A CAD solution for querying and maintaining CAD data in remote systems for part search and version control

Functional Specification Proposal

Draft 1

July 11h, 2023

Terms:

PDM	Product Data Management
PLM	Product LifeCycle Management
ERP	Enterprise Resource Management
SCM	Supply chain Management
SQL	Structured Querty Language
SMB	Small and Medium Business
CAD	Computer Aided Design.
ECAD	Electronics CAD
MCAD	Mechanical CAD
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
HTTP	hyper Text Transport Protocol.
REST	Representational State Transfer
endpoint	an URI

History

Revision	Date	Author	Details
Draft 1	July 11, 2023	symdeb (@gitlab)	Initial draft

Making edits

Please add [name][YYMMDD] into the file where making edits or comments.

Problem Statement

CAD symbols, footprint and models are availability from websites, retailers or the manufacturers directly. User search by the partnumber or characteristic of the part, download them and import into the local CAD file system. Datasheet related information might be added into the footprint or symbol. This all takes a lot of time and effort.

Searching for parts from a local centralized database or remote resources, is not possible directly from CAD

Several professional CAD systems offer a central repository for footprints and symbols. These provide access directly from the GUI.

if such functionality is not available in the CAD, shared network drives, dropbox or google drives could be used with access to a share folders. Though such solutions carry security risks or IP concerns. Such shares also need to be setup per each client computer and per user

Requirements

This document describes a solution for following requirement to enhance the CAD system:

[1] Searching for parts and related files and download the CAD symbol, footprint/ model files and a schema for parts data.

[2] Connecting to a local or on a remote cloud system that has part information and CAD resources such as footprints and symbols. The coding of such service to connect is defined by CAD and is an open source solution that 3rd parties easily can implement

[3] The implementation of a system or resource that records and maintains the version(s) of the CAD drawings such as symbols and footprints. This should be easy to implement using SQL or non-SQL. The actual code is not in scope of this proposal and should be documented in a technical specification . It should be easy to be implemented the open source community.

Background

Searching for partnumbers (and their characteristic) and a central repository for footprints and symbols are related but are two very different requirements. CAD system lacking these functionality have been identified as a major differentiator between some CAD and other professional solutions.

Partnumbers generally exists in ERP and PLM systems, not in the CAD system. These ERP and PLM systems are, in general, not aware actual CAD resources such as footprints, symbols. Sometimes they contain drawings such as layout and schematic buts these are just linked as a “document” to the project or partnumber. This often flows out of the requirement to keep product documents together as a controlled file. In the past when IT systems, that could hold such information in electronic form, did not exist, this was a file with printed material of the designs and related information.

Partnumber can be physical electrical and mechanical parts, software, assemblies or even non-physical parts which is a single or a group of parts that is non-stocked and not manufactured or purchased . Parts can be procured or in house-assembled.

At the start of the design there may not be actual partnumber all, just drawing numbers maintained in a PDM. PDM systems maintain the CAD data structure from data provided by the the ECAD and MCAD system. They normally do not maintain firmware and software. A design is often started using drawings and build a structure of drawing to an top assembly by some numbering systems. Ultimately drawings or a structure is linked to an PLM/PDM Partnumber but this does not need to be the case for all drawings. The PDM just maintains the relation between drawings and their structures or whatever other nomenclature is used to define such “objects”. Integrated software solution makes the link between PDM and PLM easier. As stated in [2] smaller companies start of with E/MCAD, add a PDM and only after that a PLM and ERP or even SCM.

Part-numbers in PLM and ERP systems are not necessarily the same as the ones used to procure. Vendors may change their partnumber for minor changes that PLM and ERP’s do not need to manage. These partnumbers are managed in procurement or SCM systems.

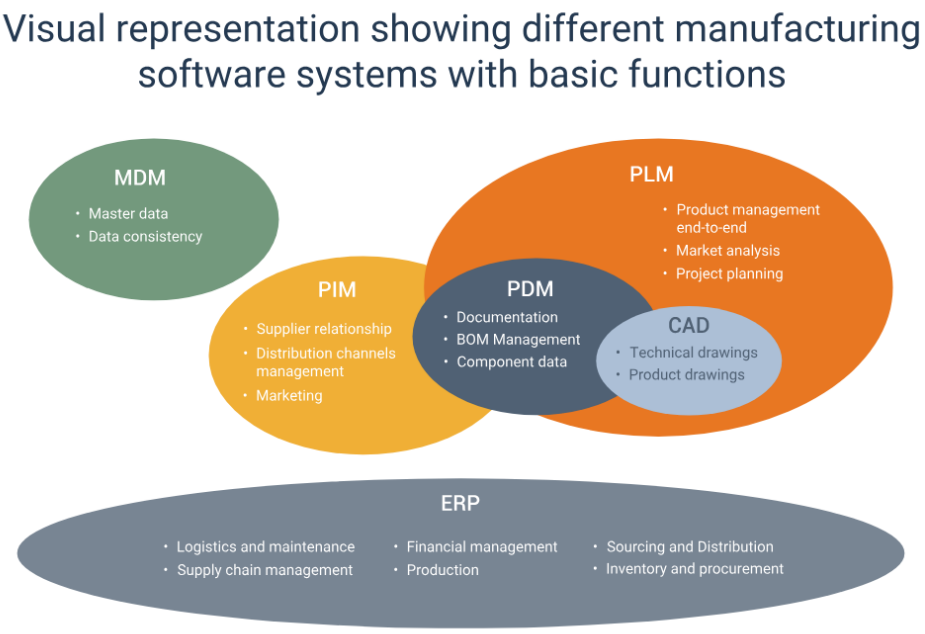

Figure 1: Systems and their purposes [1]

PLM/ERP systems (mostly) do not maintain electrical and mechanical characteristic of partnumbers, nor their footprints and symbols. Such characteristics are normally in the PDM or in external resources such as retailers. (Digikey, Mouser, Element14)

PDM system may not have relations between the footprints, and symbols and the partnumbers in the PLM/ERP

To find characteristics, symbols and footprints for parts from the PDM, the partnumber of the PLM need to be linked with PDM information.

To realize this, the CAD system must provide the drawings to the PDM. Second, the PDM must be able to obtain partnumbers from the PLM. The CAD system could provide the PLM/ERP partnumber along with the symbol or drawing.

One this is done, the CAD client could search for footprints and symbols based on the partnumber from the PDM.

Commercial solutions, such as PTC Creo and Windchill PLM, often integrate functions found in PLM, ERP and SCM system which blurs the boundaries between these. These systems are very complex and costly and are not a solution for individual or SMB or users looking for an free and open source solution. Companies are often locked in to the use the of CAD, PDM and PLM of one vendors instead of the ability to chose different vendors for these functions.

CAD (or PLM) systems provide the design drawings to the manufacturer CAM and CIM systems to manufacturer the PCB and mechanical components

PLM and ERP system provide information go the in in house or subcontracted manufacturing system.

The information flow between the systems can be informal, informal , automated and manual. The following figure shows the flow or data between systems (in gray color)

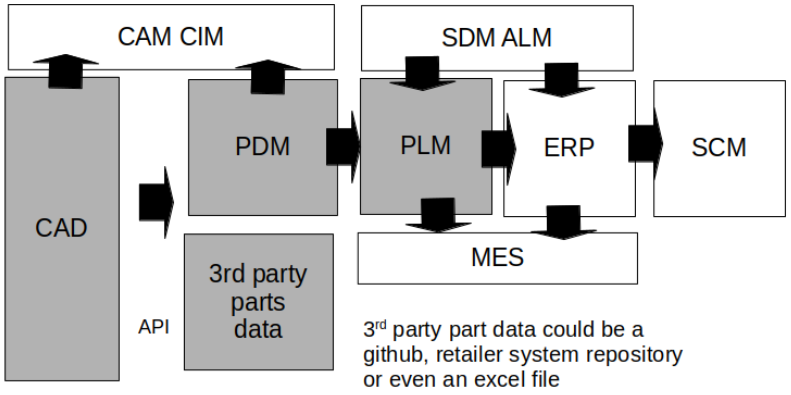

Figure 2: Information flow between systems. In gray the blocks applicable to this requirements specification [author]

It is important to separate the primary purpose, need and functions of these different systems in order to create a modular solution that allows to integrate any 3rd party solution with low barriers and cost. The following chart provides the basic key functions and interactions between these systems with a focus on drawings, partnumbers and BOM's.

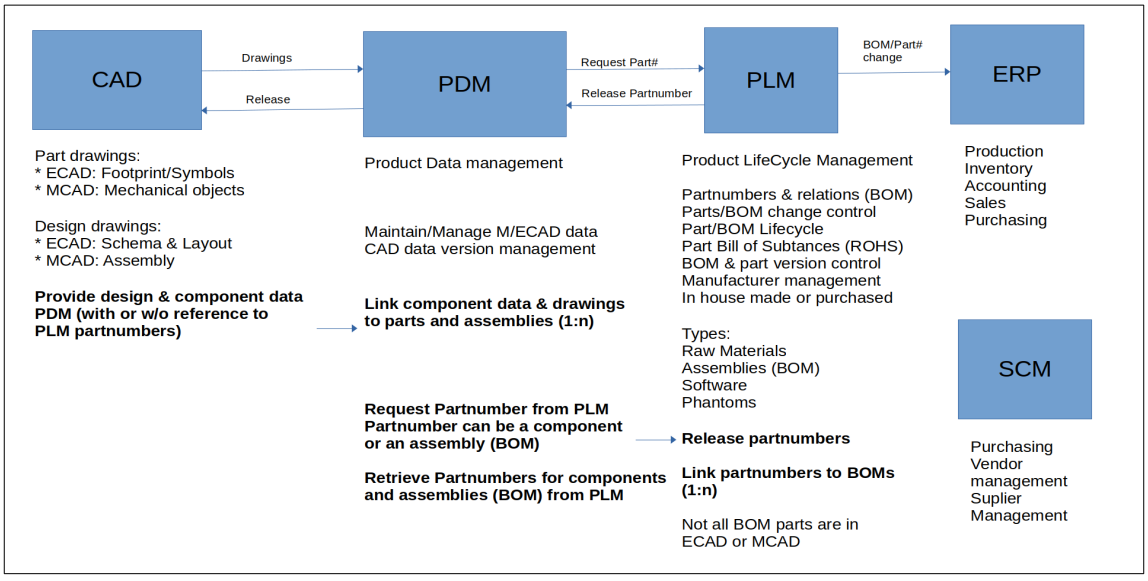

Figure 3: Key functions and interactions of systems for part data management. [author]

Proposal

This proposal contain a functional description of a solution to establish:

- Part Search from CAD int the PDM, PLM, ERP or external resources
- Change management of CAD data
- CAD data to partnumber mapping (symbols, footprints, models)

Additionally some recommendation for the implementation are provided.

Part search

Functionality for searching parts in PDM, PLM, ERP or external services (resources) can be done in different way. The step below provide one solution.

Implement a REST based HTTP API using JSON that the CAD uses to call an external service. Function calls use HTTP REST and schema is based on OpenAPI (Swagger)

Multiple endpoints can be configured in the CAD, for example ne to the PDM, one to PLM and another to ERP or SCM systems

The search for part can use one or more keywords and/or parametric key:value pairs where the keys are predefined.

To provide links to the actual footprint, symbol files is optional and depends on PDM capabilities. In that way the service could function as a library manager. (see next section how to enable part and partnumber linkage).

The service may return only the latest footprint/symbol/model version or older versions as well. It depends on PDM capabilities to maintain the current and older version and revisions.

The partnumber is not the key of search result. The service returns results based on matching records only even with the partnumber being blank. It could be that more than one footprint and symbol using the same partnumber is returned. This all depends on the implementation of the service

The CAD will may have key:value fields for symbol or footprint. There CAD may not have functionality to map to map the keys from the search results to another key. If the CAD implements this, then the mapping function must generic and be applicable to used with any service.

An adapter can easily be coded to connect to retailers such as Digikey, Mouser, Element14 among others by either a local or remote HTTP service to transform the data from the service. In this the case, the mapping to the CAD field names should be done in the adapter itself.

The API does not return part grouped as substitutes , not does the CAD provide rules to identify substitutes. The requirements of parts to be considered substitutes varies per organization. By using more search terms, should enable to nail down parts that can be considered as substitutes.

Change management of CAD data

A REST based HTTP API using JSON. Function calls and schema using HTTP REST based on an OpenAPI (Swagger) schema

The change API endpoint does not have to be the same as for part search

In the CAD system, the following fields need to be added to the symbols and footprints . This could be done per schematic setup per project but for this API the requirement is to add these to all project in CAD global preferences:

- Version
- Revision
- Status
- ChangeNumber
- ChangeReason

Since these fields may conflict with user's existing fields the CAD needs to provide a map function to which fields from the symbols and footprint should be used for these API fields instead. the CAD will then use the data form those fields and map then to the version, revision, status, changenumber and change reason fields

Version, Revision and ChangeNumber cannot be blank for in an API call.

The CAD system does not need to maintain any new database or data, it only needs to add these new fields. The CAD system does not need to retain older versions of the symbol or footprints.

CAD engineers are supposed to only use the latest version for new designs. The assure backwards compatibility with previous versions used in older designs is the sole responsibility of PDM management.

When a new (version) of a symbol or footprint is stable and can be released to the PDM, it is marked in the CAD as changed (frozen). A symbol file can be created in the format library:symbol:version:revision:changenumber. The CAD specifies provided a global setting to define this location.

Sending the actual (new or changed) footprint, symbol or model file to the PDM is optional. This is done by the CAD to provide a name or link to the file. One option is the PDM to provide an upload URI for file upload, another is to place the file, that was created by the CAD, via FTP or SCP to a location shared by the CAD and PLM.

Any change to the symbol or footprint will need a different version or revision before marking it as changed again. A previous version:revision combination could be used (to revert to an older one similar as to canceling a change) but this is not recommended.

A change cannot be submitted more than once unless the API call was unsuccess full (non HTTP 200 error) The user needs to change the version:revision number to resubmit.

Best practice is to put the version & revision in the reason description of the object as the PDM may not retain this data, nor may the PDM it retain the accompanied files, but the PDM may retain the the description, so that the change and it's reason can be traced back in the PDM

In case of failure of the call , the user need to retry. Processing change request using a (asynchronous) request/response process may be too complex for the initial release of such solution.

Some symbols and footprint do not have parts associated with them. still these could be submitted to the PDM (without the part information)

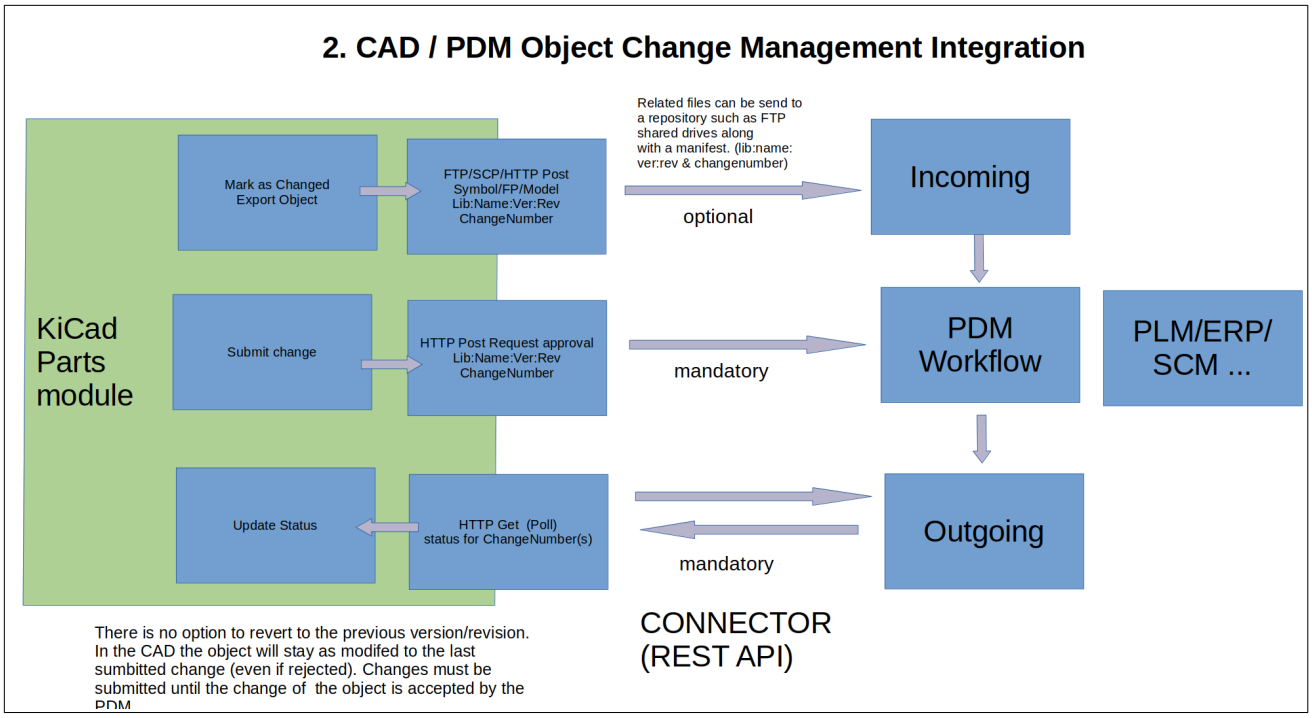

Fig 3: CAD change management process [author]

CAD data partnumber mapping

CAD data symbol, footprint or model to (PDM/PLM/ERP) partnumber mapping

A REST based HTTP API using JSON. Function calls and schema using HTTP REST based on an OpenAPI (Swagger) schema

This is an extension to the change management API only adding fields the request

This functionality allows to link the symbol, footprint and model to an actual partnumber (SKUs) maintained in a PLM or ERP. These symbols, footprints and models could be used for multiple partnumbers. This functionality can also benefit a PDM management to understands the purposes and usage of the footprints/symbols and models.

The CAD system pops up a window to find a partnumber using the part search API service. To narrow down the results, the CAD can use data form the symbol, footprint or model field that can be be used as a default search terms to find parts. if not the user needs to enter those search terms, the same as when searching for parts.

Multiple part can be selected to make the change. The service shall reject the transaction if not all updates are approved.

The external service (PDM, PLM or ERP) is now able to establish the link between the part and the footprint, symbol or model

Recommendations

Change the symbol library to individual files instead of in a one file library

Users may use CAD files from 3rd parties and do not have the skills or work in an environment were an internal MCAD team adds the 3D model into the PDM via an internal MCAD system User may not have a CAD design system. Keep the 3D models using a file structure as well (i.e manifest with link to the STEP, IGS or other files) so that the model can have version control data.

To manage and allow multiple footprints, symbols or models per partnumber is up to the PDM system capabilities

The CAD may not be able to prevent use of approved symbols, footprints or models that were approved for another partnumber in the PDM (that is a symbol of part A and footprint of part B), The backend process upon release of a design should verify the combinations upon release of the design to production. This can be done to download the netlist and parse each symbol, footprint and model and verify in the PDM if those are acceptable to use.

A symbol, footprint or model name always has a library as it's namespace. The will always be combined into one string <library>:<name>. The library will be used to insert the object in the correct local library.

Version, revision and change format are all up to the user.

All JSON fields have no limit on length or type. Just text.

No authentication. the CAD system won't handle authentication for the API,such as basic (user/password), OAuth2 client code/credentials or API-key's etc. The backend PDM,PLM,ERP, system owner is responsible to handle the security aspects. For example add the API key or session token into the request by a proxy service between the CAD and the backend system. In future version API key or user:password or OAuth2 authentication could be added as fields for requests.

A local custom made backend system to run PDM/PLM,ERP type of functions, can be created using, for example, python or NPM to translate the API request and interact with the PDM database.

Newer version fo the API will be backwards compatible with older ones. Each API request will have the version of the API the caller is using. An older or newer service will function will function with newer or older API's

Preferably the number of records return for part search API is limited between 25 and 50 records (or less). So that the user need to select the next “page” of records. More than this amount of records wont fit in a screen window so another roundtrip to the services should not cause too much problem for the user. This reduces the transaction time and load on the external service. Some external services have a day, hour or month quota for requests or even the number records returned, so this prevents to use up the quota to quickly. the CAD system could provide an option to have a larger amount records count returned per call, but it them but must then be able to cache and split of the data into pages.

The twp REST API endpoints could be:

<URI>/search (POST)
<URI>/change (POST)
<URI>/resource (GET) - for file downloads
<URI>/resource (POST) - for file uploads

and the contents is JSON

in the CAD the endpoint has following properties:

- Name
- The URI/URL
- Active/Inactive
- If the symbol, footprint can be be inserted into the CAD local libraries preferences. This to avoid unapproved data sources to be mixed with controlled symbol and footprint data on the local drive
- The footprint, symbol and model folders path or environment variable where those resources are located. This allows to separate central controlled or approved libraries from 3rd party ones.

it would be nice to have functionality for multiple alternate pin settings (configurations) for a symbol, so that the alternative pin configuration is part of the symbol file.

Time/date fields ISO8601 formatted

API and PDM can handle all languages.

Even though the fields in appended A and B start with a capital letter, the API should be case insensitive

Appendix A - Parts field names

This does not provide the schema but a recommendation for consistent naming and hierarchy to group the information of parts. The idea is to keep the data as flat as possible to make it easy readable. (M) are mandatory field everything else is optional.

The values are only for reference, value may be hard to defined. retailer and companies use their own rules. Additional names can be returned inside the groups.

A mapping function could be feature to map these fields to the ones the user prefers to use in their CAD.

For links, the CAD system uses the exact link to download (i.e: wget/curl) from the resources url . How the PDM handles a request to retrieve the file from local storage is up to the PDM. The url does not even have to be a url, just a name, or id.

Data is returned the latest version of symbols, footprints, model first. There is no linkage to limit the use of specific symbols, footprints and models

Request:

header group [M]

Version [M]	The version of API of the caller

Search group [M]

Keyword [M]	A string of words
Match	exact|like
Library	library to search in

Part group

Manufacturer	name
ManufacturerPartnumber	partnumber
Partnumber	partnumber in PDM/PLM/ERP
BOM	yes|no
Lifecycle	active|discontinued|nrnd|obsolete
Status	review|approved|disqualified|obsolete
Preferred	yes|no
Type	part|assembly
Sourcing	produced|procured
Version	version as maintain in the system
Revision	version as maintained in the system

Properties group :

Records	records per page
Pages	number of pages to return

Response:

Header group [M]

Result [M]	ok|fault
Message	
Records	number of part records returned
Version [M]	The version of the structure of the response defined in API specification

Part records

Part group

Manufacturer	name
Manufacturer-partnumber	partnumber
Partnumber	partnumber in PDM/PLM/ERP (*)
HasBOM	yes|no (if part has a BOM)
Lifecycle	active|discontinued|nrnd|obsolete
Status	review|approved|disqualified|conditional|eol
Preferred	yes|no
Type	part|assembly
Sourcing	produced|procured|subcontract
Version	version as maintain in the system
Revision	revisionass maintained in the system

(*)A part cannot be disassembled (broken) into sub-parts that can be replaced and then reconstructed by re-assembly using other parts

characteristics group

Category	capacitor resistor, inductor, resistor, transistor, optocoupler, resistor pack, bead, IC, connector, diode, zener,led, regulator, boot converter etc..
Sub-category	bipolar transistor
Series	<series of product>
Value	i.e 10-E03, 0.01 10E05, 1000
Description	<any text>
Resistance	i.e 10K
Capacitance	i.e 10uF
Inductance	i.e 0.1mH
Size	i.e LxWxHmm
Height	i.e 5cm
Width	i.e 5mm
Length	ie. 5mm
Voltage	i.e 10V
Current	i.e 5A
Power	i.e 5W
Tolerance	ie. 10ppm, 10%
ESR	ie. 90mohm
TemperatureMax	i.e. 10F, 10C
TemperatureMin	i.e. 10F, 10C
HumidityMax	i.e. 10%
HumidityMin	i.e. 10%
Case	0805, SIOC-8, SOT-23-8 ...
Orientation	horizontal|vertical|front|side|top|bottom
Ron	on resistance
Termination	smd|th
Polarity	pnp|npn|pmos|nmos
Polarized	yes|no
Technology	film|elec|mlcc
Configuration	single|quad|octal|hex|bussed|isolated|10P8R etc..

Packaging group:

Type	tube|reel|tape
Size	7”/12”

Process group:

Mounting	smd|th|hybrid
ReflowMaxTemp	temperature
ReflowMaxDuration	duration in seconds

document group:

Type	symbol|footprint|model
Name	library:name [M]
Link	link to resources file for download
Version	version
Revision	revision
Description	description
Number	an ID or the change number
Status	approved|review|deprecated

compliance group:

RoHS	rohs|rohs2
RoHSExemptions	yes|no|exempt
RoHSLink	link to rohs declaration
HGFree	yes|no
Prop65	yes|no
UL	yes|no
FCC	yes|no
CE	yes|no
TUV	yes|no
UKCA	yes|no
China-RoHS	yes|no
Automotive	yes|no
Healthcare	yes|no
Industrial	yes|no
Consumer	yes|no

Pricing and availability group:

Bracket	starting quantity
Price	i.e 11.5
Currency	ISO format
Stocked	stocked|nonstocked
Amount	current amount available

Appendix B - CAD data change management field names

Request:

Header group [M]

Version [M]	The version of API of the caller
Type [M]	create : for new items change: to change item check: to obtain status of request

document group [M]

Type [M]	symbol|footprint|model (*)
Name [M]	library:name
Link	link to resource (file) for upload
Version [M]	version
Revision [M]	revision
Description	description
Number [M]	request number
Priority	high|low|normal
Requestor	i.e email, name of employee ID

(*) This could be expanded with “file” or “design” to upload an assembly (CAD project) or individual documents to the PDM. The version could be equal to the release tag and the revision to the tag in VCS such as github and the parr group would be needed for the PDM to link the document/design to a partnumber.

Part group:

Manufacturer	name
ManufacturerPartnumber	partnumber
Partnumber	partnumber in (PDM/PLM/ERP)
HasBOM	yes|no
Type	part|assembly
Sourcing	produced|procured

Response:

Header group [M]

Result [M]	ok|fault
Message	
Status [M]	approved|review|rejected
Number [M]	request number
Details	details about the response for example comments from a rejection in the PDM or PLM workflow.
Version [M]	The version of API spec the structure defined in the specification

References and resources

[1] https://www.to-increase.com/manufacturing/blog/plm-pdm-pim-cad-mdm-connecting-to-erp

[2] https://www.solidworks.com/sw/docs/pdmvsplm_2010_eng_final.pdf

[3] https://nordicapis.com/ebooks/api-as-a-product/

[4] https://resources.pcb.cadence.com/blog/2022-the-differences-between-pdm-and-plm-software