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- LIGO -
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INTEGRATED LAYOUT DRAWINGS: USAGE & MAINTENANCE

Title

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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.

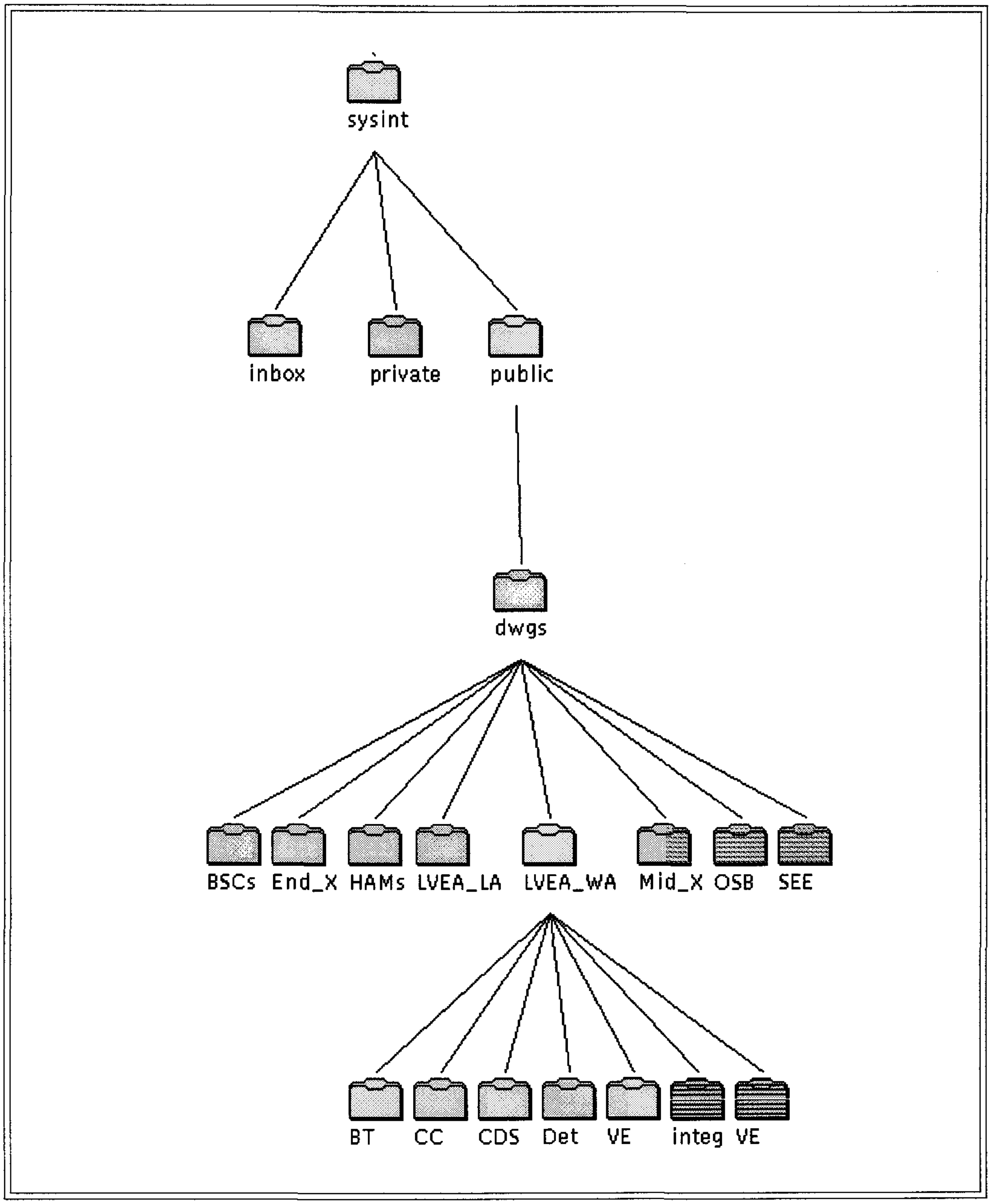
2.3 Characteristics & Style Guides

The <u>initial</u> 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[1]; 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

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[1] 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[2].
- Use the LIGO standard nomenclature[3].
- 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)[4]. 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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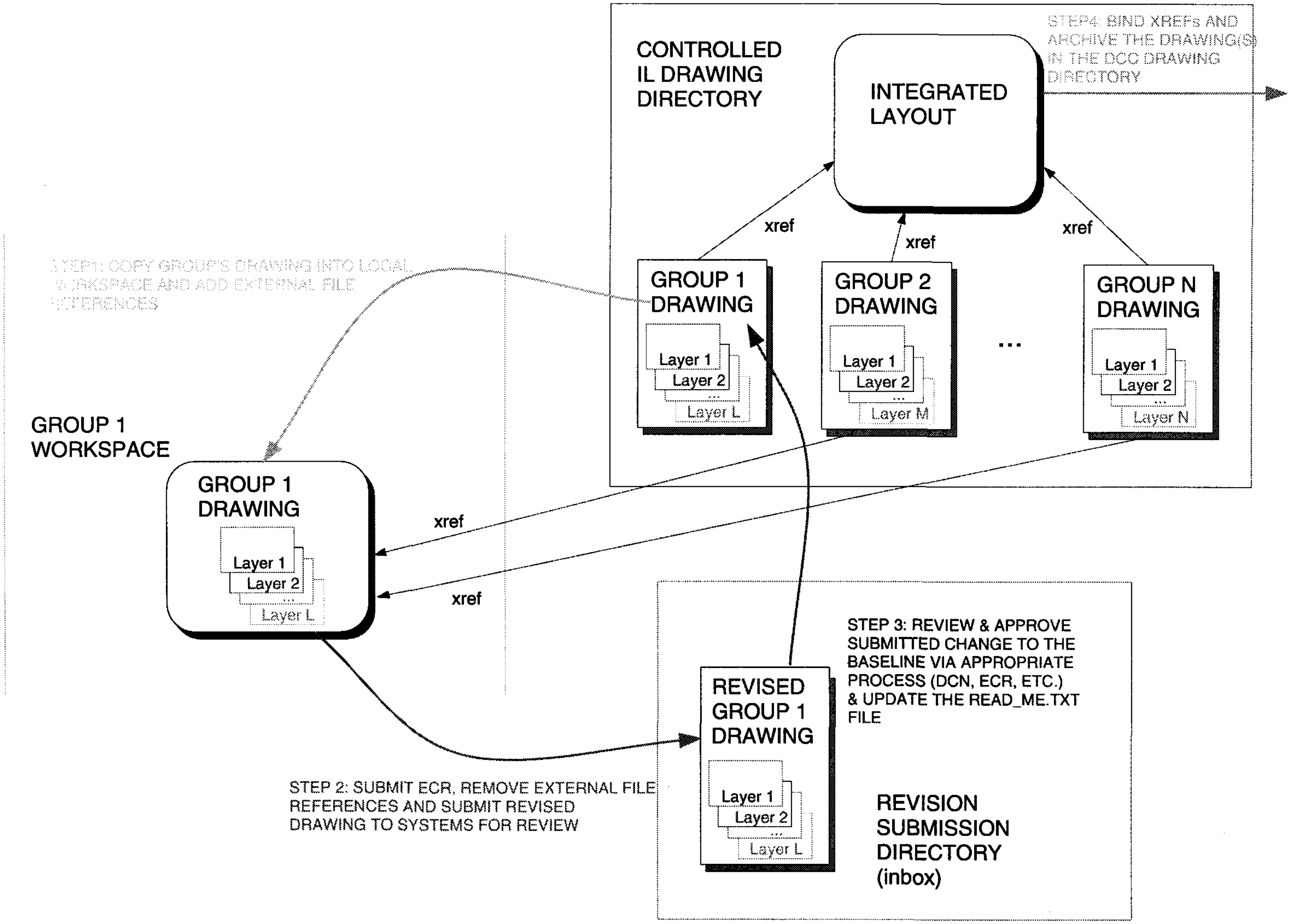
1. TBD
2. W. Althouse and G. Stapfer to A. Lazzarini, LIGO Coordinate System, LIGO-L950128, 15 Feb 96.
   A. Lazzarini, Derivation of Global and Local Coordinate Axes for the LIGO Sites, LIGO-T950004-A-E, 3 Jul 95.
3. B. Young to A. Lazzarini, LIGO Naming Conventions, LIGO-L950810-00-E, 30 Oct 95.
   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).

Figure 2-2:



INTEGRATED LAYOUT DRAWING STRUCTURE AND REVISION PROCESS

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[1].

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

<table>
<tr><th rowspan="2">Integrated Layout filename (description)</th><th colspan="2">Referenced Drawings</th><th rowspan="2">(Primary) Content</th></tr>
<tr><th>Name</th><th>Group (Owner)</th></tr>
<tr><td rowspan="4">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)</td><td>LVEA_LA_ Integ.dwg</td><td>Integration & Systems Engineering</td><td>Clean Rooms
Access Stiles
Build/integration Sequence “Snapshots”</td></tr>
<tr><td>LVEA_LA_ Det.dwg</td><td>Detector</td><td>PSL
Optical Lever/alignment Tables
Seismic Stack Projections</td></tr>
<tr><td>LVEA_LA_ CDS.dwg</td><td>CDS</td><td>Electronics Racks
Electrical Power Locations
Signal Routing Cable Trays</td></tr>
<tr><td>LVEA_LA_ VE.dwg</td><td>VE</td><td>Vacuum Chambers
Vacuum Manifolds/tubes
Pumps
Electrical Power Locations</td></tr>
<tr><td rowspan="6">Mid_X_IL.dwg

(integrated layout of the VEA, VE support room, Mechanical Room, etc. for the mid-station, X-arm)</td><td>Mid_ Integ.dwg</td><td>Integration & Systems Engineering</td><td>Clean Rooms
Access Stiles
Build/integration Sequence “Snapshots”</td></tr>
<tr><td>Mid_ Det.dwg</td><td>Detector</td><td>Optical Lever/alignment Tables
Seismic Stack Projections</td></tr>
<tr><td>Mid_ CDS.dwg</td><td>CDS</td><td>Electronics Racks
Electrical Power Locations
Signal Routing Cable Trays</td></tr>
<tr><td>Mid_ VE.dwg</td><td>VE</td><td>Vacuum Chambers
Vacuum Manifolds/tubes
Pumps
Electrical Power Locations</td></tr>
<tr><td>Mid_End CC.dwg</td><td>CC</td><td>Building Backgrounds
Electrical Power Panels
Crane Coverage Limits/pickup Areas
Access Doors & Walkways
Floor Drains, Etc.</td></tr>
<tr><td>Mid_ BT.dwg</td><td>BT</td><td>BT
Termination Valve & Support
BT Pump Cart Arrangement
BT Installation Clean Room</td></tr>
</table>

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

Acronym	*Meaning*
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_2	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.

BATCH START

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00	3/19/96	Draft	All	All
01	6/9/97	Draft	None	None -- Rev. 01 is just an electronic submission of Rev. 00
02	6/10/97	Draft		(a) Revised for multiple integrated layout drawings (b) Changed references from ECR to DCN (c) Added several layout drawings for the Detector Group for use in the Integrated Layout Drawings (ILD) (d) removed reference to OSB and SEE layout drawings (they aren't really integrated layouts)

1 INTRODUCTION

The System Engineering Group and the Detector Group are developing several Integrated Layout Drawings (ILD). 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.

The directory structure resides on the LIGO/CIT network and will be mirrored on the LIGO/MIT site.

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.

If a constituent drawing externally references (x-refs) a "sub-constituent" drawing, then that drawing must be placed in a different directory. Nested xrefs must be in different directories or the path can be lost.[1]

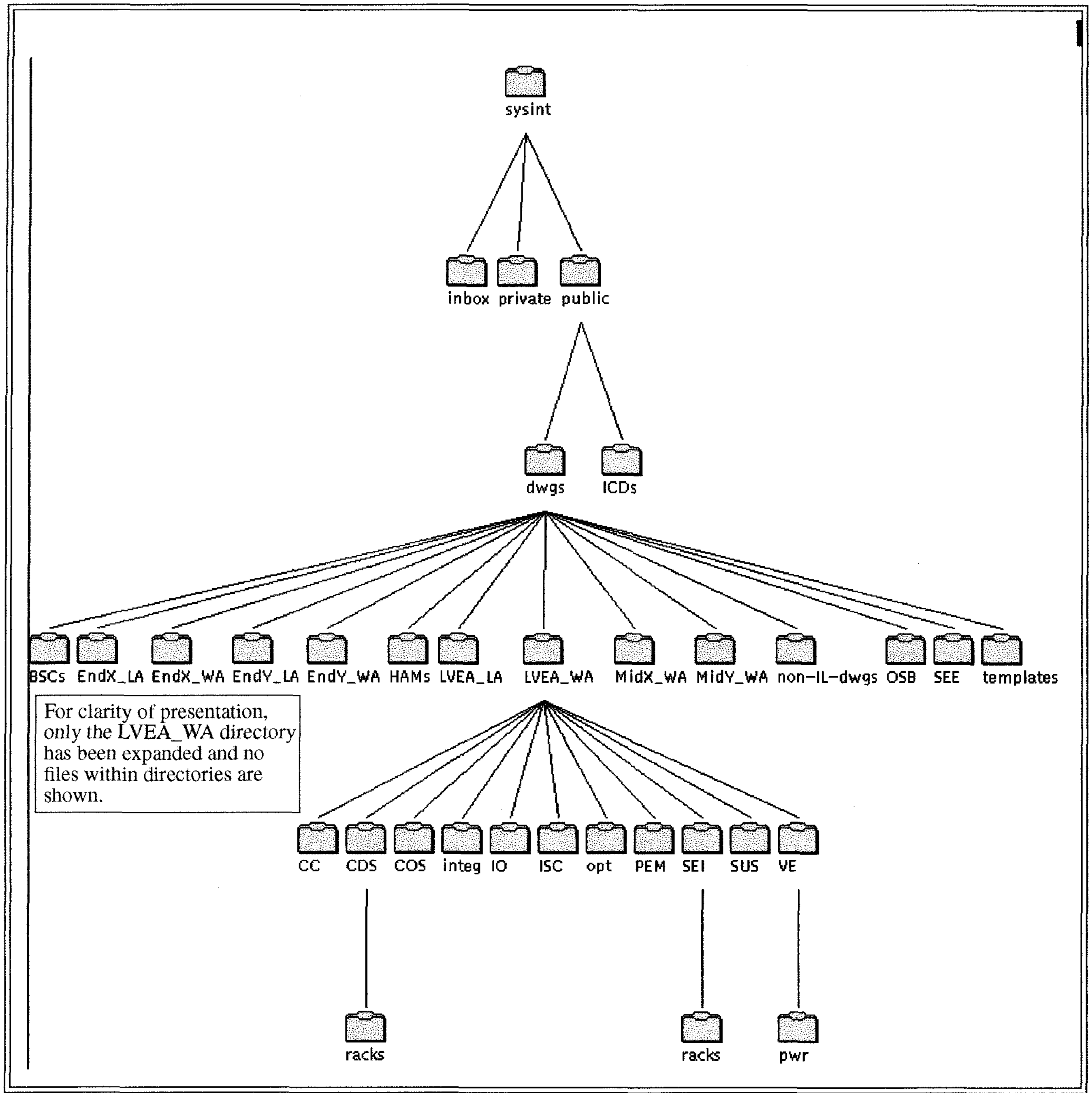
2.3 Characteristics & Style Guides

The <u>initial</u> 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 13, PC version. (AutoDesk is dropping support for the unix versions.)

1. An externally referenced drawing in the same directory as the parent drawing has an incomplete path reference. As a consequence if the parent is moved or copied, the xref'd drawing is not found.

Figure 2-1: Directory Structure



- The maximum length of a directory pathname is 65 characters.
- The Integrated Layout (ILDrawings (ILD) 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 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)].

- Each layer must be homogeneous in its content; drawing objects, dimensions and labels shall each be separated into different drawing layers. (This is not a requirement which is imposed upon subcontractors.) The purpose is to make it easier for other groups which xref a drawing to select the content needed without cluttering their drawing.
- 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 information
  - Use the LIGO drawing template[1] 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.
  - labels should be placed into a separate layer(s)
  - dimensions should be placed into a separate layer(s)
- Use the LIGO standard local coordinate systems[2].
- Use the LIGO standard nomenclature[3].
- 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 basically a shell which references the group drawings; The ILD has a drawing block and notes, but the geometry should be put into xref drawings.

2.5 Updating and Configuration Control

All modifications to the baseline are governed by the procedures in the LIGO Configuration Con-

1. TBD
2. W. Althouse and G. Stapfer to A. Lazzarini, LIGO Coordinate System, LIGO-L950128, 15 Feb 96.
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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.

trol Plan (CCP)[1]. 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 Document Change Notice (DCN) after modifications have been made to the drawing owned by the group
- submit the DCN for approval and, as part of the DCN submission, inform the IL responsible engineer of the proposed change (cite the DCN 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)

Systems Engineering will then:

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

2.6 Archival

Electronic archival and submission to the Document Control Center (DCC) is defined in L960641. Each time an ILD changes (because a constituent drawing changes), the ILD is to be archived in electronic (*.pdf) form to the Document Control Center (DCC). All of the references are bound into the ILD and archived as a single print file.

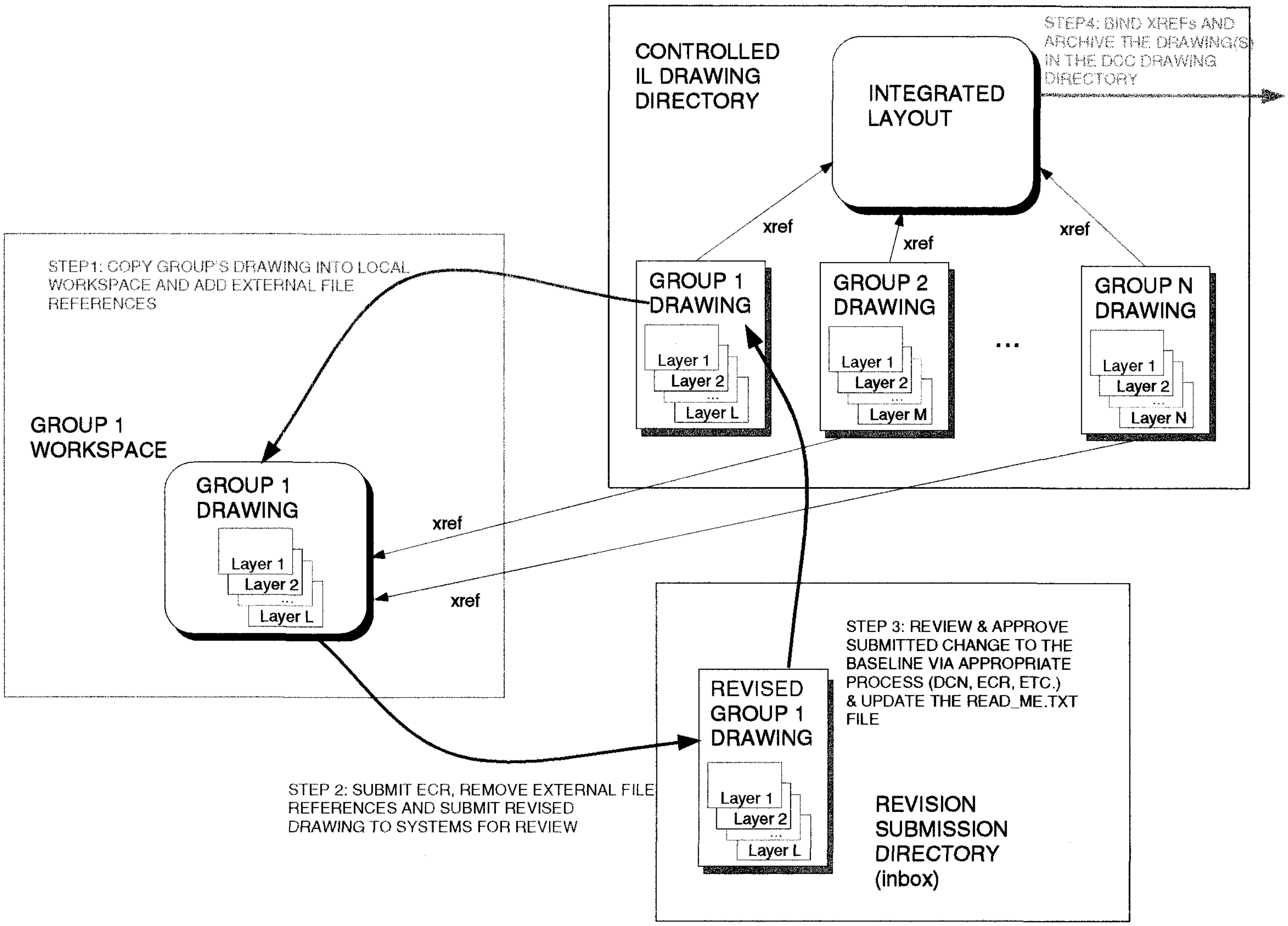
There is no intent to archive the source CAD files -- only to maintain the latest versions in the ~sysint directory.

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 ILD responsible systems engineer consider carefully for each drawing change, what drawings need to be revised and re-issued.

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

Figure 2-2:



INTEGRATED LAYOUT DRAWING STRUCTURE AND REVISION PROCESS

Each time a drawing is issued (i.e. a drawing number is assigned) or a constituent drawing is modified, the following shall be done by the responsible systems engineer:

all ILDs effected by the change shall be identified and incremented in version (increment number if it's a draft (unsigned) or increment letter is its been issued), filed in the DCC electronically (per section 2.6) and copies distributed (with an approved DCN per section 2.5)

2.8 File Naming Conventions

All ILD 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>-<version number/letter>.dwg

where the filenames are per section 3 or per L960641. The version number (draft dwg) or letter (released dwg) 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 <u>not</u> automatically incorporated into the ILD 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 ILD 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 ILD 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[1].

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

3 INTEGRATED LAYOUT DRAWINGS

The basic structure of the ILDs are indicated in Figure 3-1. The ILDs are at a top level and contain no geometry content -- just notes and a drawing block, title and number. The geometry content is incorporated by drawings at the layout (or assembly) level for each of the subsystems. The level of detail can be at the envelope or top level assembly level. Detailed component level information can be incorporated, but may only add unnecessary information and clutter the drawing.

The subsystem designers basically own and maintain these drawing files and their associated directories. Subsystem layout drawing files can be single drawing files or they can in turn xref other subsystem drawing files. The subsystem layout drawing files are not necessarily drawings, i.e. they may not have a separate drawing number. This is because in many cases they require an xref to another drawing file to be in proper context, so the information is issued as an ILD, not a single subsystem layout. There will of course be exceptions to this rule. In the even that a subsystem layout drawing needs to be issued as a separate drawing, then a title block is added to the paper space of the drawing file. (The xref brings in the model space of a drawing file, not the paper space, so the ILDs which refer to the subsystem layout drawing file will be unaffected.)

To emphasize the fact that the ILDs are issued as drawings whereas the subsystem layout information are simply drawing files (but not issued drawings with numbers), the naming convention is to name the ILDs with their drawing number but to use a descriptive filename for the subsystem drawing files, as indicated in the following tables. The directory in which each ILD resides has a descriptive name, so the content of the ILD will be clear from where it is located in the directory structure. For example, the LVEA equipment arrangement at the Hanford site is drawing number D97xxxx. Consequently its filename is D97xxxx.dwg and it will be in the directory ~sysint/public/dwgs/LVEA_WA. Any associated print files should also reside in the same directory and be named D97xxxx.plt (or better yet submitted to the DCC electronically so that it is archived as a compressed *.pdf file).

As an example of the use an ILD by a subsystem designer, Figure 3-1 also defines the relationship between the Optical Layout (or optical model) and the Optomechanical Layout Drawing. Whereas the Optical Layout is strictly has just optical elements and rays, the Optomechanical Layout also includes the physical elements which can interface with the optical system (chambers, baffles, optical tables, telescope structures, etc.).

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.

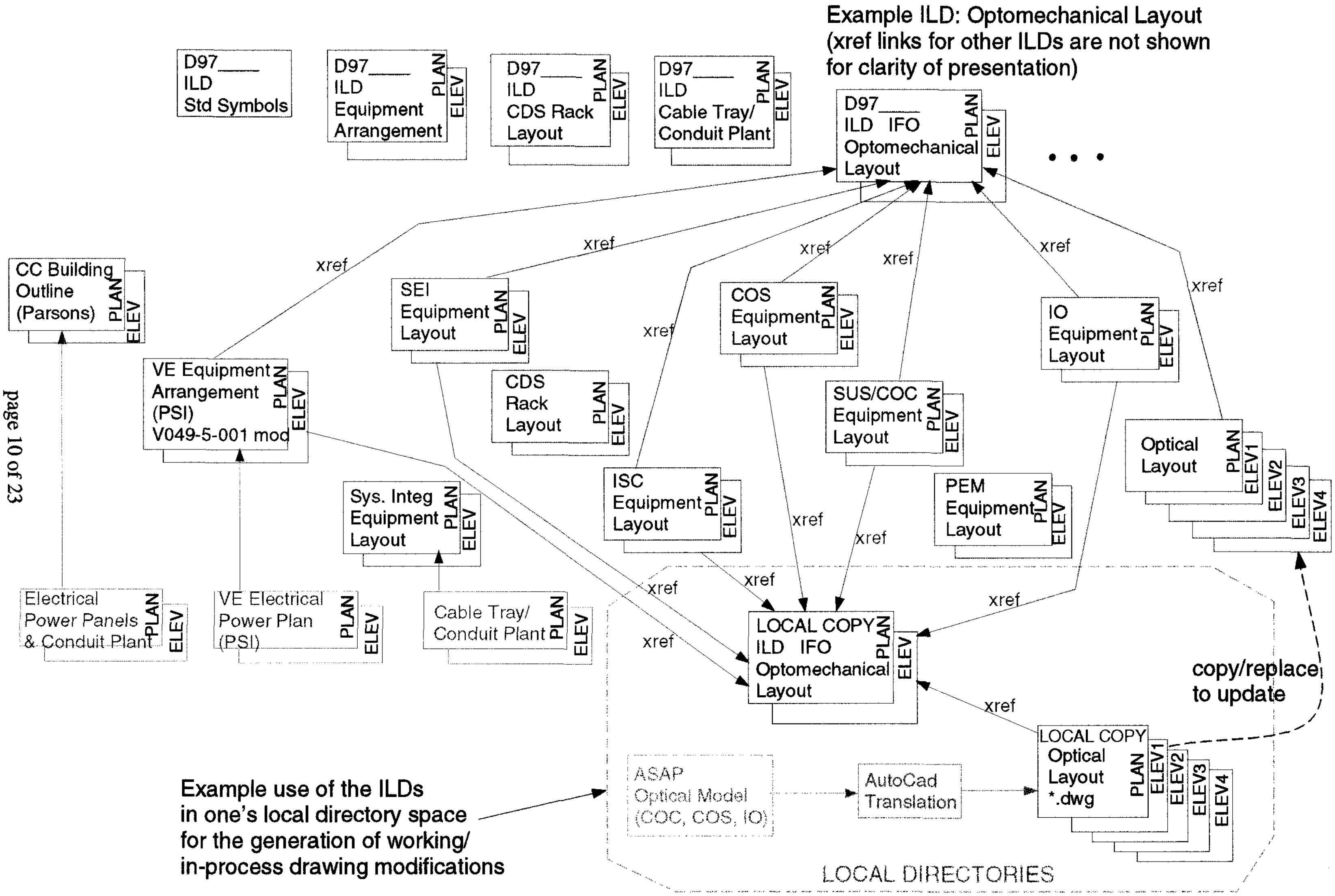


Figure 3-1: ILD Structure

Table 3-1: Subsystem Layout Drawings
(which are used in the Integrated Layout Drawings by external referencing)

Site	*Building*	*Layout Dwg Filename (*.dwg)*	*Dwg# (if req'd)*	*Group[a] (Owner)*	(Primary) Content
Hanford, WA	Corner Station	LVEA_WA_Integ		Systems Engin.	clean rooms, access stiles, clean flow benches, storage cabinets, alignment benchmarks (for VE and ASC), etc.
		LVEA_WA_CC		Civil Const.*	building backgrounds (walls, doors, slab boundaries, etc.) electrical power panels, crane coverage limits & pickup areas, access doors and walkways, floor drains, etc.
		LVEA_WA_VE		Vacuum Equip.*	vacuum chambers, spools, manifolds and gate valves, plumbing in support of the vacuum system, pumps and stay clear areas for the pumps, electrical power conduit stub-up locations for VE, etc.
		LVEA_WA_SEI		Seismic Iso.*	seismically isolated optics tables, support structures, actuators, rack for actuator electronics, etc.
		LVEA_WA_CDS		CDS*	electronics racks, cable/conduit plant for power and signal, electrical power stub-up areas/locations, etc.
		LVEA_WA_ISC		ISC	ISC (ASC + LSC) optics tables (incl. dust covers) and stay clear areas, optical lever assemblies, air path covers from chamber portals to ISC tables, Line Of Sight (LOS) restrictions for initial alignment, etc.
		LVEA_WA_COS		COS	relay optics in the vacuum, beam reduction telescopes, baffles, etc.
		LVEA_WA_SUS		Det. Sys. Engin.	suspension assemblies (SUS) for each of the COCs, vacuum cabling to each SUS
		LVEA_WA_PEM		PEM**	stay clear for centralized building monitoring equipment, 3-axis magnetometer locations, shaker/accelerometer potential locations on the SEI subsystems, etc.
		LVEA_WA_IO		Input Optics	Input Optics (IO) physical components (the optical layout is incorporated through an integrated ASAP model -- see LVEA_WA_Opt) incl. the Mode Matching Telescope (MMT) and Mode Cleaner (MC)
		LVEA_WA_Opt		Det. Sys. Engin.	Optical Layout incl. COC and COS ray tracing with ghost beams

Table 3-1: Subsystem Layout Drawings
(which are used in the Integrated Layout Drawings by external referencing)

Site	*Building*	*Layout Dwg Filename (*.dwg)*	*Dwg# (if req'd)*	*Group[a] (Owner)*	(Primary) Content
Hanford, WA	Mid-Station, X-Arm	MidX_WA_Integ		as-above	as-above
		MidX_WA_CC		as-above	as-above
		MidX_WA_VE		as-above	as-above
		MidX_WA_SEI		as-above	as-above
		MidX_WA_CDS		as-above	as-above
		MidX_WA_ISC		as-above	as-above
		MidX_WA_COS		as-above	as-above
		MidX_WA_SUS		as-above	as-above
		MidX_WA_PEM		as-above	as-above
		MidX_WA_IO		as-above	as-above
		MidX_WA_Opt		as-above	as-above
Hanford, WA	Mid-Station, Y-Arm	MidY_WA_Integ		as-above	as-above
		MidY_WA_CC		as-above	as-above
		MidY_WA_VE		as-above	as-above
		MidY_WA_SEI		as-above	as-above
		MidY_WA_CDS		as-above	as-above
		MidY_WA_ISC		as-above	as-above
		MidY_WA_COS		as-above	as-above
		MidY_WA_SUS		as-above	as-above
		MidY_WA_PEM		as-above	as-above
		MidY_WA_IO		as-above	as-above
		MidY_WA_Opt		as-above	as-above

Table 3-1: Subsystem Layout Drawings
(which are used in the Integrated Layout Drawings by external referencing)

Site	*Building*	*Layout Dwg Filename (*.dwg)*	*Dwg# (if req'd)*	*Group[a] (Owner)*	(Primary) Content
Hanford, Wa	End-Station, X-Arm	EndX_WA_Integ		as-above	as-above
		EndX_WA_CC		as-above	as-above
		EndX_WA_VE		as-above	as-above
		EndX_WA_SEI		as-above	as-above
		EndX_WA_CDS		as-above	as-above
		EndX_WA_ISC		as-above	as-above
		EndX_WA_COS		as-above	as-above
		EndX_WA_SUS		as-above	as-above
		EndX_WA_PEM		as-above	as-above
		EndX_WA_IO		as-above	as-above
		EndX_WA_Opt		as-above	as-above

Table 3-1: Subsystem Layout Drawings
(which are used in the Integrated Layout Drawings by external referencing)

Site	*Building*	*Layout Dwg Filename (*.dwg)*	*Dwg# (if req'd)*	*Group[a] (Owner)*	(Primary) Content
Hanford, WA	End-Station, Y-Arm	EndY_WA_Integ		as-above	as-above
		EndY_WA_CC		as-above	as-above
		EndY_WA_VE		as-above	as-above
		EndY_WA_SEI		as-above	as-above
		EndY_WA_CDS		as-above	as-above
		EndY_WA_ISC		as-above	as-above
		EndY_WA_COS		as-above	as-above
		EndY_WA_SUS		as-above	as-above
		EndY_WA_PEM		as-above	as-above
		EndY_WA_IO		as-above	as-above
		EndY_WA_Opt		as-above	as-above
Hanford, WA	LVEA and VEAs	WBSC<n>_IL		Det. Sys. Engin.	3D layouts in and around BSC chamber "n" (may be done in Ideas instead of AutoCad). Content to include: vacuum cabling/harnesses, tie-points and connectors all optomechanical and vacuum hardware elements, e.g. SUS structures, COS telescopes, COS baffles, etc.
Hanford, WA	LVEA and VEAs	WHAM<n>_IL		Det. Sys. Engin.	3D layouts in and around BSC chamber "n" (may be done in Ideas instead of AutoCad) Content to include: vacuum cabling/harnesses, tie-points and connectors all optomechanical and vacuum hardware elements, e.g. SUS structures, COS telescopes, COS baffles, etc.

Table 3-1: Subsystem Layout Drawings
(which are used in the Integrated Layout Drawings by external referencing)

Site	*Building*	*Layout Dwg Filename (*.dwg)*	*Dwg# (if req'd)*	*Group[a] (Owner)*	(Primary) Content
Livingston, LA	Corner Station	LVEA_LA_<as-above>		as-above	as-above
	End Station, X-Arm	EndX_LA_<as-above>		as-above	as-above
	End Station, Y-Arm	EndY_LA_<as-above>		as-above	as-above
	LVEA and VEAs	LBSC<n>_IL		Det. Sys. Engin.	3D layouts in and around BSC chamber "n" (may be done in Ideas instead of AutoCad). Content to include: vacuum cabling/harnesses, tie-points and connectors all optomechanical and vacuum hardware elements, e.g. SUS structures, COS telescopes, COS baffles, etc.
	LVEA and VEAs	LHAM<n>_IL		Det. Sys. Engin.	3D layouts in and around BSC chamber "n" (may be done in Ideas instead of AutoCad)Content to include: vacuum cabling/harnesses, tie-points and connectors all optomechanical and vacuum hardware elements, e.g. SUS structures, COS telescopes, COS baffles, etc.

a. * = maintained by Systems Engineering
** = maintained by Detector Systems Engineering

Table 1: Integrated Layout Drawings (ILD)

Title	Dwg#	Referenced Layout Drawings (*.dwg)	Content
Integrated Layout Drawing (ILD) Standard Symbols	D97____	none	standard symbols and notes for the ILDs, e.g.: alignment benchmark, annulus ion pumps, roughing pumps, vacuum manifold structural support locations, electronic racks, etc.
Equipment Arrangement Hanford Site Laser Vacuum Equipment Area (LVEA)	D97____	LVEA_WA_Integ LVEA_WA_CC LVEA_WA_VE LVEA_WA_SEI LVEA_WA_CDS LVEA_WA_ISC LVEA_WA_COS LVEA_WA_SUS LVEA_WA_PEM LVEA_WA_IO LVEA_WA_Opt	Integrated physical layout of the LVEA and Mechanical Room for the Washington site corner station. Basically everything is on this drawing so that interferences and aisle/access clearances can be seen. For Clarity very few dimensions and labels are included sheet 1: plan sheet 2: four cardinal elevation cuts (along IFO arms)
Equipment Arrangement Hanford Site, Mid-Station, X-Arm Vacuum Equipment Area (VEA)	D97____	MidX_WA_<as-above>	Integrated physical layout of the Mid-Station VEA along the X-Arm for the Washington site. Basically everything is on this drawing so that interferences and aisle/access clearances can be seen. For Clarity very few dimensions and labels are included sheet 1: plan sheet 2: elevation

Table 1: Integrated Layout Drawings (ILD)

Title	Dwg#	Referenced Layout Drawings (*.dwg)	Content
Equipment Arrangement Hanford Site, Mid-Station, Y-Arm Vacuum Equipment Area (VEA)	D97____	MidY_WA_<as-above>	Integrated physical layout of the Mid-Station VEA along the Y-Arm for the Washington site. Basically everything is on this drawing so that interferences and aisle/access clearances can be seen. For Clarity very few dimensions and labels are included sheet 1: plan sheet 2: elevation
Equipment Arrangement Hanford Site, End-Station, X-Arm Vacuum Equipment Area (VEA)	D97____	EndX_WA_<as-above>	Integrated physical layout of the End-Station VEA along the X-Arm for the Washington site. Basically everything is on this drawing so that interferences and aisle/access clearances can be seen. For Clarity very few dimensions and labels are included sheet 1: plan sheet 2: elevation
Equipment Arrangement Hanford Site, End-Station, Y-Arm Vacuum Equipment Area (VEA)	D97____	EndY_WA_<as-above>	Integrated physical layout of the End-Station VEA along the Y-Arm for the Washington site. Basically everything is on this drawing so that interferences and aisle/access clearances can be seen. For Clarity very few dimensions and labels are included sheet 1: plan sheet 2: elevation
CDS Rack Layout Hanford Site Laser Vacuum Equipment Area (LVEA)	D97____	LVEA_WA_CC LVEA_WA_VE LVEA_LA_CDS	Locations of the CDS rack and stay clear zones around rack clusters. Dimensions in the LIGO coordinate system and (reference) to the walls are shown as well as rack designations. sheet 1: plan sheet 2: four cardinal elevation cuts (along IFO arms)

Table 1: Integrated Layout Drawings (ILD)

Title	Dwg#	Referenced Layout Drawings (*.dwg)	Content
CDS Rack Layout Hanford Site, Mid-Station, X-Arm Vacuum Equipment Area (LVEA)	D97____	MidX_WA_<as-above>	Locations of the CDS rack and stay clear zones around rack clusters. Dimensions in the LIGO coordinate system and (reference) to the walls are shown as well as rack designations. sheet 1: plan sheet 2: elevation
CDS Rack Layout Hanford Site, Mid-Station, Y-Arm Vacuum Equipment Area (VEA)	D97____	MidY_WA_<as-above>	as-above
CDS Rack Layout Hanford Site, End-Station, X-Arm Vacuum Equipment Area (VEA)	D97____	EndX_WA_<as-above>	as-above
CDS Rack Layout Hanford Site, End-Station, Y-Arm Vacuum Equipment Area (VEA)	D97____	EndY_WA_<as-above>	as-above
Cable Tray/Conduit Plant Hanford Site Laser Vacuum Equipment Area (LVEA)	D97____	LVEA_WA_CC LVEA_WA_VE LVEA_WA_SEI LVEA_WA_CDS	Locations of all surface or elevated power and signal cable tray & conduit runs (i.e. not embedded conduit). sheet 1: plan sheet 2: elevations (at least the four cardinal IFO arms) sheet 3: details as required ...
Cable Tray/Conduit Plant Hanford Site, Mid-Station, X-Arm Vacuum Equipment Area (LVEA)	D97____	as-above	as-above

Table 1: Integrated Layout Drawings (ILD)

Title	Dwg#	Referenced Layout Drawings (*.dwg)	Content
Cable Tray/Conduit Plant Hanford Site, Mid-Station, Y-Arm Vacuum Equipment Area (VEA)	D97____	as-above	as-above
Cable Tray/Conduit Plant Hanford Site, End-Station, X-Arm Vacuum Equipment Area (VEA)	D97____	as-above	as-above
Cable Tray/Conduit Plant Hanford Site, End-Station, Y-Arm Vacuum Equipment Area (VEA)	D97____	as-above	as-above
Interferometer Optomechanical Layout Hanford Site Laser Vacuum Equipment Area (LVEA)	D97____	LVEA_WA_VE LVEA_WA_SEI LVEA_WA_ISC LVEA_WA_SUS LVEA_WA_IO LVEA_WA_Opt	Locations of all of the in vacuum optical and optomechanical components (incl. COC, suspension structures, COS telescopes, etc.) and the ISC optical tables with COS<-->ISC optical interfaces locations (ray direction and port location call outs). Ghost beams used for pickoffs and for beam dumps & baffles are also included. sheet 1: plan sheet 2: four cardinal elevation cuts (along IFO arms)
Interferometer Optomechanical Layout Hanford Site, Mid-Station, X-Arm Vacuum Equipment Area (LVEA)	D97____	as-above	as-above
Interferometer Optomechanical Layout Hanford Site, Mid-Station, Y-Arm Vacuum Equipment Area (VEA)	D97____	as-above	as-above

Table 1: Integrated Layout Drawings (ILD)

Title	Dwg#	Referenced Layout Drawings (*.dwg)	Content
Interferometer Optomechanical Layout Hanford Site, End-Station, X-Arm Vacuum Equipment Area (VEA)	D97____	as-above	as-above
Interferometer Optomechanical Layout Hanford Site, End-Station, Y-Arm Vacuum Equipment Area (VEA)	D97____	as-above	as-above
Equipment Arrangement Livingston Site Laser Vacuum Equipment Area (LVEA)	D97____	LVEA_LA_<as-above>	as-above
Equipment Arrangement Livingston Site, End-Station, X-Arm Vacuum Equipment Area (VEA)	D97____	EndX_LA_<as-above>	as-above
Equipment Arrangement Livingston Site, End-Station, Y-Arm Vacuum Equipment Area (VEA)	D97____	EndY_LA_<as-above>	as-above
CDS Rack Layout Livingston Site Laser Vacuum Equipment Area (LVEA)	D97____	LVEA_LA_<as-above>	as-above
CDS Rack Layout Livingston Site, End-Station, X-Arm Vacuum Equipment Area (VEA)	D97____	EndX_LA_<as-above>	as-above

Table 1: Integrated Layout Drawings (ILD)

Title	Dwg#	Referenced Layout Drawings (*.dwg)	Content
CDS Rack Layout Livingston Site, End-Station, Y-Arm Vacuum Equipment Area (VEA)	D97____	EndY_LA_<as-above>	as-above
Cable Tray/Conduit Plant Livingston Site Laser Vacuum Equipment Area (LVEA)	D97____	LVEA_LA_<as-above>	as-above
Cable Tray/Conduit Plant Livingston Site, End-Station, X-Arm Vacuum Equipment Area (VEA)	D97____	EndX_LA_<as-above>	as-above
Cable Tray/Conduit Plant Livingston Site, End-Station, Y-Arm Vacuum Equipment Area (VEA)	D97____	EndY_LA_<as-above>	as-above
Interferometer Optomechanical Layout Livingston Site Laser Vacuum Equipment Area (LVEA)	D97____	LVEA_LA_<as-above>	as-above
Interferometer Optomechanical Layout Hanford Site, End-Station, X-Arm Vacuum Equipment Area (VEA)	D97____	EndX_LA_<as-above>	as-above
Interferometer Optomechanical Layout Hanford Site, End-Station, Y-Arm Vacuum Equipment Area (VEA)	D97____	EndY_LA_<as-above>	as-above

4 NOMENCLATURE AND ACRONYMS

Acronym	*Meaning*
Arm	One of the two perpendicular beam lines which constitute the LIGO interferometer vacuum envelope between stations
ASC	Alignment Sensing and Control
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
COC	Core Optics Component
COS	Core Optics Support
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
IO	Input Optics
ISC	Interferometer Sensing and Control (the union of ASC and LSC)
LIGO	Laser Interferometer Gravitational Wave Observatory
iff	if and only if

LN_2	Liquefied nitrogen (cryogenic fluid)
LSC	Length Sensing and Control
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
OSB	Operations Support Building
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)
PEM	Physics Environment Monitoring system
PSI	Process Systems International; the VE contractor
RMP	Ralph M. Parsons; the LIGO Architectural and Engineering Firm
SEE	Service Entrance Enclosure (part of the Beam Tube enclosure)
SEI	Seismic Isolation System
SUS	Suspension
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.