for the system and must accompany system even if commercial power is available.

- Antenna Panel Transport Trailer (approx. 40 ft. long)

Contains reflector panels for the antenna.

- Pedestal Trailer (approx. 34 ft. long)

A heavy trailer (approx. 30 tons) holding the antenna pedestal.

- A 30 foot, man basket, cherry picker is required for assembly and servicing the antenna.

7.2 Operational

- Site Elevation – not critical
- Light interference not a problem.
- Radio Frequency Interference (RFI). Unit can tolerate some RFI, but too much noise can drive the amplifiers to saturation. In particular, military transmitting sources with sweep frequencies should be avoided as well as localized sources of multiple transmissions such as airports or microwave relay towers.

- Obscurations. Avoid obstructions higher than twenty degrees above the antenna horizon measured from the antenna horizontal axis of about 21 feet above ground level.

- Climate. Clouds or haze do not bother the system. Dust, dirt, salt spray or temperature extremes are not desirable due to antenna structure and subsystem damage.

- Survey monument. Primary control is located under vertical axis of antenna pedestal. Secondary control is three outer markers surrounding antenna at a distance of 20 to 100 meters (at earlier sites, later sites conform with monumenting described in Section 5.0).

- Services. Similar to MOBILAS.

7.3 Facilities

- Selected site should have a cleared area of at least 100 x 100 feet. Antenna van should have a level area with asphalt or better paving (weight per unit ground area is low). Two 20 foot long outriggers are required on antenna mount. At least two cement counter weights approximately 2 x 2 meters in area and 1 meter thick are needed to tie down the antenna in case of high winds. Detailed dimensions are given in JPL "Foundation Plan – ARIES Antenna" #23835.

- Commercial power highly desirable, but generator can be used. A 600 gallon fuel tank must accompany generator. Commercial power required is 50 KVA, 1 phase, 120/240 volts and is a must if the system is permanently located.

- One or preferably two telephone lines are highly desirable and is required if system is permanently located.

- Access road should accommodate the 35 foot, 30 ton pedestal van.

7.4 Environmental Impacts

- Unless diesel generator is required, system is completely passive.
- Personnel work odd hours, sometimes on continual 24 hour operations. Staffing is typically one person/work shift.

- Stations usually will be occupied for 1 to 6 months duration. Re-occupation should occur on an average of once per year.

7.5 Safety

- No unusual safety problems exist.

8.0 MV-2 SITE LOCATION CRITERIA

8.1 General

The MV-2 meter antenna system consists of the following units:

- One tractor truck pulling:
 - a. Electronics van
 - 27,000 lbs. total
 - Approx. 32' long
 - 8' wide
 - 8'4" high (w/o wheels)
 - 12'4" high (incl. wheels)
- One tractor truck pulling:
 - a. Antenna transport van
 - 16,000 lbs. total
 - Approx. 26'3" long
 - 8' wide (antenna mount is 10' wide)
 - 13'5" high -- antenna in stowed position
 - 8'4" high -- antenna dismounted from pedestal
- Site support truck (one ton pickup)

8.2 Operational

- Elevation not critical
- Light interference no problem
- ^f ● Avoid major transmission sites such as airports and military bases because of RFI.
- Obscuration. Avoid obstructions higher than 20° above horizon measured from

the horizontal antenna axis 12 feet above ground level (max. antenna height is 19 feet).

- Cloud or haze no problem.
- Services. Less stringent than MOBLAS or MV-1 requirements because of shorter

occupation time at a given site.

8.3 Facilities

- Site should have a cleared area of at least 60 x 60 feet, and a flat area of 60' x 20' (for details see MV-3 Section 9.2). Bare ground is satisfactory if it is hard and compact. Lightly paved areas such as parking lots or driveways are acceptable because wheel loading is not excessive. No outriggers or guy-wires are required, but tie downs are desirable for sites with strong winds.

- Observing monument is centered under vertical axis of antenna (approx. center of antenna van). See Figure 3 for antenna footprint.

- Commercial power not needed, but if available will avoid using portable generator. Power needed is 50 KVA, 3 phase, and 208, 240, 416 or 480 volts.

- At least one telephone line desirable.
- Road should accommodate 35 ft. long electronics van.

8.4 Environmental Impacts

- Diesel generator gives off some fumes and noise.
- May operate on a continual 24 hour basis.
- Station will be occupied for several days to two weeks duration, once or twice a year.

9.0 MV-3 SITE LOCATION CRITERIA

9.1 General

The MV-3 system is a more transportable MV type system of advanced design. In general, it shares the same site selection criteria as MV-2. Only differences are discussed below.

- The MV-3 system consists of the following vehicles:
 - a. Electronics van
30,000 lbs. total, include 5,000 lbs. of wheels and undercarriage
38'10" long
8' wide
8'4" high (w/o wheels)
12'4" high (with wheels)
 - b. Antenna transporter
35,100 lbs. including 5,000 lbs. of wheels and racks
39'6" long
8' wide
8'4" high (w/o wheels)
12'6" high (with wheels)
 - c. Two tractors (each with generator capable of supporting system).
17,000 lbs. each
21' long
8'5" high (w/o wheels)
9'6" high (with wheels)

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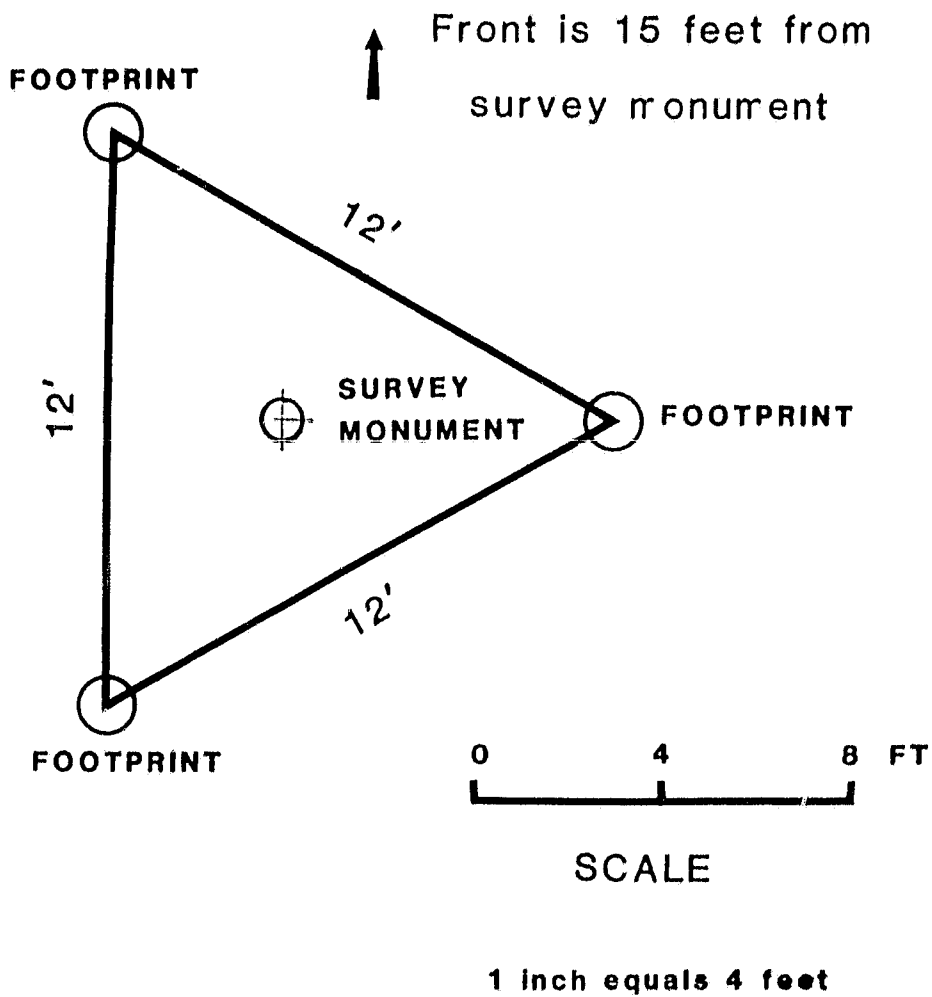


FIGURE 3: MV-2 FOOTPRINT

9.2 Facilities

- Observing monument is centered under positioning arm which extends from the rear of the van. Back of van is approximately three to six feet from the monument. See Figure 4 for footprint.

- Any MV-2 site must accommodate MV-3 (in which case the site will automatically accommodate the TLRS systems). Because all observations must be taken from the same monument, the observing monument must be positioned so it can be centered under the MV-2 van and off the end of the MV-3 van.

- Minimum clearances for the observing monument from a vehicle barrier are 15 feet on each side, desirable clearance is at least 17 feet (Figure 5). For the MV-2, when observing, 2.75 feet long outriggers are extended on both sides of the antenna trailer, so the van is then 13 feet 6 inches wide. However, extra room is needed to work. For the MV-3 while observing, the antenna transport has 8 feet wide side panels which must be let down on both sides, making the size of the antenna van 41 feet x 24 feet. The maximum antenna height while observing is about 24 feet.

- For joint MV-2/MV-3 sites, a level 20 feet x 60 feet observing area should be included in the 60 feet x 60 feet cleared area (Figure 6). For hard packed, consolidated bedrock, no paving is necessary. For unconsolidated, soft ground, pad shown in Figure 1 should be constructed.

- Desirable commercial power is 50 KVA, single phase, 120/240 volts.

- Tie-down anchors desirable in windy locations.

10.0 TLRS-1 (U. OF TEXAS) SITE LOCATION CRITERIA

10.1 General

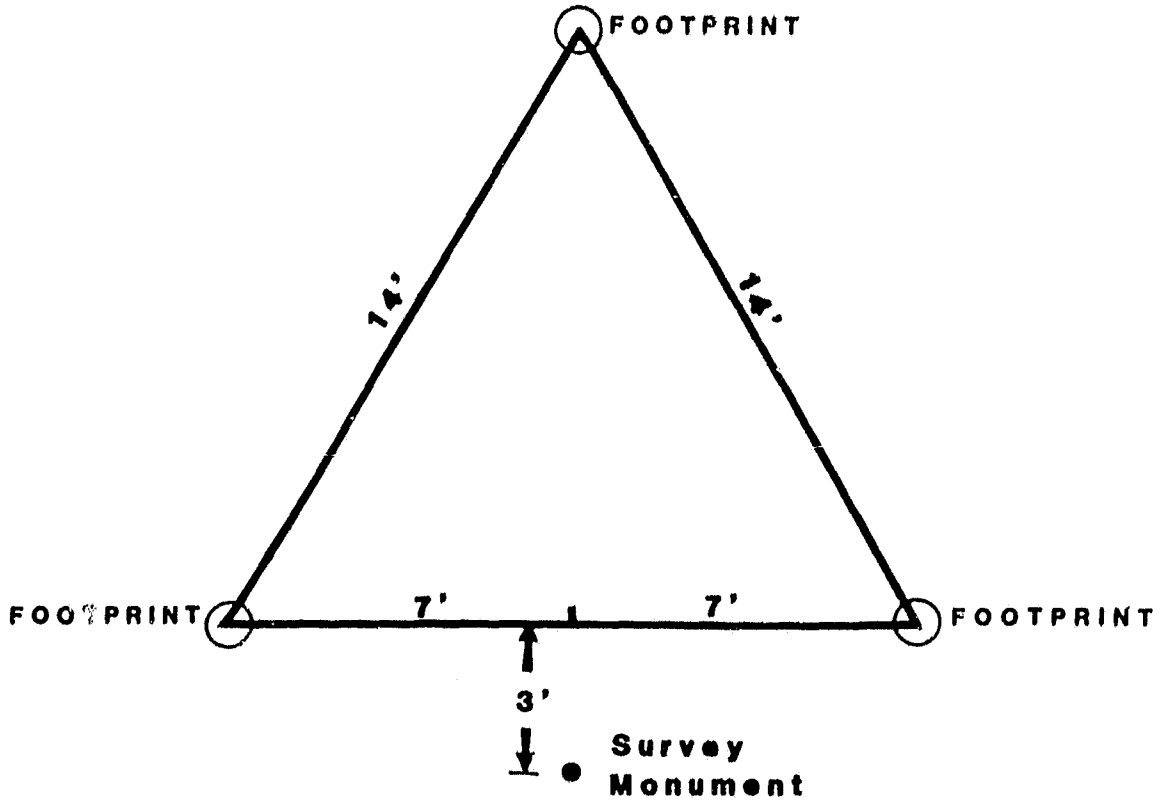
The TLRS system consists of:

- A laser ranging system mounted on a two axle recreation vehicle chassis approximately 22 ft. long.

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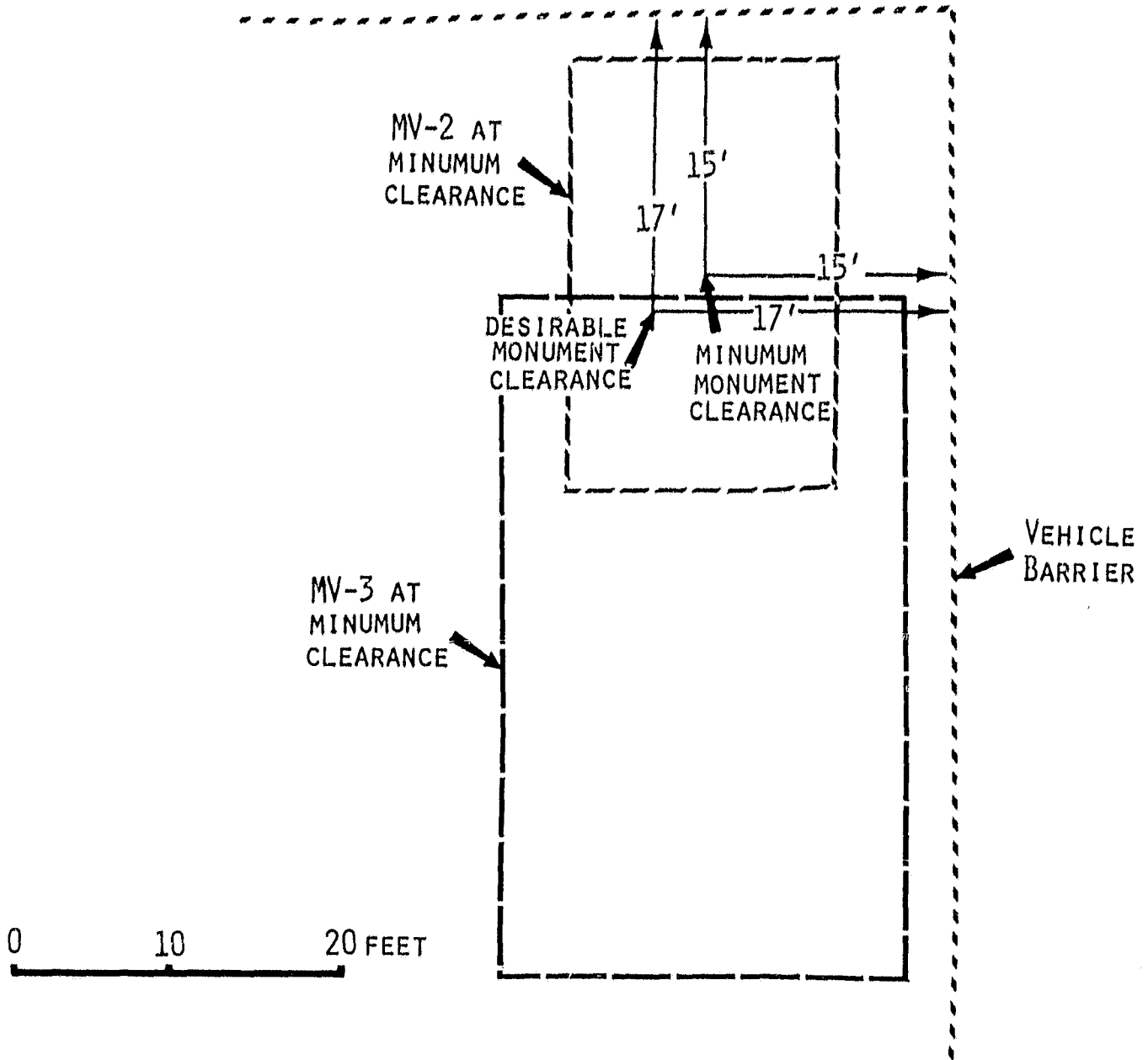
Trailer extends 46 feet in this
direction from survey monument



SCALE

1 inch equals 4 feet

FIGURE 4: MV-3(5-meter) FOOTPRINT



NOTE: SUFFICIENT CLEARANCE NEEDED TO
BACK MV-3 OVER MONUMENT



FIGURE 5 :
MINIMUM HORIZONTAL MONUMENT CLEARANCE
HIGHLY MOBILE SITE

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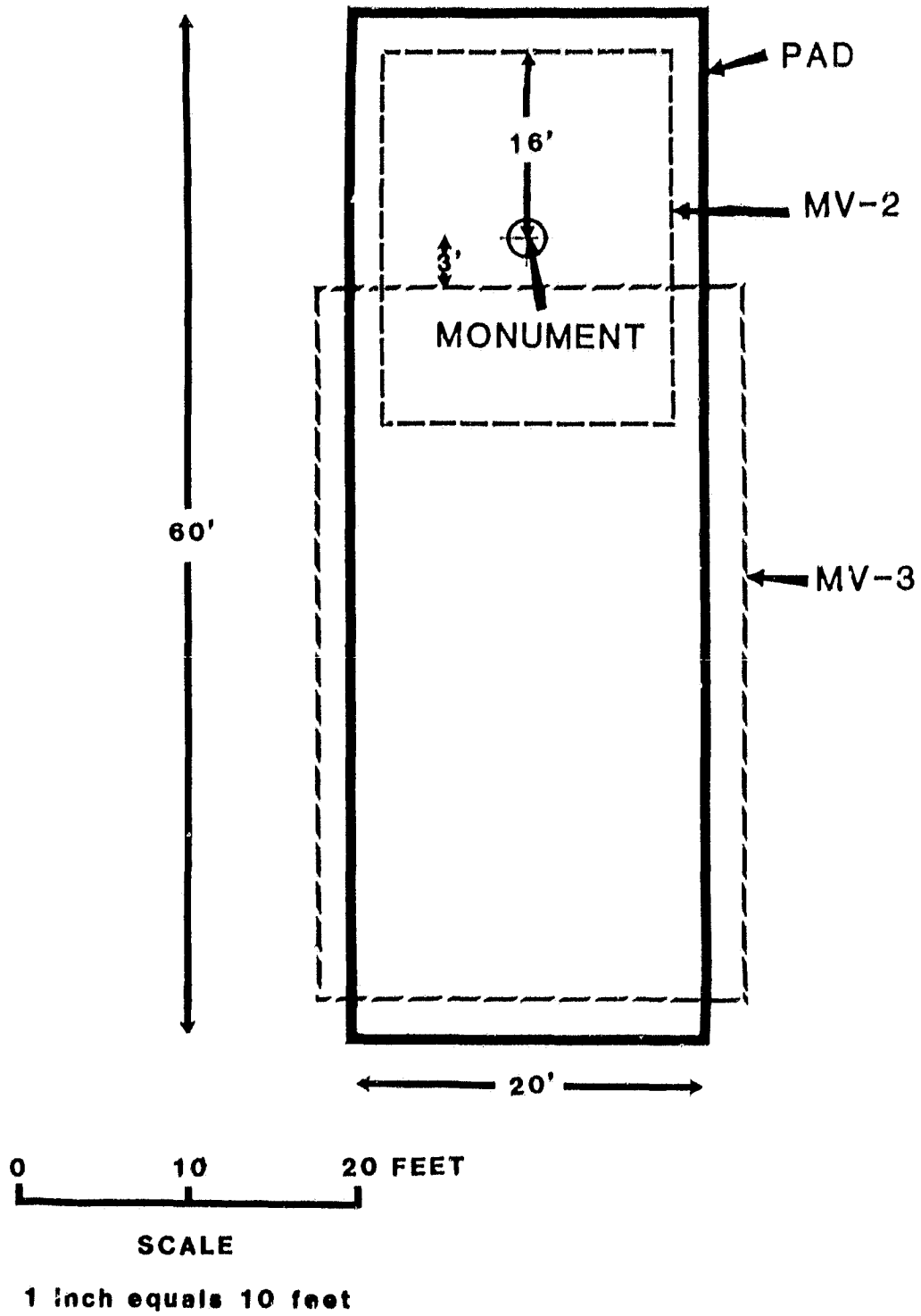


FIGURE 6:
Configuration of Mobile VLBI Systems and Pad

- A 32 foot support travel trailer towed by a 4 wheel drive pickup truck.
- An auxiliary power generator mounted on a small tandem axle trailer.

10.2 Operational

● Elevation -- Same as MOBLAS, higher dry sites preferred. On high mountain tops system may be used as a horizontal ranging system with a range of over 70 km.

- Light interference -- site should be isolated from sources of light interference.

● Radio Frequency Interference -- System will not interfere with neighboring radio systems. Laser may interfere with neighboring optical telescopes.

● Obscuration -- Avoid obstructions higher than 20 degrees above 12 foot reference level of horizontal telescope axis.

● Climate -- Same as MOBLAS. Clouds, dust particles, or fog interfere with operations. Clear, dry, higher sites advantageous. System, per se, can tolerate large extremes in temperature, wind and moisture.

● Survey monument -- Located so that truck can park along side marker. Must be tied into local grid.

● Services -- Because of shorter stays at each site, not as demanding as for MOBLAS or MV-1.

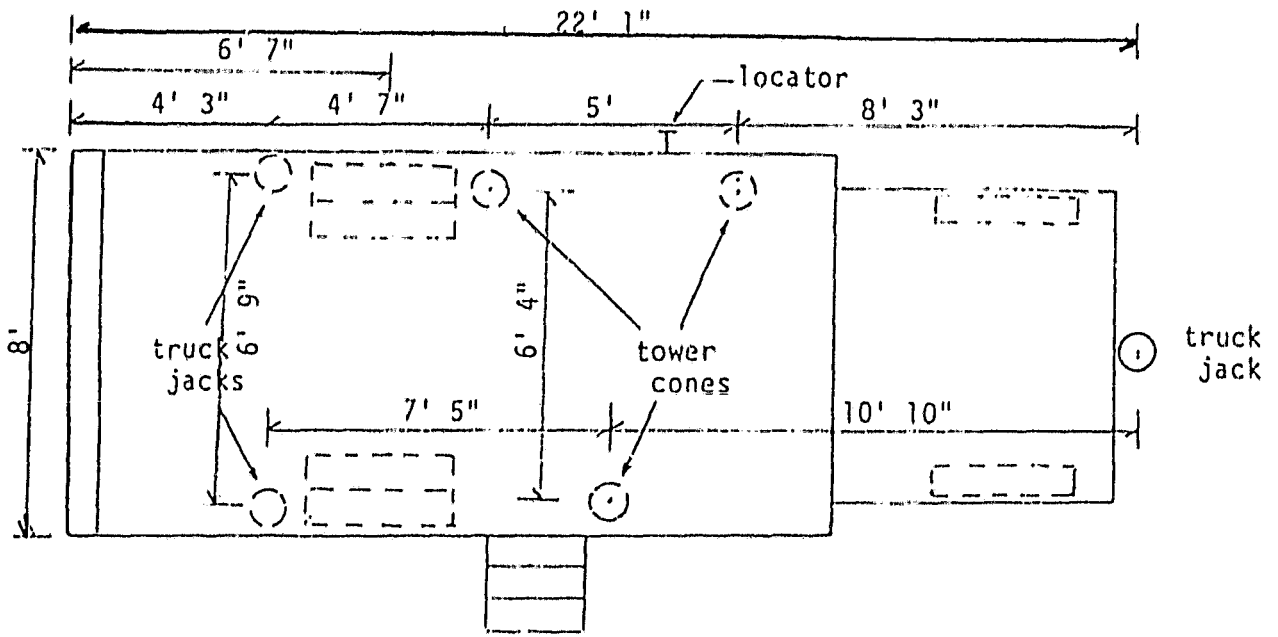
- The less air traffic over the site the better.

10.3 Facilities

● Selected site should be a cleared area of about 60 x 60 feet. Area under observing truck should be firm and flat (gradient less than 1/8 inch per foot). Observing area can consist of compact ground, packed fill or asphalt paving.

● Observing monument is centered under positioning arm locator approximately midway on left side (driver's side) of truck (Figure 7). Stability of the 3 truck jacks is not critical; they are used only to level the truck. The three tower cones must be stable because they support the optical mount system, which is isolated from the rest of the truck.

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scale: 1" = 4'

FIGURE 7: TLRS-1 Observing Truck

- Commercial power highly desirable, but generator can be used. Power required is 20 K watts of single phase 110/220 VAC. Generator, if used, requires about 40 gallons of diesel fuel/day which should be available within a reasonable distance. It is desirable to locate the power generator 200-300 feet from the electronic van if at all possible.

- Phone line highly desirable, but not mandatory.

- Access road should be capable of accomodating a 22 foot long, two-wheel drive heavily loaded recreational vehicle.

- A calibration board is not required.

10.4 Environmental Impacts

- If generator is not required, system is quiet. Laser beam is bright green and can be seen approximately 1 km from the site.

- Personnel work odd hours, often including 24 hour continuous operations.

- Station will be occupied for a duration of 1 to 3 weeks once or twice a year.

10.5 Safety

- The laser is certified eye safe at aircraft distances.

- High risk fire areas can be utilized with occupations scheduled for period of low fire risk.

11.0 TLRS-2 (GSFC) SITE LOCATION CRITERIA

11.1 General

The TLRS-2 is a satellite laser ranging system similar to the TLRS-1, except that the operating system fits into three metal boxes that can easily be air shipped. In operation, the three boxes can lock together to form a three-sided grouping with the removed covers forming a shelter for the operator. Except where noted, criteria are the same as for TLRS-1.

The TLRS-2 system consists of:

- Three boxes for electronics and antenna mount. Each box is:

53" x 45" x 40" (55 ft.³ each, 166 ft.³ total)

Approx. 500 lbs. each, 1500 lbs. total

- One metal box
31" x 50" x 40" (36 ft.³)
Approx. 500 lbs.
- One box
28" x 28" x 48" (22 ft.³)
Approx. 400 lbs.
- One box
30" x 24" x 48" (20 ft.³)
Approx. 500 lbs.
- Plus two additional boxes of similar size and weight for spare parts, HF transmitter, etc.

For a total system of around 300 ft.³ and 4000 lbs.

11.2 Facilities

- Observing monument is centered under vertical axis of optical mount.
- Optical mount structure weighs about 400 lbs. and is 6 ft. high. Structure rests on an equilateral triangular support with 40" sides. The optical mount structure requires a cement pad and three tie-down bolts spaced 120 degrees apart and on a one foot radius from the monument center (Figure 8). One hole must be aligned with true south from the monument. A minimum pad for the TLRS-2 *only* would consist of the 4' x 4' x 4' isolated monument section of the pad shown in Figure 1. In practice a 13' x 9' thinner paved skirt should also be laid around the isolated antenna block to protect the operators and the rest of the equipment.

- Where possible, such as in the United States or mainland South America, the system will be mounted on pallets that will be transported either in a pickup truck or in a towed trailer. Pending final design, access road should be capable of accomodating a one ton pickup truck with a small towed trailer. Around the pad there should be a flat area of approximately 40' x 40' so the trailer can maneuver.

- System requires approximately 6 KVA, single phase, 110 volts of power.

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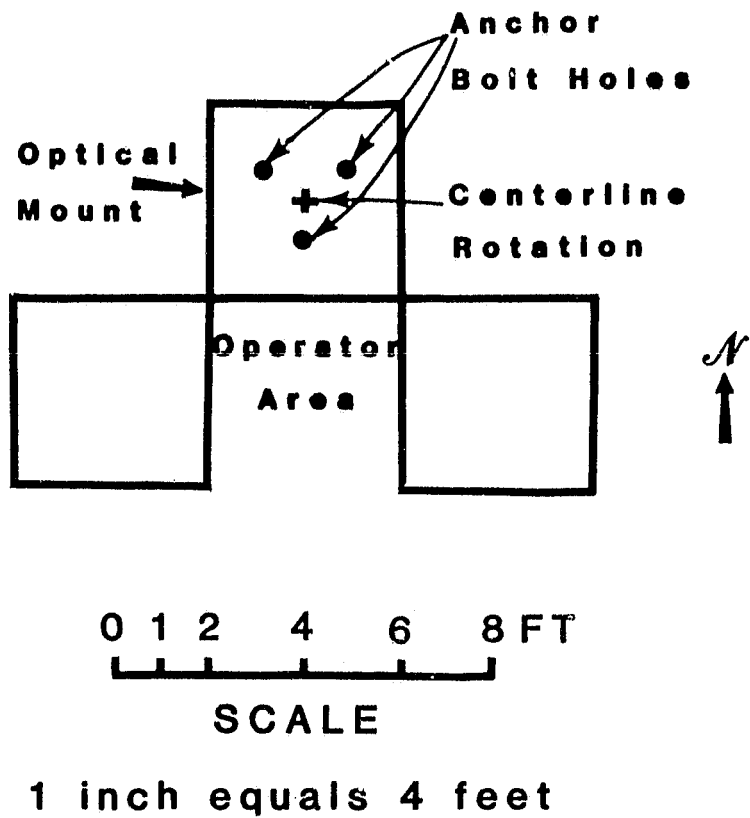


FIGURE 8: TLRs-2 Configuration

12.0 TLRS-3 AND TLRS-4 (GSFC)

- The systems, now under construction, are essentially improved versions of the TLRS-2. They will use the same pad configurations and antenna tie-down holes. Present plans envision these systems packed in two to four water tight, metal shipping boxes of approximately 2' x 3' x 4' size. The system will be transported on a pickup truck and trailer system similar to the TLRS-2 set-up discussed above.

13.0 SATELLITE EMISSION RADIO INTERFEROMETRIC EARTH SURVEYING (SERIES) (JPL)

The system now underdevelopment by JPL, is a VLBI system that uses the GPS radio transmission as its signal source. Compared to existing VLBI instruments it will be able to utilize any of our existing or planned observation sites.

14.0 ACKNOWLEDGEMENTS

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