LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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[see DCC for approval record]

Drawing Requirements

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Distribution of this document:
LIGO Science Collaboration

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1 Scope

The purpose of this document is to provide requirements on the format, distribution, control and archiving of LIGO drawings. The scope includes all drawings initiated by the LIGO Lab regardless of application (detector, civil construction, etc.) or discipline/type (mechanical, optical and electronics). This requirement applies to Initial LIGO (and it's upgrades, though not retro-actively) and Advanced LIGO.

2 Relevant Documents

1) R. Bork, “Detector Configuration Control Procedures”, E000037-00, 14 Jan 00.
http://www.ligo.caltech.edu/docs/E/E000037-00.pdf

2) G. Sanders, “Detector Subsystem (Re-)Design Review Process", M020382-A,
http://www.ligo.caltech.edu/docs/M/M020382-A/M020382-A.pdf

3) P. Lindquist, "LIGO Configuration Management Plan", M950005-00, Dec 94.
http://docuserv.ligo.caltech.edu/docs/internal/M/M950005-00.pdf

4) G. Sanders, “LIGO Project Management Plan”, M950001-C, Oct 97.
http://www.ligo.caltech.edu/docs/M/M950001-C.pdf

5) W. Althouse, “Electronic Submissions to the Document Control Center” (DCC), L960641-05, 9 Oct 96.
http://docuserv.ligo.caltech.edu/docs/internal/L/L960641-05.pdf

6) W. Althouse, “Procedure for Release of Controlled Drawings and Specifications”, L970164-02, 9 Apr 97.
http://docuserv.ligo.caltech.edu/docs/internal/L/L970164-02.pdf

7) Key to LIGO Document Numbers:
http://admdbsrv.ligo.caltech.edu/dcc/docinfo.html

8) Document Change Notice (DCN) Form:
http://docuserv.ligo.caltech.edu/docuserv/ppt_templates/DCN-04.dot
[N.B.: The distribution list on this form needs revision! CIT + LB working on alternative version]
A temporary updated version can be found at :-
http://www.ligo.caltech.edu/~ctorrie/documents+downloads/LIGO_DCN_template_CTorrie-01.doc

9) LIGO Specification Template, e.g. for drawing tree or material list
http://docuserv.ligo.caltech.edu/docuserv/WordSpecTemplate.doc
[CIT working on EXCEL version to automate drawing tree lists etc… from SolidWorks]

10) C. Torrie, M. Perreur-Lloyd, M. Pedraza, “A Summary of the Drawing and Data Templates, Macros, Bill of Materials and Customized Toolbox created for SolidWorks and an Introduction to the LIGO Caltech PDMWorks Data Management Vault”, LIGO-D030382.
http://www.ligo.caltech.edu/docs/D/D030382-05.pdf (includes embedded .ZIP file of templates etc …)

11) C. I. Torrie, M. Perreur-Lloyd, “Customized Toolbox for SolidWorks, Customized Tools for Design & Documentation of LIGO Parts, Assemblies and Drawings”, LIGO-D030383.
http://www.ligo.caltech.edu/docs/D/D030383-04/D030383-04.pdf

12) M. Perreur-Lloyd, C. I. Torrie, “Designing in SolidWorks”, LIGO-T030143.
http://www.ligo.caltech.edu/docs/T/T030143-03.pdf

13) M. Zucker, "LIGO Interferometer Electronics EMC Requirements", E020986-01
http://www.ligo.caltech.edu/docs/E/E020986-01.pdf

14) M. Zucker, J. Heefner, "EMC, “Shielding and Grounding Retrofit Plan”, E020350-08,
http://www.ligo.caltech.edu/docs/E/E020350-08.pdf

15) B. Abbott, "Installation of RFI Mitigated HEPI System at LLO", E040288-00, 18 Jun 04
http://www.ligo.caltech.edu/docs/E/E040288-00.pdf

16) D. Coyne, et. al., "Advanced LIGO Detector Organization, Responsibilities, Authority and Decision Tree", M030177-03, 14 Jan 04
http://www.ligo.caltech.edu/docs/M/M030177-03/M030177-03.pdf

3 Requirements

3.1 Generic

The following guidelines apply to all drawings.

1) **CAD Package Versions & Upgrading**: All upgrades to the CAD software packages (defined below) will be coordinated by the LIGO Lab, General Computing Group (which might mean that the LSC is informed when we are upgrading and given a chance to prepare themselves, i.e. we will not necessarily stop a transition because one LSC player can't or won't perform the upgrade.) Do not automatically upgrade when a new release is made available.

2) **DCC Numbers**: All parts and assemblies must have drawing numbers and revisions per DCC Instructions. http://www.ligo.caltech.edu/~turner/number_explanation.htm & http://www.ligo.caltech.edu/~turner/ligo_number_assignment.htm
See also section 4.8.7 for an explanation of DCC number fields, especially guidelines related to the revision field associated with draft and released drawings. Section 3.2.4 describes reserving a DCC number for a drawing.

3) **Checking**: All drawings must be checked by a colleague or peer prior to release. The purpose of the check is to ensure that, for example, (1) the drawing has been implemented with a LIGO approved CAD tools, (1) all technical details are complete, correct, and consistent, (2) the design is compatible with design and interface requirements, (3) the

design is safe (including a check of supporting stress analysis if applicable), (4) the drawing conforms with drawing standards and good practices, and (5) the design complies with all relevant LIGO standards (EMI, UHV, etc.). The checker's signature(s) or initial(s) should be placed in the drawing template.

4) **Approval**: Approvals are only required for released drawings and are based (among other things) on a satisfactory check. Released drawings are drawings which are placed into configuration control (see section 4). Approval signatures are indicated on the Document Change Notice (DCN) form which is the authority for the drawing release. (see section 4.5 for DCN approvals).
5) **Part & Serial Number Marking**:All parts and assemblies are required to have their part number (i.e. DCC number) marked on them. Serial numbers are in general optional, but encouraged. However, serial numbers are required for all electronic modules/boards and required when the need for matching parts or tracking parts is anticipated. (See also additional comments on part and serial number marking specific to mechanical and electronics drawings in the subsections below.) For the specific nomenclature used in drawing and part numbering, see section 3.2.12.

6) **Drawing Templates**: All drawings should use the standard LIGO drawing templates:
http://www.ligo.caltech.edu/~coyne/optomech/templates/
[We need a set of electronics drawing templates as well.]
A set of LIGO drawing templates for SolidWorks that incorporate equations that link to the custom properties of a part are available in:
http://www.ligo.caltech.edu/docs/D/D030382-05.pdf (includes embedded .ZIP file of templates etc …)
http://www.ligo.caltech.edu/docs/D/D030382-06.pdf (updated & includes set of .dxf)

These templates can also be obtained from the LIGO internal bulletin board:
http://docuserv.ligo.caltech.edu/

The drawing template must (as a minimum) indicate the DCC number (Dyyxxx), the revision code, the item name, the date, the author, and the DCN number which releases the drawing (if the drawing is under configuration control, i.e. has a letter in the revision code). The group code does not need to appear on the drawing. The DCC number field in the drawing should only contain the root drawing number (i.e. it can be confusing to read D991234-A-D, where A is the revision code and D is the group code).

7) **File Sharing for Collaborative Design**: If sharing files with other institutions and vendors, have the LIGO systems administrator set up an appropriate web site or server location. Care must be exercised to maintain control of the drawings and not violate LIGO network security policies. A PDMWorks vault has been set up by the General Computing Group for use in Advanced LIGO mechanical design by the Suspension (SUS) and Seismic Isolation (SEI) groups. LIGO-D030382, explains the use of the vault.

8) **Drawing Trees**: A hierarchical, indented drawing 'tree' or list, with optional html links to the drawings, shall be created and updated for each assembly and sub-assembly. A drawing tree should include the parts list. An E number shall be given to each tree and it shall be released and revised via the DCN process. Drawing trees can be made in Microsoft Word or

Excel. Hyperlinks to Acrobat .pdf files in the DCC are best. They shall include revision numbers for associated drawings. A drawing tree example: http://www.ligo.caltech.edu/docs/D/D970599-B.pdf

9) **Drawing Size, Type Size and Readability**: The minimum font type should be no less than 10 pt. If the content can't fit, then increase the drawing size or split the drawing into multiple sheets. LIGO uses standard A, B, C, D and E drawing sizes. A and B sizes are preferred, but when necessary larger drawings should be created. When rendering into an Adobe Acrobat (*.pdf) format for electronic filing into the DCC check to make sure that the *.pdf file is the proper size (i.e. C-size for a C drawing) and that the resolution is such that the content is readable.
10) **Multiple Page Drawings**: Multiple sheets are permitted. All sheets should have the same DCC number, and the same revision code, and a sheet (page) number. The separate sheets should never be given separate DCC numbers. If a change is made to a single sheet then the entire drawing (all sheets) are marked as revised.

11) **Fasteners**: All fasteners shall be Imperial (SAE, ASME) i.e. no metric fasteners. A customized toolbox has been created for SolidWorks users and is available at: http://www.ligo.caltech.edu/docs/D/D030383-04/

12) **Dates**: Please use the designation 7 JUL 04, JUL 7 2004, or similar on all drawings, DCN's etc. This is intended to prevent confusion between US and European date conventions.

13) **DCN's**: Example Document Change Notices (DCN's) can be found on the DCC by searching for DCN under title. These documents are always "E" (engineering) type documents.

14) **DCN Distribution**: There is a canned list of recipients for each DCN. The originator of the DCN should add to this list additional personnel who have a need to be aware of the changes.

15) **DCN Number on the Drawing**: In the revision history block on the drawing template, the Document Change Notice(s) (DCN) used to release the drawing version(s) (revision(s)) must be cited. This provides a cross-reference to the DCN that explains the reason for the drawing change, the implications of the change and has the signatures authorizing release. The DCN number should appear only on the first sheet of multiple sheet drawings.

16) **"Incorporate Change" or "Attach DCN to Drawing"**: The LIGO DCN has provision to describe a change on the DCN form which is then "attached" to the last drawing version as a means of quickly creating a new revision; *This should only be used in rare instances*. In general the source (CAD) file should be revised with the change described on the DCN and the DCN marked to indicate that the change has been "incorporated" into the new version.

17) **Electronic Filing in the Document Control Center (DCC)**
All drawings, drawing trees, and Bill of Materials (BOM) or Parts Lists must be electronically filed into the DCC as both source files and Adobe Acrobat files. Document

Change Notices (DCN) must be filed electronically into the DCC with electronic signatures as Adobe Acrobat files.

3.2 Mechanical Drawings

The following guidelines are specific to mechanical drawings (including mechanical piece part drawings, mechanical assembly drawings, optical layouts, civil construction drawings, piping & instrumentation, etc.).

1. **Initial LIGO Mechanical CAD Packages**: For initial LIGO drawings the preferred CAD packages are I-DEAS and AutoCad (or Mechanical Desktop). SolidWorks is also acceptable for new or revised designs for initial LIGO. Other drawing packages require approval by the Chief Engineer.

2. **Advanced LIGO Mechanical CAD Packages**: The advanced LIGO systems requirements review (http://www.ligo.caltech.edu/docs/G/G010242-00/G010242-00.pdf) defined the CAD standard software packages for advanced LIGO design work to be SolidWorks and in 3D as preferred, with use of AutoCAD (or Mechanical Desktop) and in 2D as potentially acceptable (to be reviewed on a case by case basis by the Chief Engineer). SolidWorks is the "official" CAD tool for Advanced LIGO.

3. **Solid vs 2D**: Solid models are the preferred method for generating drawings and will be required for all complex assemblies.

4. **Reserving a DCC Number**: http://antares.ligo.caltech.edu/dcc/numdefault.htf. E.g.
   (i) The Category denotes document type, such as: **D** for drawing, **T** for technical note, **E** for Engineering specification/description, etc ...
   (ii) The Group denotes the author's group, such as **D** for Detector, **K** for UK, etc.
   (iii) Title usually includes for example, reference section 3.2.11: -

System	Sub-System	Next Assembly	Description
ADVANCED LIGO	**SUSPENSIONS**	**ETM N-PTPYE**	**TEST MASS**

   (iv) The author ID is as shown on the linked list, such as **HayT.**
   E-mail dcc@ligo.caltech.edu to have your name added.

5. **Dimensioning and tolerancing**: Dimensioning and tolerancing per ANSI Y14.5M - 1994. Even with this standard, there are many ways to dimension and tolerance. We will use the initial LIGO seismic isolation system drawings (created by Hytec) as a style guide/standard for dimensioning and tolerancing (if in conflict with the ANSI Y14.5M-1994 standard, the standard takes precedence). A good example drawing from the initial LIGO seismic isolation set is the following: http://www.ligo.caltech.edu/docs/D/D972217-D.pdf

6. **Units**: Drawings shall be dimensioned in inches, except for layouts where dual dimensions are preferred, in the following format: inches [mm].

7. **Part Variant or "Type"**: For some parts it is convenient to define a few variants which are (generally) identical with the exception of a single (or a few) dimension(s). Generally the variants are defined by a variable dimension(s) and a table of the part "type" code and the associated dimension. The variant or "type" code should be a two digit number. For example see: http://www.ligo.caltech.edu/docs/D/D972217-D.pdf
(Note: In this example the part number designation is an old convention; see section 3.2.12 for the proper notation.)
Variants should only be used when one or two design parameters / dimensions have changed.

8. **Bill of Materials (BOM)**: All mechanical assemblies shall have a bill of materials (BOM). It is preferred to include this on the first page of the assembly drawing, for example: http://www.ligo.caltech.edu/docs/D/D972501-00.pdf & http://www.ligo.caltech.edu/docs/D/D020700-A.pdf
In this approach a sub-assembly is listed as a single item on the top-level assembly. One must then go to the sub-assembly drawing to see the parts that comprise this sub-assembly. An (optional or additional) overall BOM for a major assembly, or subsystem, which adds up all the parts across all sub-assemblies, can be issued as a "materials list", e.g.: http://www.ligo.caltech.edu/docs/D/D990440-A.pdf

9. **Scripts:** LIGO Lab has developed SolidWorks scripts and templates to automatically generate a bill of materials (BOM) and drawing tree based on customized properties in a part. Use of these scripts/tools are encouraged . These can be downloaded at: - http://www.ligo.caltech.edu/docs/d/D030382-05.pdf

   Examples of them in use can be found at: - http://www.ligo.caltech.edu/docs/E/E030507-A.pdf (Drawing Tree) & http://www.ligo.caltech.edu/docs/E/E030508-A.pdf (Materials List)

10. **Name of Designer / Engineer**. In order to aid in identification, it is recommended to indicate your name(s) on the drawing with your first initial and last name e.g. C. Torrie and not CIT.

11. **Drawing Title.** Each drawing should have the System, Sub-System, Next Assembly and Part Name indicated. E.g.

(i) D020225-A: ADVANCED LIGO	SUS	MC D020535	COIL ASSEMBLY
(ii) D020188-A: ADVANCED LIGO	SUS	MC D020225	COIL FORMER
(iii) D040136-03: ADVANCED LIGO	SUS	ETM PEN TEST MASS	MAIN BODY

As a drawing is submitted these title areas will be cross referenced by the folks in the DCC and checked against the drawing title, see section 4.8.

12. **Part and Serial Number Marking**:
For mechanical drawings a note similar to the following should be added to every part.

SCRIBE, ENGRAVE OR MECHANICALLY STAMP (NO DYES OR INKS) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALL CHARACTERS. A VIBRATORY TOOL MAY BE USED. EXAMPLE:

D040123-A, TYPE-01 S/N 009

Some other examples:

(i) For parts that are very small the following may be used:

SCRIBE, ENGRAVE OR MECHANICALLY STAMP (NO DYES OR INKS) A UNIQUE THREE DIGIT SERIAL NUMBER & REVISION NUMBER TO EACH PART IN AN ASSEMBLY START AT 001 FOR THE FIRST PARTS AND PROCEED CONSECUTIVELY. THEN BAG AND TAG PART OR ASSEMBLY WITH ITS DRAWING PART NUMBER, REVISION AND QUANTITY. EXAMPLE: D040182-A QUANTITY 2.

(ii) A part that started out as a prototype bench test part and progressed through to being a released and then subsequently modified part, it would have the following scribed on it:

D040904 - ~~05~~, S/N 001 - ~~A~~ - B

13. **Weldments**: Typical practice is to only provide a drawing with the dimensions of the final weldment (e.g. D972710-G). If deemed, by the cognizant engineer for the subsystem, to be useful for LIGO to provide piece part drawings to the manufacturer, then the following note must be placed on each piece part drawing:

This piece is part of a weldment. Dimensions shown are approximate; weld induced shrinkage or fill, and post weld annealing and machining considerations are not included. See DXXXXXXX-vY for required dimensions of structure after welding.

where DXXXXXXX-vY is the drawing of the weldment. This note should be prominent -- not just buried in a list of notes, but large, bold text.

3.3 Electronics Drawings

The following guidelines are specific to electronics drawings (including schematics, board layouts, power distribution, wiring/interconnect diagrams, block diagrams, etc.).

1) **Electronics CAD Packages**: The preferred CAD packages are Protel DXP and Protel 2004 for electronics schematic capture and layout/routing drawings.
2) **Required Drawing Types**: Board level designs must be documented with a schematic drawing and a board layout (artwork) drawing. A block diagram is optional at the board level. Subsystem/system level design must be documented with a block diagram(s) and a system wiring drawing(s) which details the pin out assignments and interconnection cables/wiring.
3) **Parts List**: A parts list for board level or system level designs shall be produced as well. The parts list can be incorporated into a table in the drawing, or as a separate "E" type document.

4) **Grounding/Shielding and Cable/Connector scheme**: The grounding/shielding and cable/connector plan shall be conveyed in the drawing(s), and must be in compliance with the LIGO EMI requirements as defined in E020350. See also examples of EMI compliant implementation as guidance in E040288.
5) **Part and Serial Number Marking**:
For electronic layout drawings the part number should be silk screened onto the artwork with a space available to add (by hand) a numerical designation after the letter revision code. (See section 4.8 for an explanation of revision codes for electronics modules.) A space for a serial number designation (to be written in by hand) must also appear on the silk screen. Example:

D040123-A_____ S/N _____

4 Configuration Control & Archiving

The basic approach and procedure for configuration control within LIGO is defined in E000037. The following is an interpretation and specialization of this configuration control process with regard to drawings for both Initial and Advanced LIGO designs.

4.1 Purpose

The purpose of configuration control is to:

1) maintain a documentation record of the state of the system at all times,

2) review the cost and schedule impact of proposed changes at the system level,

3) review the impact to interfaces and system-level performance and function

4.2 What is placed under control?

All documentation which is relied upon to define and build the system. This includes drawings (mechanical, optical, electrical, layout, etc.), requirement documents, specifications, procedures and Interface Control Documents (ICDs).

Documents that are generally not placed under configuration control include:

1) technical memorandum (e.g. used to derive requirements)

2) publications

3) design descriptions

4) presentations

However these documents should still be submitted to the DCC.

4.3 When are documents placed under configuration control?

Requirements Documents should be placed into configuration control once baseline ICDs and costs are established. As soon as fabrication of full scale prototypes are contemplated, the specifications

and drawings must be placed under configuration control. Deviations from this are accepted in early stages of design with prior approval from the Chief Engineer.

4.4 How are documents placed under configuration control?

The Document Change Notice (DCN) places the associated document(s) into configuration control. An initial release (revision code "A") is initiated with a signed DCN. The text of the DCN may say "initial release for prototype fabrication", or similar explanation of the reason for the release. Subsequent revisions (e.g. revision "B") would detail the changes on the DCN. DCN forms are available from the "internal bulletin board" off of the main LIGO web page.

The DCN is to be electronically signed using Adobe AcroBat (self-sign feature). The DCN and its associated documents are then filed electronically into the Document Control Center (DCC). For electronic submission of documents see L960641-05. For instructions in completing the DCN, see L970164-02.

4.5 Who approves the DCN?

4.5.1 Initial LIGO

For Initial LIGO a minimum of three signatures are required: (1) the "originator", (2) the "task leader", and (3) the "group leader", or "chief engineer" (unless one of more of these positions are held by the same individual). Depending upon the organizational structure of a particular project, additional signatures may be required by the group, in which case the block of three signature slots under "Other Approvals (Specify)") are used.

4.5.2 Advanced LIGO

For advanced LIGO the signatures for Document Change Notices (DCNs) are as follows:

1) The originator signs (generally a cognizant engineer)
2) The Subsystem Cognizant Engineer signs
3) The Subsystem Cognizant Scientist signs
4) The Subsystem Leader signs
5) The Systems Engineer signs
6) Then under "Other Approvals, e.g. Interface Related" we leave a few empty signature fields to be used as appropriate. If the DCN has interface related information, then the Cognizant Scientist, Cognizant Engineer and Subsystem Leader for the other subsystem should also sign.

4.6 What is the nature and level of review associated with the DCN approval?

for the Cognizant Scientist: Signature means that they concur that the design as represented by the associated document (drawing, specification, etc.) should meet the performance and feature requirements defined for the component, assembly or system and, if it relates to an interface, does not pose a risk of failure to meet requirements of the interface, the interfacing system or the overall system.

for the Cognizant Engineer: Signature means that they have reviewed the implementation of the design as represented by the associated document (drawing, specification, etc.) and it should meet all LIGO standards (for drawings, EMI guidelines, in-vacuum practices, etc.), is a sound and reasonable engineering implementation and complies with all defined interface requirements (if applicable). If there are safety risks or implications, the Cognizant Engineer should so indicate on the DCN.

for the Subsystem Leader: Signature means that they concur that the set of documentation is appropriate and within the scope of the planned activities, or if outside of the scope or costs, the implications for a CCB review should be noted. The Leader's signature also indicates that the due process was followed in the development and review of the material in accordance with LIGO procedures, e.g. that a design review was held if/as appropriate and that all comments from such reviews were addressed or closed out.

Of course in reality it is not so black-and-white; Each individual can and should make comments on any aspect of the documentation that they feel is questionable or incomplete or wrong. The above is meant to convey the emphasis in each persons review depending upon their role in the organization. Finally a signature means (if nothing else) that the individual was informed and had the opportunity to object or provide input. All too often it is possible to skip review due to time constraints. This DCN process helps to get the attention of the key individuals. Of course for this to work the DCN should be timely (i.e. before the work has already been undertaken), otherwise the DCN signature is just a 'rubber stamp".

4.7 What is the change process?

There are basically two levels of Change Requests (CRs) in LIGO: engineering change requests and major (cost, schedule or technical risk) change requests. At present, Engineering Change Requests (ECR), are handled informally through the either (1) the Revision Technical Review Board (see M020382-A) for Initial LIGO, or (2) the Systems Group (see http://www.ligo.caltech.edu/~coyne/AL/SYS/default.htm) for Advanced LIGO. No formal ECR process is defined. However, one should check with the Cognizant Engineer before spending time and resources on pursuing a change.

If there is significant impact to cost (> $50,000), schedule, development risk or safety then it is necessary for the Configuration Control Board (CCB) to review the change request. A change request (CR) form is prepared and submitted to the CCB secretary (Phil Lindquist), who assigns a CR document number and schedules a CCB review. Some examples (and some *.doc "templates") can be found here:
http://www.ligo.caltech.edu/~phil/ChangeBoard/

The role of the CCB and the change process is described in the LIGO Management Plan, M950001, and the LIGO Configuration Control Plan, M950005.

4.8 LIGO Lab

1) **Document Control Center (DCC) Release**: Releases and revisions shall follow the DCC requirements; see E000037-00, L960641-05 and L970164-02.

All drawings must be released into configuration control (i.e. all subsequent changes are tracked and explained on a DCN) before production, or before installing into a LIGO interferometer or an observatory operations facility (e.g. LDAS installation, Mass Storage Room (MSR) rack layout, etc.) This also applies to "prototypes" if they are to be installed into the interferometer even if only for a limited test run. (The purpose is to have a controlled, stable and known configuration to associate with test results.)

2) **Electronic Filing**: All drawings must be filed electronically in the DCC; see L960641-05.

3) **Change Authority**: Only the cognizant engineer for a part or assembly has the authority to initiate changes. This is an expediency to insure that changes from different interested individuals are coordinated. The cognizant engineer is the last engineer listed on the drawing and/or DCN for the last release. The cognizant engineer can be re-assigned by the Chief Engineer or the Revision Technical Review Board Chairperson.

4) **Change Review and Approval**: All released drawings require review and signatures on the Document Change Notice (DCN) before formal release; see L970164-02. The required signatures on the DCN are the originator (often the cognizant engineer), the cognizant engineer (if not the originator), the task or subsystem leader, the group leader or chief engineer, as a minimum. Additional signatures may be required (e.g. the cognizant scientist) at the discretion of the task or group leader.

5) **Drawings for Bid/Quote must be Released**: No drawing shall be released to a vendor for quote, bid or comment without first releasing the drawing with a Document Change Notice (DCN), which placed the drawing under configuration control; All subsequent changes must be documented and the drawing revision increment with subsequent DCNs.

6) **Filing Timeliness**: Documentation shall be filed into the DCC archives immediately after DCN sign-off.

7) **DCC Number and Revision Code**: A DCC archived drawing number has the following format: Dyyxxxx-r-G where yyxxxx is the DCC assigned number (yy happens to be the last two digits of the year in which the number was first requested), r is the revision code, defined as follows:
- a two digit, sequential (ascending) number if a draft prior to DCN release and configuration control (e.g. 00, 01, 02, 03, etc.)
- a single, sequential (ascending) capital letter indicating the formal release revision (e.g. A, B, C, D, … I and O should not be used)
- a single, sequential (ascending) capital letter followed by a single digit, sequential (ascending) number (e.g. A1, A2, … or E1, E2, E3, …). This sequence is to be used for electronics where the artwork remains at the lettered revision and "cut & jumper" or parts substitutions cause rework to the artwork. A DCN explaining the "cut & jumper" changes and providing the revised associated schematic must be filed in the DCC. An example: http://www.ligo.caltech.edu/docs/E/E010168-00.pdf

This sequence (e.g. A1, A2, … or E1, E2, E3, …) should not be needed (in general) for

mechanical drawings. However, it can be used with the PDMWorks vault or exchange prior to release of the next sequential (ascending) capital letter. These PDMWorks intermediate revisions (A1, A2, or E1, E2, E3) for mechanical drawings are not required to go the DCC.

8) **DCC Archival Documentation**: DCC archived documentation shall include the following:
1) The drawing in Adobe pdf format with a filename Dyyxxxx-r.pdf (see above for nomenclature).
2) The CAD source file(s) associated with the pdf drawing in native file format. These files should be given the same name as the associated pdf or part number plus an optional descriptive name, e.g. for a SolidWorks part file associated with the drawing (part) named D020004-B.pdf it's name might be D020004-B_housing_hydraulic.sldprt.
For mechanical drawings, it is preferred that the file first be translated into SolidWorks (latest, or recent revision level) if necessary. If the translation is problematic, then the file should be submitted in its native format (e.g. ProE format from the UK group).
3) For "As-Built", or final drawings, in addition to the pdf and native file formats, each CAD source file(s) associated with the pdf drawing must be filed in a "universal" file format for long term archival. The preferred formats are as follows:

Mechanical CAD: **STEP**
http://www.ligo.caltech.edu/docs/T/T040112-00.pdf
Electronic Schematics: Orcad? Protel?
Electronics artwork: Orcad? Protel?

[Are there any "universal" electronics drawing file standards?]

All ancillary files are then zipped together and submitted to the DCC in a common folder (the folder name would be "Dyyxxx-r") with the Adobe AcroBat drawing file.
If the drawing is an assembly with multiple part files, then a STEP file can be used. Once imported the STEP file recreates the individual parts associated with the assembly and assigns them their original number and description e.g.
http://www.ligo.caltech.edu/docs/D/D030269-A.pdf &
http://www.ligo.caltech.edu/docs/D/D020196-A.pdf
The CAD source file(s) can be embedded in the pdf drawing. This can be done, for example, using the paperclip in the advanced commenting tool in Adobe Pro.

It should be noted that it is also possible to embed a Microsoft Word, PowerPoint or Excel file into a .pdf if one was submitting a technical note or presentation.

9) **DCC Reserved, Submittal and Retrieval**:
To view a reserved number: http://antares.ligo.caltech.edu/dcc/logdefault.htf
For instructions in how to submit documents: -
http://www.ligo.caltech.edu/~turner/electronic_docs.htm
It should be noted that between the time of reserving a document and sending it for submittal that if the title or author(s) need to be changed or updated or if you would like particular keywords to reference your document please indicate this in an e-mail to dcc@ligo.caltech.edu.
Once a document is released it can be found at http://antares.ligo.caltech.edu/dcc/default.htf
A useful help file is available at: http://antares.ligo.caltech.edu/dcc/help1.html

4.9 Collaborators

1) Collaborator organizations, which have their own configuration control procedures and documentation standards, can use these procedures and standards with LIGO Laboratory approval (through the LIGO Chief Engineer). However, it is preferred that they use the configuration control procedures within the LIGO Laboratory.
2) LIGO would prefer that individuals obtain their own LIGO document numbers and that these appear on the drawings. This can be done easily by following the instructions: http://www.ligo.caltech.edu/~turner/ligo_number_assignment.htm
However, if this is not possible the LIGO Document Control Center (DCC) can arrange for the LIGO document numbers to be added to the *.pdf documentation.

4.10 Contractors

1) Contractor organizations which have their own configuration control procedures and documentation standards can use these procedures and standards with LIGO Laboratory approval (through the LIGO Contract Technical Monitor or the LIGO Chief Engineer, respectively). If possible contractors are encouraged to put the LIGO numbers directly on the documents. The DCC can assign a block of numbers for this. If this is not possible the LIGO Document Control Center (DCC) will add LIGO document numbers to the *.pdf documentation submitted by the Contractors and Collaborators.