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Pan-STARRS Project Management System

PS1-MOPS To MPC Data Export

Grant Award No.	: F29601-02-1-0268
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Document No.	: PSDC-530-007-02
Document Date	: October 19, 2007
Revision	: 02

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1 Overview

PS1-MOPS Derived Objects (DOs) and associated data will be exported to the MPC according to the criteria specified in the Pan-STARRS Data Release Policy (PSDC-530-005). MOPS software objects that are referenced during export include DerivedObjects, Orbits, Tracklets, and Detections. Data will be reported in the PS1-MOPS DES (Data Exchange Standard) format (PSDC-530-004). PS1-MOPS to MPC export will consist of two sequential processes. In the first process, exportable data is determined. Following export determination, data is exported to the MPC. Both of these processes will run for the lifetime of PS1-MOPS on a periodic schedule.

The first process determines exportable DOs. The DO is the primary reference object for the export process. On a daily basis, the MOPS database will be scanned to determine DOs meeting release criteria. Data associated with DOs include detections, tracklets and orbits. For each DO satisfying release parameters, a revision snapshot will be recorded in the database table **mpcexport**. This record will include the DO's ID. The detections for that DO will be recorded in table **mpcexport_dets**. The parent revision record will be given an export status of pending.

The second process exports the pending export records to DES format for retrieval by the MPC. For each pending revision record in **mpcexport**, the related data including an orbit along with its reportable detections, will be extracted and saved in DES format. These files will then be placed in a PS1-MOPS DataStore where they may be retrieved by the MPC via an HTTP-protocol interface. The revision record export status will then be marked as reported.

These processes are tentatively designed to be invoked on a daily basis. They will synchronize the export records with all of the exportable data in the MOPS database and export the data for retrieval by the MPC. They serve to maintain the current set of exportable data in the database along with providing data necessary for the MPC to maintain synchrony with the MOPS data set.

2 Export determination and maintenance

The determination of the exportability of a DO is based on whether the data for that object satisfies export criteria. This is determined by a software implementation of the PS Data Release Policy. The set of export data requires maintenance as detections will be added and removed from DOs. By creating revision records for every set of detections to be exported, the set of exportable detections may be synchronized with the detections in the MOPS database. New detections that are added to an object are added to the export set. Detections that are removed from the database will be flagged for removal.

3 Data export

Data will be exported to the MPC in DES format via a DataStore interface. Export files will consist of text files formatted according to the guidelines specified in the Data Exchange Standard. These files will be placed on a server implementing a DataStore interface. The individual files will be bundled using standard archive utilities. Data verification will be provided by the particular archive tool that is used. The MPC will be able to retrieve the archived files through the DataStore. The

DataSource connection is able to be encrypted. The server hosting the DataSource may require an SSH tunnel to be accessed. It is intended that all data transfer will occur via an encrypted connection.

4 Implementation

4.1 Determining exportable data

The criteria for exportable data are defined in the data release policy and include orbit quality, number of observations, number of lunations, number of oppositions and object class. The release schedule for objects varies according to the object's class. Each DO will be analyzed by calling library routines that implement the data release criteria. For DOs that satisfy release criteria, their associated detections are considered exportable. These exportable detections are compared with the corresponding set of export detections, if it exists. This allows for the maintenance of a current set of exportable detections.

4.2 Maintaining export data

In general, the database records for MPC export serve as a revision tracking system. Their purpose is to provide a means of incrementally synchronizing the set of exported data with the MPC as changes occur over time. This is accomplished by maintaining a history of revisions necessary to produce a set of exportable data for any particular export time. In the initial state of MPC export, no exportable data will be recorded. Every existing DO may then be analyzed for release. For suitable DOs, their detections will be added to table `mpcexport_dets`. During subsequent analyses of DOs, detections may or may not change for a given DO.

The algorithm for MPC export data maintenance, illustrated in Figure 1, is for each DO satisfying release criteria, if the DO is not in table `mpcexport` or has updated data, then it is recorded in the table in a revision record. The set of exportable detections is retrieved for the DO. The detections are compared with the existing set of detections in `mpcexport_dets`. If no detections are present, then all of the exportable detections are added to `mpcexport_dets`. If detections exist for the DO in `mpcexport_dets`, then the exportable detections will be compared with the pre-existing export detections. If a detection is new, it will be added to the export set. If a detection exists in the export set, but is not present in the current set of exportable detections, it will be marked for removal.

During the analysis of each DO, it is necessary to retrieve the full export set for comparison. The revision recording algorithm as described provides for data storage savings at the expense of computation time during the rebuilding of export sets. Each export set, during set comparison, requires its re-creation from the revision records stored in the database. This amounts to performing the recorded additions and removals from the export data set. At the end of an MPC export invocation, the export detection set and the exportable MOPS detection set should be synchronized.

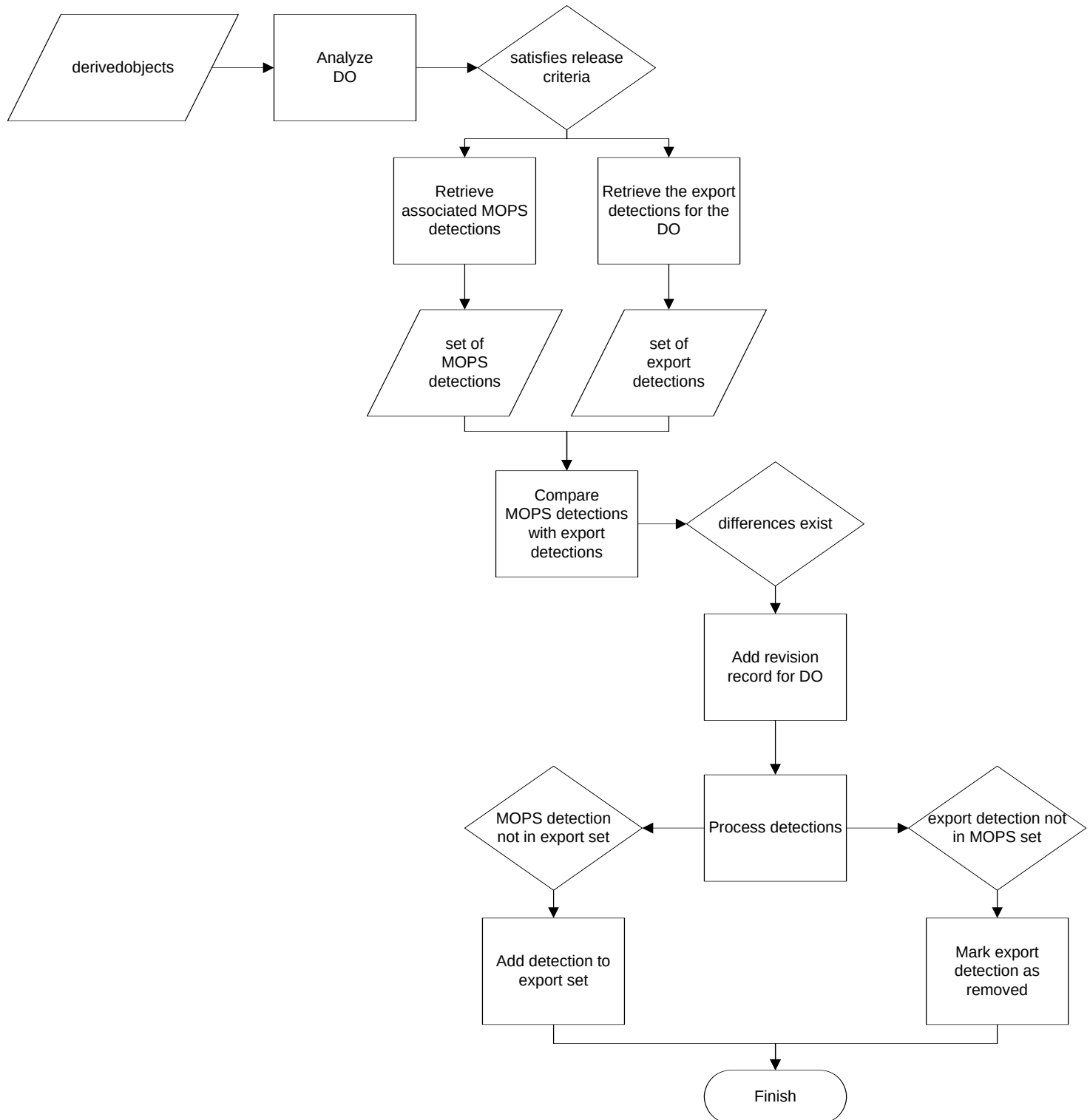


Figure 1: Flowchart for maintaining export data. The paths shown are for affirmative evaluations in the decision diamonds. From table `derivedobjects`, each DO is analyzed. If the DO satisfies release criteria, then the set of MOPS detections and the set of export detections are retrieved. These sets are compared. If differences exist, a revision record is added to table `mpcexport`. If the detection is not in `mpcexport_dets`, it is considered new and added to the table. If there is a `mpcexport_det` detection that is not in the MOPS detection set, then that detection will be marked for removal.

4.3 Handling updates to DOs

As new tracklets become available for existing DOs, their associated orbits will be recalculated. These updates are managed through the end-of-night (EON) processing. DOs that have updated data are placed in the EON queue. At this point, the MPC export process will be invoked to update the export records. For each DO in the EON queue, the existing detections will be compared with the export detections. Any changes to the detections will be handled by the maintenance protocol previously described.

4.4 Data verification and redundancy

By design, synchronization between the MOPS detections and the export detections is maintained after every MPC export process invocation. The export data may be verified by comparing it to the MOPS data. For the purpose of redundancy, a separate log file will be maintained that will record every action performed on the export data tables. This will allow for the verification of the data should the database become corrupted. It should also allow for the rebuilding of the export data set.

4.5 Exporting data

The data associated with DOs to be exported will be formatted in the PS1 DES format. The current calculated orbit for a particular DO, at the time of the preparation of this data, will be exported along with the set of detections previously recorded in `mpcexport_dets`. The export data will also include corrections to previously submitted data in the form of detections flagged for removal by the MPC. It is intended that all data transfers will occur over secure connections.

4.5.1 DataStore access

During development of the export process, data will be copied to a DataStore that may be accessed via HTTP. Data export will likely occur at 24-hour intervals. After a certain period of time, the files will expire and be removed from the DataStore. The MPC may configure their retrieval schedule according to the available data window.

4.5.2 File format

Data will be exported in ASCII text files with space-delimited data columns. Each file will contain one type of data with one data item per line. Column format templates are given below. A brief description of the column and its units, if applicable, is listed after the format template. The formats being used are intermediate formats that roughly implement the DES. They are subject to change with further development.

4.5.2.1 Detection column template

```
do_id det_id epoch ra dec mag filter obscode raSigma decSigma magSigma s2n removal
```

do_id MOPS unique Derived Object ID. Not part of the DES.

det_id MOPS unique Detection ID. Not part of the DES.

epoch Epoch (MJD).

ra Right ascension (deg).

dec Declination (deg).

mag Apparent magnitude.

filter Filter type.

obscode MPC observatory code.

raSigma Error in right ascension.

decSigma Error in declination.

magSigma Error in magnitude.

s2n Signal-to-noise ratio.

removal Detection no longer associated with the DO in the MOPS database.

4.5.2.2 Orbit column template

```
do_id orbit_id orbit_type q e i node argPeri timePeri hv epoch
```

do_id MOPS unique Derived Object ID. Not part of the DES.

orbit_id MOPS unique Orbit ID. Not part of the DES.

orbit_type Value of COM. Orbit data will be reported in cometary format as described in the DES.

q Perihelion (AU).

e Eccentricity.

i Inclination (deg).

node Longitude of node (deg).

argPeri Argument of perihelion (AU).

timePeri Time of perihelion (MJD).

hV Absolute magnitude.

epoch Epoch (MJD).

4.5.3 File naming scheme

Exported files will be named according to the following template,

yyyymmdd_hhmmss-{data type}-nnn.txt

where yyyy is the four-digit year, mm is the month number, dd is the day number, hh is the hour, mm is the minute, ss is the second, data type is either 'detections' or 'orbits' and nnn is the file number for this particular sequence. All numerical values will be zero-padded. File numbers begin with 001 and advance sequentially. Multiple file numbers exist so that large files may be split into smaller files circumventing file system limitations. The time indicated in the filename corresponds to the time of the last pending revision record in the data set being exported. Current split limits are 250,000 lines per detection file and 250,000 lines per orbit file.

4.6 Program files

MPC export is implemented as a Perl module named PS::MOPS::DC::MPCEXport and a Perl script named mpc-export.pl that uses the library module.

4.7 Database schema

The MPC export process is accomplished by the addition of two tables to the PS1-MOPS database. These tables are named mpcexport and mpcexport_dets. They respectively contain the DO IDs and detection IDs for objects that will be exported to the MPC. These tables and their relationships are diagrammed in Figure 2. The table definitions are documented in Tables 1 and 2. These tables have foreign key relationships with tables derivedobjects and detections. Once records are added they are not intended to be modified or deleted except to update export status and export time.

5 Summary

PS1-MOPS to MPC export will consist of two sequential processes. Derived objects will be scanned to determine if they are exportable. For those that satisfy export requirements, as detailed in the PS1-MOPS Data Release Policy, a revision record will be written to table mpcexport and they will be marked as pending for export. Pointers to the detections

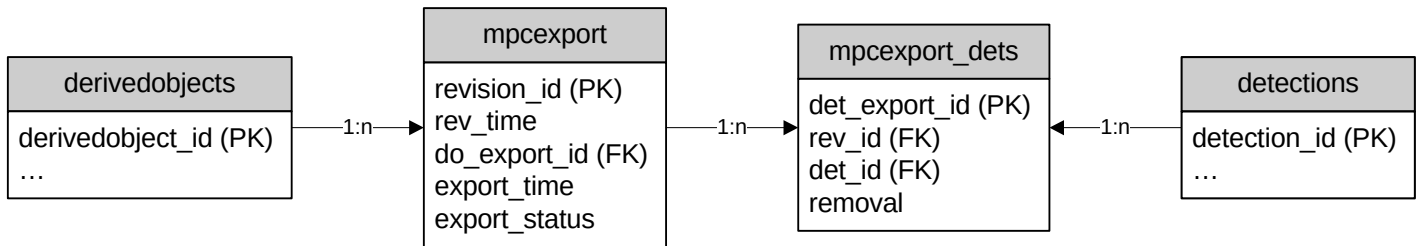


Figure 2: Database schema diagram for MPC export. The two tables that are added to implement MPC export are **mplexport** and **mplexport_dets**. The table **mplexport** contains derived object IDs along with a revision ID to be used for grouping detection sets. Detection IDs are found in table **mplexport_dets**. This table includes a column to indicate that a detection should be removed by the MPC. References to tables **derivedobjects** and **detections** are included to note their relationship with the export tables.

Table 1: Table definition for **mplexport**. Records in this table serve to group detection set snapshots or revisions. Each DO has a set of detections associated with it. The exportable set of detections are stored in **mplexport_dets**.

Column	Type	Size (bytes)	Description
revision_id	bigint	8	Primary key. Used to group detection sets.
rev_time	datetime	8	Time of addition of revision record.
do_export_id	bigint	8	Derived object ID. Foreign key from derivedobjects .
export_time	datetime	8	Time of export.
export_status	char	8	Indicates state of export. {P $\implies$ pending, E $\implies$ exported}

Table 2: Table definition for **mplexport_dets**. This table contains the sets of detections that are associated with the DO references in **mplexport**. The column named **removal** indicates that a particular detection is flagged for removal by the MPC.

Column	Type	Size (bytes)	Description
det_export_id	bigint	8	Detection ID. Foreign key from detections .
rev_id	bigint	8	Foreign key from mplexport .
det_id	bigint	8	Foreign key from detections .
removal	char	8	Indicates that detection should be removed by the MPC.

associated with the DO will be added to `mpcexport_dets`. If there are changes in the detections for an existing exportable DO, then the changes in the detections for that DO will be recorded. Those detections requiring removal by the MPC will be appropriately annotated. Subsequently, the associated data of the DOs—to include orbits, tracks, and detections—will be exported to the MPC in the PS1-MOPS DES format. This data will be made available through a DataStore interface allowing retrieval by the MPC over an encrypted HTTP connection. The MPC may develop their own schedule for the processing of the data. The MPC export process facilitates the timely export of high-quality MOPS data to the MPC and provides for its synchronization with the MPC over the lifetime of PS1.