

This document describes the MPC\_ORB.JSON format.

This document is generated programatically from a schema file.

## 000:Top Level of MPC-ORB.JSON object

\$schema: <http://json-schema.org/schema#>

version: 0.4

title: Best Fit Orbit Data for Single Solar System Object

description: Standardized MPC JSON format for the exchange of orbit-fit data. Designed to communicate the best-fit orbit for a single minor planet or comet.

type: object

Required Properties: ['CAR', 'COM', 'designation\_data', 'orbit\_fit\_statistics', 'non\_grav\_booleans', 'magnitude\_data', 'epoch\_data', 'moid\_data', 'categorization', 'software\_data', 'system\_data']

Allowed Properties: ['CAR', 'COM', 'designation\_data', 'software\_data', 'system\_data', 'orbit\_fit\_statistics', 'non\_grav\_booleans', 'magnitude\_data', 'epoch\_data', 'moid\_data', 'categorization']

## 001:CAR

type: object

description: Cartesian Element Specification: Description of the best-fit orbit based on a cartesian coordinate system (plus any non-gravs). Contains the best-fit orbit and covariance matrix. Heliocentric coordinates.

Allowed Properties: ['coefficient\_specification', 'coefficient\_names', 'coefficient\_values', 'coefficient\_uncertainties', 'eigenvalues', 'covariance']

Required Properties: ['coefficient\_names', 'coefficient\_values', 'coefficient\_uncertainties', 'eigenvalues', 'covariance']

## 002:coefficient\_specification

description: Description of fitted quantities within Cartesian element specification.

type: object

Allowed Properties: ['x', 'y', 'z', 'vx', 'vy', 'vz', 'yarkovski', 'srp', 'A1', 'A2', 'A3', 'DT']

003:x

Cartesian Position Component [See below for detailed specification]

004:y

Cartesian Position Component [See below for detailed specification]

005:z

Cartesian Position Component [See below for detailed specification]

006:vx

Cartesian Velocity Component [See below for detailed specification]

007:vy

Cartesian Velocity Component [See below for detailed specification]

008:vz

Cartesian Velocity Component [See below for detailed specification]

009:yarkovski

Yarkovski Component [See below for detailed specification]

010:srp

Physical Units associated with Solar-Radiation Pressure Component [See below for detailed specification]

011:A1

Physical Units associated with A1, A2 & A3 non-grav components [See below for detailed specification]

012:A2

Physical Units associated with A1, A2 & A3 non-grav components [See below for detailed specification]

#### 013:A3

Physical Units associated with A1, A2 & A3 non-grav components [See below for detailed specification]

#### 014:DT

Physical Units associated with DT non-grav component [See below for detailed specification]

#### 015:coefficient\_names

description: Names of the cartesian elements (and any non-grav components) used in this fit. Of length 6 if gravity-only, or 7-10 if we have non-gravs.

type: array

minItems: 6

maxItems: 10

items: {'type': 'string', 'enum': ['x', 'y', 'z', 'vx', 'vy', 'vz', 'yarkovski', 'srp', 'A1', 'A2', 'A3', 'DT']}

#### 016:coefficient\_values

Numerical values of the best-fit orbital elements (and any non-grav components). Of length 6 if gravity-only, or 7-10 if we have non-gravs. [See below for detailed specification]

#### 017:coefficient\_uncertainties

Uncertainties on the best-fit orbital elements (and any non-grav components). N.B. These correspond to the square-root of the diagonal terms in the covariance matrix. Of length 6 if gravity-only, or 7-10 if we have non-gravs. [See below for detailed specification]

#### 018:eigenvalues

Eigenvalues for the orbital elements (and any non-gravitational parameters). Of length 6 if gravity-only, or 7-10 if we have non-gravs.

[See below for detailed specification]

#### 019:covariance

Covariance matrix elements (upper triangular) for the orbital elements (and any non-gravitational parameters). Reconstructed square matrix is of size 6x6 if gravity-only, or 7x7 -to- 10x10 if we have non-grav parameters. [See below for detailed specification]

#### 020:COM

description: Description of the best-fit orbit using cometary coordinates (plus any non-gravs) in heliocentric coordinates. Contains the best-fit orbit and covariance matrix.

Allowed Properties: ['coefficient\_specification', 'coefficient\_names', 'coefficient\_values', 'coefficient\_uncertainties', 'eigenvalues', 'covariance']

Required Properties: ['coefficient\_names', 'coefficient\_values', 'coefficient\_uncertainties', 'eigenvalues', 'covariance']

#### 021:coefficient\_specification

description: Description of allowed fitted quantities within the cometary coordinate specification system.

type: object

Allowed Properties: ['q', 'e', 'i', 'node', 'argperi', 'peri\_time', 'yarkovski', 'srp', 'A1', 'A2', 'A3', 'DT']

#### 022:q

Cometary Pericenter Distance [See below for detailed specification]

#### 023:e

Cometary Eccentricity [See below for detailed specification]

#### 024:i

Cometary Inclination [See below for detailed specification]

025:node

Cometary Longitude of Ascending Node [See below for detailed specification]

026:argperi

Cometary Argument of Pericenter [See below for detailed specification]

027:peri\_time

Cometary Time from Pericenter Passage [See below for detailed specification]

028:yarkovski

Yarkovski Component [See below for detailed specification]

029:srp

Physical Units associated with Solar-Radiation Pressure Component [See below for detailed specification]

030:A1

Physical Units associated with A1, A2 & A3 non-grav components [See below for detailed specification]

031:A2

Physical Units associated with A1, A2 & A3 non-grav components [See below for detailed specification]

032:A3

Physical Units associated with A1, A2 & A3 non-grav components [See below for detailed specification]

033:DT

Physical Units associated with DT non-grav component [See below for detailed specification]

#### 034:coefficient\_names

description: Names of the cometary elements (and any non-grav components) used in this fit. Of length 6 if gravity-only, or 7-10 if we have non-gravs.

type: array

minItems: 6

maxItems: 10

items: {'type': 'string', 'enum': ['q', 'e', 'i', 'node', 'argperi', 'peri\_time', 'yarkovski', 'srp', 'A1', 'A2', 'A3', 'DT']}

#### 035:coefficient\_values

Numerical values of the best-fit orbital elements (and any non-grav components). Of length 6 if gravity-only, or 7-10 if we have non-gravs. [See below for detailed specification]

#### 036:coefficient\_uncertainties

Uncertainties on the best-fit orbital elements (and any non-grav components). N.B. These correspond to the square-root of the diagonal terms in the covariance matrix. Of length 6 if gravity-only, or 7-10 if we have non-gravs. [See below for detailed specification]

#### 037:eigenvalues

Eigenvalues for the orbital elements (and any non-gravitational parameters). Of length 6 if gravity-only, or 7-10 if we have non-gravs. [See below for detailed specification]

#### 038:covariance

Covariance matrix elements (upper triangular) for the orbital elements (and any non-gravitational parameters). Reconstructed square matrix is of size 6x6 if gravity-only, or 7x7 -to- 10x10 if we have non-grav parameters. [See below for detailed specification]

039:designation\_data

type: object

description: The designations, numbers and names that may be associated with the object

Allowed Properties: ['permid', 'packed\_primary\_provisional\_designation', 'unpacked\_primary\_provisional\_designation', 'orbfit\_name', 'packed\_secondary\_provisional\_designations', 'unpacked\_secondary\_provisional\_designations', 'iau\_name']

Required Properties: ['iau\_name', 'orbfit\_name', 'packed\_primary\_provisional\_designation', 'permid', 'unpacked\_primary\_provisional\_designation', 'packed\_secondary\_provisional\_designations', 'unpacked\_secondary\_provisional\_designations']

040:permid

type: ['null', 'string']

041:packed\_primary\_provisional\_designation

type: string

042:unpacked\_primary\_provisional\_designation

type: string

043:orbfit\_name

type: string

044:packed\_secondary\_provisional\_designations

type: array

items: {'type': 'string'}

045:unpacked\_secondary\_provisional\_designations

type: array

items: {'type': 'string'}



046:iau\_name

type: string

047:software\_data

type: object

description: Details of the software used to perform orbital fit and to create mpcorb output file

Allowed Properties: ['fitting\_software\_name', 'software\_version', 'fitting\_datetime', 'mpcorb\_schema\_version', 'mpcorb\_schema\_sha256', 'mpcorb\_creation\_datetime']

Required Properties: ['fitting\_software\_name', 'fitting\_software\_version', 'fitting\_datetime', 'mpcorb\_version', 'mpcorb\_creation\_datetime']

048:fitting\_software\_name

description: name of software used to perform orbit-fit

type: string

enum: ['orbfit']

049:software\_version

description: version of software used to perform orbit-fit

type: string

050:fitting\_datetime

description: datetime at which the orbit fitting software was executed  
[null should only allowed for template]

type: ['null', 'string']

051:mpcorb\_schema\_version

description: version of the mpcorb schema used to validate this json

type: string

enum: ['0.1', '0.2', '0.3']

052:mpcorb\_schema\_sha256

description: sha256 hash of the mpcorb schema used to create this json

type: string

053:mpcorb\_creation\_datetime

description: datetime at which the mpcorb software was executed to create this json [null should only allowed for template]

type: ['null', 'string']

054:system\_data

type: object

description: Ephemeris model assumed when integrating the motion of the object, and the frame of reference used to specify the best-fit orbital elements.

Allowed Properties: ['eph', 'refplane', 'EclipticObliquityArcseconds', 'refframe', 'force\_model']

Required Properties: ['eph', 'refsys', 'EclipticObliquityArcseconds', 'refframe', 'force\_model']

055:eph

description: The ephemeris model used in the orbit-fit, E.g. DE431

type: string

enum: ['DE431', 'DE441']

056:refplane

description: The X-Y Reference Plane

type: string

enum: ['Equatorial', 'Ecliptic']

057:EclipticObliquityArcseconds

description: Obliquity angle from JPL 777 (heliocentric IAU76/J2000 ecliptic)

type: string

enum: ['84381.448']

058:refframe

description: The frame of reference for the best-fit orbital elements

type: string

enum: ['ICRF']

059:force\_model

description: The planetary / asteroidal perturbbers that were used in the orbit-fit. [need to decide exactly how to populate: url-link?]

type: string

enum: ['????']

060:orbit\_fit\_statistics

type: object

description: Summary fit statistics associated with the best-fit orbit, the observations used, etc

Allowed Properties: ['sig\_to\_noise\_ratio', 'snr\_below\_3', 'snr\_below\_1:', 'U\_param', 'score1', 'score2', 'orbit\_quality', 'normalized\_RMS', 'not\_normalized\_RMS', 'nobs\_total', 'nobs\_total\_sel', 'nobs\_optical', 'nobs\_optical\_sel', 'nobs\_radar', 'nobs\_radar\_sel', 'arc\_length\_total', 'arc\_length\_sel', 'nopp', 'numparams']

061:sig\_to\_noise\_ratio

description: SNR of the orbital parameters

type: array

items: {'type': 'number'}

062:snr\_below\_3

description: True if any value in the SNR list is <3, False otherwise

type: boolean

063:snr\_below\_1:

description: True if any value in the SNR list is  $<1$ , False otherwise  
type: boolean

064:U\_param

description: U parameter per  
<https://minorplanetcenter.net/iau/info/UValue.html>  
type: number

065:score1

description: 1st score for numbering ...  
type: number

066:score2

description: 2nd score for numbering ...  
type: number

067:orbit\_quality

description: Orbit quality: good, poor, unreliable, no orbit (def = good)  
type: string

068:normalized\_RMS

description: Normalized RMS (def = 0)  
type: number

069:not\_normalized\_RMS

description: Not normalized RMS (def=0)  
type: ['null', 'number']

070:nobs\_total

description: Total number of all observations (optical + radar) available  
type: number

071:nobs\_total\_sel

description: Total number of all observations (optical + radar) selected  
type: number

072:nobs\_optical

description: Total number of optical observations available  
type: number

073:nobs\_optical\_sel

description: Total number of optical observations selected  
type: number

074:nobs\_radar

description: Total number of radar observations available  
type: number

075:nobs\_radar\_sel

description: Total number of radar observations selected  
type: number

076:arc\_length\_total

description: Arc length over nobs\_total  
type: ['number', 'string']

077:arc\_length\_sel

description: Arc length over nobs\_total\_sel  
type: ['number', 'string']

078:nopp

description: Number of oppositions  
type: number

079:numparams

description: Number of parameters used for fit: E.g. 6-orbital params plus

N-non\_grav params

type: integer

080:non\_grav\_booleans

type: object

description: Booleans to indicate whether any non-gravitational parameters are used in the orbit-fit. The actual fitted values and their covariance properties are reported within the CAR and COT parameter sections.

Allowed Properties: ['non\_gravs', 'non\_grav\_model', 'non\_grav\_coefficients']

non\_grav\_units: {'description': 'Physical Units associated with any non-gravitational fit-parameters.', 'type': 'object', 'properties':

{'yarkovski\_coeff': {'type': 'string', 'enum': ['10<sup>-10</sup>\*au/day<sup>2</sup>']},

'srp\_coeff': {'type': 'string', 'enum': ['m<sup>2</sup>/ton']}, 'A1\_coeff': {'type':

'string', 'enum': ['au/day<sup>2</sup>']}, 'A2\_coeff': {'type': 'string', 'enum':

['au/day<sup>2</sup>']}, 'A3\_coeff': {'type': 'string', 'enum': ['au/day<sup>2</sup>']},

'DT\_coeff': {'type': 'string', 'enum': ['day']}}, 'required':

['yarkovski\_coeff', 'srp\_coeff', 'A1\_coeff', 'A2\_coeff', 'A3\_coeff', 'DT\_coeff']}]

Required Properties: ['non\_gravs', 'non\_grav\_model', 'non\_grav\_coefficients']

081:non\_gravs

description: Boolean to indicate whether any non-gravitational parameters are used in the orbit-fit.

type: boolean

082:non\_grav\_model

description: Booleans to indicate which specific non-gravitational model is used in the orbit-fit.

type: object

Allowed Properties: ['yarkovski', 'srp', 'marsden', 'yc', 'yabushita']

Required Properties: ['yarkovski', 'srp', 'marsden', 'yc', 'yabushita']

083:yarkovski

description: Yarkovski model

(<https://www.sciencedirect.com/science/article/pii/S0019103513000456>)

boolean

type: boolean

084:srp

description: Solar Radiation Pressure model () boolean

type: boolean

085:marsden

description: Marsden model () boolean

type: boolean

086:yc

description: Yeomans & Chodas model () boolean

type: boolean

087:yabushita

description: Yabushita model

(<https://www.sciencedirect.com/science/article/pii/S0019103513000456>)

boolean

type: boolean

088:non\_grav\_coefficients

description: Booleans to indicate which non-gravitational coefficients are used in the orbit-fit.

type: object

Allowed Properties: ['yarkovski', 'srp', 'A1', 'A2', 'A3', 'DT']

Required Properties: ['yarkovski', 'srp', 'A1', 'A2', 'A3', 'DT']

089:yarkovski

description: Yarkovski Coefficient A1 boolean

type: boolean

090:srp

description: SRP Coefficient A2 boolean

type: boolean

091:A1

description: Non-Gravitational Coefficient A1 boolean

type: boolean

092:A2

description: Non-Gravitational Coefficient A2 boolean

type: boolean

093:A3

description: Non-Gravitational Coefficient A3 boolean

type: boolean

094:DT

description: Non-Gravitational Coefficient DT boolean: Only used in yc  
(Yeomans & Chodas) model

type: boolean

095:magnitude\_data

type: object

description: The absolute magnitude, H, and slope parameter, G, information  
derived from the fitted orbit in combination with the observed apparent  
magnitudes.

Allowed Properties: ['H', 'G', 'G1', 'G2', 'G12', 'photometric\_model']

Required Properties: ['photometric\_model', 'H', 'G']

096:H



type: number

097:G

type: number

098:G1

type: ['null', 'number']

099:G2

type: ['null', 'number']

100:G12

type: ['null', 'number']

101:photometric\_model

type: string

enum: ['????']

102:epoch\_data

type: object

description: Data concerning the orbit epoch: I.e. The date at which the best-fit orbital coordinates are correct

Allowed Properties: ['timesystem', 'timeform', 'epoch']

Required Properties: ['epoch', 'timesystem', 'timeform']

103:timesystem

type: string

enum: ['TDB', 'TDT']

104:timeform

type: string

enum: ['JD', 'MJD']

105:epoch

type: number

106:moid\_data

type: object

description: Calculated MOIDs (Minimum Orbital Interception Distances) at Epoch

Allowed Properties: ['Venus', 'Earth', 'Mars', 'Jupiter', 'moid\_units']

107:Venus

type: ['null', 'number']

108:Earth

type: ['null', 'number']

109:Mars

type: ['null', 'number']

110:Jupiter

type: ['null', 'number']

111:moid\_units

type: string

enum: ['au']

112:categorization

type: object

description: Various different ways to categorize / sub-set orbit / object types

Allowed Properties: ['object\_type\_str', 'object\_type\_int', 'orbit\_type\_str', 'orbit\_type\_int', 'orbit\_subtype\_str', 'orbit\_subtype\_int', 'parent\_planet\_str', 'parent\_planet\_int']

Required Properties: ['object\_type\_str', 'object\_type\_int',

'orbit\_type\_str', 'orbit\_type\_int', 'orbit\_subtype\_str',  
'orbit\_subtype\_int']

113:object\_type\_str

description: # Minor-Planet / Comet / Dual-Status / Binary MP / ...

type: string

114:object\_type\_int

description: # 0 10 20 1

type: ['null', 'number']

115:orbit\_type\_str

description: # NEAs / MBAs / TNOs / ...

type: string

116:orbit\_type\_int

description: # 0 /1/2/3/4

type: ['null', 'number']

117:orbit\_subtype\_str

description: # Apollo / Amor / ...

type: string

118:orbit\_subtype\_int

description: # ...

type: ['null', 'number']

119:parent\_planet\_str

description: # For Nat-Sats

type: string

120:parent\_planet\_int

description: # For Nat-Sats

type: ['null', 'number']

#### 121:coefficient\_values

description: Numerical values of the best-fit orbital elements (and any non-grav components). Of length 6 if gravity-only, or 7-10 if we have non-gravs.

type: array

minItems: 6

maxItems: 10

items: {'type': 'number'}

#### 122:coefficient\_uncertainties

description: Uncertainties on the best-fit orbital elements (and any non-grav components). N.B. These correspond to the square-root of the diagonal terms in the covariance matrix. Of length 6 if gravity-only, or 7-10 if we have non-gravs.

type: array

minItems: 6

maxItems: 10

items: {'type': 'number'}

#### 123:eigenvalues

description: Eigenvalues for the orbital elements (and any non-gravitational parameters). Of length 6 if gravity-only, or 7-10 if we have non-gravs.

type: array

minItems: 6

maxItems: 10

items: {'type': 'number'}

#### 124:covariance

description: Covariance matrix elements (upper triangular) for the orbital elements (and any non-gravitational parameters). Reconstructed square

matrix is of size 6x6 if gravity-only, or 7x7 -to- 10x10 if we have non-grav parameters.

type: object

```
properties: {'cov00': {'type': 'number'}, 'cov01': {'type': 'number'},
  'cov02': {'type': 'number'}, 'cov03': {'type': 'number'}, 'cov04': {'type':
  'number'}, 'cov05': {'type': 'number'}, 'cov06': {'type': ['null',
  'number']}, 'cov07': {'type': ['null', 'number']}, 'cov08': {'type':
  ['null', 'number']}, 'cov09': {'type': ['null', 'number']}, 'cov11':
  {'type': 'number'}, 'cov12': {'type': 'number'}, 'cov13': {'type':
  'number'}, 'cov14': {'type': 'number'}, 'cov15': {'type': 'number'},
  'cov16': {'type': ['null', 'number']}, 'cov17': {'type': ['null',
  'number']}, 'cov18': {'type': ['null', 'number']}, 'cov19': {'type':
  ['null', 'number']}, 'cov22': {'type': 'number'}, 'cov23': {'type':
  'number'}, 'cov24': {'type': 'number'}, 'cov25': {'type': 'number'},
  'cov26': {'type': ['null', 'number']}, 'cov27': {'type': ['null',
  'number']}, 'cov28': {'type': ['null', 'number']}, 'cov29': {'type':
  ['null', 'number']}, 'cov33': {'type': 'number'}, 'cov34': {'type':
  'number'}, 'cov35': {'type': 'number'}, 'cov36': {'type': ['null',
  'number']}, 'cov37': {'type': ['null', 'number']}, 'cov38': {'type':
  ['null', 'number']}, 'cov39': {'type': ['null', 'number']}, 'cov44':
  {'type': 'number'}, 'cov45': {'type': 'number'}, 'cov46': {'type': ['null',
  'number']}, 'cov47': {'type': ['null', 'number']}, 'cov48': {'type':
  ['null', 'number']}, 'cov49': {'type': ['null', 'number']}, 'cov55':
  {'type': 'number'}, 'cov56': {'type': ['null', 'number']}, 'cov57':
  {'type': ['null', 'number']}, 'cov58': {'type': ['null', 'number']},
  'cov59': {'type': ['null', 'number']}, 'cov66': {'type': ['null',
  'number']}, 'cov67': {'type': ['null', 'number']}, 'cov68': {'type':
  ['null', 'number']}, 'cov69': {'type': ['null', 'number']}, 'cov77':
  {'type': ['null', 'number']}, 'cov78': {'type': ['null', 'number']},
  'cov79': {'type': ['null', 'number']}, 'cov88': {'type': ['null',
  'number']}, 'cov89': {'type': ['null', 'number']}, 'cov99': {'type':
  ['null', 'number']}}
```

```
required: ['cov00', 'cov01', 'cov02', 'cov03', 'cov04', 'cov05', 'cov11',
```

'cov12', 'cov13', 'cov14', 'cov15', 'cov22', 'cov23', 'cov24', 'cov25',  
'cov33', 'cov34', 'cov35', 'cov44', 'cov45', 'cov55']

125:cartesian\_posn

type: object

description: Cartesian Position Component

properties: {'unit': {'description': 'Physical Units associated with  
Cartesian Position Component', 'type': 'string', 'enum': ['au']}}

126:cartesian\_vel

type: object

description: Cartesian Velocity Component

properties: {'unit': {'description': 'Physical Units associated with  
Cartesian Velocity Component', 'type': 'string', 'enum': ['au/day']}}

127:cometary\_q

type: object

description: Cometary Pericenter Distance

properties: {'unit': {'description': 'Physical Units associated with  
Cometary Pericenter Distance', 'type': 'string', 'enum': ['au']}}

128:cometary\_e

type: object

description: Cometary Eccentricity

properties: {'unit': {'description': 'Physical Units associated with  
Cometary Eccentricity', 'type': 'string', 'enum': ['null']}}

129:cometary\_i

type: object

description: Cometary Inclination

properties: {'unit': {'description': 'Physical Units associated with  
Cometary Inclination', 'type': 'string', 'enum': ['degrees']}}

130:cometary\_node

type: object

description: Cometary Longitude of Ascending Node

properties: {'unit': {'description': 'Physical Units associated with Cometary Longitude of Ascending Node', 'type': 'string', 'enum': ['degrees']}}

131:cometary\_argperi

type: object

description: Cometary Argument of Pericenter

properties: {'unit': {'description': 'Physical Units associated with Cometary Argument of Pericenter', 'type': 'string', 'enum': ['degrees']}}

132:cometary\_peri\_time

type: object

description: Cometary Time from Pericenter Passage

properties: {'unit': {'description': 'Physical Units associated with Cometary Time from Pericenter Passage', 'type': 'string', 'enum': ['days']}}

133:yarkovski\_coeff

type: object

description: Yarkovski Component

properties: {'unit': {'description': 'Physical Units associated with Yarkovski non-grav component', 'type': 'string', 'enum': ['10<sup>-10</sup>\*au/day<sup>2</sup>']}}

134:srp\_coeff

type: object

description: Physical Units associated with Solar-Radiation Pressure Component

properties: {'unit': {'description': 'Physical Units associated with component', 'type': 'string', 'enum': ['m<sup>2</sup>/ton']}}

135:A123\_coeff

type: object

description: Physical Units associated with A1, A2 & A3 non-grav components

properties: {'unit': {'description': 'Physical Units associated with component', 'type': 'string', 'enum': ['m^2/ton']}}

136:DT\_coeff

type: object

description: Physical Units associated with DT non-grav component

properties: {'unit': {'description': 'Physical Units associated with component', 'type': 'string', 'enum': ['v']}}