

UNIVERSITY OF HAWAII AT MĀNOA

Institute for Astronomy

Pan-STARRS Project Management System

IPP-MOPS ICD

Pan-STARRS IPP-MOPS ICD for PS-1

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02	2011 Apr 19	Synchronization with "ICD Lite" wiki page
01	2010 Oct 27	New CMF Parameters
00	2006 Mar 01	Initial version

Referenced Documents

Internal Documents

Reference	Title
PSDC-230-001	PS-1 Design Reference Mission
PSDC-430-011	Pan-STARRS PS-1 IPP System/Subsystem Design Description
PSDC-510-001	Pan-STARRS PS-1 MOPS System Concept Definition
PSDC-530-003	Pan-STARRS PS-1 MOPS Software Design Description

External Documents

Reference	Title
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1 Scope

1.1 Identification

This document defines the interface between the Image Processing Pipeline (IPP) and Moving Object Processing System (MOPS) for the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) for the prototype telescope PS-1, and is a System-level controlled specification/design description document in the official Pan-STARRS engineering specification tree.

1.2 System Overview

The Institute for Astronomy at the University of Hawai‘i is developing a large optical synoptic survey telescope system, the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS). The science goals, priorities, top-level concept of operations with associated operational requirements, and system performance drivers with associated system performance requirements are described in the Pan-STARRS Science Goals Statement (SGS). As described in this document, The system conceptual design for Pan-STARRS utilizes an array of four 1.8m telescopes each with a 7 degree² field of view, giving the system an étendue larger than all existing survey instruments combined (defined as the product of the collecting area A multiplied by the field-of-view solid angle Ω). Each telescope will be equipped with a 1 billion pixel CCD camera with low noise and rapid read-out, and the data will be reduced in near real time to produce both cumulative static sky and difference images from which transient, moving, and variable objects can be detected. Pan-STARRS will be able to survey up to $\approx 6,000$ degree² per night to a detection limit of approximately 24th magnitude. This unique combination of sensitivity and sky coverage will open up many new possibilities in time domain astronomy including a major goal of surveying the Potentially Hazardous Object (PHO) population down to a diameter of ≈ 300 meters. In addition, the Pan-STARRS data will be used to investigate a broad range of astronomical problems of extreme current interest concerning the Solar System, the Galaxy, and the Cosmos at large. A prototype single telescope system, PS-1, is being developed as a preliminary step before construction of the complete four telescope system.

Project sponsor: AFRL, United States Air Force
Acquirer: University of Hawaii Institute for Astronomy
User: Astronomical community
Developer: University of Hawaii Institute for Astronomy, participating institutions, and associated subcontractors

1.3 Document Overview

This document identifies the interface between the IPP and MOPS subsystems of the Pan-STARRS PS-1 Telescope.

2 Referenced Documents

2.1 Internal Documents

Reference	Title
PSDC-230-001	PS-1 Design Reference Mission
PSDC-230-002	PS-1 System Concept Definition

2.2 External Documents

Reference	Title
POSIX Standard	Open Group Based Specifications Issue 6, IEEE Std 1003.1, 2003
FITS Standard	Definition of the Flexible Image Transport System (FITS), March 29, 1999, NOST 100-2.0

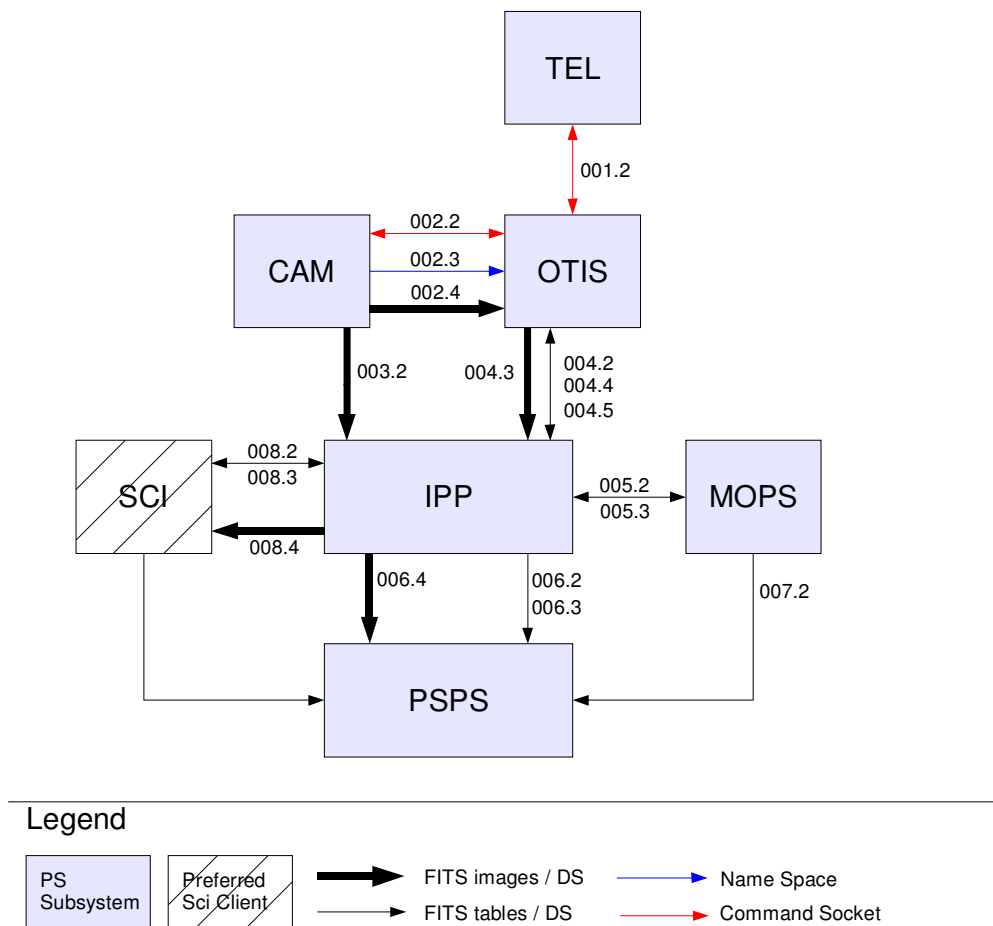


Figure 1: Overview of Pan-STARRS Software Interfaces.

3 Interface Overview

3.1 Pan-STARRS Software Interfaces

The Pan-STARRS PS-1 Telescope system has multiple subsystem-to-subsystem interfaces, illustrated in Figure 1. The subsystem-to-subsystem interfaces are each documented in separate documents. The interface numbers refer to the Pan-STARRS Document Control numbering scheme for the interface documents. All Interface Control Documents are numbered PSDC-940-XXX-VV, while all Interface Requirements Specifications are numbered PSDC-930-XXX-VV, where XXX is the number listed above and VV is a document version number. Table 1 lists the organizational structure of all Pan-STARRS interfaces, giving the corresponding interface number listed in Figure 1, the group of data being transferred (the assembly), the method in which the data is formatted (packing), and the data transfer method (protocol).

This document discusses the software interface between IPP and MOPS. IPP must send transient detection descriptions to the MOPS; MOPS must be able to query the IPP regarding whether a particular (RA, Dec) pair could have been detected in a particular focal plane array (FPA). This document defines the data to be transferred between IPP and MOPS and the mechanisms to be used for that interchange. These interfaces are identified as #005 in Figure 1. The Interfaces addressed by this document are marked in the table.

Table 1: Pan-STARRS Interface Data Organization

Interface #	Assembly	Packaging	Protocol
001.2	Telescope Commands	EOST Command Language	Command Socket
002.2	Camera Commands	Conductor Command Language	Command Socket
002.3	Camera Status	???	Shared Name Space
002.4	IQ Images	FITS Images	Data Store
003.2	GPC Images & Metadata	FITS Images & Headers	Data Store
004.2	OTIS Metadata	FITS Tables	Data Store
004.3	ISP Images & Metadata	FITS Images & Headers	Data Store
004.4	Reference Star Catalog	FITS Tables	Data Store
004.5	Focal Plane Layout	FITS Tables	Data Store
005.2	Detections	FITS Tables	Data Store
005.3	Test Positions	FITS Tables	Data Store
006.2	Detections	FITS Tables	Data Store
006.3	Metadata	FITS Tables	Data Store
006.4	Images	FITS Tables	Data Store
007.2	Orbits & Detections	FITS Tables	Data Store
008.2	Detections	FITS Tables	Data Store
008.3	Metadata	FITS Tables	Data Store
008.4	Images	FITS Tables	Data Store

Layers of network communications are often classified using the OSI Reference Model. When addressing network connectivity between subsystem interfaces, this Interface Control Document is primarily concerned with two highest layers of the interface communication: the presentation layer, or how the data is packaged, and the application layer, or the high-level details of the data contents. The lower layers of the network communication in the OSI model are addressed briefly below.

The leased line between the IPP and MOPS is currently expected to have a practical maximum sustainable throughput of 50Mbps/s, since the systems will be connected through the University of Hawaii ITS network. Higher and lower bit rates are available, and the cost differences are quite significant.

3.1.1 Physical Layer

MOPS and IPP will each be connected to local inbound and outbound hardware interfaces at rates of no less than 1Gbit/sec using fiber or twisted pair and onboard NICs where possible.

3.1.2 Data Link Layer

The endpoints of the route between IPP and MOPS will be Gigabit Ethernet with normal (1500 byte) max. transmission units (MTU).

3.1.3 Network Layer

Internet Protocol v4 will be used. Data Store's HTTP server will have an IP address visible (routable) to IPP.

3.1.4 Transport Layer

TCP will be used on top of IPv4.

3.1.5 Session Layer

IPP-MOPS communication will take place entirely via the Data Store mechanism.

3.1.6 Presentation Layer

All data exchanged between IPP and MOPS will be in the form of FITS Tables and FITS images.

The primary header will not contain any information beyond that written automatically by cfitsio, and is present only for compliance with the FITS standard.

Though efforts have been made to avoid this from occurring, where header keyword names are longer than the usual 8 character maximum, the HIERARCH convention will be used.

3.2 IPP-MOPS Exchange

MOPS requires from the IPP a stream of transient detections and their FPA metadata obtained from processing of difference images acquired by the PS-1 camera. IPP is additionally required by MOPS to be able to indicate whether a set of detections (with RA, Dec, flux, length, orientation, etc.) on a previously acquired FPA was detectable by the PS-1 telescope.

3.2.1 Conventions

3.2.1.1 Celestial coordinates are in ICRS;

3.2.1.2 Magnitudes are AB magnitudes (flux zero point is 3631 Jy);

3.2.1.3 Unless otherwise noted, error values are statistical only, and include no contribution by systematic errors.

3.2.2 Transient Detection and Metadata Exchange

Transient detections and their metadata are assembled nightly into FITS files, one file per FPA. IPP will submit outgoing data into the IPP-MOPS outbound datastore. Metadata for the detections belonging to a FPA will be described in the file's FITS headers, and detection data will be listed in a subsequent FITS BINTABLE table in the same file.

Each column in the FITS table shall correspond to a detection attribute. The data type of a FITS column shall be chosen to represent the attribute without loss of information.

The FITS table will include all detections within an exposure.

Duplicates from overlapping skycells will have been filtered out by IPP, with the measurements from the source closest to the centre of a skycell included (and all others discarded).

3.2.3 Detectability

MOPS will need to query the IPP periodically to inquire whether a particular elongated trailed detection specified by a $(RA_0, Dec_0, Time_0, RA_1, Dec_1, Time_1)$ tuple was detectable by the PS-1 telescope. This query is important in evaluating “non-detections,” or failures of MOPS to locate predicted detections of a known object, and for accurate simulation of detections of synthetic objects that are injected into the MOPS pipeline to measure efficiency.

MOPS will assemble a list of (RA, Dec, Time) tuples in a single FITS file and submit them to the MOPS-IPP outgoing datastore. Later MOPS will poll the IPP datastore for results of this query. If results of a query do not appear after a pre-configured timeout, an operator is notified.

3.2.4 Table Description Files

FITS tables generated by IPP or MOPS shall be described by table description files. These files shall be controlled by CVS, with the authoritative versions of these files being the ones contained in Appendix A of this document. FITS header data units (HDUs) which do not conform to the corresponding table description files shall be rejected by the receiver, and the ingest software shall notify an operator about the error.

In addition to the required keywords specified in the FITS standard for a BINTABLE extension, each FITS HDU shall have the following keywords:

- EXTNAME - Giving a unique name for the metadata table. Such a name shall contain only the characters a-z, and “_”.
- CMFVERSION - A string specifying the version of the table description file for this table.

The format of the metadata tables is described in the following sections.

3.2.5 Fields in Table Description Files

The IPP software generating the FITS tables may change. Parameters, i.e. columns in FITS tables, may also be added requiring changes both in ICD and in software. To keep track of such changes, a Version will be assigned to each keyword in the tables descriptions.

To improve the readability, we will use the following conventions for the Version:

- X+ (where X is a software version) Means that the keyword appears from software version X until the current version.
- X (not used): Means that the keyword appears in FITS file only in software version X.
- Version 0 (zero) is the version in the preliminary ICD (Version 00 of this document). Some keywords (e.g. RA_SIG) appear only in the preliminary ICD. They were renamed in software version 1.

3.2.6 ICD/Software Versions

Version	ICD Version	Software Version	Software Tag	Comment
0	00	0	n/a	Preliminary ICD. No sw tag
1	01	1	20100823	First software release
2	01	2	20101029	"V2" software version
3	02	2	20110406	Deletion of "ICD lite" wiki page

3.2.7 Transfer via Data Store

The FITS files containing metadata shall be transferred using the protocol described in [Data Store doc]. There will be one instance of a datastore within IPP that will be used to submit transient detections and results of detectability queries to MOPS, and another instance residing within MOPS to submit detectability requests to the IPP.

During a datastore transaction, the "sender" places a file into the datastore with a unique transfer ID. The "receiver" must regularly poll the datastore to detect new FITS files. The receiver then downloads each file from a URL provided by the Data Store interface. The receiver is responsible for managing which files it has already downloaded. Files remain in the datastore for a preset period of time and then are deleted without warning. If a file transfer fails, the receiver may retry the transfer. If a retry fails, the failure must be resolved by operator intervention.

The data transfers will have the following parameters:

Table 2: Data transfer parameters

Parameter	IPP to MOPS	MOPS to IPP
Dump interval	Per FPA	Per FPA
Max polling Interval	60s	60s
File Lifetime	30 days	10 days
Datastore location	IPP	MOPS

3.3 Transient Detection List

IPP will submit all transient detections per FPA and their associated metadata in a single FITS file. The metadata will be placed in FITS header data unit (HDU) key-value pairs, and the detection attributes will be placed in the associated FITS table following the header. All time-dependent table values shall be provided at the midpoint of the exposure.

In addition to the required BINTABLE extension header keywords described above, the FITS header shall include the keywords shown in table 3. The subsequent FITS table, with EXTNAME of MOPS_TRANSIENT_DETECTIONS, shall include columns whose definitions are listed in table 5.

Table 3: IPP-MOPS Transient Detection Keywords

FITS Keyword	Version	Precision	Description
Version Information			
SWSOURCE	1+	string	source of software (e.g., "60eb6cdc-a59c-4636-a4e0-dba66a9721fd")

SWVERSN	1+	string	version of software (e.g., "trunk/ppMops@24658")
HIERARCH_CMFVERSION	2+	char(7)	Either PS1_DV1 or PS1_DV2
TABLEVER	0+	-	<i>Obsolete.</i> Replaced by SWSOURCE, SWVERSN ¹
Provenance Information			
EXP_NAME	1+	string	Exposure name (e.g., "o1234g5678")
EXP_ID	1+	S64	Exposure identifier
CHIP_ID	1+	S64	Chip stage identifier
CAM_ID	1+	S64	Camera stage identifier
FAKE_ID	1+	S64	Fake stage identifier
WARP_ID	1+	S64	Warp stage identifier
DIFF_ID	1+	S64	Diff stage identifier
DIFF_POS	1+	boolean	Sense of subtraction; T for forward, F for backward
FPA_ID	0	char(20)-	<i>Obsolete.</i> IPP-assigned identifier that can be used to trace back to this FPA ²
Exposure Details			
MJD-OBS	0+	F64	midpoint time of the exposure as a MJD and day fraction
RA	0+	HH:MM:SS.SSS	field center RA at exposure midpoint, string
DEC	0+	sDD:MM:SS	(s is + or -) field center declination at exposure midpoint, string
EXPTIME	0+	F64	exposure time in seconds
ROTANGLE	0+	F64	image rotation of the y-axis in degrees, from local N toward E
FILTER	0+	char(3)	effective filter used for the exposure, one of g, r, i, z, y, B, V, w appended with '.00000'
AIRMASS	0+	F64	airmass at exposure midpoint
OBSCODE	0+	char(5)	MPC three-character observatory code
TEL_ALT	0+	F64	telescope altitude at exposure midpoint, in degrees
TEL_AZ	0+	F64	telescope azimuth at exposure midpoint, in degrees
SEEING	1+	F32	Measured seeing at diff stage, arcsec
MAGZP	1+	F32	Magnitude zero point
MAGZPERR	1+	F32	Error in magnitude zero point
ASTRORMS	1+	F32	RMS of astrometric fit, arcsec
LIMITMAG	0	F64-	<i>Obsolete.</i> limiting magnitude of detections for this FPA ³

Table 5: IPP-MOPS Transient Detection Table Columns

Column	Version	Precision	Description
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¹This entry should be removed in ICD version 04

²This entry should be removed in ICD version 04

³This entry should be removed in ICD version 04

RA_DEG	0	F64	<i>Obsolete.</i> Detection center coordinates in degrees ⁴
RA	1+	F64	detection center coordinates in degrees
RA_SIG	0	F64	<i>Obsolete.</i> Error in the detection center, in degrees ⁵
RA_ERR	1+	F64	error in the detection center, in degrees
DEC_DEG	0	F64	<i>Obsolete.</i> Detection center coordinates in degrees ⁶
DEC	1+	F64	detection center coordinates in degrees
DEC_SIG	0	F64	error in the detection center, in degrees
DEC_ERR	1+	F64	error in the detection center, in degrees
MAG	1+	F32	Magnitude
MAG_ERR	1+	F32	Magnitude error
FLUX	0	F64	flux
FLUX_SIG	0	F64	error in the flux value
STARPSF	0	F64	probability that the PSF matches a starlike PSF
ANG	0	F64	detection's elongation angle in degrees, local N toward E
ANG_SIG	0	F64	error in the angle, in degrees
LEN	0	F64	elongation length of the detection in degrees
LEN_SIG	0	F64	error in the length, in degrees
PSF_CHI2	1+	F32	χ^2 of PSF fit
PSF_DOF	1+	S32	Degrees of freedom of PSF fit
CR_SIGNIFICANCE	1+	F32	Significance of CRSC: CR?
EXT_SIGNIFICANCE	1+	F32	Significance of extendedness
PSF_MAJOR	1+	F32	PSF major axis (pixels)
PSF_MINOR	1+	F32	PSF minor axis (pixels)
PSF_THETA	1+	F32	PSF position angle (deg on chip)
PSF_QUALITY	1+	F32	PSF quality factor
PSF_NPIX	1+	S32	Number of pixels in PSF
MOMENTS_XX	1+	F32	xx moment
MOMENTS_XY	1+	F32	xy moment
MOMENTS_YY	1+	F32	yy moment
FLAGS	1+	U32	Detection bit flags
SC: Bits should be detailed in ICD?			
DIFF_SKYFILE_ID	1+	S64	Identifier for diff skyfile
N_POS	1+	S32	Number of positive pixels
F_POS	1+	F32	Fraction of positive pixels
RATIO_BAD	1+	F32	Ratio of positive pixels to negative
RATIO_MASK	1+	F32	Ratio of positive pixels to masked
RATIO_ALL	1+	F32	Ratio of positive pixels to all
IPP_IDET	2+	U32	IPP detection identifier index
PSF_INST_FLUX	2+	F32	PSF fit instrumental magnitude
PSF_INST_FLUX_SIG	2+	F32	Sigma of PSF instrumental magnitude
AP_MAG	2+	F32	magnitude in standard aperture
AP_MAG_RAW	2+	F32	magnitude in real aperture

⁴This entry should be removed in ICD version 04

⁵This entry should be removed in ICD version 04

⁶This entry should be removed in ICD version 04

AP_MAG_RADIUS	2+	F32	radius used for aperture mags
AP_FLUX	2+	F32	instrumental flux in standard aperture
SC: Was it FLUX in version 0?			
AP_FLUX_SIG	2+	F32	aperture flux error
SC: FLUX_SIG in version 0?			
PEAK_FLUX_AS_MAG	2+	F32	Peak flux expressed as magnitude
CAL_PSF_MAG	2+	F32	PSF Magnitude using supplied calibration
CAL_PSF_MAG_SIG	2+	F32	measured scatter of zero point calibration
SKY	2+	F32	Sky level
SKY_SIGMA	2+	F32	Sigma of sky level
PSF_QF_PERFECT	2+	F32	PSF coverage/quality factor (poor)
MOMENTS_R1	2+	F32	first radial moment
MOMENTS_RH	2+	F32	half radial moment
KRON_FLUX	2+	F32	Kron Flux (in 2.5 R1)
KRON_FLUX_ERR	2+	F32	Kron Flux Error
KRON_FLUX_INNER	2+	F32	Kron Flux (in 1.0 R1)
KRON_FLUX_OUTER	2+	F32	Kron Flux (in 4.0 R1)
DIFF_R_P	2+	F32	distance to positive match source
DIFF_SN_P	2+	F32	signal-to-noise of pos match src
DIFF_R_M	2+	F32	distance to negative match source
DIFF_SN_M	2+	F32	signal-to-noise of neg match src
FLAGS2	2+	U32	psphot analysis flags (group 2)
SC: Bits should be detailed in ICD?			
N_FRAMES	2+	U16	Number of frames overlapping source center
PADDING	2+	S16	padding

SC: I didn't change anything from this point till the end

3.4 MOPS Detectability Query

MOPS will query the IPP regarding the detectability of hypothetical elongated detections specified using $(RA_0, Dec_0, Time_0, RA_1, Dec_1, Time_1)$ tuples by submitting all information required to construct a FPA PSF at the time of the detections. It is the responsibility of MOPS to generate and manage unique query IDs.

All MOPS detectability queries will occur with respect to an already-ingested FPA transient detection list. The query being asked by MOPS is essentially whether a particular trail in an acquired FPA image was masked for any reason and to what degree. Thus the originating IPP FPA_ID is required.

MOPS will simulate elongated (“trailed”) PSFs, relevant for fast-moving objects. Since some or all of a trail may be masked, MOPS will for all detections provide starting and ending RA and Dec. For most detections these two positions will be nearly coincident, appearing as a circular point-source PSF, but for fast-moving objects these positions may differ by many pixels in the FPA.

In addition to the required BINTABLE extension header keywords described above, the FITS header for the detectability query shall include the following required keywords shown in table 7. The subsequent FITS table, with EXTNAME of MOPS_DETECTABILITY_QUERY, shall include columns whose definitions are listed in table 8.

Table 7: MOPS-IPP Detectability Query Keywords

Column	Precision	Description
QUERY_ID	char(20)	MOPS query ID for this batch query
FPA_ID	char(20)	original FPA_ID used at ingest
MJD-OBS	F64	starting time of the exposure, MJD
FILTER	char(3)	effective filter used for the exposure as a string, allowed values of g, r, i, z, y, B, V, w
OBSCODE	char(3)	site identifier (MPC observatory code)

Table 8: MOPS-IPP Detectability Query Table Columns

Column	Precision	Description
ROWNUM	char(20)	identifier for this row in the table
RA1_DEG	F64	coordinate at the start of exposure, in degrees
DEC1_DEG	F64	coordinate at the start of exposure, in degrees
RA2_DEG	F64	coordinate at the end of exposure, in degrees
DEC2_DEG	F64	coordinate at the end of exposure, in degrees
MAG	F64	apparent magnitude

3.5 IPP Detectability Response

IPP will return a table listing the submitted query detections and a pair of values (N, f) indicating the number of pixels relevant to the detection's PSF and a fraction of pixels detectable by IPP.

For infrequent cases where a trail may completely traverse a masked area (due to chip gap, streak removal, or similar), the response may be erroneous or incomplete. This error and its effects will be studied during PS-1 operations.

In addition to the required BINTABLE extension header keywords described above, the FITS header for the detectability response shall include the following required keywords shown in table 9. The subsequent FITS table, with EXTNAME of MOPS_DETECTABILITY_RESPONSE, shall include columns whose definitions are listed in table 10.

Table 9: MOPS-IPP Detectability Response Keywords

Column	Precision	Description
QUERY_ID	char(20)	originating MOPS query ID
FPA_ID	char(20)	IPP FPA ID used in detectability request

Table 10: MOPS-IPP Detectability Response Table Columns

Column	Precision	Description
ROWNUM	char(20)	matching rownum from original request
DETECT_N	U32	number of pixels used in the hypothetical PSF for the query detection
DETECT_F	F64	detectability, indicating the fraction of PSF pixels detectable by IPP

A Appendix

A.1 IPP to MOPS

Table 11: IPP-MOPS FITS Table Description Files

Table Name	EXTNAME	Description
Transient Detections	MOPS_TRANSIENT_DETECTIONS	list of transient detections for an FPA
Detectability Query Result	MOPS_DETECTABILITY_RESPONSE	table of detectability values in response to query

A.2 MOPS to IPP

Table 12: MOPS-IPP FITS Table Description Files

Table Name	EXTNAME	Description
Detectability Query	MOPS_DETECTABILITY_QUERY	table of detectability query tuples (RA, Dec, FPA)

A.3 Acronyms

Table 13: Acronyms used in this document

Acronym	Definition
MOPS	Pan-STARRS Moving Object Processing System
IPP	Pan-STARRS Image Processing Pipeline
FPA	Focal plane array
MPC	Center for Astrophysics Minor Planet Center

A.4 Limitations

- The IPP is not yet calculating detection efficiencies (it is still being developed). Further, it is not yet clear how to merge the detection efficiency measurements for different skycells. Until these issues are resolved, the detection efficiency values will be fake (Expected fields: DE_MAGnn (F32): Magnitude (calibrated) for detection efficiency; DE_EFFnn (F32): Detection efficiency (0..1)).
- ANGLE, ANGLE_SIG, LENGTH, LENGTH_SIG removed; these can be calculated from the moment;
- FLUX, FLUX_SIG renamed MAG, MAG_ERR since IPP writes magnitudes;
- FLAGS added to allow additional weeding out of bad detections;
- DIFF_SKYFILE_ID added to allow trace back to IPP diff skyfile, for postage stamps;
- STARPSF renamed EXT_SIGNIFICANCE to be more clear

A.5 Example

```
XTENSION= 'BINTABLE'           / binary table extension
BITPIX   =      8              / 8-bit bytes
NAXIS    =      2              / 2-dimensional binary table
NAXIS1   =     120             / width of table in bytes
NAXIS2   =    42032            / number of rows in table
PCOUNT   =      0              / size of special data area
GCOUNT   =      1              / one data group (required keyword)
TFIELDS  =     25              / number of fields in each row
TTYPE1   = 'RA'                / label for field 1
TFORM1   = '1D'                / data format of field: 8-byte DOUBLE
TTYPE2   = 'RA_ERR'            / label for field 2
TFORM2   = '1D'                / data format of field: 8-byte DOUBLE
TTYPE3   = 'DEC'               / label for field 3
TFORM3   = '1D'                / data format of field: 8-byte DOUBLE
TTYPE4   = 'DEC_ERR'           / label for field 4
TFORM4   = '1D'                / data format of field: 8-byte DOUBLE
TTYPE5   = 'MAG'               / label for field 5
TFORM5   = '1E'                / data format of field: 4-byte REAL
TTYPE6   = 'MAG_ERR'           / label for field 6
TFORM6   = '1E'                / data format of field: 4-byte REAL
TTYPE7   = 'PSF_CHI2'          / label for field 7
TFORM7   = '1E'                / data format of field: 4-byte REAL
TTYPE8   = 'PSF_DOF'           / label for field 8
TFORM8   = '1J'                / data format of field: 4-byte INTEGER
TTYPE9   = 'CR_SIGNIFICANCE'   / label for field 9
TFORM9   = '1E'                / data format of field: 4-byte REAL
TTYPE10  = 'EXT_SIGNIFICANCE'  / label for field 10
TFORM10  = '1E'                / data format of field: 4-byte REAL
TTYPE11  = 'PSF_MAJOR'         / label for field 11
TFORM11  = '1E'                / data format of field: 4-byte REAL
TTYPE12  = 'PSF_MINOR'         / label for field 12
TFORM12  = '1E'                / data format of field: 4-byte REAL
TTYPE13  = 'PSF_THETA'         / label for field 13
TFORM13  = '1E'                / data format of field: 4-byte REAL
TTYPE14  = 'PSF_QUALITY'       / label for field 14
TFORM14  = '1E'                / data format of field: 4-byte REAL
TTYPE15  = 'PSF_NPIX'          / label for field 15
TFORM15  = '1J'                / data format of field: 4-byte INTEGER
TTYPE16  = 'MOMENTS_XX'        / label for field 16
TFORM16  = '1E'                / data format of field: 4-byte REAL
TTYPE17  = 'MOMENTS_XY'        / label for field 17
TFORM17  = '1E'                / data format of field: 4-byte REAL
TTYPE18  = 'MOMENTS_YY'        / label for field 18
TFORM18  = '1E'                / data format of field: 4-byte REAL
TTYPE19  = 'N_POS'             / label for field 19
TFORM19  = '1J'                / data format of field: 4-byte INTEGER
TTYPE20  = 'F_POS'             / label for field 20
TFORM20  = '1E'                / data format of field: 4-byte REAL
TTYPE21  = 'RATIO_BAD'         / label for field 21
TFORM21  = '1E'                / data format of field: 4-byte REAL
TTYPE22  = 'RATIO_MASK'        / label for field 22
TFORM22  = '1E'                / data format of field: 4-byte REAL
TTYPE23  = 'RATIO_ALL'         / label for field 23
TFORM23  = '1E'                / data format of field: 4-byte REAL
TTYPE24  = 'FLAGS'             / label for field 24
TFORM24  = '1J'                / data format of field: 4-byte INTEGER
TZER024  =      2147483648      / offset for unsigned integers
TSCAL24  =      1              / data are not scaled
TTYPE25  = 'DIFF_SKYFILE_ID'   / label for field 25
TFORM25  = '1K'                / data format of field: 8-byte INTEGER
SWSOURCE= '60eb6cdc-a59c-4636-a4e0-dba66a9721fd' / Software source
SWVERSN  = 'branches/pap_mops/ppMops@25227' / Software version
HISTORY  ppMops at 2009-09-02T03:48:46.695783
HISTORY  psLib version: branches/pap_mops/psLib@25227
HISTORY  psLib source: 60eb6cdc-a59c-4636-a4e0-dba66a9721fd
```

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HISTORY ppMops version: branches/pap_mops/ppMops@25227
HISTORY ppMops source: 60eb6cdc-a59c-4636-a4e0-dba66a9721fd
EXP_NAME= 'o4995g0129o' / Exposure name
EXP_ID = 77164 / Exposure identifier
CHIP_ID = 24019 / Chip stage identifier
CAM_ID = 17726 / Cam stage identifier
FAKE_ID = 10227 / Fake stage identifier
WARP_ID = 8842 / Warp stage identifier
DIFF_ID = 19219 / Diff stage identifier
DIFF_POS= F / Positive subtraction?
MJD-OBS = 54995.4740598313 / MJD of exposure midpoint
RA = '18:25:01.988' / Right Ascension of boresight
DEC = '-17:20:40.069' / Declination of boresight
TEL_ALT = 51.951873 / Telescope altitude
TEL_AZ = 179.483883 / Telescope azimuth
EXPTIME = 38. / Exposure time (sec)
ROTANGLE= 333.1039 / Rotator position angle
FILTER = 'r.00000 ' / Filter name
AIRMASS = 1.269 / Airmass of exposure
OBSCODE = 'F51 ' / IAU Observatory code
SEEING = 1.678401 / Mean seeing
MAGZP = 28.65226 / Magnitude zero point
MAGZPERR= 0.353063 / Error in magnitude zero point
ASTRORMS= 0.3111496 / RMS of astrometric fit
EXTNAME = 'MOPS_TRANSIENT_DETECTIONS'

```