

The New MPC Observation Format

Minor Planet Center, 2001 June 19

Modified 2003 May 1

Modified 2004 February 23

Modified 2005 July 11

Modified 2005 August 5

Modified 2006 June 20

This document was prepared in Icon Technology's TechWriter Pro+ V8.43 on a Kinetic RisePC running RISC OS 4.03. The ASCII, Word, HTML and PostScript™ versions were output directly from TechWriter. The pdf version was derived from the PostScript™ version using the RISC OS port of ps2pdf.

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The New MPC Observation Format

This document describes the new MPC format for submitting astrometric observations of minor planets, comets and natural satellites. The purpose of the document is to enable writers of astrometric software to support the new format.

Version of 2003 May 1:

The changes from the previous version of this document are (with one exception) minor and are marked in the text by a vertical bar in the right-hand margin:

- Added details on the new record 5
- Added details on support for minor-body satellites
- Replaced the readable designation in record 1 with additional record-keeping information
- Altered the way reference catalogues are indicated
- Expanded and clarified some descriptions

Changes 3 and 4 were deemed necessary following work on implementing the new format. It was determined that there would be too many problems enforcing consistent use of the readable designation and textual reference catalogue, with the consequent complication of code designed to use the information. In newly-submitted observations the relevant columns will simply be blanked out by MPC processing software, so that already-written software that generates new-format observations will not require alteration.

Version of 2004 February 23:

The changes from the previous version of this document relate to support of additional types of data and are highlighted in the text by a double vertical bar in the right-hand margin:

- Added support for occultation records
- New support for comet magnitudes

The second change was required as a result of the new IAU procedures for reporting comet magnitudes.

Version of 2005 July 11:

The description of conversion of observatory codes from the old format to the new format was incorrect. This has been amended. Changes from the previous version of this document are highlighted in the text by a single thick vertical bar along the right-hand edge.

Version of 2005 August 5:

The only change in this version of the document is support for observation timescales other than UTC. Some more explanation has been added on the formatting of data for roving-observer locations. Changes from the previous version of this document are highlighted in the text by a double vertical bar (one thin, the other thicker) along the right-hand edge.

Version of 2006 June 20:

The only change in this version of the document is better support for highly-fragmented comets (such as 73P at the 2006 return). The MPC processing pipeline will recognize observations formatted according to the 2005 August 5 version of this

document and will automatically convert them to the 2006 June 20 format. Distribution of astrometric observations will be made only in the 2006 June 20 format. Changes from the previous version will be highlighted by a red background for new material and a light blue background for modified material.

1: The Existing Format

The existing observation format is documented on the MPC's website. It was derived from a format originally developed in the 1940s, when the MPC was at Cincinnati Observatory, for use on punched cards. The current format has been very successful and has subsequently been extended to cope with observations of natural satellites, observations from space-borne platforms, radar observations and roving observers. Originally a single 80-column record, many observations (such as radar and space-borne observations) now occupy two records.

Consideration was given to extending this dual-record 80-column format to a multi-record 80-column format. This was rejected for a number of reasons:

- There is one feature of the current format that makes it difficult to extend it to multiple records.
- A new format should look nothing like a previous format, so that there is absolutely no chance of mistaking one for the other.

2: Need for a New Format

A fundamental change, such as this proposed observation format change, is not something that is to be undertaken lightly.

Nevertheless, the need to record additional information for each observation has become apparent recently, partly as a result of increased accuracy in the orbit computations and partly from the vast increase in the number of observed minor planets.

Examples of information it might be desirable to record are:

- Astrometric reference catalogue used.
- Photometric reference catalogue used.
- Estimated uncertainties in the given quantities.

The quantities that should be extended include:

- Designations.
- References to publication.
- Observatory codes.
- R.A. and Decl., to cope with sub-milliarcsecond accuracy observations.

The current packed designation scheme copes with 619999 numbered minor planets and 15500 new designations in any one half-month period. However, the designations become slightly less easy to read when there are more than 99999 numbered minor planets and more than 2500 new discoveries in any one half-month period. By extending the number of characters available for the packed designations we can extend greatly the range of "easily-readable" packed designations.

A similar situation exists with observatory codes, where there are 6200 observatory codes available for use. Of these, 1000 are “easily readable”.

Currently only five characters are allocated for recording the reference. This has been somewhat limiting, particularly with the introduction of the *Minor Planet Supplement*.

3: Requirements for a New Format

The primary requirements for a new format are:

- that it is an improvement over the existing format,
- that it is extensible as future needs dictate, with the following proviso,
- that the initial definition be sufficient to cope with any reasonable assessment of the short- to medium-term change in the volume of observational material.

Some features of the existing format will be retained:

- sexagesimal format for R.A.s and Decl. for all but ultra-high precision observations,
- the use of observatory codes.

The length of the record(s) should not be excessive. It is very useful to be able to view or edit observational records on-screen. In practical terms, this sets a limit on the length of each record to 132 columns.

4: Extending Packed Designations and Observatory Codes

The use of packed designations will be continued. Packed designations have advantages with respect to sorting observations (e.g., observation files can be sorted using the inbuilt SORT command found in many operating systems).

The current lengths of the packed designations are five (for numbered minor planets, numbered periodic comets and numbered natural satellites), seven (for unnumbered minor planets) or eight (for unnumbered comets and natural satellites). Under the new scheme, these lengths will be seven, nine and ten, respectively. The basic form of each type of packed designation will be unchanged, but the extra length will enable many more designations to be assigned. The new schemes will cope with 61999999 numbered minor planets, 999999 numbered periodic comets, 99999 natural satellites (for each planet), 1550000 designations in each half-month and 10000 observatory codes.

Observatory codes will be extended from their current three-character length to four. Existing observatory codes in the range ‘000’ to ‘999’ will be retained with the addition of a leading zero: e.g., Palomar will become ‘0675’. Existing codes outside that range will be assigned new four digit codes. The list of observatory codes maintained by the MPC will list both the old three-character code and the new four digit code.

When submitting old-format observations, observers must use the old three-character codes on the COD line. When submitting new-format observations a

four-character observatory code must be specified on the COD line. This can either be the new four-character code or the old three-character code with a leading zero. The processing code will change the latter into the relevant four-digit observatory code. So new-format observations from code A08 may be submitted with 'COD 0A08' in the header, or with whatever four-character code is eventually assigned to that site. This approach allows observers to retain use of the originally-assigned observatory codes.

5: The New Format

The new observation format is based on one or more 132-character records. The format of each of these records is described below. Most of the required information will be supplied by the observer. Some of the information will be added by the MPC.

Note that the repetition of some material on all records is dictated by internal MPC requirements.

Record 1

Record 1 contains the basic observational data.

Columns	Format	Description
1–16	A16	Packed designation(s)
17–18	A2	Fragment designation
19	'1'	Indicates that this is the first record for this observation. This character will be 'A' for the first record of a secondary component.
20	A1	= '*' if a discovery observation, = '+' if last record
21	A1	Mode of observation: = 'C' for CCD observations = 'R' for radar observations = 'T' for transit-circle/meridian-circle observations = 'M' for visual micrometer observations = 'S' for satellite-based observations = 'P' for photographic observations = 'O' for offset observations = 'E' for occultation observations = 'A' for observations adjusted to J2000.0 from B1950.0 (or other equinox) [not for new submissions] = ' ' for unknown/unspecified [not for new submissions]
22–25	I4	Year of observation
26–27	I2	Month of observation
28–39	F12.9	Day of observation
40	A1	Time scale for time of observations (ASCII 32 = UTC). Other time scales will be defined as needed.

		For optical observations:
41–53	A13	J2000.0 R.A., in HH MM SS.dddd form
56–68	A13	J2000.0 Decl., in \pm DD MM SS.ddd form <i>OR</i>
41–55	F15.14	J2000.0 R.A., in radians
56–71	F16.14	J2000.0 Decl. in radians
72–80	A9	Magnitude (see section 8)
		For radar observations:
41–61	F21.7*	Delay/ μ s
62–81	F20.7*	Doppler shift/Hz.
		For offset observations:
41	I1	Type of offset = 1, Δ R.A. in seconds of arc, Δ Decl. in seconds of arc = 2, Δ R.A. in seconds of time, Δ Decl. in seconds of arc = 3, Distance in seconds of arc, P.A. in $^{\circ}$ = 4, Distance in minutes of arc, P.A. in $^{\circ}$
42	A1	Mode of observation ('C' = CCD, etc.)
43–53	F11.5*	Either Δ R.A. or Distance, as defined by type of offset
55–65	F11.5*	Either Δ Decl. or P.A., as defined by type of offset
67–70	I4	Equinox of offset <i>OR</i>
	A4	= 'APP.' for apparent offset
72–80	A9	Magnitude
		For Occultation Observations:
		See section 6 for format of occultation records
		For all types of observations:
82–84	A3	Up to three alphabetic notes
85	A1	Telescope identifier ('1' = 1st telescope, '2' = 2nd, ...)
86–97	A12	Reference (must be blank on new submissions)
99–110	A12	Packed form of an earlier previous designation assigned to this observation or a reference to an earlier previous publication (this must be blank on new submissions)
112–123	A12	Packed form of a previous designation assigned to this observation or a reference to a previous publication (this must be blank on new submissions)
124	A1	MPC-assigned program code used to distinguish between different programs at the same site

125–128	A4	Transmitting site observatory code (given only for radar observations)
129–132	A4	Observatory code (receipt observatory code for radar observations)

The normal form of the R.A. will be HH MM SS.dd. The normal form of the Decl. will be \pm DD MM SS.d. Ultra-high precision observations, those with a precision of better than 0".001, will be given in radians.

The fragment designation will be stored as a two-character base-62 value, using the characters '0'–'9', 'A'–'Z' and 'a'–'z'. Fragments A through Z will be designated, in decimal, as fragments 1–26 (and in base 62 as '00'–'0Q'), AA through AZ will be 27–52 ('0R'–'0q'), BA through BZ will be 53–78 ('0r'–'1G'), etc. Conversion from publishable alphabetic form to internal base-62 value, or vice versa, is trivial.

Record 2

Record 2 contains uncertainty estimates and reference catalogue information.

Columns	Format	Description
1–40		As for record 1, except that column 19 contains '2' (unless the observation refers to a secondary component, in which case it contains 'B'). For most observations this will be the record that requires the '+' in column 20.
		For optical observations:
41–46	F6.3	R.A. uncertainty in seconds of arc
48–53	F5.2	Decl. uncertainty in seconds of arc <i>OR</i>
41–48	F8.7**	R.A. uncertainty in units of 10^{-7} radians
49–56	F8.7**	Decl. uncertainty in units of 10^{-7} radians
57–64	F8.5	Correlation of R.A. and Decl. uncertainties
65	A1	Uncertainty flag = 'F' if quoted values are formal = 'X' if quoted values are estimates (in such cases, the correlation may not be given) = 'C' if quoted values are simply the r.m.s. fit of comparison stars (correlation should be omitted)
66–72	A7	Uncertainty in magnitude (see section 8)
73–84	F12.10	Uncertainty in date of observation/days
85–89	F5.3	$\log_{10}(\text{SNR}+1)$, where SNR is the integrated SNR of the imaged object, not the peak SNR
90–93	Z4	Astrometric reference catalogue
94–97	Z4	Photometric reference catalogue
98–102	F5.1	P.A. of the semimajor axis of the positional error ellipse If these columns are non-blank, the R.A. and Decl.

		positional uncertainties will be interpreted as the n - σ semi-major and semi-minor, respectively, axes of the positional error ellipse
103	I1	Value of n for specifying positional error ellipse (typically '1' or '3')
107	A1	Astrometric user flag (see end of section 9)
For radar observations:		
41–61	F21.7*	Uncertainty in delay/ μ s
62–81	F20.7*	Uncertainty in Doppler shift/Hz
82–97	F16.10*	Transmitter frequency/MHz
98	A1	Type of radar return = 'S' for surface bounce = 'C' for (hypothetical) center-of-mass bounce
For offset observations:		
41	I1	Type of offset (as for record 1)
43–53	F11.5*	Uncertainty in Δ R.A. or distance, as appropriate
55–65	F11.5*	Uncertainty in Δ Decl. or P.A., as appropriate
66–72	A7	Uncertainty in magnitude (see section 8)
73–84	F12.10	Uncertainty in date of observation/days
85–89	F5.3	$\log_{10}(\text{SNR}+1)$, where SNR is the integrated SNR of the imaged object (not the peak SNR)
90–93	Z4	Astrometric reference catalogue
94–97	Z4	Photometric reference catalogue
98–102	F5.1	P.A. of the semimajor axis of the positional error ellipse If these columns are non-blank, the R.A. and Decl. positional uncertainties will be interpreted as the n - σ semi-major and semi-minor, respectively, axes of the positional error ellipse
103	I1	Value of n for specifying positional error ellipse (typically '1' or '3')
107	A1	Astrometric user flag (see end of section 8)
For all types of observations:		
108–115	A8	Time stamp indicating when observation was processed (this will be blank on newly-submitted observations)
116–123	A8	Time stamp when observation was altered subsequently (this will be blank on newly-submitted observations)
124–132		As for record 1

The astrometric and photometric catalogues are specified by a four-digit hexadecimal code. Lists of allocated codes will be maintained on the MPC website.

Records 3 and 4

Records 3 and 4 contain details on the observing site(s), where observatory codes are not assigned or are inadequate.

Columns	Format	Description
1–40		As for record 1, except that column 19 contains ‘3’ or ‘4’ (for secondary components, ‘C’ or ‘D’)
41	I1	Parallax type = 0, geocentric J2000.0 in km = 1, geocentric J2000.0 in A.U. = 2, east longitude (in °), latitude (in °), altitude (in meters) = 3, heliocentric J2000.0 in A.U.
42–59	F18.12*	X component or east longitude, as appropriate (dp in 49)
60–77	F18.12*	Y component or latitude, as appropriate (dp in 67)
78–95	F18.12*	Z component or altitude, as appropriate (dp in 85)
124–132		As for record 1

When using parallax type 2, the longitudes should be zero padded at left to make the integer part of the longitude occupy three characters: e.g., a longitude of 34.33° E would be given as “034.033”. Similarly, latitudes within 10° of the equator should be given with a leading zero: e.g., a latitude of 2.895° S would be given as “-02.895”.

Record 5

Record 5 contains up to five additional magnitudes and their uncertainties.

Columns	Format	Description
1–40		As for record 1, except that column 19 contains ‘5’ (for secondary components ‘E’)
41–49	A9	Magnitude (see section 8)
50–56	A7	Uncertainty on magnitude (see section 8)
57–65	A9	Magnitude (see section 8)
66–72	A7	Uncertainty on magnitude (see section 8)
73–81	A9	Magnitude (see section 8)
82–88	A7	Uncertainty on magnitude (see section 8)
89–97	A9	Magnitude (see section 8)
98–104	A7	Uncertainty on magnitude (see section 8)
105–113	A9	Magnitude (see section 8)
114–120	A7	Uncertainty on magnitude (see section 8)
124–132		As for record 1

General Comments

Records 1 and 2 will be given for every observation. Record 3 will be given for satellite-based and roving-observer observations. Record 3 and 4 may be given for radar observations, even though the radar observation sites have observatory codes, to permit the site coordinates to be given to high precision. For radar observations, record 3 will define the reception site (by analogy to the optical record) and record 4 will define the transmitter site. If the radar reception and transmission site are the same only record 3 should be given. Record 5 will be given when there are simultaneous (or nearly so) magnitude estimates in a number of different band passes. Relevant portions of all records will be completed by the MPC.

Observer-assigned temporary designations, which may now be up to eight characters in length, must start in column 8 and extend no further than column 15. Use of column 16 is reserved for use by the MPC.

If no magnitude estimate is provided for a particular observation, there should be no magnitude uncertainty estimate. Neither should there be an indication of a bandpass.

The formats (given in the usual Fortran style) in the above descriptions define the maximum precision with which quantities may be recorded. In practice, quantities will be given to an appropriate precision without trailing zeroes.

In addition, some quantities (such as radar transmitter frequency) may be given without a decimal point and decimals. These are marked in the above tables by an asterisk in the format column and the format specifiers given there will cope with either integer or floating-point values. Note that, e.g., a specifier of "F11.5*" is to be interpreted as "F11.4" if there is no decimal part to be output.

Those formats marked with double asterisks refer to quantities that are stored without explicit decimal points.

Columns not explicitly described in the tables above must contain spaces (ASCII 32).

6: Occultation Observations

There are currently two defined forms of occultation observations. They differ only upon the form in which the coordinates of the occulted star are specified.

Record 1

Record 1 contains the offset from the comparison star to the minor planet at the time of closest approach.

Columns	Format	Description
1-40		As defined for record 1 in section 5
41	I1	Type of occultation record = 1 if comparison star coordinates are specified in sexagesimal form = 2 if comparison star coordinates are specified in decimal degrees

43–51	F9.2	Minimum separation (in milliarcseconds)
53–58	F6.2	Uncertainty in separation (in milliarcseconds)
61–67	F7.3	Position angle of minimum separation (in degrees)
70–81	F12.10	Uncertainty in time of closest approach
82–132		As defined for record 1 in section 5
Record 2		
Record 2 contains the coordinates and other details of the occulted star.		
Columns	Format	Description
1–40		As defined for record 2 in section 5
41	I1	As for record 1
43–56	A14	Equinox J2000.0/epoch of date R.A. for occulted star (HH MM SS.ddddd format)
58–71	A14	Equinox J2000.0/epoch of date Decl. for occulted star (\pm DD MM SS.dddd format) <i>OR</i>
43–56	F14.11	Equinox J2000.0/epoch of date R.A. for occulted star (decimal hours)
58–71	F14.10	Equinox J2000.0/epoch of date Decl. for occulted star (decimal degrees, sign in column 58, decimal point in column 61)
73–76	Z4	Astrometric reference catalogue
78–82	I5	Number of chords used in solution
108–132		As defined for record 2 in section 5

7: Potential Problems

One of the major problems currently with the submission of observations via e-mail is the breaking of the 80-column lines by the mail package used by the observer. Many observers seem unable to force their mailers not to break the lines: this may be a reflection of the e-mail systems rather than the observers! The use of attachments tends to alleviate the line-breaking problem, but use of anything other than plain-text attachments (e.g., UUENCODEd or Base-64 encoding) cause additional overhead in the processing at the MPC. (The MPC is moving rapidly towards totally automatic processing of incoming observation batches and the current routines will not unpack any encoded message and will thus not recognise that the message contains observations.) These problems will likely become worse following adoption of a 132-column format.

It is therefore recommended that authors of astrometric software packages have a user-selectable option to output the observations in either the full 132-column format or in a split-line format (see section 9). The transformation from 132-column to split-line format is utterly trivial and will not cause any programming headaches.

Another problem is the additional storage space that will be required for each observational record. With the current format, most observations occupy a single 80-column record. With the new format, most observations will occupy two 132-column records, a three-fold increase. While this three-fold increase is not a real problem with regard to storage on the multi-GB hard disks now available, it will more than triple the time taken to download observational data sets from the MPC.

The continued (human) readability of the observation record is desirable, therefore it was decided not to compress the records to the extent that they could be only be decoded by a computer program.

8: Magnitudes, Photometric User Flag and Astrometric User Flag

The proposed magnitude format occupies nine characters. It must be remembered that the astrometric record is not intended to record photometric observations. However, it has the ability to record photometric-quality magnitudes. The format of the nine-character magnitude is as follows:

Columns	Format	Description
72–77	F6.4*	Observed magnitude
78–79	A2	Band = ‘V’ or ‘R’ or ‘I’ or ‘B’ or ‘J’ or ‘H’ or ‘Ks’ or ‘U’, as appropriate. Other bands will be defined if standard conversions to <i>V</i> are available.
80	A1	Aperture flag for comet magnitudes. Use the flag value that is the closest larger value to the measurement aperture Lowercase letters are used to represent apertures in arcseconds: ‘a’ = 3”, ‘b’ = 6”, ‘c’ = 9”, ..., ‘z’ = 78” Uppercase letters are used to represent apertures in arcminutes: ‘A’ = 1’, ‘B’ = 2’, ‘C’ = 3’, ..., ‘S’ = 19’, ‘T’ = 20’, ‘U’ = 25’, ‘V’ = 30’, ‘W’ = 35’, ‘X’ = 40’, ‘Y’ = 50’, ‘Z’ = 1°

The format of the seven-character uncertainty in the magnitude is as follows:

Columns	Format	Description
66–70	F5.4*	Uncertainty in magnitude
71	A1	Magnitude uncertainty flag = ‘N’ if uncertainty is based only on noise in image = ‘S’ if systematic effects have been included
72	A1	User flag (see below)

The user flag is intended to allow the observer to convey information about possible correlations between magnitude estimates. The single character has meaning only for the particular object on the particular night of observation at a particular site. Any alphanumeric character may be used. For instance, if the magnitudes of the first three observations of a particular NEO at a particular site were obtained with respect to the same comparison star, this column might contain '1'. If the next three magnitude estimates were made with respect to another comparison star, this column might contain '2'. If all magnitude estimates were made to the same comparison star(s), this column may be left blank.

The astrometric user flag, stored in column 107 of record 2, serves a similar purpose for the astrometric solution. The single character has meaning only for the particular object on the particular night of observation at a particular site. If all astrometric solutions of the object on a particular night were made with respect to the same set of comparison stars, this column may be left blank.

9: Continued Use of the Current Format

The specification for the new format is now final and has been adopted by the MPC. When use of this new format is introduced, it is unrealistic to expect that all observers will immediately begin submitting observations in the new format. The past experience of the changeover from B1950.0 to J2000.0 indicates that some observers will continue to do things in the old way for months or years past the changeover date. The MPC will therefore have the ability to create new-format observational records from newly-submitted old-format observational records. The necessary computer code will be derived from the program that will be written to do the *en-masse* initial conversion of the existing astrometric data.

Additional header keywords will need to be defined to allow additional information to be specified for old-format observations. Examples of such additional keywords might be 'ERR 0.08, 0.3, 0.23' (indicating the estimated uncertainties on the R.A., Decl. and mag., respectively) and 'PHO Tycho2' (showing that the source for the photometric reduction was the Tycho 2 catalogue). This will be somewhat troublesome for the observer, so it should help to encourage adoption of the new format.

10: A Split-Line Format

The split-line submission format is for those observers whose e-mail systems continue to break long lines. Use of the split-line format must be indicated in the observation header by the new keyword 'FMT SPLIT-LINE'. All forms of observations may use this split-line format. The split-line format simply breaks each 132-column record after column 66.

11: Examples of New-Format Packed Designations

The following table shows the old and new formats for packed designations. The columns occupied by the packed format are shown in 'Columns' and the type of object in 'Type'.

Old	New	Unpacked form	Columns	Type
K00A00A	K00A0000A	2000 AA	8–16	MP
K00A01A	K00A0001A	2000 AA ₁	8–16	MP
K00A10A	K00A0010A	2000 AA ₁₀	8–16	MP
K00AA0A	K00A0100A	2000 AA ₁₀₀	8–16	MP
K00Aa0A	K00A0360A	2000 AA ₃₆₀	8–16	MP
	K00A9999A	2000 AA ₉₉₉₉	8–16	MP
PLS2001	PLS002001	2001 P-L	8–16	MP
T2S2801	T2S002801	2801 T-2	8–16	MP
00433	0000433	(433)	1–7	MP
0034P	000034P	34P	1–7	Comet
CK00A010	CK00A00010	C/2000 A1	7–16	Comet
J013S	J00013S	Jupiter XIII	1–7	Satellite
SK00S010	SK00S00010	S/2000 S 1	7–16	Satellite
SJ99J010	SJ99J00010	S/1999 J 1	7–16	Satellite

12: Recommendations for Software Authors

The following recommendations should be followed by the authors of all software packages that produce new-format observations:

- Make the split-line format the default output format from your code. This requires the “FMT SPLIT-LINE” line to be given in the header, but it should minimise problems with mail systems butchering the 132-column records.
- Ensure that the new keyword “CNT x” is given after the observations. This specifies how many observations are in the file and will help the MPC’s processing code to determine when badly-formatted observations have been submitted. Examples are “CNT 3” or “CNT 18429”, indicating that the messages contain 3 and 18429 observations, respectively. If observers append together reports for e-mailing, there can be multiple CNT keywords in the resulting file.

Old-format observations will continue to be sent to `mpc@cfa.harvard.edu`. New-format observations will need to be sent to a new e-mail address. This address will be announced closer to the change-over date.