IMTG

GIS Support Services Division

LAWA Photogrammetry and Interior Space Measurement Standards

Document history

revision letter	release date	major changes	approved by
A	January 2013	new version of standards	
B	June 2014	General Review	
C	August 2014	IMTG GIS Support Services Division	
D	August 2017		

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About this book

The standards described in this document are provided to help LAWA staff, surveyors, consultants and project partners prepare and exchange survey information for LAWA projects.

By using these standards, LAWA will achieve a standardized approach to spatial data management and related record document(s) that will bring many benefits to both the organization and its staff. These benefits include, but are not limited to:

- consistent and more reliable data that will lead to more informed decision making
- closer integration with other LAWA information systems and LAWA spatial data users
- portability of staff skills
- greater interoperability with organizations outside of LAWA

Relation to existing standards

These standards have adopted a series of standards already in use for Surveying and Remote Sensing developed by NGS, FAA, and LAWA.

Who should read this book

These survey data standards are for use in-house by LAWA and for survey consultants, in order to ensure all survey drawings and digital CAD data files will meet LAWA standards.

How this book is organized

After the introduction, this book contains the following chapters and appendixes:

Survey and remote sensing standards in use at LAWA

provides an overview of LAWA specific standards, plus related federal, local, and national standards

Overview of survey and remote sensing data processes

summarizes survey and remote sensing data collection methods, including best practices and required levels of accuracy

Survey data submission

outlines LAWA policy for CAD file and other formats to be used when submitting survey data.

Measurement standards for drawings inside buildings

summarizes a consistent approach toward accurate field measurements for the creation of new as-built drawings inside buildings.

Related documents

CAD, BIM, GIS, Metadata and EDI standards along with other documentation related to these standards are available on the LAWA website. LAWA Standard Documents and Guidelines

Abbreviations

AEGIS	Airport Enterprise Geographical Information System
AC	Airport Circular (FAA)
AIP	Airport Improvement Program
ALM	airborne LIDAR mapping
ATLM	Airborne Terrestrial LIDAR mapping (alternative name for ALM)
BIM	Building Information Modeling
CAD	Computer Aided Design and Drafting
EDM	electronic data measuring
CPPE	Capital Planning, Programming and Engineering
FAA	Federal Aviation Administration
FGDC	Federal Geographic Data Committee
FIDS	Flight Information Display System
GBL	ground based LIDAR
GBLS/GBLM	ground based LIDAR scanning/mapping (alternative name for TLM)
GIS	Geographic Information System
GISSSD	GIS Support Services Division
GPS	global positioning systems
IMTG	Information Management Technology Group
LAWA	Los Angeles World Airports
LAX	Los Angeles International Airport
LIDAR	light imaging detection and ranging
MCLM	mobile compensated LIDAR mapping
MLE	Master Lease Exhibits
NGS	National Geodetic Survey
NSRS	National Spatial Reference System
NSSDA	National Standard for Spatial Data Accuracy
ONT	Ontario Airport
OPUS	Online Positioning User Service (from NGS)
PAC	Primary Airport Control Station
PMD	Palmdale Airport
RTK GPS	Real Time Kinematic GPS
SAC	Secondary Airport Control Station
SDSFIE	Spatial Data Standard for Facilities Infrastructure and Environment
VNY	Van Nuys Airport

Introduction

The Survey and Remote Sensing Standards document is not intended to define a surveyors method of data collection. These standards apply, whether traditional theodolites, electronic data measuring (EDM) devices, global positioning systems (GPS), light imaging detection and ranging (LIDAR) or aerial photography are used.

The surveyor is free to choose the data capture technologies and methods that give the best results for the type of project and the required levels of accuracy.

This manual is set up in such a way, that the building specific measurements and civil site specific typical topics are separated. Consultants working on building specific projects see section "Measurement standards for drawings inside buildings".

- except for some specialized schematics, the software used to produce CAD drawings is AutoCAD (a recent version)
- the unit of measurement used for CAD architectural drawings is the inch
- the unit of measurement used for CAD civil drawings is the U.S. foot
- project codes are defined by LAWA on a project per project basis
- all civil drawings must be created in NAD 83 California State Planes, Zone V, US Foot coordinate system
- all civil drawings will identify the survey epoch used, for example Multi-Year CORS solution 2011, National adjustment of 2011 (NA2011), Geoid Model GEOID12A 2012
- all architectural drawings must use positive values for coordinates
- all spatial data must be created in Model Space
- all graphical elements must be in Paper Space

These standards and specifications are intended to improve data consistency and availability of information, and facilitate spatial information dissemination and sharing within LAWA.

❖ ❖	All files and documents submitted to LAWA must be accompanied by a transmittal form holding all required metadata. Transmittal forms along with other documentation related to these standards are available on the LAWA website. LAWA Standard Documents and Guidelines

Survey and remote sensing standards in use at LAWA

LAWA Standards

This section provides an overview of LAWA specific standards, plus related federal, local, and national standards. LAWA standards have been created to improve productivity and reliable information exchange through the full life-cycle of geospatial data, CAD and BIM files along with related documents.

LAWA Metadata Standards

Metadata is structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource. Metadata is often called data about data or information about information.

LAWA CAD Standards

The LAWA CAD standards are based largely on the AIA CAD Layer Guidelines and the National CAD Standards (NCS), adapted where necessary to suit LAWA-specific requirements.

LAWA GIS Standards

The LAWA GIS standards are directly based on the ANSI Spatial Data Standard for Facilities Infrastructure and Environment (SDSFIE), Release 2.60, extended in certain areas to handle specific information relevant to LAWA. *GIS Standards for LAWA Projects* presents the most important aspects of SDSFIE as it applies to LAWA.

LAWA Survey Standards

The LAWA Survey and Remote Sensing Standards are based on requirements laid out in Airport Circulars published by the FAA, adapted where necessary to suit LAWA-specific requirements.

LAWA BIM Standards

These guidelines focus primarily on adaptation of standards for practical and efficient application of BIM, particularly at the handover (Record - As-Built) stage of a project.
Based on USACE_CAD-BIM_Technology Center: version 1.1 and National BIM standard (United States): version2

LAWA EDI (Electronic Data Interchange) Standards

This Standard provides a framework for all data requests and all hard copy or electronic data submittals to or from LAWA, thus ensuring a streamlined data exchange process

❖	These standards along with other documentation related to these standards are available on the LAWA website. [LAWA Standard Documents and Guidelines]

Related FAA circulars

❖	Check the FAA site for information on latest versions

AC 150/5300-13 Airport Design

http://www.faa.gov/documentLibrary/media/advisory_circular/150-5300-13/150_5300_13.pdf (current version change 18, draft of change 19 is available on FAA website)

AC 150/5300-16 General Guidance and Specifications for Aeronautical Surveys

For setting and recovering Geodetic Control Monuments (primary and secondary control points) at the airport http://www.faa.gov/documentLibrary/media/advisory_circular/150-5300-16A/150_5300_16.pdf (current version 16)

Existing PAC and SAC marks can be retrieved from http://www.ngs.noaa.gov/cgi-bin/airports.prl?TYPE=PACSAC

AC 150/5300-17 Standards for Using Remote Sensing Technologies in Airport Surveys

Standards for remote sensing technologies such as aerial photography and LIDAR http://www.faa.gov/documentLibrary/media/Advisory_Circular/150_5300_17c.pdf (currently version c)

AC 150/5300-18 General Guidance and Specifications for Submission of Aeronautical Surveys to NGS Field Data Collection and Geographic Information System (GIS) Standards

Guidance for surveyors, including data capture rules for airport specific features such as runways, navaids and point line markings. http://www.faa.gov/documentLibrary/media/Advisory_Circular/150_5300_18b.pdf. (current version b)

❖	The data standard format defined in AC150/5300-18 is not used at LAWA. The FAA GIS Standard is an aggregation of detailed features outlined in the LAWA GIS Standards.

Local standards

City of Los Angeles, Bureau of Engineering Manual Part J – Survey

Based on traditional survey methods (theodolite measurements), but also covers certain safety issues such as testing for gas in manholes.

http://eng.lacity.org/techdocs/survey_man/Survey_Manual.pdf

State of California standards

- All cadastral surveys must comply with all State of California regulations
- Coordinates are based on the California Coordinate System of 1983 (CCS83), Zone 5. US Foot
- Orthometric Elevations use the North American Vertical Datum of 1988 (NAVD 88)

National standards

National standards are to be followed only when other standards (LAWA, State of California, or FAA) do not provide guidance. Surveyors must have LAWA approval before implementing national standards in a LAWA project.

Digital Photogrammetry: An Addendum to the Manual of Photogrammetry, Chapter 3

American Society for Photogrammetry and Remote Sensing (ASPRS) publication ASCE C - I 38 -02

Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data – Section 5, Quality Levels of Service Attributes, A through D

FGDC-STD-008-1999

Content Standards for Digital Ortho-Imagery, 1999

Federal Geographic Data Committee, Subcommittee on Base Cartographic Data
http://www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/GI_FrameworkDataStandard_Part2_DigitalOrthoimagery.pdf

Engineering & Design Photogrammetric Mapping, 2002

U.S. Army Corps of Engineers (USACE 2002)
http://publications.usace.army.mil/publications/eng-manuals/EM_1110-1-1000_sec/EM_1110-1-1000.pdf

Spatial Data Standard for Facilities, Infrastructure, and Environment

U.S. Army Engineer Research and Development Center, CADD/GIS Technology Center (SDSFIE)
http://www.sdsfie.org/

Compliance

Having timely up to date, accurate, fully compliant data available to the LAWA community forms an integral part of planning within any project. The aim of these standards is to ensure a smooth data transfer of information into the LAWA geospatial data base and efficient data maintenance through the complete data lifecycle. Accordingly, the terms and conditions of a LAWA contract require compliance with these standards.

Failure to comply with these standards may result in organizations being back-charged for any financial costs incurred by LAWA for rectifying inconsistencies and errors

❖	See EDI for standards governing data submitted to LAWA, this along with other documentation related to these standards are available on the LAWA website. LAWA Standard Documents and Guidelines

The individual or organization submitting the files is also responsible for ensuring that all links between non-graphic data and graphic data, and all relationships between database tables, shall be preserved or automatically reconstructed when data is transferred to the LAWA GIS environment.

Request of Variance

Compliance with the LAWA standards and data deliverables demands are the cornerstone of achieving trustworthy and relevant data.

Suggestions for improvements or extensions to these standards and demands are encouraged, to meet unforeseen requirements and as a way to improve effectiveness and clarify any ambiguities; any such deviation must be approved by LAWA, in advance and in writing. . Requests need to be submitted on the “Request for variance” form, this form along with other documentation related to these standards are available on the LAWA website. LAWA Standard Documents and Guidelines

Overview of survey and remote sensing data processes

The LAWA Survey and Remote Sending Standards cover items such as:

- setting airport geodetic control points or temporary monuments
- topographical surveys
- LIDAR surveys
- aerial photogrammetric projects

Projects at LAWA that receive AIP grant funds must follow the most recent versions of the survey and submission requirements laid out in FAA Advisory Circulars AC 150/5300/16, AC 150/5300-17 and AC 150/5300-18.

The data standard format defined in AC150/5300-18 is not used at LAWA. The FAA GIS Standard is an aggregation of detailed features outlined in the LAWA GIS Standard.

The following items required by the FAA must also be provided to LAWA:

- imagery plans
- survey quality control plans
- any survey and remote sensing submissions required under the FAA Airport GIS program

At the beginning of any project, LAWA will provide the surveyor with all necessary or available digital files in AutoCAD .dwg format, plus any relevant LAWA documentation related to survey standards. LAWA will also provide a plot of existing data within the area to be surveyed, if the project specifications require this.

LAWA requires that all survey data returns are provided both in hard copy and digital AutoCAD .dwg format. Returns follow the file breakdown and standards as set out in the LAWA CAD standards and the LAWA survey and remote sensing standards.

Where the returns are to be delivered incrementally, each subsequent submission after the first contains only the features that were not included in any previous submission. Submission 3, for example, isolates only the features that have not been previously included in submissions 1 and 2. Each digital submission is accompanied by a Transmittal letter and a plot of the data in the digital files.

At the end of a project which has used a series of submissions, LAWA must be provided with a final report. This report is accompanied by a complete set of final digital .dwg files, including a final survey point data file, and a plot of the data in the digital files.

LAWA must always be provided with a project related comprehensive survey report at completion, even if the project does not require a FAA Airport GIS submission. This report must include all information necessary to confirm the integrity of the survey, and an outline of all processes involved and used to collect the survey data.

Any outstanding or unresolved problems, for example unopened manholes/catchbasins or features still unidentified, are noted in the final report so that appropriate action can be taken by LAWA.

General airport control points can be obtained from LAWA upon request

The final digital files submitted contain all features collected during the project, and reflect any changes/updates made during the project. All civil site or utility projects that submit survey data to LAWA must be tied to the NSRS. For all internal building surveys, see section "Measurement standards for drawings inside buildings".

Survey and remote sensing data collection methods

All civil site or utility projects that submit survey data to LAWA must be tied to the NSRS.

A second order horizontal and vertical control network has been established at the site.

This network consists of approximately 109 survey monuments and temporary benchmarks. In some areas, above ground features were pre-marked with paint to meet municipal utility color coding standards and help feature recognition during data capture. These PAC and SAC control marks can be obtained from the NGS. Any additional LAWA control points can be obtained from LAWA.

LAWA survey standards for NSRS

Obtain the current list of existing control points at use at LAWA. PAC and SAC data can be obtained from the NGS
http://www.ngs.noaa.gov/cgi-bin/airports.prl?TYPE=PACSAC

Geodetic verification

After recovering the PAC and SAC data, the contractor will conduct two independent GPS sessions, each 10 minutes or longer, between the existing stations. The collected data will be post-processed and adjusted while constraining to PAC data.

The results of the network adjustment will be compared to published values for each SAC, and should identify any possible disturbance. The computed distance from the PAC must agree to within ± 3 cm in distance; the difference in ellipsoidal height must agree to within ± 4 cm, and the difference in orthometric height must agree to within ± 5 cm.

The contractor must contact LAWA for guidance in repositioning the SAC point (or points) if any discrepancy outside these tolerances is found.

Positional accuracy

Shall be tested and reported following the guidance in the National Standard for Spatial Data Accuracy (FGDC-STD-007.3-1998). All projects require independent NSSDA check points as defined in AC 150/5300-17C.

- for small projects, one independent check point is required
- for large projects such as aerial control for the entire airport, five NSSDA check points are required

Check points for GPS

When using remote sensing technologies, additional check points provide a means of verifying the georeferencing of the data. Collect and provide additional NGS Online Positioning User Service (OPUS) check points within the project area, for an independent check of accuracies. Do not use these check points as part of georeferencing solution for the data. Submit a copy of the OPUS and GPS solution for each check point.

Check point traverse for theodolite surveys

If using traditional theodolite survey methods create a separate traverse that ties your check point traverse to your main project adjusted traverse and provide the comparison of coordinate values of the tie points.

Surveyed accuracies

- accuracy requirements shown are relative to the PACs and SACs or other approved airport control points used for the project
- hard surfaces and features: 0.03 feet horizontally and 0.02 feet vertically
- original ground and graded dirt areas: 0.10 feet horizontally and vertically
- features captured by aerial photography from various scales over the runways and built up areas attain accuracy's of 0.66 feet horizontally and 1.0 feet vertically.

Federal Geographic Data Committee (FGDC) standard FGDC-STD-008-1999 compliant metadata assigned during the survey contains the accuracy and date of data capture of the feature or point.

Global Positioning Systems (GPS)

GPS has become the primary method for data collection of most surveys. Here are a set of best practices that should be followed when doing work at LAWA.

Suggested best practices for static GPS

- establish new station (PAC, SAC or temporary control, etc.) in accordance with FAA AC150/5300-17
- use observation times based on required accuracy and baseline length
- complete GPS log sheet for all observations
- set GPS receivers to a 15° elevation mask
- utilize ground planes for all control observations
- utilize fixed height tripods or rover poles for all observations (mitigating instrument height errors)
- inspect and calibrate plumb of fixed height tripods and rover poles before performing observations
- monitor receiver during all session to ensure uninterrupted and good quality GPS data
- verify fixed height tripod height prior to all sessions
- capture required hand-held digital photographs for specific station types (see AC 150/5300-18b section 1.5.2)

Suggested best practices for RTK GPS

- create a new observation (DC) file on a daily basis
- set base station PDOP mask to 5.0
- set base station antenna mask for 15°
- set base station RMS limits to 0.20
- set base station to collect IN-FILL data for the duration of full day at 15-second epochs
- periodically check base station for plumb and battery power supply
- periodically check in other existing control for accuracy check

Light Imaging Detection and Ranging (LIDAR)

Specific standards and recommended practices must apply when using LIDAR scanners.

LIDAR scanners are used for a variety of survey tasks and currently fall into four principle categories:

- ground based LIDAR (GBL), generally used for measuring atmospheric composition
- airborne LIDAR mapping (ALM), also known as airborne terrestrial LIDAR mapping (ATLM)
- mobile compensated LIDAR mapping (MCLM)
- terrestrial LIDAR mapping (TLM),sometimes referred to as ground based LIDAR scanning (GBLS or GBLM)

LIDAR scanning technologies, regardless of type, are line-of-sight instruments and unable to detect what is not visible to the sensor. Be aware of your scanner's limitations and local terrain variations, and plan your project to cover any potential gaps or shadows in data coverage.

LIDAR projects are to follow all requirements outlined in AC 150/5300-17 Standards for Using Remote Sensing Technologies in Airport Surveys

Aerial imagery

Specific standards and recommended practices apply when working with aerial imagery.

LAX has been flown with three different flying heights. Make use of existing photo control from previous projects where possible.

Existing flight lines will be used when any new aerial photo is acquired. Only models that require updating will be re-triangulated.

The imagery flight missions can consist of any of these three flying altitudes, dependent upon the Project Statement of Work:

1920 feet above-mean-terrain (1"=320' photo scale)

The coverage area for this photo scale is limited to the airport property boundaries and the areas immediately adjacent to the airport which have already been digitally mapped.

Figure 1. ***Coverage area for 1"=320'***

This flying height will produce sufficient accuracy confidence to collect planimetric features at a scale of 1"=40' as well as topographic contours at a 1 foot interval.

Due to the canyon type effect that can occur around the terminal areas an additional 1:320 flight is done over the terminal areas.

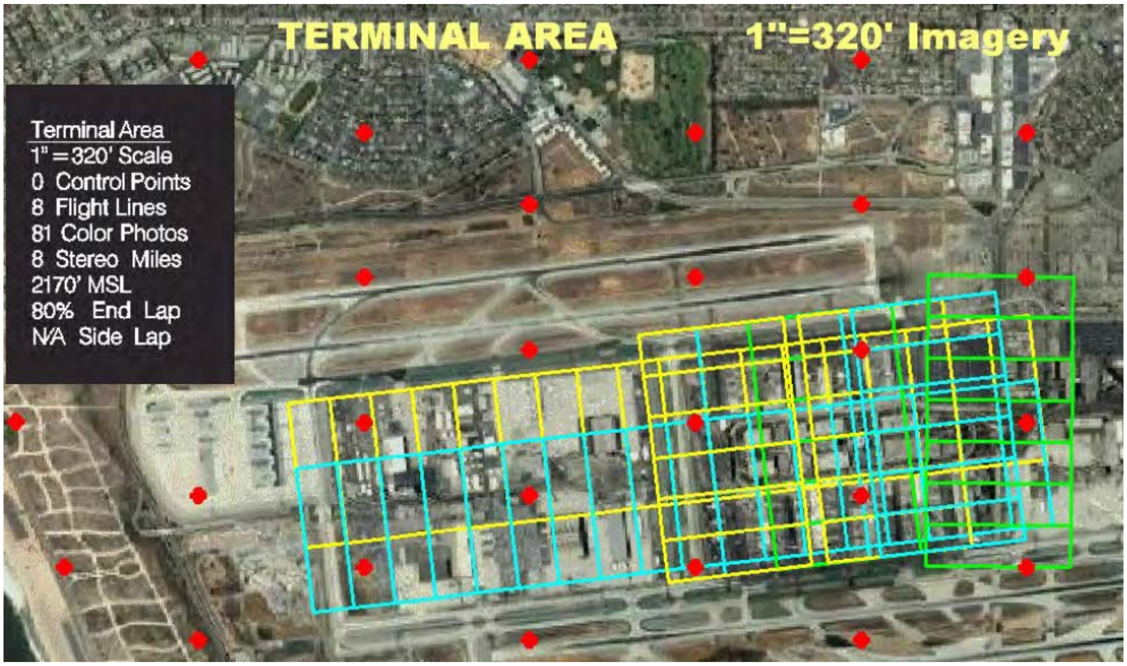

Figure 2. ***Terminal Area Model Limits***

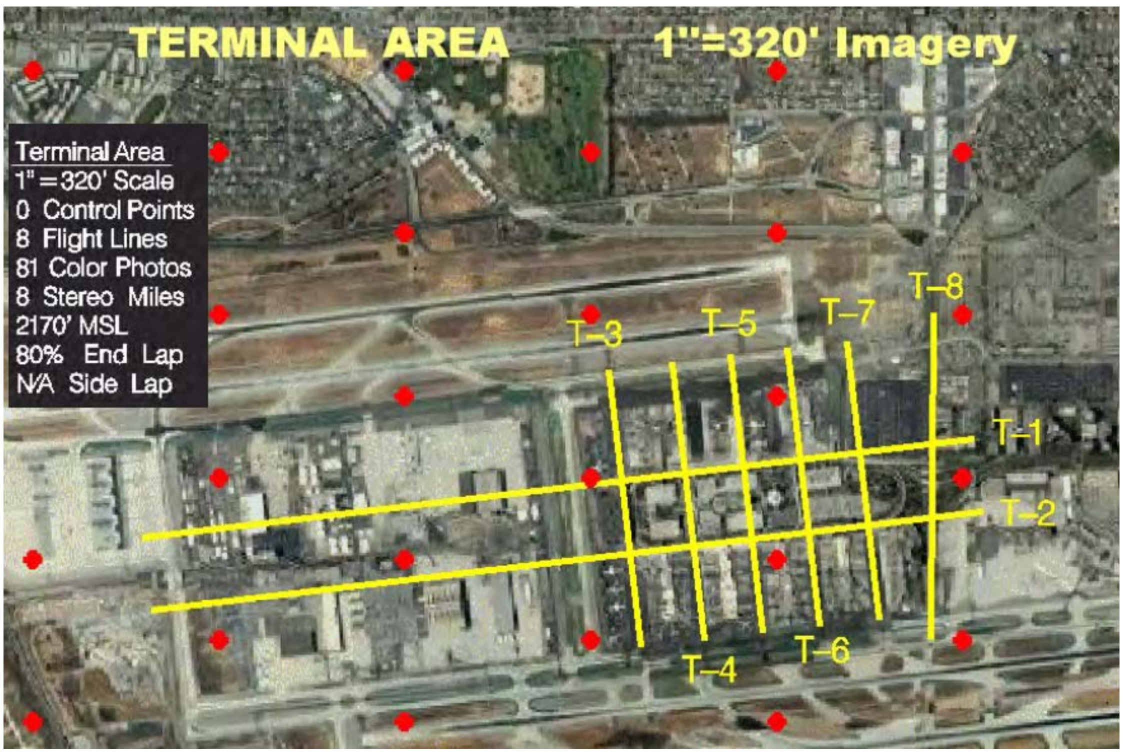

Figure 3. ***Terminal Area Flight line locations***

This imagery will be used to produce orthophotography having a ground pixel resolution of 0.20' suitable for a 1"=40' scale

4000 feet above-mean-terrain (1"=667' photo scale)

The coverage area for this photo scale includes the lateral limits of the AC 150/5300-18 obstruction identification surfaces, excluding horizontal/conical surfaces. This imagery will be utilized for analysis of the primary, connection, approach, protection, and transitional surfaces.

This basically equates to that area which extends 20,200 feet from the runway ends, as well as 4,000 on both sides of the runway centerline.

Figure 4. ***Coverage area for 1"=667' photo scale (mid-level)***

This imagery will be used to produce orthophotography having a ground pixel resolution of 0.50' suitable for a 1"=100' scale.

The flight mission at 4000 feet above-mean-terrain consists of 7 flight-lines, each having 150 images

9000 feet above-mean-terrain (1”=1500’ photo scale)

The coverage area for this photo scale will span the entire lateral limits of the vertically guided surfaces area. It will be utilized in analyzing the horizontal and conical obstruction identification surfaces.

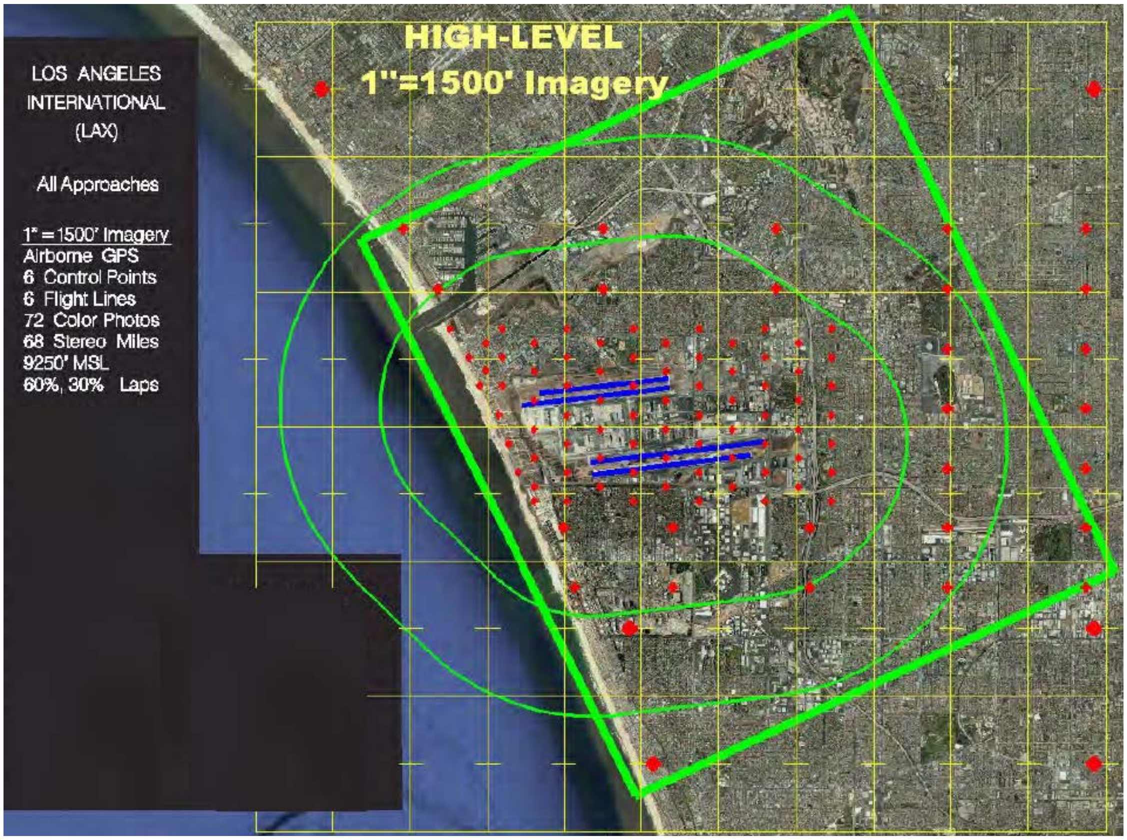

Figure 5. ***Coverage area for 1”=1500’ photo scale (high-level)***

This imagery will be used to produce orthophotography having a ground pixel resolution of 1.0’ suitable for a 1”=200’ scale.

The flight mission at 9000 feet above-mean-terrain consists of 6 flight-lines, with a total of 72 images.

Selection of flight altitudes

The flight altitudes mentioned above will allow for collection of obstruction data, planimetric features, and topographic data within the accuracies prescribed by section 5 of AC150/5300-18B.

This circular requires the following levels of accuracy

- horizontal position of obstructions within +/-20 feet
- within the primary, connection, transitional, protection, and approach surfaces, vertical orthometric height of obstacles within +/-3 feet
- within the horizontal and conical surfaces, orthometric height of obstacles within +/-10 feet.

All three of the planned photo scales were selected to ensure these accuracies will be met using remote sensing. The flying heights are designed to deliver a level of detail which will allow these imagery layouts to be utilized in future projects.

Methodology for controlling collection of imagery photos

The LAWA photo control network consists of 109 control points and 5 independent check points.

The position for each of the five check points was determined with OPUS software from the NGS. These check points were not utilized in the control solution of the imagery.

The 109 control points are distributed throughout the photo area, assuring quality control of the entire imagery area. A special concentration of control points is utilized in the immediate vicinity of the airport, where accuracy requirements are more stringent and where the planimetric and topographic data will be collected.

Survey data submission

This section outlines LAWA policy for CAD file and other formats to be used when submitting survey data.

CAD policy

It is the policy of the Los Angles World Airways (LAWA) that all CAD deliverables submitted to LAWA shall be in a AutoCAD *.dwg file format, structured in accordance with LAWA CAD

The LAWA CAD standards are based largely on the AIA CAD Layer Guidelines and the National CAD Standards (NCS), adapted where necessary to suit LAWA-specific requirements. The document *CAD Standards for LAWA Projects* is available from the LAWA web site at www.lawa.org/laxdev/Handbook.aspx. These standards currently cover .dwg files only.

The LAWA Standards include, but are not limited to: file naming conventions, drawing numbers, file and level structure, fonts, line colors, line weights, symbols, patterns and reference files.

The CAD system in use at LAWA for drawing/data management, which is also the basis of facility management systems, is AutoCAD by Autodesk.

If any secondary consultant uses a CAD package other than AutoCAD, it shall be the responsibility of the prime consultant to ensure all CAD data submitted to LAWA is structured in accordance with LAWA CAD Standards.

Templates

Project partners and subcontractors who need to implement the CAD standards for LAWA projects can download templates to provide a working environment based on the LAWA CAD Standards. Each template (.dwt file) defines the layers for a specific discipline. Sample title blocks can also be downloaded

Submission formats for survey data

The submission format for survey data is based on AC 150/5300-17, with slight modifications. The following directory structure is to be used when submitting data.

1. Summary
2. Project control or photo control notes
3. Project control coordinates
4. Photo control network diagram
5. LIDAR & camera calibration report
6. LIDAR path or flight report
7. LIDAR path or flight layout
8. LIDAR or aerial triangulation
9. Digital model imagery
10. AutoCAD drawings

LIDAR projects are to follow all requirements outlined in AC 150/5300-17.

An explanation and sample data requirements for each directory follows.

Section 1 – Summary

This section contains project summary and summary of any deviations

Summary Report should contain a report of any issues that could affect the project, such as problems with Control points, accuracy issues, site access problems, or changes in flight lines or camera during a flight. The report should ensure that any deviations from the project plan are annotated and properly recorded due to unusual circumstances or problems, equipment malfunctions, changes to proposed methodologies/equipment or any deviations from these specifications.

SUBMISSION FORMAT .pdf

Section 2 – Project Control or Photo Control Point Notes

This section contains survey documentation.

Station location sketch and visibility diagrams are required for each point listed in the control coordinate listing of the files. All station location sketch and visibility reports are to be uniquely numbered and correspond to the hand held photographs supplied, and numbers match the point numbers in the project control or photo control coordinate listing.

SUBMISSION FORMAT .txt, Excel

Hand held photographs are required for each control point, navaid or runway end. Each point should have one hand held photo (up close) taken from 5-6 feet away and one hand held photo taken from 10-30 feet away. All photos include the airport name or airport call letters and survey point number.

SUBMISSION FORMAT .pdf or .jpg

Rinex Version of all GPS station data is required in RAW format as below

Raw GPS input files	**aaaaddds.xxx**	**aaaa = alphanumeric 4-character station identifier** **ddd = day of year** **s = session** **yy = year of observations** **xxx = receiver-dependent file extension (for example .DAT, .EPH, .ION, or .MES)**

Rinex Sample Raw observation is shown below

RINEX2 Observation File	**aaaaddds.yyo**

NSSDA check Points

- Raw GPS observations must be provided for all points listed as the NSSDA check points
- 5 check points are required for FAA photogrammetric imagery projects
- submit OPUS results for each temporary GPS station including the NSSDA check points

SUBMISSION FORMAT .txt, Excel, .pdf or .jpg

Section 3 – Project control or photo control coordinates

This section contains survey data and Airborne GPS data collected during the acquisition of GPS and Aerial Photography GPS (ABGPS) data.

Provide an ASCII text file of the final imagery control point values identifying any changes from the remote sensing plan, as illustrated in Table 3-2 of AC 150/5300-17C. This section should only include the coordinate values (easting, northing, elevation) for the control points being used in the project and the five OPUS check points

SUBMISSION FORMAT .txt, Excel, .pdf or .jpg

Section 4 – Project control or photo control network diagram

This section contains the ground control diagram.

Provide a KML or PDF depicting all control stations the data used in geo-referencing the project including information regarding their tie to the NSRS

SUBMISSION FORMAT .pdf, .jpg or .kml

Section 5 – LIDAR or camera calibration report

This section contains a .pdf of the calibration report

There is no standard format for the calibration reports. However, they must contain, at a minimum, the following information:

- date the calibration was performed
- name of the person, company, or organization responsible for performing the calibration
- methods used to perform the calibration
- final calibration parameters or corrections determined through the calibration procedures.
- discussion of the results
- sensor maintenance reports with maintenance history of the sensors used in data collection

Calibration submission for LIDAR equipment must follow AC 150/5300-17, Section 5.4 "What are the system calibration requirements for using LIDAR to collect airport data"

SUBMISSION FORMAT .pdf or .jpg

Section 6 –LIDAR or flight report

Only required for Aerial Photogrammetric projects

SUBMISSION FORMAT .pdf or .jpg

Section 7 – Flight or path layout

This directory contains a diagram that depicts the flight paths or paths used in LIDAR data acquisition, plus altitudes that were flown during imagery acquisition.

SUBMISSION FORMAT .pdf or .jpg

Section 8 –LIDAR and Aerial Triangulation (AT)

This directory contains AT reports, spreadsheets, or ASCII files that describe the triangulation results for project including LIDAR and aerial photography projects as defined in AC 150/5300-17c section 3.4.d.7.
SUBMISSION FORMAT .txt, Excel or .pdf

Section 9 – Digital Model Imagery

This directory contains raw stereo images (TIF images) or LIDAR point clouds

SUBMISSION FORMAT Tiff or point cloud

Section 10 – AutoCAD drawings

AutoCAD submission best practices (.dwg)

Project partners and subcontractors who need to implement the CAD standards for LAWA projects can download templates to provide a working environment based on the LAWA CAD Standards. Each template (.dwt file) defines the layers for a specific discipline. Sample title blocks can also be downloaded.

AutoCAD Best Practices

- all spatial data must be created in model space
- all graphical elements must be in paper space
- the unit of measurement used for cad civil drawings is the u.s. foot
- all civil drawings must be created in nad 83 california state planes, zone v, us foot coordinate system
- proper orientation of point features should be maintained wherever possible
- underground services should be connected wherever possible.
- for any feature that cannot be identified by the field crew, enter the point into the digital file as an unidentified feature, using the block ID from the LAWA block library. At the same time, a LAWA engineer or GIS specialist should be notified of the point in question so that an investigation can be started by LAWA to obtain identification for the feature. A photograph, taken by the field crew of the unidentifiable point and forwarded to LAWA, will aid in the identification process. When identification has been obtained, LAWA will notify the surveyor so that the proper symbology for the point can be input into the digital file.
- if a new feature has been collected that does not match any existing feature, a LAWA representative should be notified. The representative will then determine the proper symbology and feature number to be used and forward this to the surveyor for input in the digital file.
- survey plans submitted to LAWA should be legible at the plotted scale, with the spot elevations not appearing too dense in nature

- digital spot elevations are to be structured so the elevations of a specified interval are on the appropriate layer within the CAD file. The remaining elevations must be placed on a separate CAD layer specified in the LAWA CAD Standards. This will allow for spot heights to be shown on any drawing without being too dense in appearance, yet still contain all collected spot elevations within the file which can be used for design, planning, etc. purposes.
- when submitting a CAD file, the settings for the relevant layers should be "tuned on" and "thawed"

Typical civil site projects

All drawings submitted with survey data will have a file-name starting with V- , as outlined in the CAD Layer Assignment table for LAWA projects.

Prefix	**Data**
V-SURV	**Survey lines (Traverse/Base Lines)**
V-AIRF	**Airfield**
V-BLDG	**Buildings**
V-PROP	**Property**
V-SITE	**Site**
V-TOPO	**Topography**
V-UTIL	**Utilities**

Submission of borehole data

Data submission requirements

All borehole locations are to be submitted geo-referenced according to LAWA standards. LAWA will then use this data to update the digital graphics database for the design and management of the facility.

Deliverables

- hard copy of the geo-technical report describing project findings and test results including borehole logs and the corresponding hard copy site plan drawings
- ASCII file with x,y and z coordinates and number of each borehole

Note: Although it is not a requirement, it would be preferable to be given all site plan drawings in an AutoCAD.dwg format.

- reports in PDF Format

Borehole numbering convention policy

Each borehole must be numbered consisting of the **Project Number** and a sequential **log number.** If a borehole is not associated with a project, the number 999 will be assigned as the project number.

BRH 265-001

Figure 6. ***Sample borehole where BRH265 represents the project number and 001 represents the sequential number***.

Measurement standards for drawings inside buildings

The buildings digital graphics database was built up from hard-copy drawings for many of the existing airport buildings, including terminals, administration building, central work shop, central utility plant, fire hall/maintenance garage and so on. These drawings included architectural floor plans and a combination of reflected ceiling plans, structural, electrical and mechanical information.

These files use the same coordinate system as the site data. Therefore, the buildings and their corresponding data sets fit directly on top of the site information.

Other airport buildings, including aircraft hangars, cargo buildings, airline administrative buildings and so on. are not included in the database because these tenants manage their own facilities. Drawings of these buildings are either digitized or re-drawn if they are required for a LAWA project, and are ultimately added to the building digital graphics database.

About the 'inside buildings' standards

These standards provide consistent tools toward accurate field measurements for the creation of new as-built drawings that will, in-turn, be used in facilities management to create up-to-date verifiably accurate Master Lease Exhibits (MLE) of various terminals. Using these standards, one would expect to be able to duplicate a measurement at random, and get a result reasonably similar to the original measurement.

Measurements will be used to create accurate as-built drawings in AutoCAD (.dwg) and in GIS (.shp) format. The new as-built drawings are to adhere to the latest LAWA CAD Standards published on the LAWA web site and detailed in the LAWA Design and Construction handbook.
All measuring and the resulting drawings are to follow the Standard parameters as set forth in this document. Field measurements and factual observations duly documented shall take precedence over existing As-Built Drawings or any other existing construction documents.

Methods described in this Standard are the result of several years of field experience measuring and drawing several airport terminal structures over 100,000 square feet per floor. The intention is to provide proven methods to avoid common errors, remove the necessity to repeat the entire learning curve and provide new or novice measuring teams with basic rules helpful to this end. The experienced measuring team will recognize many shared methods, and may appreciate this measuring standard as a useful tool.

Quick review list of topics covered

- paper requirements
- as-built drawing requirements
- drawing CAD setup for as-built drawings
- photographs
- equipment acceptable for use on this project
- elevators, stairs, and aligning multiple floors
- included items
- excluded items
- rounding off of field measurements
- rounding off of drawings
- accuracy in measuring and drawing
- wall thicknesses accurately measured
- dimension and measuring points
- walls – odd angles, vertically, horizontally, and curved
- redundant measurements
- door information
- security key pads (also known as Acams)
- column diameter
- areas undefined by walls or other enclosures

Standards

The standards defined and illustrated in this chapter cover:

- field measurement sheets
- drawing setup in AutoCAD
- master lease exhibit (MLE) drawing
- photographs
- equipment – measuring devices
- aligning multiple floors
- included and excluded items
- inaccessible areas
- structural changes during measuring
- gridlines in drawings
- accuracy of measurements
- wall thickness
- door dimension points
- walls - curved, non-rectilinear, and sloped
- redundant measurements
- door information to be shown on drawings
- security key pads (Acams)
- columns
- miscellaneous equipment in public areas
- areas not enclosed or defined by walls

Field measurement sheets

Field measurement sheets can be either of:

small scale sector map

all sectors per level, for one terminal

large scale sector drawing

individual sectors, for measuring

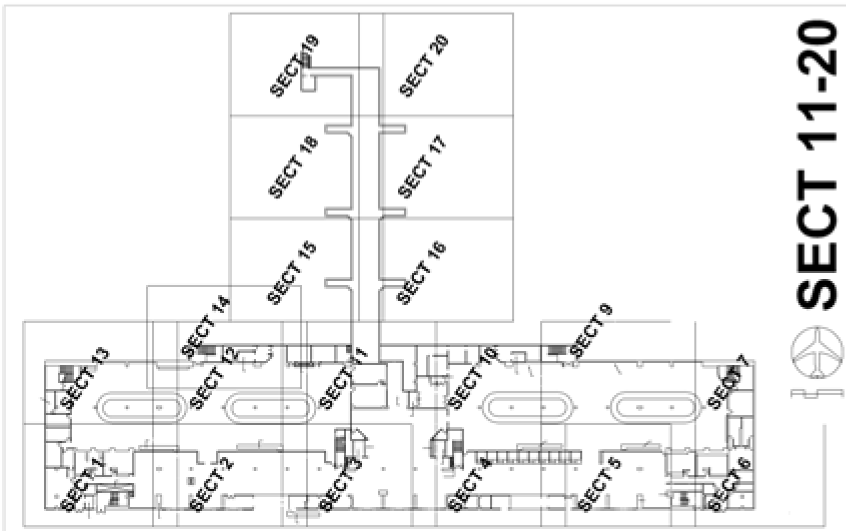

Figure 1. ***Sector map showing total floor plan***

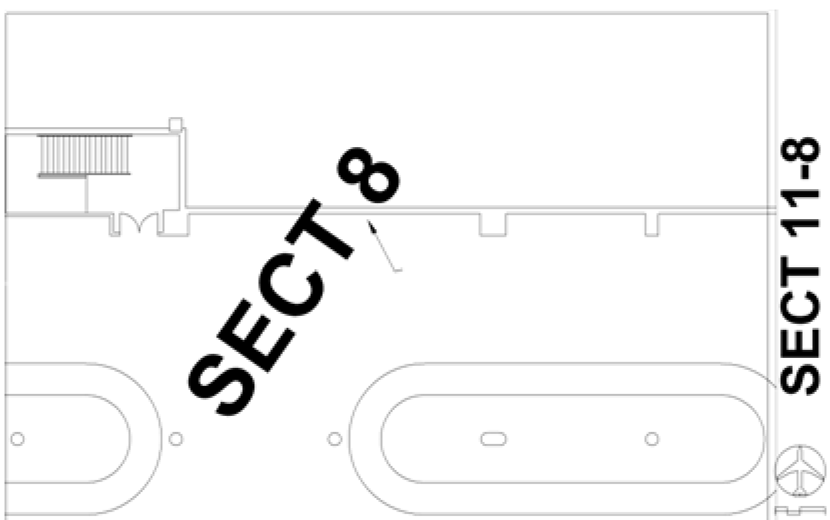

Figure 2. ***Single sector showing partial floor plan***

Drawing setup in AutoCAD

Units	**Engineering US. feet**
Precision	**1/256”**
Line Type Scale	**0.5 or 0.3 when necessary for short lines**
PSLTSCALE	**1.0**
Plotted Scale	**11" x 17" Sector Sheets for Field Measuring: 1/8" = 1’ – 0"**
	11" x 17" As-Built Drawing Sheets: 1" = 40’
Rounding Off	**CAD Dimension Round-Off: 1/16" Field Measurements to be to nearest 1/16" CAD Drawings to be to nearest recorded Field Measurement. Do not round-off recorded Field Measurements when drawing the data. Dimensions will round off to the nearest 1/16", but the drawing object data will be drawn as measured.**
Snap Setting	**Setting is ON, and 1/16" to ensure drawing accuracy.**
Sheet Size	**11" x 17" and 24” x 36”**
Drawing CAD Object Properties	**Grid Lines: refer to Grid Lines section of this Standard**
Layers	**LAWA CAD standards**
Line Types	**LAWA CAD standards**
Text Styles	**LAWA CAD standards**
Dimension Styles	**LAWA CAD standards**
Blocks or Symbols	**LAWA CAD standards**

Refer to the LAWA CAD Standards for additional properties.

Master Lease Exhibit (MLE) drawing

The typical MLE drawing shown below is a reference only to show the intended future use of this measuring work. This example shows a complete drawing using the new As-Built drawing as a base for the MLE in the next phase applying lease information and other details.

The drawings created from the field measurements will provide the basic information/raw cad data for the MLE drawings. For this reason the new As-Built drawings must conform to the LAWA CAD Standards.

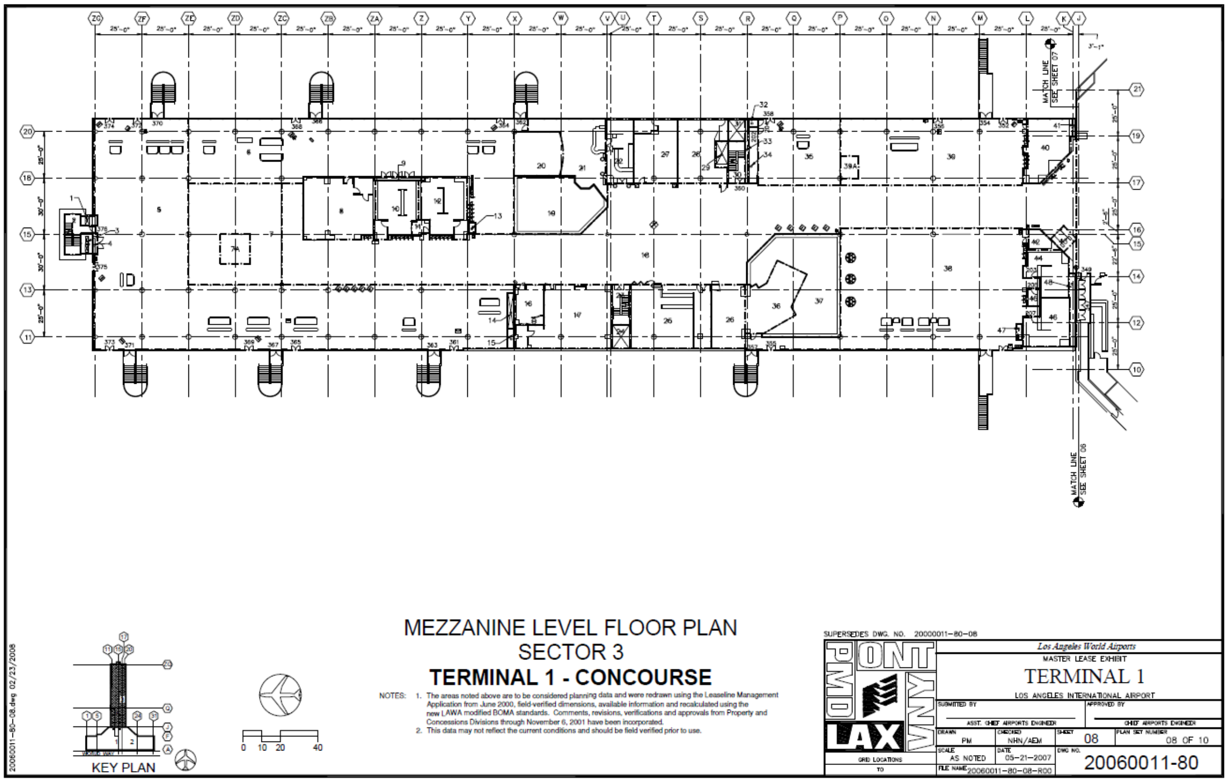

Figure 3. ***Typical MLE (Master Lease Exhibit) drawing***

Photographs

Photographs are used for one of three reasons:

for reference

Field observations of unusual conditions may require photographs for greater understanding during the conversion of field data to drawing data.

before measuring

The Measuring Team should walk the site and photograph as much in general as possible to provide a thorough over-all description of the terminal.

additional photographs

Photographs are to be taken in areas where the method of measuring needs to be explained clearly to a draftsperson.

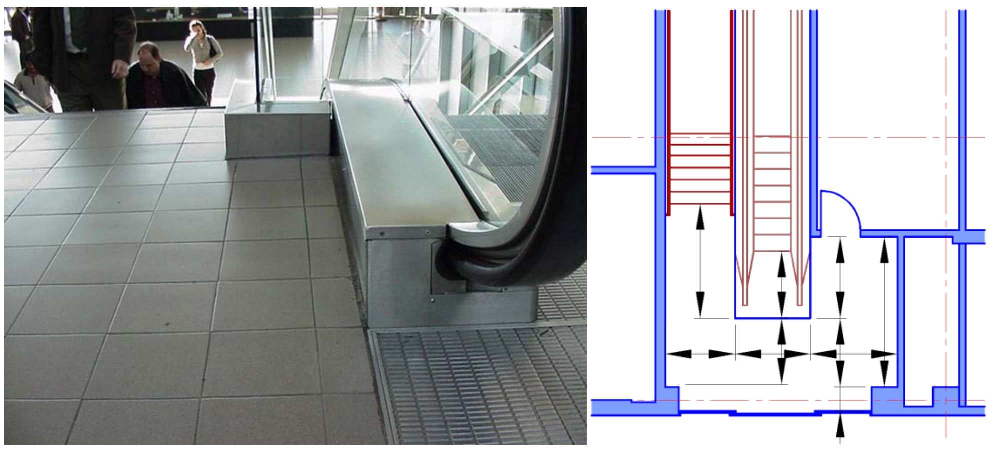

Figure 4. ***Complex stair and escalator relationship***

This example illustrates the need for precise measurements of the curbs and grates in the floor, and surrounding the stair and escalator. In order to locate them relative to each other, to total structure, and to the floors above and below, the metal grates in the floor and the curbs must be measured.

Also, sometimes these measurements will be necessary to adequately measure the location of boundary walls, not otherwise measurable.

Photographic record

Maintain a stored record of all photographs taken. This may include maps of where the photographs were taken. An example is shown below.

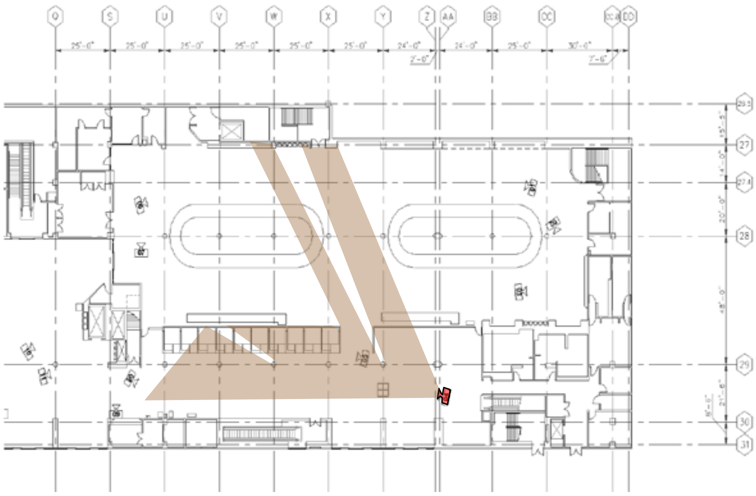

Figure 5. ***Arrival Public Lobby – overhead FIDS***

Equipment – measuring devices

❖	minimum device accuracy to be 1/16"

Acceptable measuring devices are:

- manual: recommend 100’ and 30’ metal tapes
- digital: Leika Disto Classic or equal
- LIDAR based survey

Sonar based measuring equipment, and non-metallic tapes and tapes that may stretch with use, are not acceptable.

Notes on measurements

measurements less than 18"

Because of the nature of the two primary measuring instruments, metal tape and digital, the metal tape is to be used for all measurements less than 18".

measurements greater than 100’

Great care must be taken to accurately mark the incremental beginnings and endings. Use structural landmarks whenever possible, and accurately measure the landmarks, and their relative positions to other notable landmarks in the vicinity.

measuring in sunlight

Certain measurements such as outdoors in sunlight should be done with the metal tape.

Using elevators to align multiple floors

Align floors, above to below, using elevators as a guide. Measuring correctly to vertically line up multiple floors is critical.

❖ Stairs can also be used: see **Using stairs to align multiple floors**

Elevators are excellent tools to use as datum reference (the whole cab). The cab interior is always the same physical space on every level. Key to this is to measure the interior of the cab and relate it to the exterior landing area, and then expand outward from the elevator lobby to adjoining spaces.

Refer to Figure 6 for illustrations of critical measurements inside and outside an elevator that are to be used for vertical floor alignments.

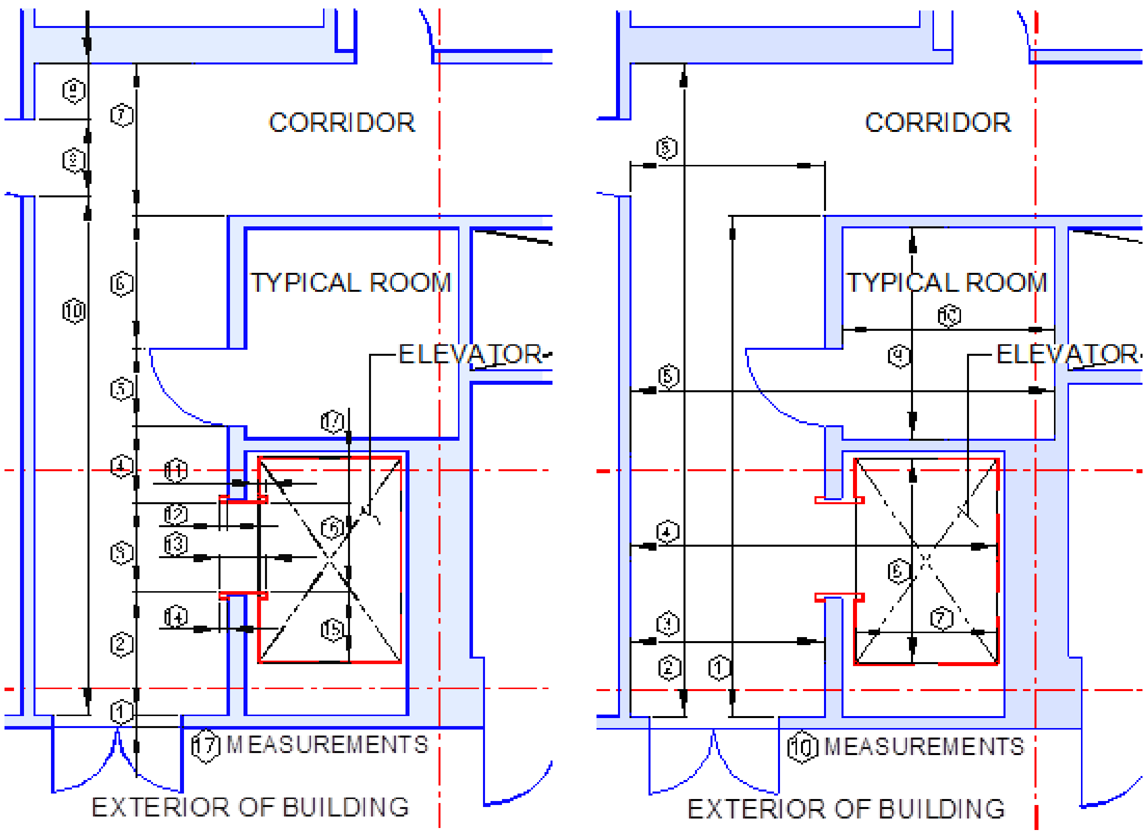

Figure 6. ***Elevator as datum***

Notice that the inside of the elevator cab is a vertical link to the floor levels above and below. In order to utilize this with accuracy, one must follow the concept as illustrated in these figures. In figure 6 the elevator cab is linked to the outside surface of an exterior wall. In addition, these drawings show how wall thickness can be determined, and also apparent redundancy can help verify measurements later in the office.

Using stairs to align multiple floors

Align floors, above to below, using stairs as a guide. Measuring correctly to vertically line up multiple floors is critical.

❖	Elevators can also be used: see Using elevators to align multiple floors

Stairs are also good tools for floor to floor alignment, but unlike the elevator cab, the stairwell walls are not always located in the same location on every landing of the stairs. This makes measuring the stairwell more complicated than the elevator, and the measurer must be observant so not to miss a critical difference. Key to this, similar to the elevator, is diligent measuring of the interior of the stairwell, and relating it to the exterior adjacent area, and then expand outward from the stair area to adjoining spaces.

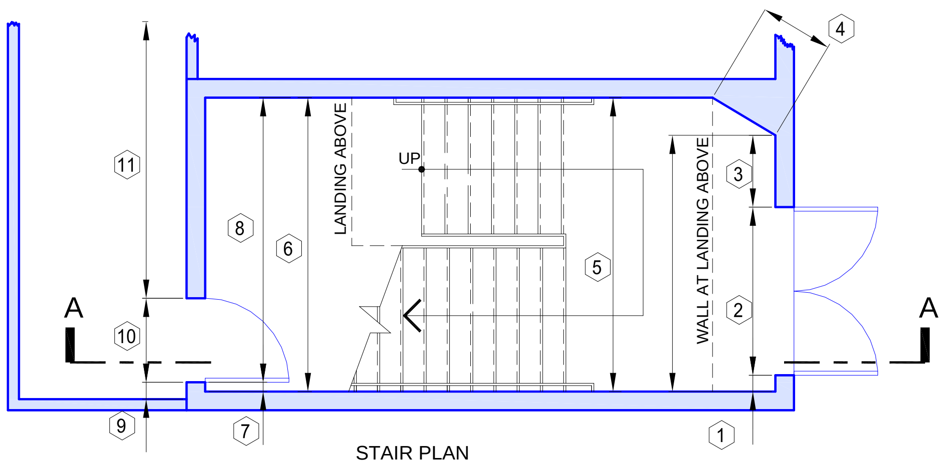

Figure 7. ***Stair plan***

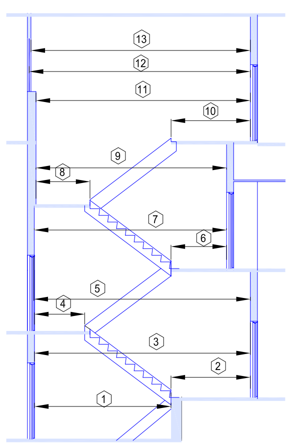

Figure 8. ***Stair section***

Included and excluded items

This list is for the purpose of answering just what is and is not to be measured or noted, in addition to the obvious physical structure of the airport terminals.

Note any unusual physical features and verify with LAWA FMG Engineers and/or GIS staff, if they are to be documented. When questioning or deciding on items not listed in this section, always verify the status with LAWA before proceeding with your own decisions. All questions are to be in writing with a clear date of asking, the name of the requestor, and who it was sent to, along with the question itself. All written material should be in a readable condition.

Included items

- all vending machines found in any public area
- all lockers found in public areas
- free standing kiosks such as might be used by a flower retailer, candy vendor or others
- baggage handling equipment such as carousels in the baggage arrival areas
- trash compaction machinery, whether private or LAWA owned
- free standing portable offices
- There are offices of this type throughout the airport facility. All of them are to be measured and noted on the drawings.
- all FIDS (Flight Information Display System) monitors

Show the correct number of monitors installed in a single cabinet. Measure and locate the cabinets, or note the monitors when flush mounted within a wall. There should be an accommodation in the wall thickness for these, or there may be a monitor that protrudes from the wall on the interior space.

- Security check points, Immigration and agricultural examination tables and booths
- other items not listed here, but included as they occur

Excluded items

- in restrooms: plumbing fixtures, stall partitions, mirrors, or counter tops
- in various public areas: movable, freestanding objects
- private non-LAWA equipment of any kind, unless LAWA specifically requests a usually excluded item to be included

Verify with LAWA exactly what other items are excluded from measurement and data documentation as to their existence and/or location and size.

Inaccessible areas

All areas, rooms, and spaces are to be measured. Any of these found to be inaccessible are to be documented and reported to LAWA in a timely manner.

Structural changes during measuring

Often during a measuring assignment, a Lessee or LAWA may make changes to a structure that was already measured, or is about to be measured while this change is taking place. Request access if necessary, and measure the newly constructed structure. If the measuring of this area is completed prior to the beginning of the change, verify with LAWA or measuring supervisors whether this change will be included in the new as-built drawings or will the measuring team ignore the change.

Each of these is subject to inclusion or exclusion in the measurement process, as a separate decision.

If at all possible for the measuring team, always try to get the latest data on the structure.

Gridlines in drawings

Grid lines in field sector sheets and new as-built drawings shall be drawn orthogonally located and labeled as represented on the existing as-built reference construction documents.

Accuracy of measurements

single measurement

½" maximum for any single measurement regardless of the distance measured.

cumulative measurements

strings of measurements, such as a series of rooms along a corridor, shall be within ½" in either direction, larger or smaller than a single measurement along an adjacent space such as an adjacent corridor. This permits a tolerance of 1", but limits it to ½" greater or smaller than the total dimension. This limit is required to assure that as these cumulative spaces are drawn, that they do not produce over-lapping areas, or an interior that extends beyond the exterior of the building.

multiple or redundant measurements

these are useful to verify accuracy and are often needed in the case of single or cumulative measurements.

Wall thickness

- measure and note all wall thicknesses as accurately as possible

See Figures 7, 9 and 13, for methods of determining the wall thickness.

- use existing as-built construction documents to verify walls when they are hidden behind temporary objects such as boxes or shelving that prohibits visual verification of the wall

Door and window jamb details can provide this information as to original intent during construction.

- measure to finish of wall

If there are two finish surfaces, (tile and paint over dry-wall), and both finishes are visible, measure to the painted dry-wall surface, and note that this is the case.

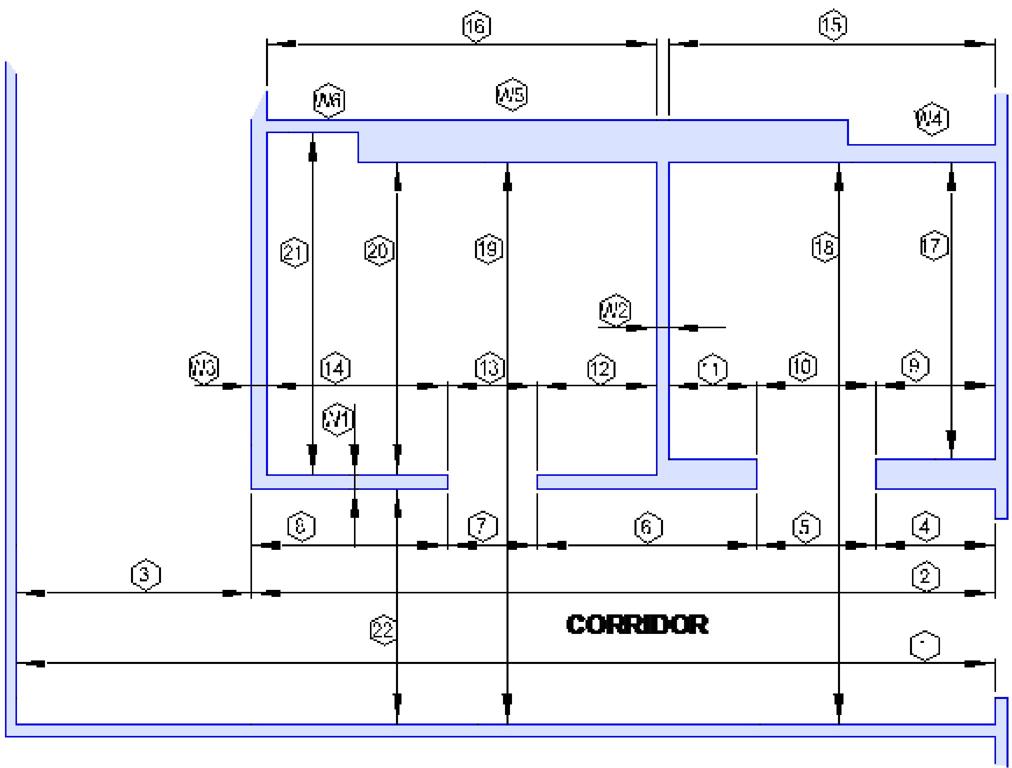

Figure 9. ***Wall thickness measurement guidelines***

Notes:

- interior rooms located along an adjacent corridor need to have their location relative to each other and the corridor defined accurately and thoroughly
- potential errors occur when a wall changes thickness inside a room, and dimensions 20 or 21 is not noted or measured
- wall thickness errors may produce errors in adjacent space locations and subsequently cause an encroachment into other spaces

Wall thickness calculation examples:

- W1 = 19 – (22 + 20)
- W2 = (4 + 5 + 6 + 7 + 12) – (15 + 16)
- W3 = 1 – (3 – 4 + 5 + 6 + 7 +12)
- W4, W5 & W6 show a potential for error

❖	Lesson: be observant and diligent

Walls - curved, non-rectilinear, and sloped

When walls are not perpendicular or parallel to each other and this becomes apparent, either through visual observation, or while drawing per the Field Measurements, but the CDs show the walls as perpendicular or parallel, measure from two diagonally opposed corners of the space, as accurately as possible to obtain the correct geometry of the space. This may require two diagonal dimensions to give the complete and accurate geometry.

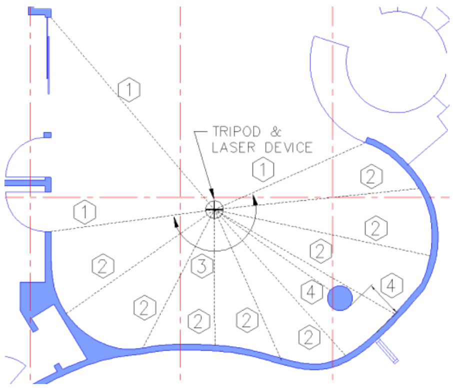

Figure 10. ***Curved walls***

1. Establish location of the tripod relative to several known points
2. Distance of lines of measurement from tripod to wall
3. Note angle of each line of measurement relative to last one
4. Known column using surrounding known fixed elements

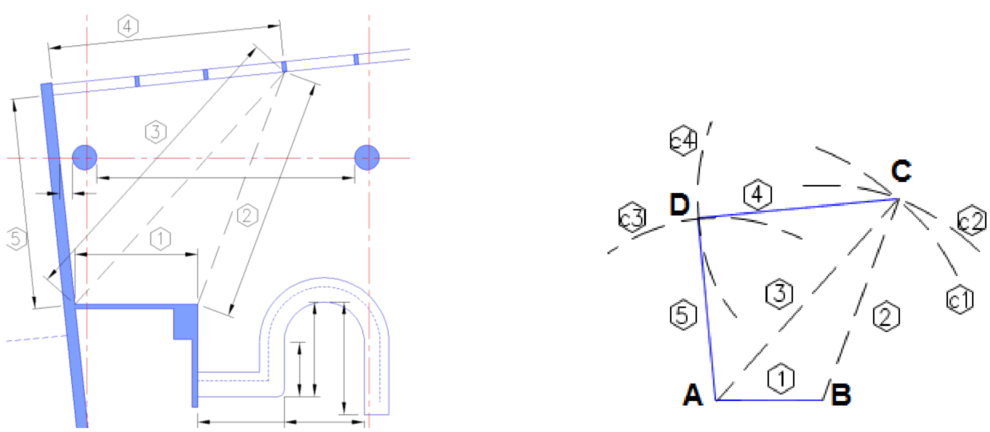

Figure 11. ***Non-rectilinear walls***

1. Use points A & B to draw circles C1 & C2
2. Use point of intersection of C1 & C2 to draw circles C3 & C4
3. Draw wall from points C to D to A to B

Figure 12. ***Sloped walls***

Measure all sloping walls at their floor line

Redundant measurements

Utilize multiple measurements when necessary to assure that accuracy is maintained. An example of this is the incremental measuring of columns, including their individual sizes, and their locations relative to each other in a large space, and an over-all measurement of the same space. Another example would be a series of contiguous offices along a corridor. In this case, interior walls between offices become important measurements.

Door information to be shown on drawings

- door swing: note door swing accurately
- door number: note number accurately
- door width: typical measurement points for doors are shown in the figure below

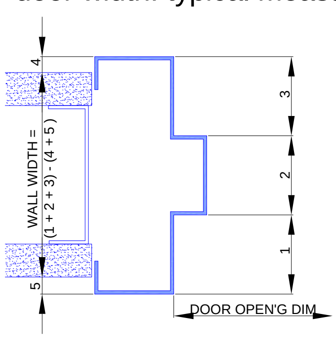

Figure 13. ***Door jamb - typical measure points***

Security key pads (Acams)

- show the location relative to the door opening
- show the number of the key pad whenever possible.
- show the door number (QR code) whenever possible

Columns

- locate columns relative to adjacent columns, and to adjacent walls or windows.

Do NOT rely on existing As-Built construction drawings to locate the columns.

- measure the finish surface of the column

This may be the actual structural column or it may be an applied finish, or box around the column.

To determine the as-built diameter of round columns, measure the circumference and calculate the diameter using the formula

Diameter (D) = Circumference (C) divided by pi or D = C ÷ 3.14

Miscellaneous equipment in public areas

This category concerns items such as:

- FIDS (Flight Information Display System) equipment
- vending machines
- baggage cart storage racks
- lockers in public areas
- security equipment
- kiosks
- wifi antennas
- internet charging stations

FIDS (Flight Information Display System) equipment

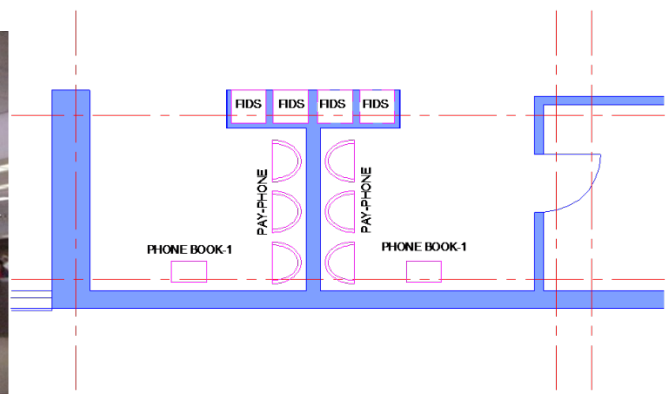

Figure 14. ***FIDS examples***

Use ceiling and floor tile grids when measuring the object is not feasible or accuracy is not possible with a tape or laser device.

Vending machines

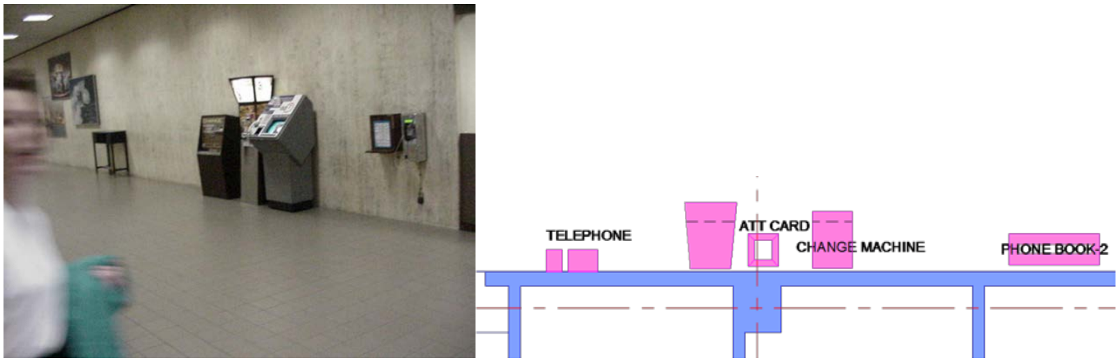

Figure 15. ***Vending machines***

Baggage cart storage racks

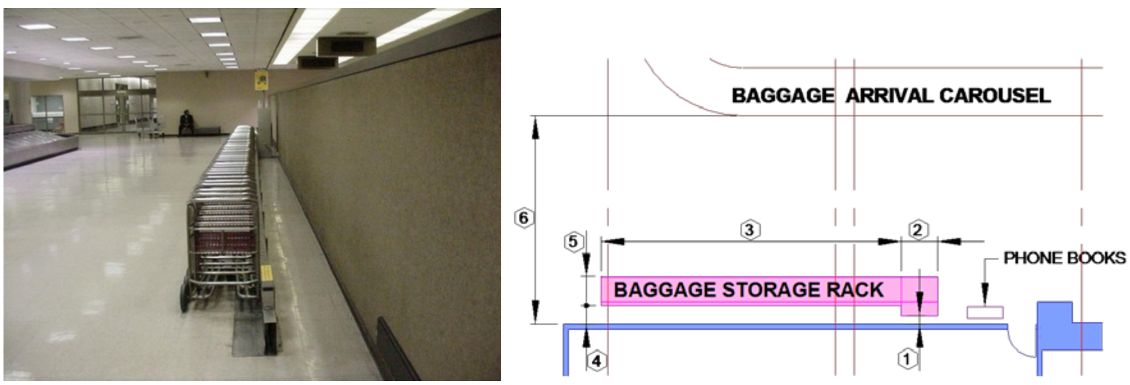

Figure 16. ***Baggage cart storage racks***

Lockers in public areas

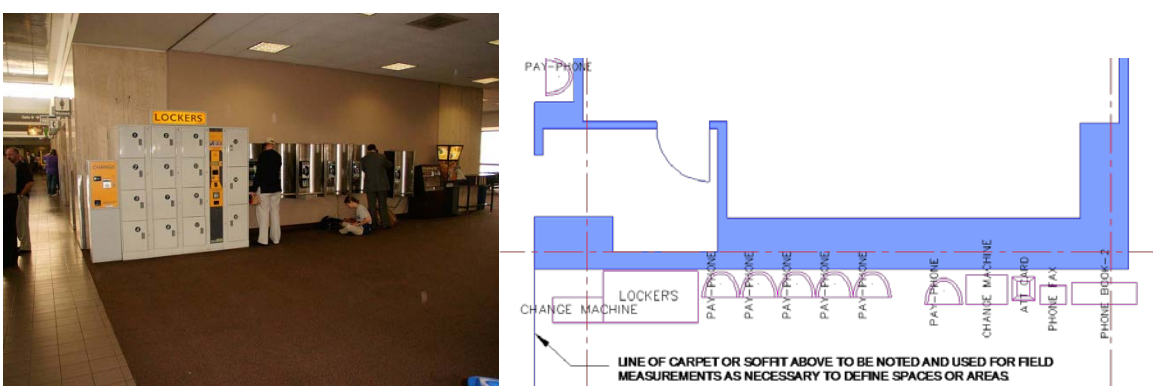

Figure 17. ***Lockers in public areas***

Security equipment

When measuring security equipment and areas:

- Always inform a TSA supervisor
- use a photograph to aid in drawing the space accurately
- measure a simple geometric shape such as a rectangle that encompasses the Security Area

See drawing below photo, as an example.

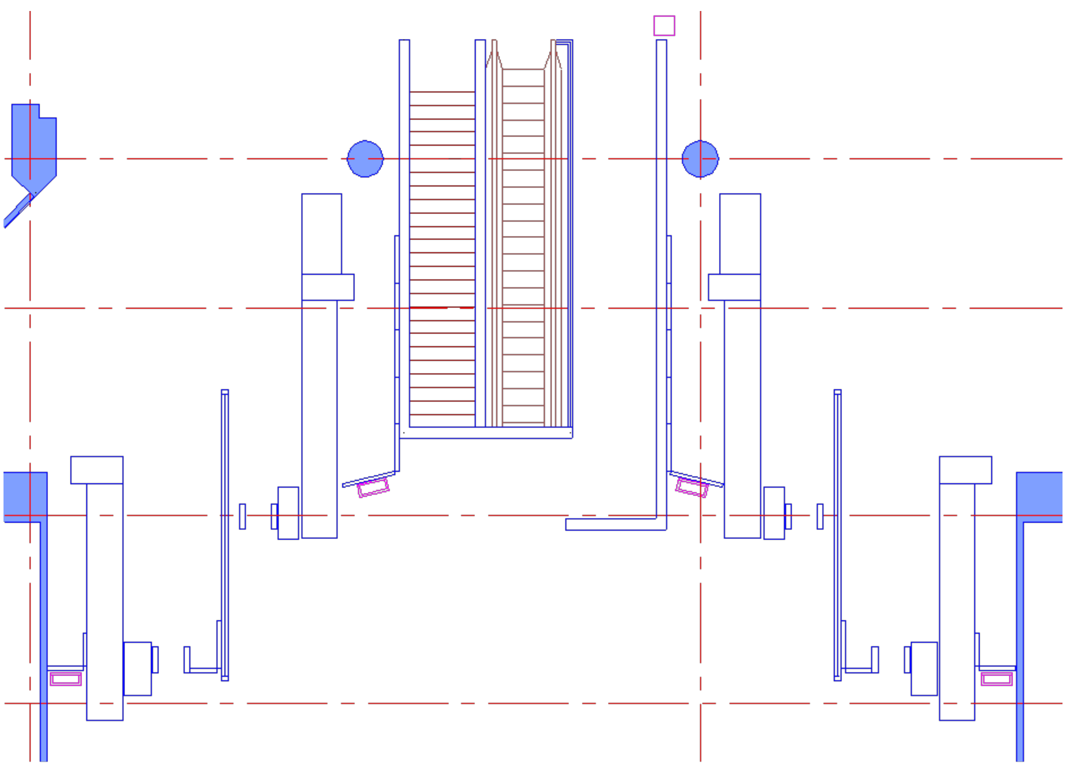

Figure 18. ***Security areas***

Kiosks

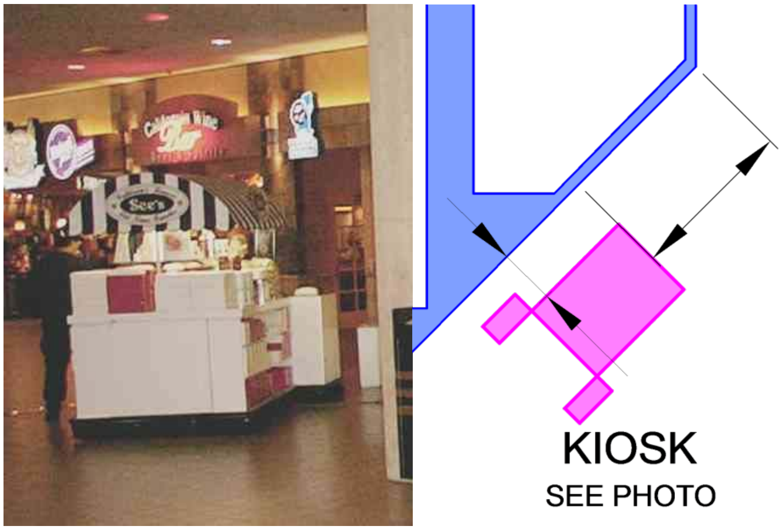

Figure 19. ***Typical kiosk area***

Areas not enclosed or defined by walls

Measure to carpet lines or soffit lines above, or other objects that delineate the space, and note that this was done. Show on the drawings the line of carpet or the soffit or other objects used.

Open areas such as exterior baggage handling areas, or interior holding areas, or eating areas to use soffit or drip lines above. for the purpose of this standard, the edge joining the horizontal to the vertical outermost edge is to be the measuring point. These lines can define the outermost edges of the building in some cases.

Figure 20. ***Areas not enclosed or defined by walls***

Carpet lines, ceilings, adjacent face of walls or columns, or exterior face of walls, also referred to as “drip lines”.