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TRACKING APS-U PRODUCTION COMPONENTS WITH THE COMPONENT DATABASE AND eTraveler APPLICATIONS*

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Abstract

The installation of the APS-U has a short schedule of one year, making it imperative to be well prepared before the installation process begins. The Component Database (CDB) has been designed to help in documenting and tracking all the components for APS-U. Two new major domains, Machine Design domain and **M**easurement and **A**nalysis **Arc**hive (MAARC) domain, have been added to CDB to further its ability in exhaustively documenting components. The Machine Design domain will help define the purpose of all the components in the APS-U design and the MAARC domain allows association of components with collected data. The CDB and a traveler application from FRIB have been integrated to help with documenting various processes performed, such as inspections and maintenance. Working groups have been formed to define appropriate work flow processes for receiving components, using the tools to document receiving inspection and QA requirements. The applications are under constant development to perform as expected by the working groups. Over some time, especially after production procurement began, the CDB has seen more and more usage in order to aid in preparation for the APS-U installation.

INTRODUCTION

The APS Upgrade has begun to receive production components in preparation for APS-U installation in 2022. The Component Database (CDB) is a tool that is actively being developed to track components through procurement, receipt, inspection, preliminary testing, and installation. A tightly coupled companion application is the eTraveler, a tool that mimics the paper travelers historically used for tracking components. As engineers and technicians begin using these tools for production hardware, numerous feature requests have been implemented to improve usability and efficiency. Previous versions of CDB [1,2] were instrumental in gaining acceptance of its use. The APS-U QA Policy relies on these tools for tracking inspections and logging discrepancies.

NEW DOMAINS IN CDB

Utilizing the generic schema that supports the Component Catalog and Component Inventory, two new domains have been added, the Machine Design and the Measurement and **M**easurement and **A**nalysis **Arc**hive (MAARC). These domains extend the use of CDB from a simple inventory system to a tool that allows engineers to specify and track the set of components needed to create a "machine". The MAARC domain supports the archiving of test data indexed and referenced to a particular component or to portion of the machine design.

Machine Design

The Machine Design domain allows users to specify a hierarchy of components to be installed to fulfill a particular function in the overall project. For example, Figure 1 shows how a hierarchical machine design can depict both electrical equipment (the contends of a rack) and accelerator equipment (components in the tunnel). Having a common mechanism to capture both electrical and mechanical components to be installed will allow for shared work processes for the assembly and installation of all APS-U components. It is also the basis for other relationships between any components, such as cables, control flow, or power distribution.

Life cycle of a Machine Design Item A machine design item is essentially a "reserved space" or "placeholder" for some type of component (from the CDB Catalog) to be installed at a given location. For example, the VME crate in Figure 1 can be entered into the machine design as "S27:VME1" housed in "S27 RTFB DAQ RACK" before the exact model of the VME crate is determined. Once the model for the VME chassis is known, it will be added into the CDB Catalog and then assigned to "S27:VME1", which will then indicate "S27:VME1 will be a Tracewell Model #XYZ VME crate". Likewise, S01A:Q1 can represent the first quadrupole in Sector 01A even before the exact characteristics of that component are known and described in the Catalog.

In addition to the machine design item holding the intended component type (from the Catalog), one can also specify which component instance (e.g.,the serial number) of that type of component is installed in that location at the current time. Since the CDB records any changes to these

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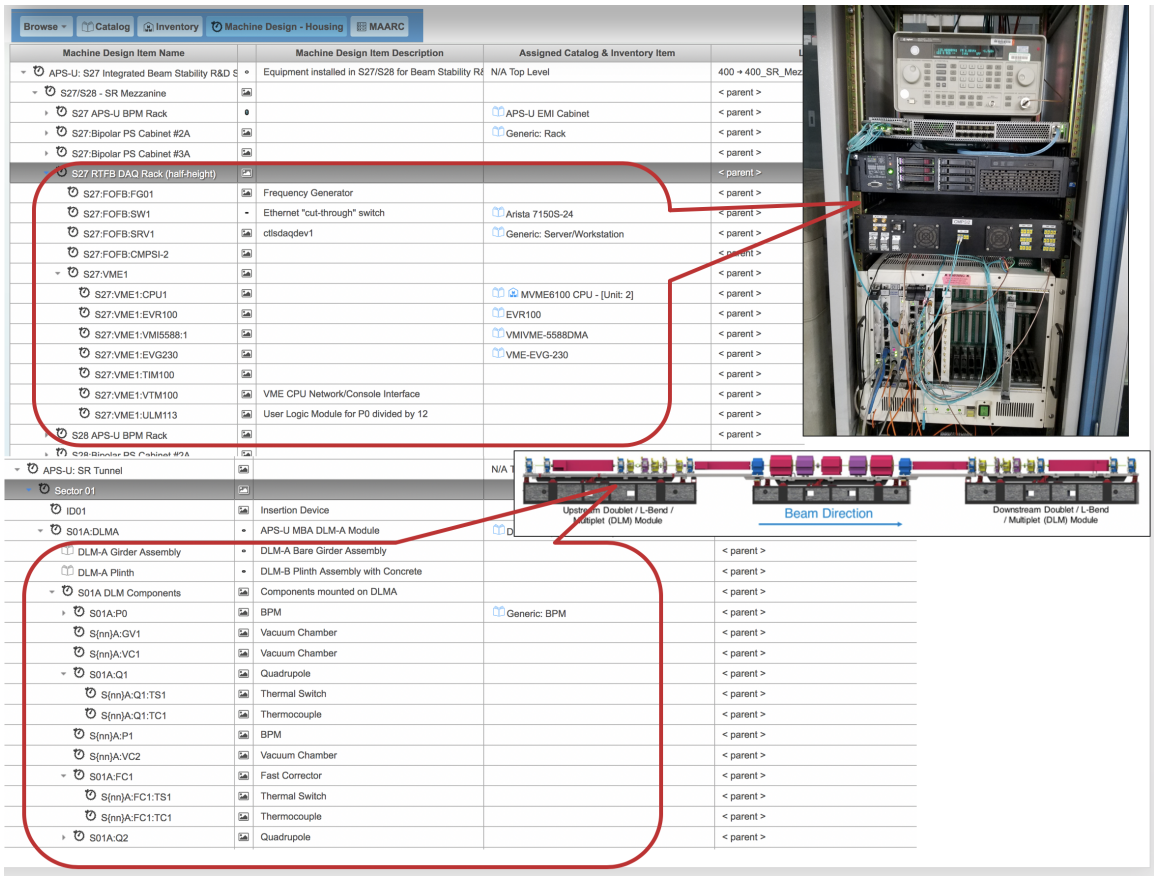

Figure 1: APS-U Components Captured in a CDB Machine Design Hierarchy.

assigned components, a history of the machine configuration (i.e., what is installed where & when) is continuously logged.

The machine design effectively captures a Bill of Materials for the entire project and tracks exactly which instance of a component is installed there. Having a common database for installed components will be heavily utilized for component maintenance, fault tracking, and control system configuration parameters.

Machine Design Locations Machine design items inherit their location from their parents, however, at any level on the hierarchy a machine design item can be assigned a building location. A building location is part of the CDB location hierarchy, it is a hierarchy of location that will not change, such as buildings and rooms. Using this information any particular machine design item can be physically located.

Measurement and Analysis Archive (MAARC)

The MAARC domain allows tracking and organizing various analysis and measurement data relevant for a given machine design or inventory item. Each file item in the MAARC domain is typically added to a MAARC document collection which is tied to the specific machine or inventory item with a CDB reference. This reference allows users to retrieve all relevant MAARC data directly from the page that belongs to a particular item, as well as to see this item from the document collection page (see Figure 2). CDB APIs allow external software systems to easily add new or update existing MAARC items, as well as to add links between items that belong to the different domains.

MOBILE APP

A mobile app for the CDB has been developed to allow user to perform quick task while out in the field. It is developed using a mobile framework called Xamarin [3]. This framework allows for cross platform app development. It currently runs only on Android; however, it would not be a significant effort to get it working on iOS as well. The app is currently designed to run on a specialized Android scanner (Zebra TC70x) as well as any standard Android device. The zebra device allows for much more efficient scanning. Figure 3 shows details page of a production magnet, this page would be shown if a user scanned CDB QR code 100011001.

QR Functionality

The app has the ability to scan CDB QR codes, this can be done using the scanner built into the Zebra device and also using the android device camera. Upon scanning the item, the user is presented with details of the scanned inventory

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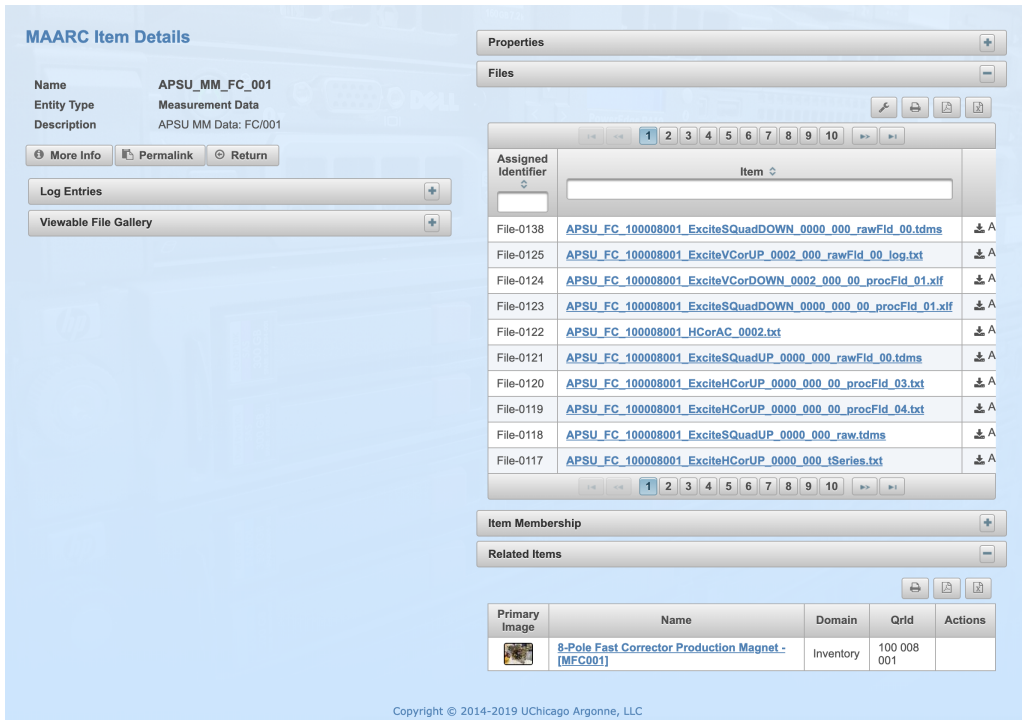

Figure 2: An example detail page of a MAARC file item.

Figure 3: A screenshot of the CDB Mobile App.

item. The app also allows user to use the scanner to quickly relocate multiple items.

Relocate Items

The mobile app provides a view that allows the user to scan multiple items and select a location to quickly update the location of all scanned items.

Details Page

The details page allows the user to fetch the item properties, log book, images, and basic information. Additionally, inventory items have a location and status information. Similarly, the catalog item's inventory list can also be fetched.

Browsing

Aside from the ability to scan item with the mobile app. The user can actually find a particular catalog item and from there navigate to specific inventory item.The user can also look for inventory items directly.

Java API

All functionality of the mobile app is supported by a new Java API. This allows for greatly improved reuse of CDB portal code. The client API for the mobile app is automatically generated using Swagger [4]. Swagger allows generation of client API in many programming languages. This means that making updates to the API on the server requires minimal effort to maintain client APIs in multiple languages.

eTraveler APPLICATION

Historically, paper-based "travelers" have been attached to components to document the workflow necessary for proper inspection, characterization, assembly and testing prior to installation. The eTraveler application [5] provides similar functionality with electronic templates and form instances by which component tracking is accomplished. Stored electronically, this information is available to any person and also available through an API for other applications.

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The eTraveler application has been tightly integrated with the CDB to provide seamless navigation between the two applications. When viewing a component instance in CDB, the progress of all associated eTravelers is conveniently displayed. This has made the eTraveler more accessible and it is now required for critical APS-U components. Several additional features have recently been added as outlined below.

Reporting

A major benefit of the eTraveler over the paper system is the accessibility of the data collected during the processing of components. Since all actions on the eTravelers are stored in a database, the progress of any component can be immediately viewed through appropriate applications. A recent modification allows every operator entry field within an eTraveler to be assigned a "reporting key" that is accessible through an API. Using this feature, different reports can be assembled to thoroughly track component status providing as much detail as necessary. In addition, statistics across components can be generated, such as "What is the minimum, maximum, and average measured width of all the Q1 magnets received so far?".

Discrepancy Traveler

A critical function for Quality Assurance is to closely track any component that does not meet prescribed characteristics. To make the reporting of such anomalies as convenient as possible, a "discrepancy traveler" has been built into the eTraveler application. This functionality allows the user to define a template of all required information to be recorded when a discrepancy occurs. Once the discrepancy template is defined, the user can assign it to a certain type of traveler where it becomes conveniently available (one mouse click) to insert into the eTraveler should an issue occur. These discrepancies can then be displayed in a tabular form (a Discrepancy Log) on the traveler instance page as shown in Figure 4.

Step Numbering

To aid in better communication, step numbering has been added to the application. The feature will automatically number steps in an eTraveler using a three tier method. The first tier is the section, the second is the instruction and finally the third is the input. For example the fourth step under the 3rd instruction of the 2nd section would be 2.3.4.

USAGE

The CDB is currently being utilized by an increased number of groups to help in preparation for the APS-U. For example the Q1 production magnet is fully utilizing the CDB and eTraveler tools. This is very helpful for QA as we now have all the records for the magnets we receivied for APS-U.

eTraveler Working Group

The eTraveler working group is where many of the discussions helped define many features and usage of the CDB and eTraveler tools. This working group also helped show many people in the APS-U the benefits of utilizing the systems. It was great to be able to interact with the users to be able to see the uses and issues from their perspective. The working group keeps on being the place where many great discussions occur on how we can best utilize and expand the functionality of the tools.

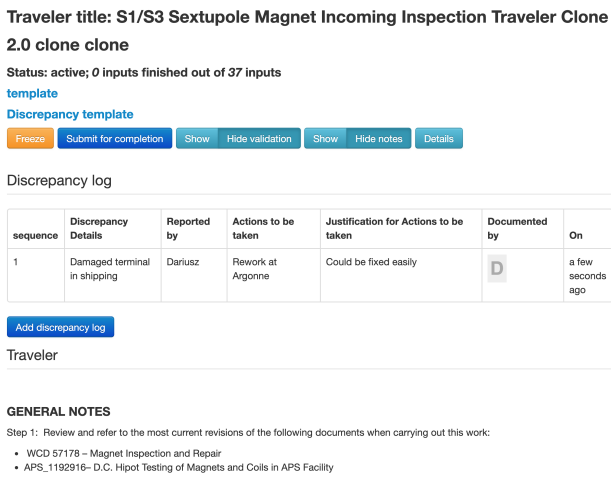

Figure 4: A screenshot of the eTraveler Web Application showing a discrepancy.

MAARC

The original use case for the MAARC domain is tracking and organizing magnet measurement data for the APS Upgrade (see Figure 5). The original data generated by the APS MM software is synchronized regularly to the primary storage, where it is directly accessible from all machines on APS networks. The APS Data Management (DM) [6, 7] system periodically uploads new and modified data to the secondary storage, and updates CDB MAARC domain using its Python API. For each magnet in CDB inventory the system creates the corresponding “Measurement Data” collection item in the MAARC domain, adds all relevant files as this item’s elements, and tags production quality data as needed. In this way one can easily find all measurement data relevant for the given magnet directly on its CDB details page. Users can also download any file directly from the APS central storage managed by the DM software. This functionality is enabled by the CDB’s Data Management plugin, which also allows CDB to generate a preview for images, PDFs, or text files.

ACKNOWLEDGEMENTS

I would like to thank all of the users of the systems. Without the users it wouldn’t be where it is today. Tom Barsz saw the value of the system for QA purposes and helped defined many features we have today in the CDB and eTraveler as well. Rob Connatser organized the eTraveler working groups, and helped get people on board with utilizing the tools to help with APS-U. Diane Wilkonson has been a tremendous part in ensuring that travelers have consistency and ensuring the components get required travelers filled out. Elizabeth

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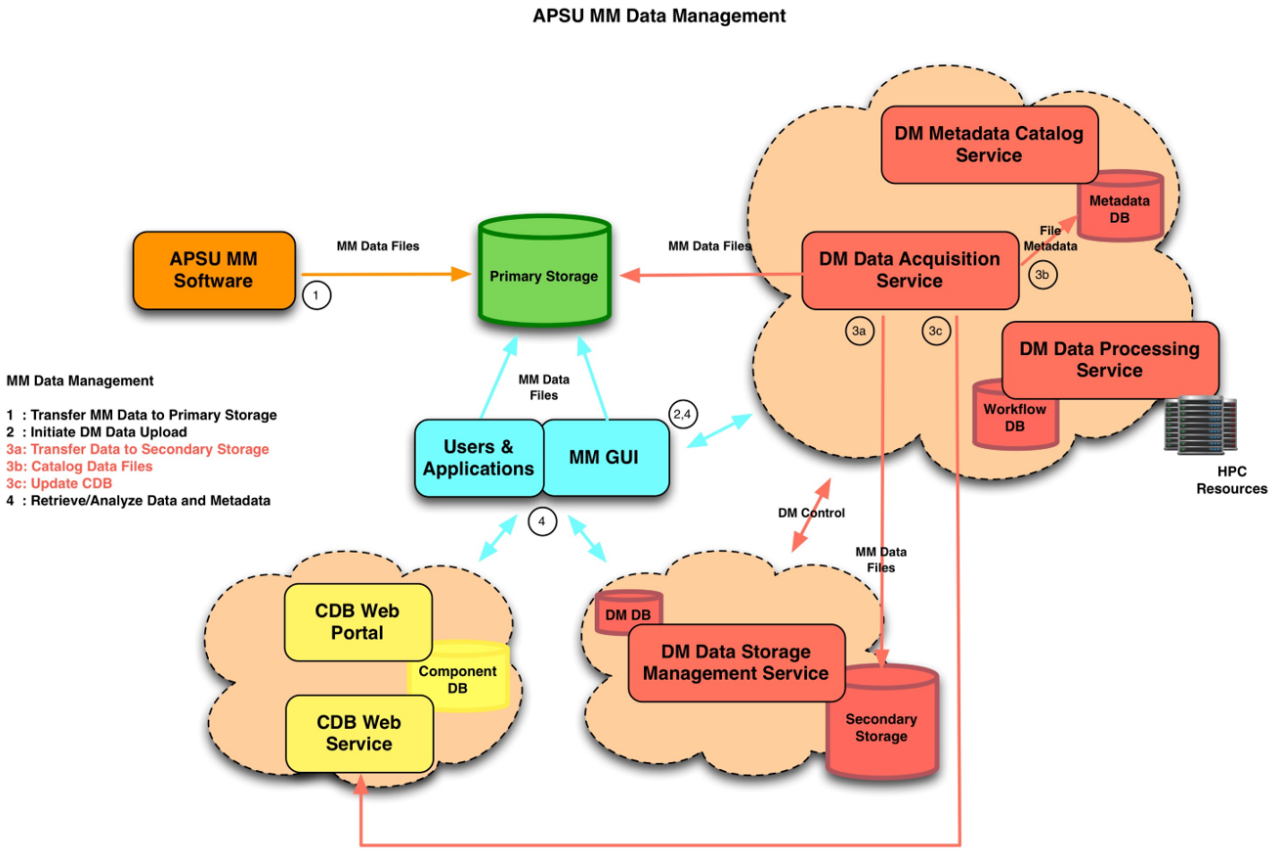

Figure 5: APSU Magnet Measurement Data Flow.

Dunn is continuing to lead the eTraveler working groups and also is heavily involved in defining the processes for utilizing the tools.

FUTURE PLANS

Cable Application

Currently this functionality is being developed. It will allow the user to connect Machine design items together using cables. This functionality will help with storing all the cable information. It will also be used to help generate input to another application that will calculate cable lengths in the raceways. Afterwards the information generated could be stored as cable metadata in CDB.

Mobile App Enhancements

The mobile app is not used much at the APS however as more users start utilizing it, the requirements will grow. The cables may also become a big part of the mobile application. It will help people to quickly and easily look up and update cable connections in the CDB.

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