SCIPP 01/14
April, 2001

Proposal of Conceptual Design of the GLAST Tracker Construction Database

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version 1.0 released on 4/04/01
version 0.4 released on 3/30/01
version 0.3 released on 3/28/01
version 0.2 released on 3/15/01
version 0.1 released on 3/13/01

Abstract

The GLAST tracker consists of many components such as about 10000 silicon strip detectors, 650 TMCM's (Tracker Multi-Chip Module; a readout electronics unit formally known as HDI), 300 detector trays, and so on. Since all the components should be kept track of during the GLAST tracker construction, we need a relational database that includes assembly status, test results, and relationship between components. In this document, we summarize what functionality of the database we will need, based on our experience in construction of the GLAST BTEM (Beam-Test Engineering Model) tracker.

About this document

This document illustrates a conceptual model of the GLAST tracker construction database. It is based on discussion about the database in the software meeting in January 2001 and some local discussions during/after the meeting. Also, the ideas described in the document has been developed by a number of informal discussions between the authors and others. **This document is not a final draft in any sense.** This is a part of our activities to seek a feasible model of the construction database for the GLAST tracker, on which all in the tracker construction team can agree. Therefore, it will further develop in the future, depending on our future discussions.

Reference

"Naming Convention for GLAST Tracker Construction and Tray Orientation in Tracker Tower", Masaharu Hirayama, February 2001, SCIPP 01/11

1 Introduction

This section summarizes boundary conditions for a conceptual design of the GLAST tracker construction database, such as a list of institutes directly contributing to the construction, a projected production flow, and flow of the tracker components. There are four institutes conducting the GLAST tracker construction, hereafter **construction institutes**, the Hiroshima University (Hiroshima), University of California at Santa Cruz (UCSC), Istituto Nazionale di Fisica Nucleare at Pisa (Pisa), and Stanford Linear Accelerator Center (SLAC). Each institute is responsible in items in the table below.

Table 1. Institute relating to the GLAST tracker construction

Construction site	Responsible to
Hiroshima	Measurements and tests of silicon strip detectors
UCSC	Production and tests of TMCM's
Pisa	Production and tests of tracker towers
SLAC	Assembly of the entire towers; calibration

Tracker components are assembled at the construction institutes, at manufacturers, and at assembling companies under their contract with the institutes. Then, the components are sent to Pisa to assemble into tracker towers and shipped to SLAC. **Flow of the tracker components between the construction institutes** are shown below.

```
                 detectors
Hiroshima -------------+           towers
                       +--> Pisa ----------> SLAC
UCSC ------------------+
                 TMCM
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Fig. 1. Flow of the tracker components between the construction institutes. Note that some components, such as a tray close-out, are manufactured or assembled by companies that are not shown here.

Yet another boundary condition comes from usage of the information collected during the construction. For example, since we definitely need the information for schedule monitoring and production control, it is strongly advised that the development of the construction database starts as soon as possible. The construction database should be available at the construction institutes with full functionalities from the first day of the construction. Furthermore, since a part of the information will be needed for instrument calibration after the tracker construction, such information should be sent to the calibration database, that will be built at SLAC.

Also, **philosophy on database management** should be discussed to define features of the database that should be implemented for completeness and usefulness of the database. Although the entire tracker construction team should find the agreement on this issue eventually, the following rules will be used in this document as a working assumption for conceptual design of the database. Note that this is not a unique choice for us nor a final agreement among the construction team. **The team should discuss about this issue** and reach to an agreement to define the database in detail.

1. During the production, new kinds of information should be added to the database in a timely manner to accommodate unexpected, newly identified failure modes.

2. The construction institutes listed in Table 1 are responsible to update the database; they should collect information from their manufacturers and their assembling companies and update the database.

3. Access to the database contents by non-constructors should be only through an interface at SLAC; therefore, all the construction institutes should send relevant information to SLAC to be browsed.

4. After the tracker construction, all the information about the tracker construction should be available in a database at SLAC. The database will then provide fundamental information (TBD) for the tracker part of the instrument calibration database, which is eventually needed to science analyses after the launch.

2 Conceptual design of the database

This section describes a conceptual design of the tracker construction database that we propose. First, our basic strategy to approach the problem will be shown; proposed below is how we should share the information among the contributing institutes scattered all over the world. Then, configuration of the entire database system will be explained. Data transfer strategy will also be explained and data categorization to match the strategy will be considered.

2.1 Strategy — distributed database —

Maintainability and flexibility of the construction database are key to efficient, timely production of the tracker. The centralized database system, however, tends to be not flexible enough to modify it for unexpected failure modes in timely manner, for instance. Also, it will be very large, which make it difficult to implement it and to maintain it. Furthermore, such a database system requires large amount of data to be transfered all over the world, which may not be in immediate need. On the other hand, a distributed system generally requires interfaces between different databases and synchronization mechanism. Simple interfaces and smooth data flow has to be maintained between distributed databases throughout the construction.

To build a flexible, workable database system, we propose that each construction institute should develop its own database system locally, separate from the main (and final) database. A local database records all information relating to production processes at an institute and the information will be used locally at the institute to control their production. To minimize data transfer, only a part of information should be reported to the main database during the construction, and the rest should stay in a local database at each institute. Some (or all) of the information in local databases could be transfered to the main database after the tracker construction, if we choose to do so.

This document and future discussions within the tracker team should set guidelines for design detailing and database implementations. The proposed approach should be validated in the future prototyping phase in practice. Before the mass production starts, we will refine our design based on achievements and performance in the prototype run.

2.2 Database configuration

The construction database that we propose here consists of one main database and four local databases; each type of databases holds certain information at a certain time during the entire GLAST mission. **The main database** stores minimal information during the construction mainly for a production monitoring purpose. It has a web-based interface for read-only database access, so that the managers in the tracker subsystem can monitor the tracker production. Most likely, the main database will reside at SLAC for various reasons. Each construction institute will have one **local database** for their own production processes. A local database stores all the information produced or collected at the institute during the tracker construction.

Exchange of information is required between the main database and local databases as a result of distributed-database approach. For example, when tracker components are shipped from one construction institute to another, a part of a local database at the shipping institute needs to be transfered to a local database at the shipped institute. Also, each institute must periodically report a summary of their production to the main database for a monitoring purpose. Update frequencies and data transfer methods will be discussed later in this section. Note that **the main database could store all the information for the future reference**, if the tracker team decides to do so. In that case, all the information will be sent to the main database after the end of the GLAST LAT construction and before the launch.

For flexibility of database management and feasibility of its implementation and maintenance, each construction institute implements the local database at their institute. Also, we propose to allow each institute to choose a database software to use at their institute. In addition, we propose NOT to require an interface to access a local database to reduce load of database implementation. Instead, all the information to be browsed should be sent to the main database.

2.3 Data transfer between institutes

Various types of data transfers are needed between the construction institutes during the tracker construction. They can be categorized in four different modes by update frequency: immediate transfer, weekly report, transfer at component shipping, and transfer after the construction to complete the main database at the end of the construction. All the four modes are explained below.

Immediate transfer

Data flow	assembly site → local database at the construction institute
Transfer method	TBD at each construction institute
Data type	measurement recording, assembly logging, etc.

At component shipping

Data flow	shipping institute → local database at shipped institute
Transfer method	Web-based? E-mail? (TBD)
Data type	information about components being shipped

Weekly report

Data flow	construction institute → the main database
Transfer method	Web-based? E-mail? (TBD)
Data type	production rate, yield, etc.

After construction (optional)

Data flow	construction institute → the main database
Transfer method	Web-based? By hand? (TBD)
Data type	all information not sent to SLAC during the construction

2.4 Data classification

All the data product produced in the construction can be categorized based on its information type, its needs in the construction flow, and update frequency required for the needs. Three levels of data products are proposed as follows. Each construction institute should be responsible to categorization of data sets to be stored in their local database. Actual pieces of data that each category should contain are not listed out yet and to be determined later.

Level 1 data — General information for production monitor

Update frequency:	Once a week
Who wants to see:	Everyone in the GLAST team
What kinds of data:	Summary information for production monitoring and quality control
Data shipped from:	Local database at a construction institute
Data shipped to:	Main database
Data entry method:	Web-based with server at SLAC? (TBD)
Example:	List of components produced/assembled
	List of rejects/spares

Level 2 data — Tracker subsystem-proper information

Update frequency:	Once per component shipment
Who wants to see:	Four construction institutes
What kinds of data:	Sub-component data needed to assemble a tracker
Data shipped from:	Local database at a construction site
Data shipped to:	Local database at the next construction institute
Data entry method:	Web-based? E-mail? other methods? (TBD)
Examples:	Strip detector measurements (Hiroshima to Pisa)
	TMCM test results (UCSC to Pisa)
	Tower test results (Pisa to SLAC)
	Component assignment (Pisa to SLAC)

Level 3 data — In-house information

Update frequency:	Immediate at operation
Who wants to see:	Operators within a construction institute ONLY
What kinds of data:	Assembly-specific information not important to the production flow
Data shipped from:	Assembly/test station
Data shipped to:	Local database at a construction institute
Data entry method:	To be developed at each construction institute
Example:	Date and time of assembly/test/measurement
	Operator's name
	Assembly jig number, test station number

3 Data type and transfer method

This section describes a tentative definitions of the level 1 and 2 data that we propose. The data transfer protocol is also discussed based on the definitions. The issues in this section should be refined within the tracker construction team as soon as possible. Before actually implementing the construction database, these issues should be settled and agreed within the team.

3.1 Level 1 data — weekly report for production summary —

The level 1 data is a collection of production logs of all components assembled at a construction institute in the week. The data will be immediately sorted and analyzed at the main database. The main database will calculate production rate, rejection rate (yield), and so on, and publish them on the web for the tracker-related managers to monitor. Tasks and query forms at the main database are to be discussed and defined. The level 1 data includes following information.

Table 2. Definition of level 1 information

Data	Remark
Date of operation	in local time
Component ID[a]	"L" for a ladder, "T" for a tray, etc.
Component number[a]	0123 (a ladder number for a ladder, etc.)
Process ID number	A sequence number of a component assembly In case of tray assembly, for example, "1" for tray close-out assembly, "2" for ladder mounting/gluing, "3" for TMCM attachment, etc. (TBD)
Result of operation	"good", "rejected", etc.

a) For naming conventions and numbering scheme, see "Naming Convention for GLAST Tracker Construction and Tray Orientation in Tracker Tower" by Masaharu Hirayama (UCSC/SCIPP preprint 01/11).

Note that these information is **a part of a local database**. A local database will be able to produce such a list automatically at the end of the week. In addition, since the level 1 data is in **a fixed format** for all the tracker components, we can easily define data transfer format/protocol between the construction institutes. The format and the protocol should be defined within the construction institutes. Furthermore, since it has only five (5) data pieces per component per assembly process, the main database can be very simple in structure. On the other hand, the main database should be designed and maintained with **careful considerations on data analysis** to summarize the production **and query forms** for the web access by the tracker-related managers.

3.2 Level 2 data — data exchange between institutes —

The level 2 data include all the information relevant to assembly processes at Pisa and at SLAC, in order to assemble subcomponents into higher-level components, such as detectors into trays and towers at Pisa, and towers into LAT at SLAC. They will be transfered when a set of subcomponents are shipped to Pisa or SLAC. Only the level 2 data of the subcomponents being shipped are transfered with the components. They should separately be stored at a shipped institute, but **as a copy of the data**. If there is any discrepancy in the level 2 data between the shipping institute and the shipped institute, the one at the shipping institute should be taken. Here is a tentative list of all the level 2 data. Note that these lists are tentative and to be discussed, refined, and defined as soon as possible.

Detector information (Hiroshima to Pisa)

1. Detector ID number
2. Bad strip list (by the manufacturer and by Hiroshima)
3. Leakage current, normalized at 25 degrees
4. Notes (special batch, lower break down voltage, etc.)

TMCM information (UCSC to Pisa)

1. TMCM ID number
2. Bad channel list
3. Currents on power lines
4. Notes (bad chip list, minor problems in tests)

Tray/Tower (Pisa to SLAC)

1. Tray/Tower ID number
2. Configuration (list of subcomponents and their locations)
3. Mechanical measurement/test results (tray)
4. Subcomponents alignment (ladder/tray)
5. Detector currents per tray, cable, and tower
6. Post-assembly bad channel list
7. Currents on electronics power lines per tray, cable, and tower
8. Notes (special instructions for testing, etc.)

To minimize the data transfer, we propose that a shipping institute should send **only the latest results** of measurements and tests performed at the institute (TBD). Note that the level 2 data sent to Pisa is not forwarded to SLAC. Such data are re-measured, re-tested, merged, or added together at the tray/tower assembly process. Details of the data format and the transfer protocol for the level 2 data are to be discussed and defined soon.

3.3 Level 3 data — local information at an institute —

The level 3 data will be defined locally at each construction institute. All the data will be transfered to the main database at the end of the tracker construction, if the tracker team decides so. At the moment, however, there is no immediate need to define the level 3 data and its data format. In fact, it may grow during the construction due to identifications of unexpected failure modes during the assembly processes. A part of the level 3 data to be transfered and stored at the main database are to be discussed and determined.

3.4 Data transfer protocol

There are a couple of ways to transfer level 1 and 2 data. Once the tracker team agrees on the (revised) definitions of the level 1 data and the level 2 data, the data format and its transfer method should be discussed. Here listed are examples of data formats and transfer methods.

Data format for the level 1 data and the level 2 data

1. ASCII file
2. Excel file
3. Database-specific format
4. Other format

Data transfer method for the level 1 data and the level 2 data

1. E-mail
2. Through web page(s)
3. File copy (ftp, scp, etc.)
4. Other method

The data transfer protocol for the level 3 data can be very different from those above, because **the level 3 data will be transfered only once** after the tracker construction. If the level 1 and 2 data are well-defined so that the level 3 data is not necessary for the pre-launch testings after the construction, there will be less time pressure for the transfer, which allows us to do it in a slow process, such as sending CD-ROM's including the entire local database. In any case, the level 3 data transfer is to be discussed and determined later.

4 Action items

The conceptual design proposed in this document still needs to be detailed. There are some open questions about the policy of database development and maintenance, on which we should make an agreement before defining the database. Then, contents of each type of database should be defined. Once the database definition is agreed, the entire database can be implemented at SLAC and each construction institute.

4.1 Open questions

1. At the end of the tracker construction, should the main database store **all the information** produced in the tracker construction? Is it possible to import them to the main database?
2. Do we publish the weekly report of the tracker production **to the whole collaboration**? Or, only to the tracker-related managers?
3. Do we want **a single database software** to use everywhere? Or, do we allow each institute to choose one different from others? What about a software for the main database?

4.2 Database definition

1. Revise and finalize the definitions of the level 1 data and the level 2 data
2. List data queries desirable at the main database
3. Choose a database software at each construction institute
4. Decide a data transfer method between the construction institutes and define a data transfer format
5. Define a point of contact for data transfer at SLAC (for the main database) and at each construction institute (for its local database)
6. Agree on all of above among the tracker subsystem group

4.3 Database implementation

1. List level 3 data local to the local database at each construction institute
2. Develop the local database at each construction institute
3. Establish data transfer between the construction institutes
4. Implement the main database at SLAC
5. Establish data transfer from the construction institutes to the main database
6. Implement the web interface at the SLAC main database