

MINETA SAN JOSE INTERNATIONAL AIRPORT
CADD DATA STANDARD COMPLIANCE QC/AQ PROCEDURES

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>
1.	INTRODUCTION	2
1.1	Scope	2
1.2	Purpose	3
1.3	Contact Information	3
2.	OVERVIEW OF THE QUALITY ASSURANCE PROCESS	3
3.	DRAWINGS ACCEPTANCE CRITERIA	4
4.	DETAILED QUALITY ASSURANCE PROCEDURES	5
4.1	Informal Review	5
4.2	Automated QA Procedures	5
4.2.1	Validation of Layer Names and Rendering Styles in AutoCAD	5
4.2.2	Validation of Layer Names and Rendering Styles in SpecChecker for MicroStation	7
4.3	Manual QA Procedures	7
4.3.1	Random Sampling	8
4.3.2	Checking Proper Placement of Features on CADD Layers	10
4.3.3	Comparison of Feature Ids	10
4.3.4	Checking Absolute Positional Accuracy	11
4.3.5	Comparison with Control Point Locations	12
5.	QUALITY ASSURANCE PROCEDURES APPLIED AT SUBMITTAL POINTS	12
5.1	30% Submittal	12
5.2	65% Submittal	12
5.3	95% Submittal	13
5.4	Final Submittal	13
6.	REPORTING OF QUALITY ASSURANCE RESULTS	13
	APPENDIX A – Sample Form for Reporting of QA Results	14



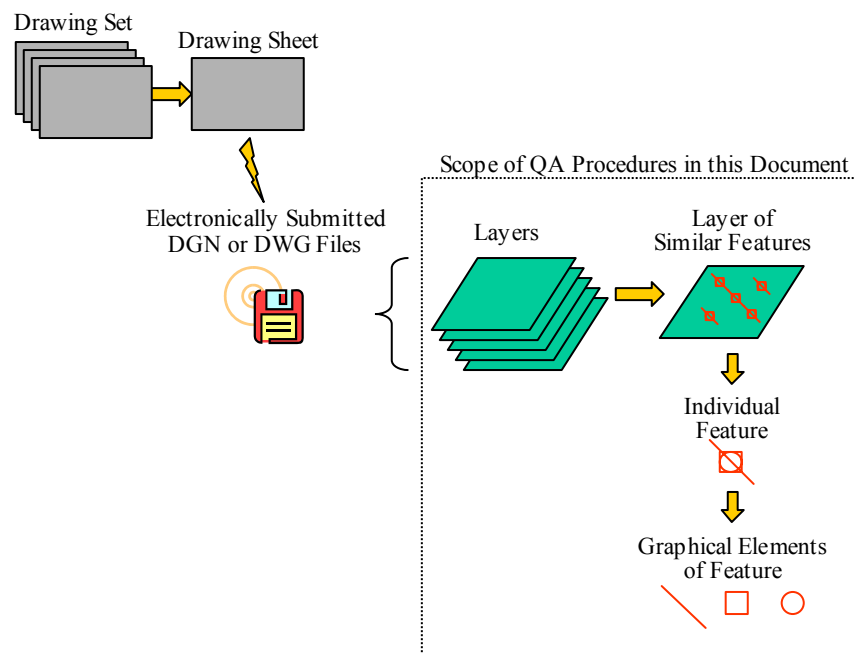
1.0 INTRODUCTION

1.1 Scope

This document details the quality assurance (QA) procedures that are to be carried out on electronic CADD drawings submitted to the Mineta San José International Airport (SJC). The data contained in these drawings can support decisions about the design, construction, operation, maintenance of the airport's infrastructure, but only if its quality can be relied upon by airport and contractor decision makers. Quality assurance is the process of reviewing data as it is submitted and before it is accepted into the airport's data repository to assure that it is of a quality that can be relied upon for its intended use.

A/E/C CADD drawings are typically submitted in drawing sets. Each set will contain one or more drawing sheets. Each of these sheets corresponds to a specific file such as a 'design file' or 'DGN' for MicroStation or a 'drawing file' or 'DWG' for AutoCAD. Within each drawing, individual geographic features, assets, fixtures or infrastructure elements are placed on a specific layer. Each layer should contain only features of a specific type (i.e. doors). Each individual feature may be made up of one or more graphic elements (i.e. points, lines, polylines, polygons). – Figure 1 below, shows the relationship between drawing components.

Figure 1 – Overview of QC/QA Process



The QA procedures outlined in this document will check all of these components of electronically submitted drawing sets.

Document No:	Revision Letter						Last Revision Date
SJC-ACM-AIMS-3220	A						Sep. 22, 2003

1.2 Purpose

To detail the QA procedures that can be applied to drawing submittals. The document is written as an instruction manual for airport staff or 3rd parties tasked with reviewing drawing submittals. The procedures are not intended for data creators who should be following quality control procedures designed to make sure that data collected meets the specifications required by the airport.

1.3 Contact Information

This document was prepared by the Carter & Burgess (C&B) Team. If you have any questions, please call Lysée Moyaert at (408) 501-7712, or David Tamir or Behzad Mohammadi of the C&B Consulting Team at (818) 784-7585.

2.0 OVERVIEW OF THE QUALITY ASSURANCE PROCESS

Quality Assurance (QA) serves as a final check of the data, to catch any problems that may have been missed by Quality Control (QC) procedures carried out as the data is created. QA also serves as a regular test of whether or not the production and QC processes are producing data of the required quality. QC, on the other hand, occurs during the development of drawings that will be submitted to the airport. These definitions are based on definitions used in ISO 8402:1994 Quality Management and Quality Assurance.

QA procedures will be performed on all drawings submitted to SJC. The QA procedures for drawing submittals have been developed independently from any QC processes that have or will be developed by data creators and are based solely on the acceptance criteria for each product. QC procedures need to be developed by data creators as an integral part of each data production process. They should be administered using checklists on a daily basis by the staff and contractors hired to collect data.

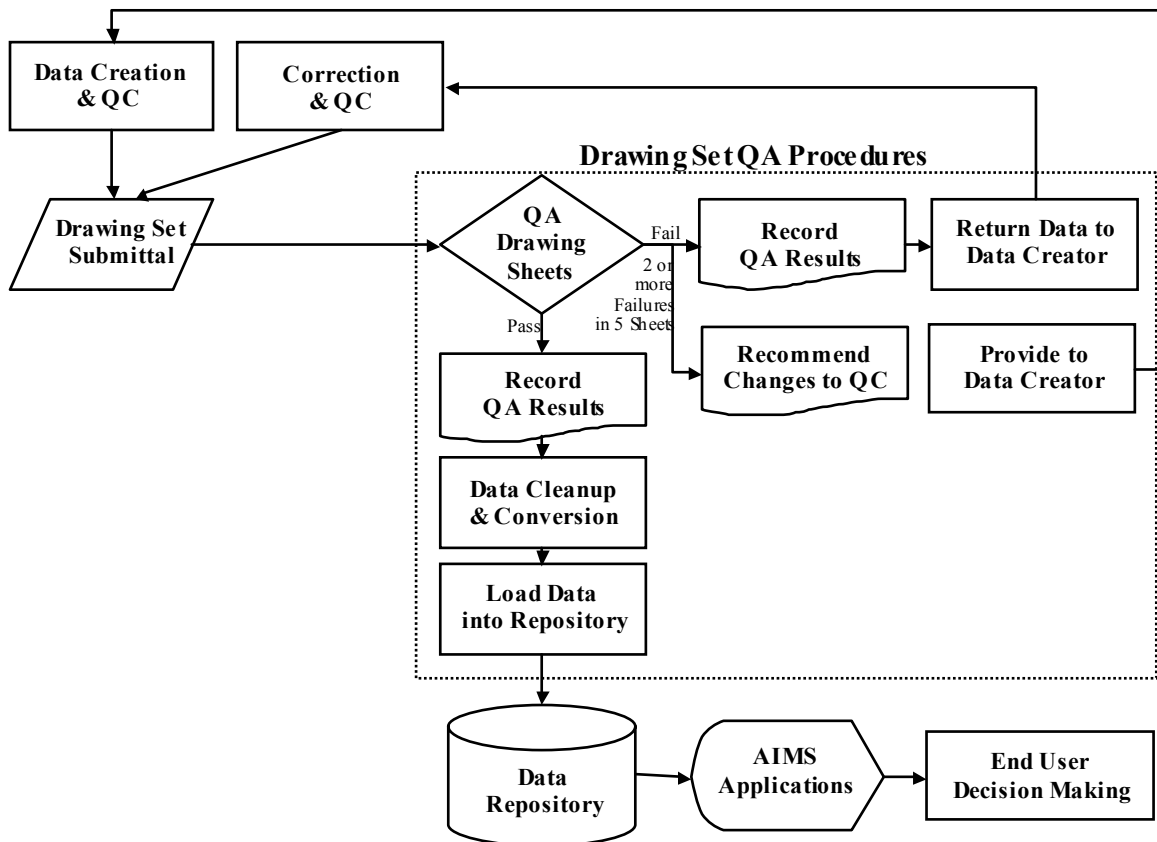
QA procedures are to be carried out by airport staff or an independent 3rd party reviewer. Some of these procedures are automated while others involve manually checking a random sampling of drawing elements against a predefined set of acceptance criteria. These procedures are used in various combinations based on the type of drawing submitted and the relative importance of the data it contains.

Drawings in which errors are found beyond an acceptable limit will be rejected and returned to the submitter for correction and re-submittal. All drawings that pass the acceptance criteria will be converted into the appropriate format and loaded into the data repository as specified in document SJC-ACM-AIMS-4140.



Figure 2 presents a generalized process for performing quality control (QC) and quality assurance (QA) on drawings.

Figure 2 –QC/QA Process



3.0 DRAWINGS ACCEPTANCE CRITERIA

SJC acceptance criteria for drawings submitted are defined by the A/E/C Projects CADD Standard (SJC-ACM-AIMS-2200). This document details the layering, rendering and formatting standards drawings must meet. In addition, documents must be submitted along with metadata a requirement specified in the metadata standard (SJC-ACM-AIMS-2600).

Document No:	Revision Letter						Last Revision Date
SJC-ACM-AIMS-3220	A						Sep. 22, 2003

4.0 DETAILED QUALITY ASSURANCE PROCEDURES

4.1 Informal Review

An informal, cursory review of submitted drawing sets and related drawing sheets is recommended prior to applying the rigor of the formal QA procedures. This cursory review should focus on obvious discrepancies between what was submitted and what was supposed to have been submitted. The correct title block with required information, the correct number of sheets, correct file names, and general placement of data are among some of the items that can be checked at this stage.

Since this check is informal and prompted by case specific requirements, it is not effective to outline a definitive procedure for this step. Instead, it is intended to be defined on a case-by-case basis by a trained CADD technician or engineer who is familiar with the type and content of data being submitted. Such personnel are more likely to spot the obvious errors that this step is intended to identify. If such errors are found, the more time consuming and costly formal QA steps can be avoided. If no such errors are found, then QA can proceed as follows.

4.2 Automated QA Procedures

Modern CADD software tools allow drawings to be checked against a predefined template that embodies SJC's CADD standards. These tools automatically check to make sure layers names included in a drawing are included within the standards and that the rendering of points, lines, polylines, polygons, annotations, hatch patterns, etc. on these layers is as specified in the standard. These tools can also be used to check for topological discrepancies such as overshoots, undershoots, polygons that aren't closed, etc. Since these tools are entirely automated they can easily be applied on 100% of the data contained in a submitted drawing. Following are the specific steps that should be carried out.

4.2.1 Validation of Layer Names and Rendering Styles in AutoCAD

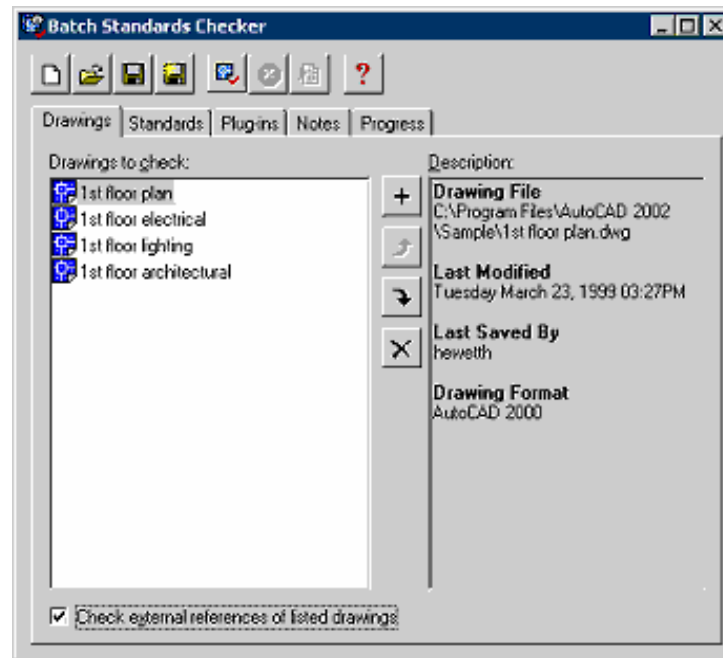
AutoCAD drawings in DWG format should be checked using the CAD Standard feature available in AutoCAD 2002 and subsequent releases. This feature can be used in an interactive mode for an individual drawing or in a batch mode. For more information on CAD standard feature see the AutoCAD 2002 User Guide.

To accomplish this, the following steps should be executed on the submitted drawing for batch mode standard checking:

1. Click Start > Programs > AutoCAD 2002 > Batch Standards Checker, which opens the Batch Standards Checker dialog box (see Figure 3).

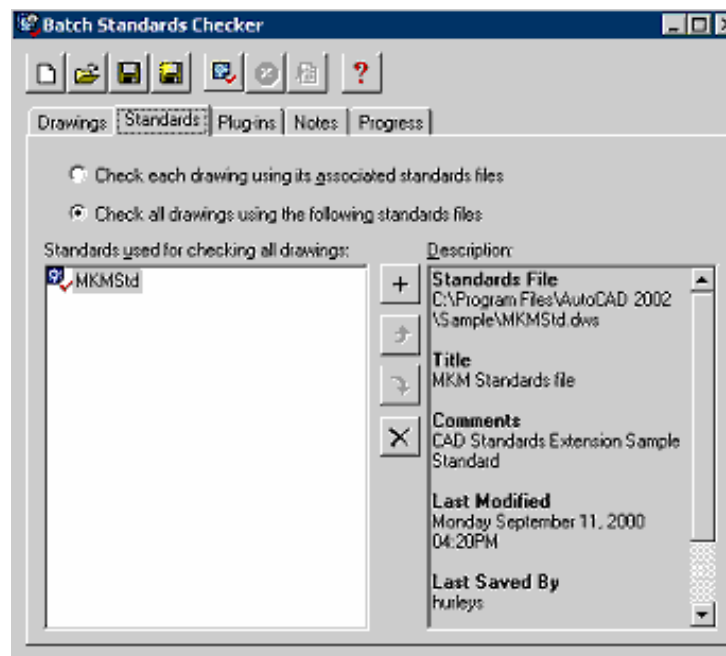


Figure 3 – AutoCAD Batch Standard Checker



2. Click the + icon to browse and select the drawings you wish to check for standards compliance.

Figure 4 – Selection of the DWS to Audit Drawings



Document No:	Revision Letter						Last Revision Date
SJC-ACM-AIMS-3220	A						Sep. 22, 2003

3. Click the Standards tab in the Batch Standards Checker dialog box and use the +icon to select the DWS file you want to use for checking (see Figure 4). The DWS files are in the "Standard" directory of CADD standard for all disciplines as well as individual categories (e.g., Architecture, Civil, etc.)

4. Click the Notes tab if you want to add notes for the final checking report.

Before actually checking the targeted drawings for compliance you should save your settings into a Standard Check File, which uses the file extension CHX. The CHX file simply enables you to rerun standards checks later without having to reinput all required parameters.

5. Click the floppy disk icon shown at the top of the Batch Standards Checker dialog box, which opens the File Save Dialog box.

6. Enter the file name and directory parameters for your CHX file. Click Save, which returns you to the Batch Standards Checker main window.

Now that you've set up the Batch Standards Checker and saved your parameters into a CHX file, you're ready to run the standards check.

7. Simply click the Check icon at the top of the dialog box (it's the fifth icon on the toolbar from the left as shown in Figure 2.0 - 3).

8. Click the Progress tab so that you can see how the check is running. As the drawings process you'll see the status messages build up in the Progress window.

When the checking process is completed, you'll receive an XML-based report that automatically opens your web browser. The browser-based report enables you to select a wide range of report formats for all drawings or only for those you select. Upon review of this report drawings which do not meet the layer naming convention of SJC standards should be rejected are returned to the submitting contractor.

4.2.2 Validation of Layer Names and Rendering Styles in SpecChecker for MicroStation

For MicroStation drawings in DGN format, a 3rd party product called SpecChecker by Axiom should be used to check a drawing for adherence to SJC layering and rendering standards. The SpecChecker is currently available for MicroStation version 7 only and will be available for Version 8 in late summer 2003. As such specific instructions for use of SpecChecker will be deferred until the new version of this software is released.

4.3 Manual QA Procedures

Manual QA procedures are required to validate aspects of drawings that current technology cannot. This encompasses checking to make sure graphics that represent certain features are on the appropriate layers, insuring that spatial data is accurately depicted at its true location and insuring that features are properly identified. Trained CADD technicians or engineers who are familiar with the type and content of data being submitted should carry out manual QA



Document No:	Revision Letter						Last Revision Date
SJC-ACM-AIMS-3220	A						Sep. 22, 2003

procedures. In some case, manual QA procedures may need to be complemented by a review of source documents and/or field observations.

4.3.1 Random Sampling

Since Manual QA procedures are labor intensive, 100% validation, is not cost justified nor it is necessary. Experience has shown that testing a statistically valid random sample of data elements is sufficient to assure quality (i.e. conformance with specifications/standards) at a 98% confidence level. This means that 98% of the data elements contained in a data set can be statistically assured to adhere to SJC A/E/C CADD drawing standards. For the application of this procedure to drawings submitted to SJC, a data set is equivalent to all of the data contained in a given drawing sheet regardless of what layer the data falls upon.

The American National Standards Institute (ANSI) MIL-STD-105E sampling standards to assure data quality is used to define the method and sample size of elements to be tested. The size of the sample to be inspected during the quality assurance testing is determined by the lot size, which is the number of elements on a given drawing sheet. Table 1, Sample Sizes and Allowable Error Rates, is derived from the ANSI standards document. This table illustrates the random sample sizes and allowable number of errors, based on the various lot sizes. For example, under Normal Inspection criteria, a data set with 20,000 elements to be tested (lot size) would produce a sample size of 125, with a maximum of three allowable errors. If a data set produces three or less errors during quality assurance testing, then it will pass the testing with a rated accuracy of 98%. Even though the data set had passed, any errors that were identified are to be corrected before the data is converted and loaded into the spatial repository.

If two out of five consecutive drawing sheets in a drawing set fail, then tightened inspection criteria are used until five consecutive drawings sheets in a drawing set pass inspection. Under tightened inspection criteria, the number of allowable errors is reduced. The far right column in Table 4.1 indicates the number of allowable errors under tightened inspection criteria. After five consecutive datasets pass tightened inspection, then normal sampling procedures will be re-instituted.



**Table 1 – Sample Sizes and Allowable Error Rates
(Derived from ANSI/ASQC Z1.4-1993)**

Lot Size	Sample Size	# of Allowable Errors – Normal Inspection	# of Allowable Errors – Tightened Inspection
2 – 15	2	0	0
16 – 25	3	0	0
26 – 90	5	0	0
91 – 150	8	0	0
151 – 280	13	0	0
281 – 500	20	0	0
501 – 1200	32	1	0
1201 – 3200	50	1	0
3201 – 10,000	80	2	1
10,001 – 35,000	125	3	2
35,001 – 150,000	200	5	3
150,001 – 500,000	315	7	5
500,001 and over	500	10	8

The application of this procedure to determine the sampling size requires knowledge of the number of features depicted on a drawing sheet (i.e. lot size). Unfortunately, estimating the lot size can be a time consuming, and therefore costly, task. This cost in many instances can lead to an unfavorable cost/benefit ratio for performing quality assurance. To avoid the effort and cost involved in estimating lot sizes, drawing sheets will be assumed to have 501 – 1200 elements on them. This requires a sampling size of 32 data elements with 1 allowable error under normal inspection and 0 allowable errors under tightened inspection, which is only used if two out of 5 consecutive sheets fail. For sheets that have less than 501 features, more stringent QA criteria will, in essence, be applied. For sheets that are known to contain more than 1,200 data elements, higher sampling and acceptance criteria should be applied per Table 4.3.1.

Based on the guidelines described above, the next step in the QA process is to randomly select 32 features from the drawing sheet. Care should be taken to insure that these 32 features are

Document No:	Revision Letter						Last Revision Date
SJC-ACM-AIMS-3220	A						Sep. 22, 2003

well dispersed over the extent of the drawing. If a drawing sheet is believed to contain more than 1,200 data elements, a greater sampling size should be selected based on Figure 4.3.1.

4.3.2 Checking Proper Placement of Features on CADD Layers

While automated checking procedures described in Section 3 above can verify that data elements on a given layer conform to the rendering (i.e. color, line size, etc.) and topological (i.e. connectivity, closure, etc.) requirements for that layer, they cannot check to make sure that the features these elements depict (e.g. a door) fall onto the proper layer (e.g. A-DOOR-PRHT). The following manual steps are therefore required to assure features are indeed placed on the correct layers:

1. For each feature in the random sample, verify that each of the elements (i.e. points, lines, polylines, polygons, etc.) are on the corresponding feature. To do this use the following steps:
 - a. Determine what type of feature it is (e.g. a partial height door or a door that does not extend all the way to the ceiling).
 - b. Look up the proper layer for that feature in the SJC CADD standard (e.g. A-DOOR-PRHT).
 - c. Turn off all layers in the drawing except for the proper layer (e.g. A-DOOR-PRHT).
 - d. Make sure all elements that compose the selected feature still appear. If any do not, then this feature is not depicted on the proper layer.
2. Next, use a similar process to check any annotations, hatch patterns and associated schedules related to this features to insure that they too appear on the proper layer (e.g. A-DOOR-IDEN for symbols and numbers used to identify that door).
3. Repeat steps 1 and 2 for all of the randomly selected features. If the number of allowable errors is exceeded, stop and record that the drawing has failed due to placement of features on wrong layers.
4. If all randomly selected features are checked and the number of allowable errors has not been surpassed record that the drawing has passed feature/layer placement quality assurance.

4.3.3 Comparison of Feature IDs

Critical to the use of drawing data is the proper identification of drawing features. To assure that features are properly identified follow the steps below for each of the randomly selected drawing features that have IDs:

1. For each feature in the random sample that is identified via annotations, verify that the annotation is of a proper format. For example, door numbers or ID symbols should adhere to SJC labeling standards.
2. For each feature in the random sample that is identified via annotations or hatching, verify that it is accurately identified. This may require looking up key values in a corresponding schedule contained on the drawing. The true value to which the indicated value should



Document No:	Revision Letter						Last Revision Date
SJC-ACM-AIMS-3220	A						Sep. 22, 2003

be compared with may need to be researched in other documents, addressing systems, etc.

3. Repeat steps 1 and 2 for all of the randomly selected features. If the number of allowable errors is exceeded, stop and record that the drawing has failed due to improperly identified features.
4. If all randomly selected features are checked and the number of allowable errors has not been surpassed record that the drawing has passed feature identification quality assurance.

4.3.4 Checking Absolute Positional Accuracy

Critical to the functionality of any spatial data repository is that all features are accurately represented in 3 dimensional geographic space so that they can be layered on top of one another and queried in relation to one another. Absolute positional accuracy refers to the difference between a specific feature's location on a drawing sheet versus its position in the geographic space used to represent the real world. In this case, the San José International Airport Grid is the geographic space used to reference features to the real world. More information on Airport Grid can be found in document SJC-ACM-AIMS-2400.

To validate that the absolute positional accuracy of a drawing sheet meets SJC accuracy requirements, the following procedure should be used:

1. The drawing sheet should be compared with a source of higher accuracy. For drawings of elements that are inside buildings (i.e. the inside domain), a floorplan whose spatial accuracy exceeds SJC accuracy requirements should be selected. For drawings of elements that are outside (i.e. the outside domain), the SJC orthophotos should be used. Two options exist for comparing elements sampled from the submitted drawing with these sources of higher accuracy:
 - a. Overlay the submitted drawing on top of the source of higher accuracy. For inside domain drawings overlaid on-top of floor plan's, it is recommended that all layers/features on the submitted drawing be colored one color, while all features on the source of higher accuracy be colored a contrasting color. This will avoid confusion between source and check data elements.
 - b. Open a separate application where the check data can be viewed and specific feature locations can be queried so that their X, Y and Z Airport Grid coordinates can be displayed. These coordinates will then be compared to the coordinates queried from the submitted drawing to indicate positional discrepancies.
2. For each of the randomly selected features, measure the distance between the position shown on the submitted drawing versus the position shown on the source of higher accuracy. Refer to CADD & GIS Accuracy Specification document (SJC-ACM-AIMS-2611) for accuracy requirements.
3. Repeat step 3 for all randomly selected features. If the number of allowable errors is exceeded, stop and record that the drawing has failed due to positional accuracy errors.



Document No:	Revision Letter						Last Revision Date
SJC-ACM-AIMS-3220	A						Sep. 22, 2003

4. If all randomly selected features are checked and the number of allowable errors has not been surpassed record that the drawing has passed positional accuracy quality assurance.

4.3.5 Comparison with Control Point Locations

Closely related to the positional accuracy test, is the correlation of control points depicted on the submitted drawing to control points in the SJC Survey Control Network. Drawings that depict outside features (i.e. outside domain) are required to depict at least two control points from the SJC Network of Control Points. The X, Y and Z coordinates of each of these points in the submitted drawing should be queried and compared with the coordinate for the point published in document SJC-ACM-AIMS-2400. Refer to CADD & GIS Accuracy Specification document (SJC-ACM-AIMS-2611) for accuracy requirements.

5.0 QUALITY ASSURANCE PROCEDURES APPLIED AT SUBMITTAL POINTS

A/E/C CADD drawings are submitted to SJC for review in a staged manner, with milestones occurring at the 30%, 65%, 95%, and Final Submittal points. Applying all of the QA steps outlined in the previous section at each submittal point is overly burdensome, especially at early submittal points. The specific quality assurance procedures that are to be followed at each delivery milestone are outlined below.

5.1 30% Submittal:

Drawings submitted at the 30% design point are preliminary in nature. Data elements depicted on these drawings are typically used for planning and design purposes and therefore do not require the accuracy level of final submittals. Experience, has shown however that layering or feature identification mistakes at this stage can cause problems that become harder and harder to fix as the drawing progresses. Accordingly, the following QA procedures are recommended at the 30% submittal point:

- Informal Review (Section 4.1)
- 100% validation of Layer Names and Rendering Styles (Section 4.2.1 or 4.2.2)

5.2 65% Submittal:

Similar to the 30% submittal point, drawing submitted at the 65% point are used primarily for planning and design purposes. Accordingly, the same QA procedures as are required at the 30% are required at the 65% point.

- Informal Review (Section 4.1)
- 100% validation of Layer Names and Rendering Styles (Section 4.2.1 or 4.2.2)

5.3 95% Submittal



Document No:	Revision Letter						Last Revision Date
SJC-ACM-AIMS-3220	A						Sep. 22, 2003

Drawings submitted at the 95% point are nearly final are will be used to monitor and coordinate construction activities as well as support development of adjacent properties and to help coordinate tenants and other users of the space. Accordingly, a higher degree of quality is required and further QA steps are justified. The following QA procedures will therefore be carried out at the 95% submittal point:

- Informal Review (Section 4.1)
- 100% validation of Layer Names and Rendering Styles (Section 4.2.1 or 4.2.2)
- Checking Proper Placement of Features on CADD Layers (Section 4.3.2)
- Checking Absolute Positional Accuracy (Section 4.3.4)

5.4 Final Submittal:

Final submittal occurs when the development of a facility is complete. The data is therefore not subject to change (barring future modifications to the facility) and therefore needs to be recorded as a baseline. This baseline is what will be used for operations and maintenance purposes by the airport staff. Final submittal is also typically the last point in the submittal process where changes can be made within the scope of a particular contract. Because of the importance of the data, its widespread use and the opportunity to make final changes, all QA procedures described above should be conducted.

- Final Plots ready for signature and final CADD files necessary for review including; coordinate Informal Review (Section 4.1)
- 100% validation of Layer Names and Rendering Styles (Section 4.2.1 or 4.2.2)
- Checking Proper Placement of Features on CADD Layers (Section 4.3.2)
- Comparison of Feature IDs (Section 4.3.3)
- Checking Absolute Positional Accuracy (Section 4.3.4)
- Comparison with Control Point Locations (Section 4.3.5)

6.0 REPORTING OF QUALITY ASSURANCE RESULTS

The results of each QA procedure should be recorded as a means to communicate identified errors to the individuals who will be converting data into the data repository, in the case of drawings that pass QA tests, and to contractors who will be required to correct drawings, in the case of drawings that fail. The results should identify the drawing set, sheet number, layer, location and nature of the error. The form shown in Appendix A should be used for this purpose.



