

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY  
- LIGO -  
CALIFORNIA INSTITUTE OF TECHNOLOGY  
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<b>INTEGRATED LAYOUT DRAWINGS: USAGE &amp; MAINTENANCE</b>		
<i>Title</i>		
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# 1 INTRODUCTION

The System Engineering Group is developing several Integrated Layout (IL) drawings. These integrated drawings will be updated routinely and maintained based upon the input from several groups (e.g VE, CC, CDS, etc.). Although the baseline/approved configuration will be controlled by Systems Engineering, all groups may have access to all the constituent drawings and can propose changes to the drawings which represent their equipment/responsibility. This document defines the integrated layout drawings that will be developed and maintained by LIGO. The logistics and methods of access, updating, maintenance and control are also described.

## 2 INTEGRATED LAYOUT DRAWING CONTROL

Integrated layout drawings are those drawings which depict assembled/installed hardware from multiple groups into a shared space, such as the LVEA or the interior volume of a BSC. The drawings can in general be two-dimensional or three-dimensional.

### 2.1 Drawing Access

The approved baseline layout drawings will be kept in a directory structure with read-only access. Anyone can copy or reference these drawing files as needed for viewing or performing design or trade-off studies, but can not make changes directly to the files.

### 2.2 Directory Structure

The integrated layout drawings will be maintained by a responsible engineer within Systems Engineering. All of the IL drawings are in subdirectories under `~sysint/public/dwgs/`. Each IL has a separate directory and each constituent drawing which is referenced by the IL has a subdirectory, as indicated in Figure 2-1.

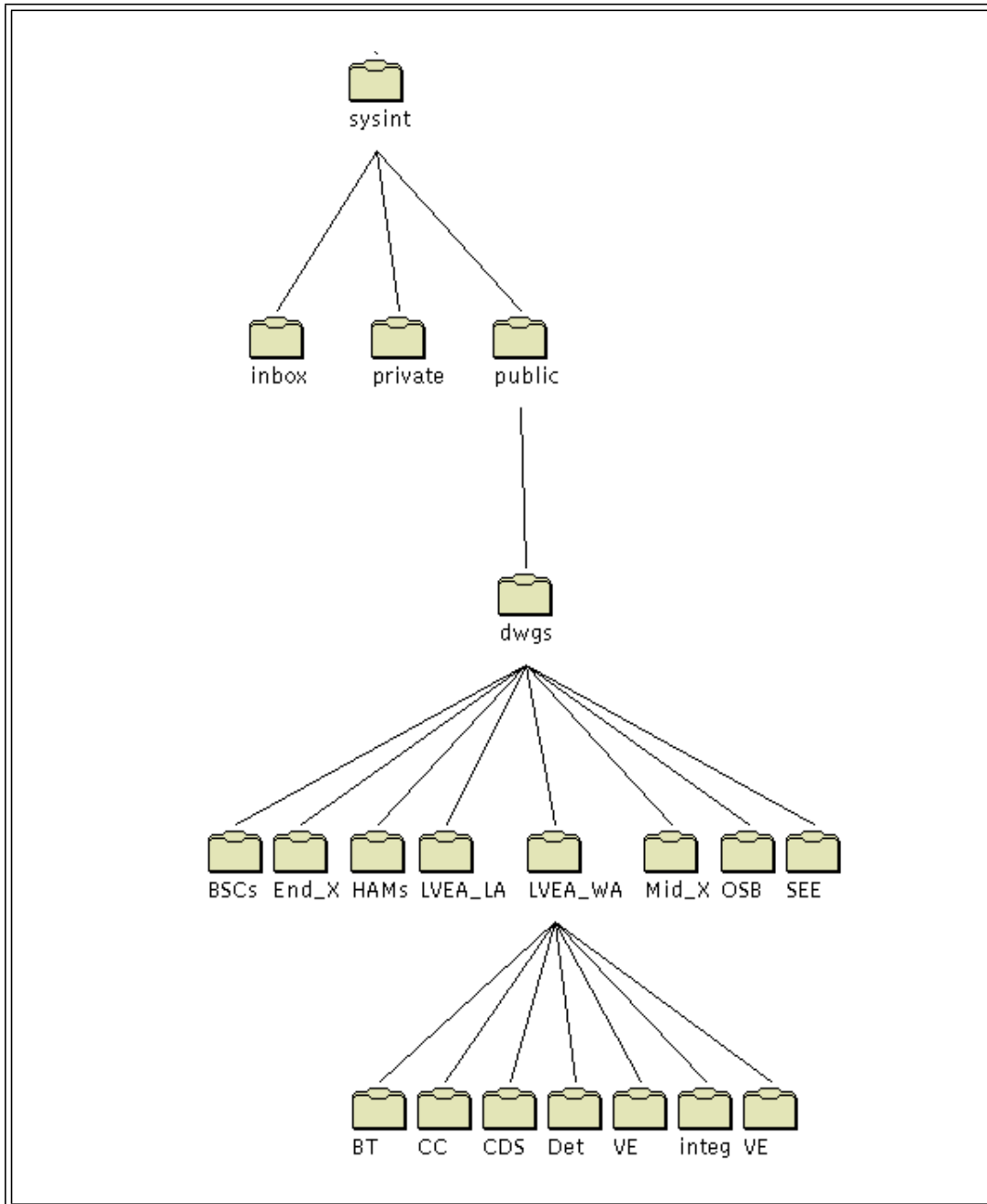
### 2.3 Characteristics & Style Guides

The initial integrated layout drawings will have the following characteristics:

- Two-dimensional (2D). Selected vacuum chamber layouts will be developed in three-dimensions (3D), but the building layouts which are of immediate concern will be 2D.
- AutoCad Release 12, unix version. Eventually it is expected that the drawings will transition to release 13. Until the time of transition, we will not accept Release 13 input<sup>1</sup>; after the transition, we will not support Release 12 output (though Release 12 input is acceptable). The transition will be coordinated and not unilateral.
- The Integrated Layout (IL) drawings will have minimal content and incorporate, through external file reference, separate drawings allocated to the groups involved (see Figure 2-2). An external file reference (xref) is a drawing file linked (or attached) to another drawing. The

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1. Currently, CDS and PSI uses AutoCad R12. PSI is committed to R12 for the duration of their involvement in the LIGO project. RMP uses Integraph, but can support AutoCad R12 and R13. CB&I uses MicroStation 5.0 and can handle AutoCad R12. In addition, AutoCad R13 can save files in R12 format, though there can be some problems in the translation if R13 unique features have been invoked.

**Figure 2-1: Directory Structure**

referenced file contents cannot be altered; however, the layer settings of the externally referenced drawing can be controlled [i.e. display of the layers can be turned on (visible) or off (invisible)].

- The following are suggested guidelines in the development of the individual referenced drawings:
  - don't duplicate information available in another group's drawing -- use external referencing to incorporate drawing information from another group
  - use copious layers (and colors), so that other groups can selectively include or exclude information from your drawings and prevent excessive clutter from irrelevant informa-

- tion
- Use the LIGO drawing template<sup>1</sup> defined by Systems Engineering in the Integrated Layout (IL) drawing file for labeling drawings to be issued (i.e. assigned a drawing number). If this is not appropriate, then use a copy of this drawing template within AutoCad's "paper space" for an assigned drawing file, not in the "model space". [See also section 2.7].
  - put detail views into a separate drawing file (i.e. separate drawing sheet) so that they don't clutter the integrated layout drawing.
- Use the LIGO standard local coordinate systems<sup>2</sup>.
  - Use the LIGO standard nomenclature<sup>3</sup>.
  - Do not incorporate an externally referenced drawing into your drawing (either directly or as an inserted block). This violates the separation of drawing content and causes duplication. (One can of course do anything desired with one's own copies of the drawings and in one's own directories -- just don't return "contaminated" drawing files for incorporation into the baseline integrated drawing set.)

## 2.4 External Referencing

AutoCad has a feature called external referencing, or "xref". One can attach another drawing file into the current drawing file through xref. The layers of the attached drawing can be turned off and on, but the drawing content can not be altered. As indicated in Figure 2-2, the Integrated Layout (IL) drawing is then nothing but a shell which references the group drawings.

## 2.5 Updating and Configuration Control

All modifications to the baseline are governed by the procedures in the LIGO Configuration Control Plan (CCP)<sup>4</sup>. The following guidance is meant to augment the CCP and indicate the mechanics of integrated layout drawing configuration control; if there are conflicts, the CCP governs.

The steps in the process of reviewing and updating a group drawing is indicated in Figure 2-2.

- copy the group drawing(s) (but not the IL drawing or the drawings developed by other groups) into a local workspace and add appropriate xrefs to the other drawing files.
- prepare an Engineering Change Request (ECR) after modifications have been made to the drawing owned by the group
- submit the ECR for approval and, as part of the ECR submission, inform the IL responsible engineer of the proposed change (cite the ECR number) and provide a file pointer to the revised constituent drawing path/filename (also if appropriate, the path/filename of a revised "read\_me" file for inclusion in the same directory as the revised drawing)

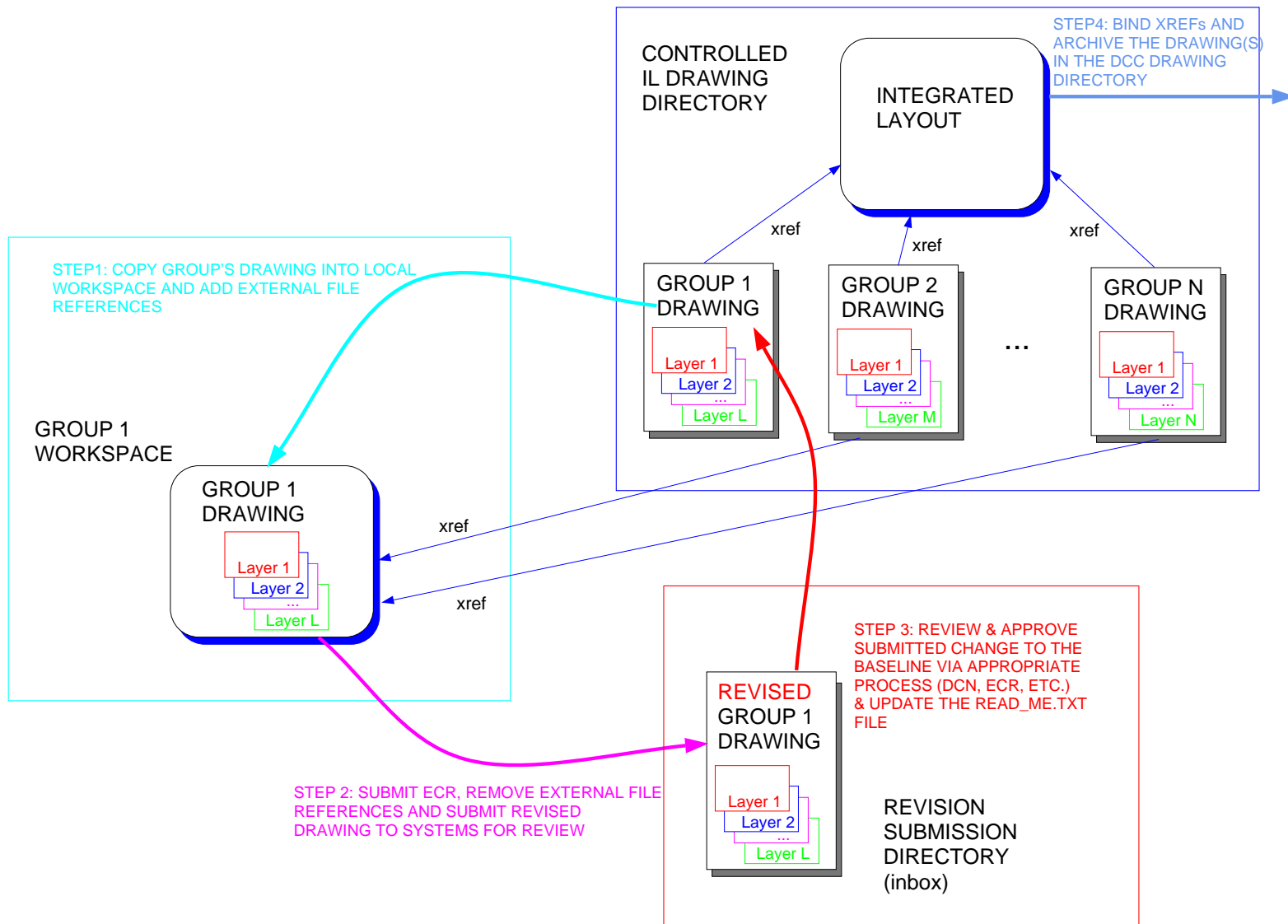
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1. TBD

2. W. Althouse and G. Stapfer to A. Lazzarini, LIGO Coordinate System, LIGO-L950128, 15 Feb 96.  
A. Lazzarini, Derivation of Global and Local Coordinate Axes for the LIGO Sites, LIGO-T950004-A-E, 3 Jul 95.

3. B. Young to A. Lazzarini, LIGO Naming Conventions, LIGO-L950810-00-E, 30 Oct 95.  
D. Coyne to B. Young, Proposed Additions to Nomenclature for Equipment within the Buildings, LIGO-L960197-01-E, 18 Mar 96.

4. LIGO Configuration Control Plan, LIGO-M96xxxx, TBD (in-process).



INTEGRATED LAYOUT DRAWING STRUCTURE AND REVISION PROCESS

Figure 2-2:

Systems Engineering will then:

- review the drawing to verify that it complies with the ECR and is compatible in all other regards with the current baseline
- upon approval of the ECR, replace the baseline drawing file with the revised file (incrementing the version number)
- revise the IL read\_me file to indicate the ECR and its affected drawing (incrementing the version number of the IL)
- archive the newly revised IL to the DCC in paper and electronic forms

## 2.6 Archival

The archival and submission to the Document Control Center (DCC) is TBD; the following are some thoughts regarding the archival:

*Each time an IL changes (because a constituent drawing changes), the IL is to be archived in electronic and paper forms to the Document Control Center (DCC). Either all of the references can be bound into the IL and archived as a single file (less useful) or, the entire directory structure, including all constituent drawings could be saved. Since this could result in a lot of duplication of large files, it would be best to archive to tape, and not on-line.*

*Since a paper copy with all layers turned on can be too complex to be legible and useful, several paper “views” may be required. It will be necessary to define these views and maintaining them so that they are consistent from one archived version to the next.*

## 2.7 Drawing Numbers and Revisions

Issuing and associating drawing numbers for specific “views” onto a complex drawing, wherein some layers and viewports are visible and others are not, can be difficult to manage and track. AutoCad cannot save different “view-configurations” which may all derive from a single drawing, but be issued separate drawing numbers (e.g. electrical conduit locations for CDS, vs optical table locations for LSC, etc.). In addition, although one can get a list of the drawings externally referenced in a particular drawing file, one cannot automatically get a list of all drawings which reference a particular drawing file. Consequently, it is imperative that the IL responsible systems engineer consider carefully for each drawing change, what drawings need to be revised and re-issued.

Each time a drawing is issued (i.e. a drawing number is assigned), the following steps shall be taken by the responsible systems engineer:

- the drawing file with the drawing label (title, number, date, revision, etc.) shall have all xrefs bound, appropriate layers set on or off and saved in the appropriate directory (generally the IL root directory) with the following name:

<drawing\_number>\_<title>\_<version\_number>.dwg

where <drawing\_number> has the format “Dyynnnn”

<title> is a brief descriptive title of the drawing

<version\_number> has the format vnn

e.g., D960101\_electrical\_interfaces\_v03.dwg

- A paper and electronic copies of the drawing shall be filed with the DCC.

## 2.8 File Naming Conventions

All IL and constituent drawing filenames shall comply with the name list provided in section 3.

All AutoCad drawing files shall have the filename extension “.dwg”.

All “read\_me” files shall be either text (with the filename extension “.txt”) or framemaker documents (with the filename extension “.fm”).

All filenames shall end with a version number tag as follows:

<drawing filename>\_v03.dwg

The version number shall be incremented each time a change occurs to the baselined/controlled drawing files. The associated “read\_me” file shall record the history and the nature of the change(s) for each version.

## 2.9 “Read\_Me” Files

“Read\_me” text or FrameMaker files should appear in all directories with descriptive comments on the contents of the directory and a revision history.

## 2.10 Subcontractor Drawings

Drawings received/submitted from subcontractors are not automatically incorporated into the IL baseline set of drawings; it is the responsibility of the responsible group engineers/managers to inform Systems Engineering if there is a drawing revision and to comply with appropriate configuration control procedures.

Drawings from subcontractors that are referenced in IL drawings should be renamed (to the filenames indicated in Section 3) since it may be necessary to turn layer information on or off, remove viewports, etc. (i.e. the resultant drawing may not be precisely what the subcontractor delivered). It is advisable to maintain a copy of the original drawing submitted by the contractor in the same subdirectory. In addition, the “read\_me” file must cite the LIGO number assigned to the contractor’s drawing which was originally used as the basis for the IL constituent drawing (optionally one can also indicate the subcontractor’s assigned drawing number, its date of issue or receipt, rev. number etc.).

## 2.11 Sequencing

Time sequenced assembly/installation is beyond the scope of this document. It is anticipated that the integrated layout drawings will be used to evaluate integration buildup and sequencing<sup>1</sup>.

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1. For example, I-DEAS has the capability to play “movie scripts” of assembly/sequence operations.



### **3 INTEGRATED LAYOUT DRAWINGS**

The following tables give brief descriptions and filenames of the integrated layout drawings, and their constituent (externally referenced) drawing filenames with an indication of the content of these drawings.

**Table 1: Integrated Layout (IL) Drawings**

Integrated Layout filename (description)	Referenced Drawings		(Primary) Content
	Name	Group (Owner)	
LVEA_IL_WA.dwg  (integrated layout of the LVEA and Mechanical Room for the Washington site corner station)	LVEA_WA_Integ.dwg	Integration & Systems Engineering	Clean Rooms Access Stiles Build/integration Sequence “Snapshots”
	LVEA_WA_Det.dwg	Detector	PSL Optical Lever/alignment Tables Seismic Stack Projections
	LVEA_WA_CDS.dwg	CDS	Electronics Racks Electrical Power Locations Signal Routing Cable Trays
	LVEA_WA_VE.dwg	VE	Vacuum Chambers Vacuum Manifolds/tubes Pumps Electrical Power Locations
	LVEA_CC.dwg	CC	Building Backgrounds Electrical Power Panels Crane Coverage Limits/pickup Areas Access Doors & Walkways Floor Drains, Etc.
	LVEA_BT.dwg	BT	BT Termination Valve & Support BT Pump Cart Arrangement BT Installation Clean Room

**Table 1: Integrated Layout (IL) Drawings**

Integrated Layout filename (description)	Referenced Drawings		(Primary) Content
	Name	Group (Owner)	
LVEA_IL_LA.dwg  (integrated layout of the LVEA and Mechanical Room for the Louisiana site corner station)  Note: References the CC and BT drawings for the WA site)	LVEA_LA_Integ.dwg	Integration & Systems Engineering	Clean Rooms Access Stiles Build/integration Sequence “Snapshots”
	LVEA_LA_Det.dwg	Detector	PSL Optical Lever/alignment Tables Seismic Stack Projections
	LVEA_LA_CDS.dwg	CDS	Electronics Racks Electrical Power Locations Signal Routing Cable Trays
	LVEA_LA_VE.dwg	VE	Vacuum Chambers Vacuum Manifolds/tubes Pumps Electrical Power Locations
Mid_X_IL.dwg  (integrated layout of the VEA, VE support room, Mechanical Room, etc. for the mid-station, X-arm)	Mid_Integ.dwg	Integration & Systems Engineering	Clean Rooms Access Stiles Build/integration Sequence “Snapshots”
	Mid_Det.dwg	Detector	Optical Lever/alignment Tables Seismic Stack Projections
	Mid_CDS.dwg	CDS	Electronics Racks Electrical Power Locations Signal Routing Cable Trays
	Mid_VE.dwg	VE	Vacuum Chambers Vacuum Manifolds/tubes Pumps Electrical Power Locations
	Mid_End CC.dwg	CC	Building Backgrounds Electrical Power Panels Crane Coverage Limits/pickup Areas Access Doors & Walkways Floor Drains, Etc.
	Mid_BT.dwg	BT	BT Termination Valve & Support BT Pump Cart Arrangement BT Installation Clean Room

**Table 1: Integrated Layout (IL) Drawings**

Integrated Layout filename (description)	Referenced Drawings		(Primary) Content
	Name	Group (Owner)	
End_X_IL.dwg  (integrated layout of the VEA, VE support room, Mechanical Room, etc. for the end-station, X-arm)  Note: References the Mid_End_CC.dwg for building backgrounds.	End_Integ.dwg	Integration & Systems Engineering	Clean Rooms Access Stiles Build/integration Sequence “Snapshots”
	End_Det.dwg	Detector	Optical Lever/alignment Tables Seismic Stack Projections
	End_CDS.dwg	CDS	Electronics Racks Electrical Power Locations Signal Routing Cable Trays
	End_VE.dwg	VE	Vacuum Chambers Vacuum Manifolds/tubes Pumps Electrical Power Locations
	End_BT.dwg	BT	BT Termination Valve & Support BT Pump Cart Arrangement BT Installation Clean Room
OSB_IL.dwg  (integrated layout of the Operations Support Building)	OSB_Integ.dwg	Integration & Systems Engineering	
	OSB_Det.dwg	Detector	
	OSB_CDS.dwg	CDS	
	OSB_VE.dwg	VE	
	OSB_CC.dwg	CC	
SEE_IL.dwg (BTE Service Entrance Enclosure)	SEE_Integ.dwg	Integration & Systems Engineering	Bake-out layout config trades with VE pumps etc. safety/access studies
	SEE_Det.dwg	Detector	Physics & Environment Monitoring (PEM)
	SEE_BT.dwg	BT	calibration equipment/carts leak hunting equipment

**Table 1: Integrated Layout (IL) Drawings**

Integrated Layout filename (description)	Referenced Drawings		(Primary) Content
	Name	Group (Owner)	
BSC_<n>_IL.dwg where n = 1,15  3D layout in I-DEAS	TBD	TBD	TBD
HAM_<n>_IL.dwg where n = 1,15  3D layout in I-DEAS	TBD	TBD	TBD

## 4 NOMENCLATURE AND ACRONYMS

<i>Acronym</i>	<i>Meaning</i>
Arm	One of the two perpendicular beam lines which constitute the LIGO interferometer vacuum envelope between stations
Bind	an AutoCAD operation of changing externally referenced drawing information to incorporated drawing content
BSC	one of a set of large evacuated chambers used by the Detector System and provided as part of the VE
BT	Beam Tube
BTE	Beam Tube Enclosure
Caltech	California Institute of Technology
CCP	Configuration Control Plan
CDS	Control & Data Systems; a group within the Detector Group
CC	Civil Construction
constituent drawing	A drawing which is one element of an overall IL drawing. The constituent drawing can itself be an assembly drawing and not comprised of a single part or component.
Corner Station	The vertex or point of intersection of the LIGO arms. Also may refer to the facilities erected around this point. It is also called the vertex or vertex station.
DCC	Document Control Center
DCCD	Design Configuration Control Document -- the requirements document for the Civil Construction design
Det	Detector System or the Detector Group
End-Station	The 4 km termini of the LIGO arms. There are buildings situated at these points at both sites.
Group	a design group within the LIGO organization
ICD	Interface Control Document
ICWG	Interface Control Working Group
IL	Integrated Layout drawing
LIGO	Laser Interferometer Gravitational Wave Observatory
iff	if and only if
LN <sub>2</sub>	Liquefied nitrogen (cryogenic fluid)
LVEA	Laser and Vacuum Equipment Area
Mid-Station	The 2 km mid-points along the LIGO arms. At the Hanford site, there are buildings located at the mid-station. At the Livingston site, there is no mid-station building, just a minor expansion of the Beam Tube Enclosure (BTE)

MIT	Massachusetts Institute of Technology
model space	a “view” within AutoCad drawings that is an arrangement of tiled viewports of the model, not necessarily in an arrangement meant to be printed, but rather for input of drawing content
N.B.	Nota bene; note well
paper space	a “view” within AutoCad drawings that is an arrangement of floating viewports of the model usually associated with a drawing title block & border (i.e. displayed as it is intended to be printed)
PSI	Process Systems International; the VE contractor
RMP	Ralph M. Parsons; the LIGO Architectural and Engineering Firm
TBD	To be determined (for as yet unspecified quantities).
TBR	To be resolved/reviewed; used when a provisional data value is possibly uncertain
VE	Vacuum Equipment or the Vacuum Equipment Group
VEA	Vacuum Equipment Area
Vertex	The point of intersection of the LIGO arms. Also may refer to the facilities erected around this point. It is also called the corner or corner station.