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OGC API - Moving Features - Part 1: Features extension

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DRAFT

i. Abstract

Moving feature data can represent various phenomena, including vehicles, people, animals, weather patterns, etc. The OGC API Moving Features (OGC API-MF) is a specification developed by the Open Geospatial Consortium (OGC) that defines a standard interface for querying and accessing geospatial data that changes over time, such as the location and attributes of moving objects like vehicles, vessels, or pedestrians. The OGC API-MF provides a standard way to manage this data, which can be helpful for applications such as transportation management, disaster response, and environmental monitoring. It also includes operations for filtering, sorting, and aggregating moving feature data based on location, time, and other properties.

The OGC API-MF Part 1: Feature extension specifies a set of RESTful web service interfaces and data formats for querying and updating moving feature data over the web. OGC API standards define modular API building blocks to spatially enable Web APIs in a consistent way. OpenAPI is used to define the reusable API building blocks with responses in JSON and HTML.

The OGC API family of standards is organized by resource type.

Table 1. Overview of Resources

Resource	Path	HTTP Method	Document Reference
Collections metadata	`/collections`	GET, POST	Resource Collections
Collection instance metadata	`/collections/{collectionId}`	GET, DELETE, PUT	Resource Collection
Moving Features	`/collections/{collectionId}/items`	GET, POST	Resource MovingFeatures
Moving Feature instance	`/collections/{collectionId}/items/{mFeatureId}`	GET, DELETE	Resource MovingFeature
Temporal Geometry Collection	`/collections/{collectionId}/items/{mFeatureId}/tgeometries`	GET, POST	Resource TemporalGeometryCollection
Temporal Geometry instance	`/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}`	DELETE	Resource TemporalGeometry
TemporalGeometry Queries	`{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/{queryType}`	GET	TemporalGeometry Query Resources
Temporal Property Collection	`/collections/{collectionId}/items/{mFeatureId}/tproperties`	GET, POST	Resource TemporalPropertyCollection
Temporal Property instance	`/collections/{collectionId}/items/{mFeatureId}/tproperties/{tPropertyId}`	GET, POST	Resource TemporalProperty

ii. Keywords

The following are keywords to be used by search engines and document catalogues.

ogcdoc, OGC document, OGC MovingFeature, MovingFeatures JSON, MovingFeature Access, API, OpenAPI, REST, trajectory

iii. Preface

OGC Declaration

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iv. Submitting organizations

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

- Artificial Intelligence Research Center, National Institute of Advanced Industrial Science and Technology
- Université libre de Bruxelles
- Geomatys
- Central Research Laboratory, Hitachi Ltd.
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Chapter 1. Scope

The scope of OGC API-Moving Features-Part 1: Feature extension is to provide a uniform way to access and manage data about moving features across different applications, data providers, and data consumers. It includes a set of RESTful web APIs that allow clients to discover, retrieve, and update information about moving features, as well as a data model for describing moving features and their trajectories.

The OGC API-Moving Features-Part 1: Feature Extension standard defines an API with two goals. First, to provide access to representations of Moving Features that conform to the OGC Moving Features JSON encoding standard. Second, to provide functionality comparable to that of the OGC Moving Features Access standard. The OGC API Moving Features standard is an extension of the OGC API-Common and the OGC API-Features standards.

Chapter 2. Conformance

This standard defines five requirements / conformance classes that describe different levels of compliance with the standard. These requirements / conformance classes help to ensure interoperability between other implementations of the standard and allow data providers to specify which parts of the standard they support. The standardization target is "Web APIs".

The conformance classes for OGC API Moving Features are:

- Collection Catalog
- Moving Features

The conformance class defines the minimum requirements for an API to be compliant with the OGC API Moving Features standard. This includes support for querying and retrieving information about moving features using HTTP GET requests. Also, the conformance class enables clients to add, modify, or delete features from the server using HTTP POST, PUT, and DELETE requests. Lastly, the conformance class adds support for querying and retrieving features based on their temporal characteristics, such as their position at a specific time or their velocity over a given time interval.

Implementers of the OGC API-MF can choose which conformance classes they want to support based on the specific needs of their use case and the capabilities of their software. However, to be considered compliant with the standard, an implementation must support at least the Core conformance class.

The URIs of the associated conformance classes are:

Table 2. Conformance class URIs

Conformance class	URI
MovingFeatures Collection Catalog	http://www.opengis.net/spec/ogcapi-movingfeatures-1/1.0/conf/mf-collection
MovingFeatures	http://www.opengis.net/spec/ogcapi-movingfeatures-1/1.0/conf/movingfeatures

Conformance with this Standard shall be checked using all the relevant tests specified in Annex A of this document. The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance are specified in the OGC Compliance Testing Policies and Procedures and the OGC Compliance Testing website.

Chapter 3. References

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

NOTE

- OGC 08-131r3: — The Specification Model — A Standard for Modular Specifications (2009). https://portal.opengeospatial.org/files/?artifact_id=34762
- OGC 16-120r3: OGC Moving Features Access (2017). https://docs.ogc.org/is/16-120r3/16-120r3.html
- OGC 19-045r3: OGC Moving Features Encoding Extension - JSON (2020). https://docs.ogc.org/is/19-045r3/19-045r3.html
- OGC 17-069r4: OGC API — Features — Part 1: Core (2022). https://docs.opengeospatial.org/is/17-069r4/17-069r4.html
- OGC 20-002: OGC API — Features — Part 4: Create, Replace, Update and Delete (Draft). http://docs.ogc.org/DRAFTS/20-002.html
- OGC 19-072: OGC API — Common — Part 1: Core (Draft). http://docs.ogc.org/DRAFTS/19-072.html
- OGC 20-024: OGC API — Common — Part 2: Geospatial Data (Draft). http://docs.ogc.org/DRAFTS/20-024.html
- IETF RFC 2616: Hypertext Transfer Protocol - HTTP/1.1. http://tools.ietf.org/html/rfc2616
- IETF RFC 2387: The MIME Multipart/Related Content-type. http://tools.ietf.org/html/rfc2387
- IETF RFC 2818: HTTP Over TLS. http://tools.ietf.org/html/rfc2818
- IETF RFC 3986: Uniform Resource Identifier (URI): Generic Syntax. https://tools.ietf.org/html/rfc3986
- IETF RFC 7946: The GeoJSON Format, https://tools.ietf.org/rfc/rfc7946.txt
- IETF RFC 8288: Web Linking https://tools.ietf.org/html/rfc8288
- IETF RFC 8259: The JavaScript Object Notation (JSON) Data Interchange Format. Available from: https://tools.ietf.org/html/rfc8259
- Open API Initiative: OpenAPI Specification, Version 3.0. The latest patch version at the time of publication of this standard was 3.1.0, available from https://spec.openapis.org/oas/v3.1.0.

Chapter 4. Terms and Definitions

This document used the terms defined in OGC Policy Directive 49, which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this standard and OGC documents do not use the equivalent phrases in the ISO/IEC Directives, Part 2.

This document also uses terms defined in the OGC Standard for Modular specifications (OGC 08-131r3), also known as the 'ModSpec'. The definitions of terms such as standard, specification, requirement, and conformance test are provided in the ModSpec.

For the purposes of this document, the following additional terms and definitions apply.

application programming interface (API)

a formally defined set of types and methods which establish a contract between client code which uses the API and implementation code which provides the API

coordinate

one of a sequence of numbers designating the position of a point

Note 1 to entry: In a spatial coordinate reference system, the coordinate numbers are qualified by units.

[source: ISO 19111]

coordinate reference system (CRS)

coordinate system that is related to an object by a datum

Note 1 to entry: Geodetic and vertical datums are referred to as reference frames.

Note 2 to entry: For geodetic and vertical reference frames, the object will be the Earth. In planetary applications, geodetic and vertical reference frames may be applied to other celestial bodies.

[source: ISO 19111]

dataset

identifiable collection of data

[source: ISO 19115-1]

datatype

specification of a value domain with operations allowed on values in this domain

Examples: `Integer`, `Real`, `Boolean`, `String` and `Date`.

Note 1 to entry: Data types include primitive predefined types and user definable types.

[source: ISO 19103]

dynamic attribute

characteristic of a feature in which its value varies with time

[source: OGC 16-140]

feature

abstraction of a real world phenomena

Note 1 to entry: A feature can occur as a type or an instance. Feature type or feature instance should be used when only one is meant.

[source: ISO 19109]

feature attribute

characteristic of a feature

Note 1 to entry: A feature attribute can occur as a type or an instance. Feature attribute type or feature attribute instance is used when only one is meant.

[source: ISO 19109]

feature table

table where the columns represent feature attributes, and the rows represent features
[source: OGC 06-104]

geographic feature

representation of real world phenomenon associated with a location relative to the Earth
[source: ISO 19101-2]

geometric object

spatial object representing a geometric set
[source: ISO 19107:2003]

leaf

<one parameter set of geometries>
geometry at a particular value of the parameter
[source: ISO 19141]

moving feature

feature whose location changes over time

Note 1 to entry: Its base representation uses a local origin and local coordinate vectors of a geometric object at a given reference time.

Note 2 to entry: The local origin and ordinate vectors establish an engineering coordinate reference system (ISO 19111), also called a local frame or a local Euclidean coordinate system.

property

facet or attribute of an object referenced by a name
[source: ISO 19143]

trajectory

path of a moving point described by a one parameter set of points
[source: ISO 19141]

Chapter 5. Conventions

This section provides details and examples for any conventions used in the document. Examples of conventions are symbols, abbreviations, use of XML schema, or special notes regarding how to read the document.

5.1. Identifiers

The normative provisions in this Standard are denoted by the URI

http://www.opengis.net/spec/ogcapi-movingfeatures-1/1.0

All requirements and conformance tests that appear in this document are denoted by partial URIs which are relative to this base.

Chapter 6. Overview

6.1. General

OGC API-Features standards enable access to resources using the HTTP protocol and its associated operations (GET, PUT, POST, DELETE, etc.) OGC API-Common defines a set of features which are applicable to all OGC APIs. Other OGC standards extend API-Common with features specific to a resource type.

This OGC API-Moving Features-Part1:Feature Extension standard defines an API with a goal:

- Provide interface for create, retrieve, update, and delete to ***Moving Features***, which conformance to the OGC Moving Features JSON encoding standard

Resources exposed through an OGC API may be accessed through a Universal Resource Identifier (URI). URIs are composed of three sections:

- Dataset distribution API: The endpoint corresponding to a dataset distribution, where the landing page resource as defined in OGC API-Common-Part 1: Core is available (subsequently referred to as Base URI or `{root}`)
- Access Paths: Unique paths to Resources
- Query Parameters: Parameters to adjust the representation of a Resource or Resources like encoding format or sub-setting

Access Paths are used to build resource identifiers. It is recommended, but not required. Most resources are also accessible through links on previously accessed resources. Unique relation types are used for each resource.

Table 3 summarizes the access paths and relation types defined in this standard.

Table 3. Moving Features API Paths

Path Template	Relation	Resource
Collections		
{root}/collections	`data`	Metadata describing the Collection Catalog of data available from this API.
{root}/collections/{collectionId}		Metadata describing the Collection Catalog of data which has the unique identifier `{collectionId}`
MovingFeatures		
{root}/collections/{collectionId} /items	`items`	Static information of MovingFeature about available items in the specified Collection
{root}/collections/{collectionId} /items/{mFeatureId}	`item`	Static information describing the MovingFeature of data which has the unique identifier `{mFeatureId}`

Path Template	Relation	Resource
{root}/collections/{collectionId} /items/{mFeatureId}/tgeometries	items	Temporal object information of TemporalGeometryCollection about available items in the specified MovingFeature
{root}/collections/{collectionId} /items/{mFeatureId}/tgeometries /{tGeometryId}	item	Temporal object describing the TemporalGeometryCollection of data which has the unique identifier {tGeometryId}
{root}/collections/{collectionId} /items/{mFeatureId}/tgeometries /{tGeometryId}/{queryType}		Identifies an Information Resource of type {queryType} associated with the TemporalGeometry instance
{root}/collections/{collectionId} /items/{mFeatureId}/tproperties	items	Temporal object information of TemporalPropertyCollection about available items in the specified MovingFeature
{root}/collections/{collectionId} /items/{mFeatureId}/tproperties /{tPropertyName}	item	Temporal object describing the TemporalPropertyCollection of data which has the unique identifier {tPropertyName}

Where:

- {root} = Base URI for the API server
- {collectionId} = An identifier for a specific Collection of data
- {mFeatureId} = An identifier for a specific MovingFeature of a specific Collection of data
- {tGeometryId} = An identifier for a specific TemporalGeometry of a specific MovingFeatures of data
- {tPropertyName} = An identifier for a specific TemporalProperty of a specific MovingFeatures of data

Figure 1 shows a UML class diagram for OGC API Moving Features (shortly API-MF) which represents the basic resources of this standard, such as Collections, Collection, MovingFeatureCollection, MovingFeature, TemporalGeometryCollection, TemporalGeometry, TemporalPropertyCollection, and TemporalProperty. In this standard, a single moving feature can have temporal geometries, such as a set of trajectories. Also, the moving feature can have multiple temporal properties, and each property can have a set of parametric values.

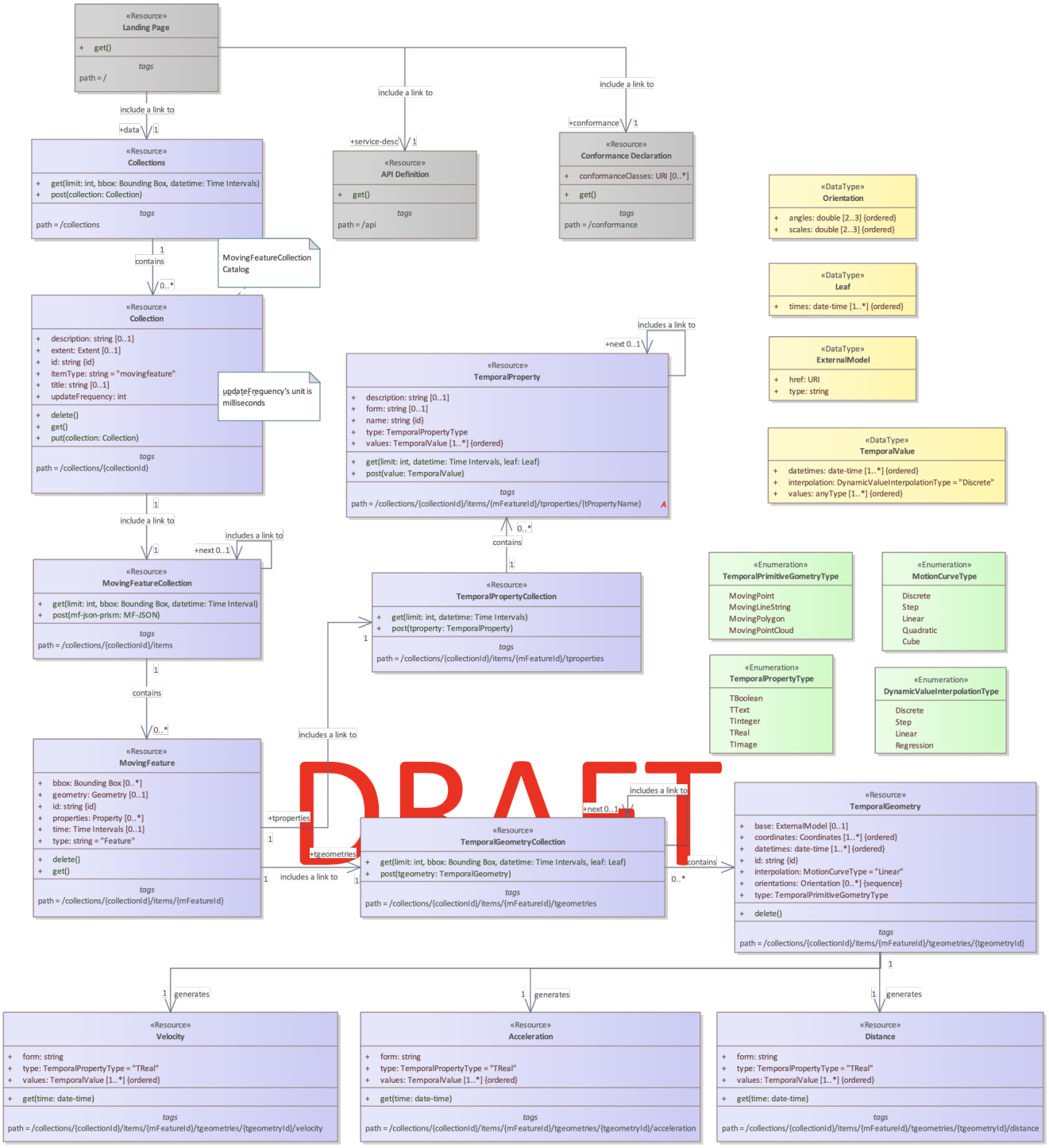

Figure 1. Class diagram for OGC API Moving Features

6.2. Search

The core search capability is based on OGC API-Common and thus supports:

- bounding box searches,
- time instant or time period searches,
- and equality predicates (i.e. *property=value*).

OGC API Moving Features extends these core search capabilities to include:

- spatio-temporal queries for accessing TemporalGeometry resources.

6.3. Dependencies

The OGC API Moving Features standard is an extension of the OGC API-Common and the OGC API-Features standards. Therefore, an implementation of OGC API-MF shall first satisfy the appropriate Requirements Classes from API-Common and API-Features. Also, OGC API-MF standard is based on the OGC Moving Features Encoding Extension for JSON (shortly, OGC MF-JSON) standards. Therefore, an implementation of OGC API-MF shall satisfy the appropriate Requirements Classes from OGC MF-JSON. Table 4, identifies the OGC API-Common and OGC API-Features Requirements Classes which are applicable to each section of this Standard. Instructions on when and how to apply these Requirements Classes are provided in each section.

Table 4. Mapping OGC API-MF Sections to OGC API-Common, OGC API-Features, and OGC MF-JSON Requirements Classes

API-MF Section	API-MF Requirements Class	API-Common, API-Features, MF-JSON Requirements Class
Collections	/req/mf-collection	http://www.opengis.net/spec/ogcapi-common-2/1.0/req/collections, http://www.opengis.net/spec/ogcapi-features-4/1.0/req/create-replace-delete
MovingFeatures	/req/movingfeatures	http://www.opengis.net/spec/ogcapi-features-1/1.0/req/core, http://www.opengis.net/spec/ogcapi-features-4/1.0/req/create-replace-delete, http://www.opengis.net/spec/movingfeatures/json/1.0/req/trajectory, http://www.opengis.net/spec/movingfeatures/json/1.0/req/prism
HTML	**inherit all requirement (no modification)**	http://www.opengis.net/spec/ogcapi-common-1/1.0/req/html
JSON	**inherit all requirement (no modification)**	http://www.opengis.net/spec/ogcapi-common-1/1.0/req/json
GeoJSON	**inherit all requirement (no modification)**	http://www.opengis.net/spec/ogcapi-features-1/1.0/conf/geojson
OpenAPI 3.0	**inherit all requirement (no modification)**	http://www.opengis.net/spec/ogcapi-common-1/1.0/req/oas30

Chapter 7. Requirements Class "MovingFeature Collection Catalog"

7.1. Overview

Requirements Class	
http://www.opengis.net/spec/ogcapi-movingfeatures-1/1.0/req/mf-collection	
Target type	Web API
Dependency	http://www.opengis.net/spec/ogcapi-common-2/1.0/req/collections
Dependency	http://www.opengis.net/spec/ogcapi-features-4/1.0/req/create-replace-delete

The `MovingFeature Collection Catalog` requirements class defines the requirements for a moving feature collection. A moving feature collection is an object that provides information about and access to a set of related MovingFeature.

7.2. Information Resources

The two resources defined in this Requirements Class are summarized in Table 5.

Table 5. MovingFeature Collection Catalog Resources

Resource	URI	HTTP Method	Description
Collections	`{root}/collections`	GET	Get information which describes the set of available Collections
		POST	Add a new resource (Collection) instance to a Collections
Collection	`{root}/collections/{collectionId}`	GET	Get information about a specific Collection ({collectionId}) of geospatial data with links to distribution
		PUT	Update information about a specific Collection ({collectionId})
		DELETE	Delete a specific Collection ({collectionId})

7.3. Resource Collections

The `Collections` resource supports retrieving and creating operations via GET and POST HTTP methods respectively.

1. Retrieving operation returns a set of metadata which describes the collections available from

this API.

2. Creating operation posts a new Collection resource instance to the collections with this API.

7.3.1. Operations

Retrieve

This operation is defined in the `Collections` conformance class of API-Common. No modifications are needed to support `MovingFeature` resources.

1. Issue a `GET` request on `{root}/collections` path

Support for HTTP GET method on the `{root}/collections` path is required by API-Common.

Requirement 1	/req/mf-collection/collections-get
A	The API implementation SHALL comply with the API-Common `Collections` operation requirement `/req/collections/rc-md-op`.

Create

This operation is defined in the `CREATE` conformance class of API-Features. This operation targeted Collection resource.

1. Issue a `POST` request on `{root}/collections` path

Support for HTTP POST method is required by API-Features.

Requirement 2	/req/mf-collection/collections-post
A	The API implementation SHALL comply with the API-Feature `CREATE` operation requirement `/req/create-replace-delete/insert-post-op`.
B	The API implementation SHALL comply with the API-Feature `CREATE` request body requirements `/req/create-replace-delete/insert-body` and `/req/create-replace-delete/insert-content-type`.
C	The content of the request body SHALL be based upon the `Collection` request body schema.

Collection Request Body Schema

```
type: object
required:
  - itemType
properties:
  title:
    description: human readable title of the collection
    type: string
  updateFrequency:
```

```
    description: a time interval of sampling location. The unit is millisecond.
    type: number
  description:
    description: any description
    type: string
  itemType:
    description:
    type: string
    default: "movingfeature"
```

The following example adds a new feature (collection information) to the feature collections. The feature is represented as JSON. A pseudo-sequence diagram notation is used to illustrate the details of the HTTP communication between the client and the server.

Create a New Collection Example

```
 Client                                                          Server
   |                                                               |
   | POST /collections   HTTP/1.1                                  |
   | Content-Type: application/json                                |
   |                                                               |
   | {                                                             |
   |   "title": "MovingFeatureCollection_1",                       |
   |   "updateFrequency": 1000,                                    |
   |   "description": "a collection of moving features to manage data  |
   |                   in a distinct (physical or logical) space",     |
   |   "itemType": "movingfeature"                                 |
   | }                                                             |
   |-------------------------------------------------------------->|
   |                                                               |
   | HTTP/1.1 201 Created                                          |
   | Location: /collections/mfc_1                                  |
   |<--------------------------------------------------------------|
```

7.3.2. Response

Retrieve

A successful response to the `Collections` GET operation is a document that contains summary metadata for each collection accessible through the API. In a typical API deployment, the `Collections` GET response will list collections of all offered resource types. The collections where the value of the `itemType` property is `movingfeature` are collections of moving features.

Requirement 3	/req/mf-collection/collections-get-success
A	The API implementation SHALL comply with the API-Common `Collections` response requirement `/req/collections/rc-md-success`.

Requirement 3	/req/mf-collection/collections-get-success
B	The content of that response SHALL be based upon the `Collections` response schema.
C	The `itemType` property of the response schema SHALL be `movingfeature`.

NOTE The usage of the `itemType` property is referred from the API-Common item Type section.

Collections GET Response Schema (collections.yaml)

```
type: object
required:
  - collections
  - links
properties:
  collections:
    type: array
    items:
      $ref: collection.yaml
  links:
    type: array
    items:
      $ref:
https://schemas.opengis.net/ogcapi/features/part1/1.0/openapi/schemas/link.yaml
  timeStamp:
    type: string
    format: date-time
  numberMatched:
    type: integer
    min: 0
  numberReturned:
    type: integer
    min: 0
```

The following JSON payload is an example of a response to an OGC API Moving Features `Collections` GET operation.

Collections Example

```
{
  "collections": [
    {
      "id": "mfc-1",
      "title": "MovingFeatureCollection_1",
      "description": "a collection of moving features to manage data in a distinct
(physical or logical) space",
      "itemType": "movingfeature",
      "updateFrequency": 1000,
```

```
      "extent": {
        "spatial": {
          "bbox": [
            -180, -90, 190, 90
          ],
          "crs": "http://www.opengis.net/def/crs/OGC/1.3/CRS84"
        },
        "temporal": {
          "interval": [
            "2011-11-11T12:22:11Z","2012-11-24T12:32:43Z"
          ],
          "trs": "http://www.opengis.net/def/uom/ISO-8601/0/Gregorian"
        }
      },
      "links": [
        {
          "href": "https://data.example.org/collections/mfc-1",
          "rel": "self",
          "type": "application/json"
        }
      ]
    }
  ],
  "links": [
    {
      "href": "https://data.example.org/collections",
      "rel": "self",
      "type": "application/json"
    }
  ]
}
```


Create

A successful response to the `Collections` POST operation is an HTTP status code.

Requirement 4	/req/mf-collection/collections-post-success
A	The API implementation SHALL comply with the API-Feature `CREATE` response requirement `/req/create-replace-delete/insert-response` and `/req/create-replace-delete/insert-response-rid`.

7.3.3. Error situations

The requirements for handling unsuccessful requests are provided in HTTP Response. General guidance on HTTP status codes and how they should be handled is provided in HTTP Status Codes.

7.4. Resource Collection

A Collection information object is the set of metadata that describes a single collection. An

abbreviated copy of this information is returned for each `Collection` in the `{root}/collections` GET response.

The schema for the collection information object presented in this clause is an extension of the collection schema defined in OGC API-Common and OGC API-Features.

Table 6 defines the set of properties that may be used to describe a collection.

Table 6. Table of collection properties

Property	Requirement	Description
id	M	A unique identifier to the collection.
title	O	A human-readable name given to the collection.
description	O	A free-text description of the collection.
links	M	A list of links for navigating the API (e.g. link to previous or next pages; links to alternative representations, etc.)
extent	O	The spatio-temporal coverage of the collection.
itemType	M	Fixed to the value "movingfeature".
updateFrequency	O	A time interval of sampling location. The time unit of this property is millisecond.

NOTE The *id*, *title*, *description*, *links*, *extent*, and *itemsType* properties were inherited from OGC API-Common and OGC API-Features.

NOTE An update frequency is one of the most important properties of moving feature collection. It is determined by a data source. It can be used to determine the continuity of the moving feature's trajectory.

Requirement 5	/req/mf-collection/mandatory-collection
A	A collection object SHALL contain all the mandatory properties listed in Table 6.

7.4.1. Operation

Retrieve

This operation is defined in the `Collection` conformance class of API-Common. No modifications are required to support `MovingFeature` resources.

1. Issue a `GET` request on the `{root}/collections/{collectionId}` path

The {collectionId} parameter is the unique identifier for a single collection offered by the API. The list of valid values for `{collectionId}` is provided in the `/collections` response.

Support for the `{root}/collections/{collectionId}` path is required by OGC API-Common.

Requirement 6	/req/mf-collection/collection-get
A	The API implementation SHALL comply with the API-Common Collection operation requirement http://www.opengis.net/spec/ogcapi-common-2/1.0/req/collections/src-md-op.

Replace

This operation is defined in the REPLACE conformance class of API-Features. This operation targeted Collection resource.

1. Issue a PUT request on {root}/collections/{collectionId} path

Support for HTTP PUT method is required by API-Features.

Requirement 7	/req/mf-collection/collection-put
A	The API implementation SHALL comply with the API-Feature PUT operation requirement /req/create-replace-delete/update-put-op.
B	The API implementation SHALL comply with the API-Feature PUT request body requirements /req/create-replace-delete/update-put-body and /req/create-replace-delete/update-put-content-type.
C	The content of the request body SHALL be based upon the Collection request body schema, except updateFrequency. If the updateFrequency is included in the request body, the server SHALL ignore it.

NOTE The update frequency cannot be changed once set.

The following example replaces the feature created by the Create Example with a new feature (collection information without an update frequency). Once again, the replacement feature is represented as JSON. A pseudo-sequence diagram notation is used to illustrate the details of the HTTP communication between the client and the server.

Replace an Existing Collection Example

```
    |<-------------------------------------------------------------|
```

Delete

This operation is defined in the `DELETE` conformance class of API-Features.

1. Issue a `DELETE` request on `{root}/collections/{collectionId}` path

Support for HTTP DELETE method is required by API-Features.

Requirement 8	/req/mf-collection/collection-delete
A	The API implementation SHALL comply with the API-Feature `DELETE` operation requirement `/req/create-replace-delete/delete/delete-op`.

The following example deletes the feature created by the Create Example and replaced with a new feature in the Replace Example. A pseudo-sequence diagram notation is used to illustrate the details of the HTTP communication between the client and the server.

Delete an Existing Collection Example

```
  Client                                                          Server
    |                                                               |
    | DELETE /collections/mfc_1   HTTP/1.1                          |
    |-------------------------------------------------------------->|
    |                                                               |
    | HTTP/1.1 204 OK                                               |
    |<--------------------------------------------------------------|
```

7.4.2. Response

Retrieve

A successful response to the `Collection` GET operation is a set of metadata that describes the collection identified by the `{collectionId}` parameter.

Requirement 9	/req/mf-collection/collection-get-success
A	The API implementation SHALL comply with the API-Common `Collection` response requirement `/req/collections`.
B	The response SHALL only include collection metadata selected by the request.
C	The content of that response SHALL be based upon the `Collection` response schema.
D	The `itemType` property of the response schema SHALL be 'movingfeature'.

Collection GET Response Schema (collection.yaml)

```
type: object
required:
  - id
  - links
  - itemType
properties:
  id:
    description: identifier of the collection used, for example, in URIs
    type: string
    example: address
  title:
    description: human readable title of the collection
    type: string
    example: address
  description:
    description: a description of the features in the collection
    type: string
    example: An address.
  links:
    type: array
    items:
      $ref:
https://schemas.opengis.net/ogcapi/features/part1/1.0/openapi/schemas/link.yaml
    example:
      - href: https://data.example.com/buildings
        rel: item
      - href: https://example.com/concepts/buildings.html
        rel: describedby
        type: text/html
  extent:
    $ref:
https://schemas.opengis.net/ogcapi/features/part1/1.0/openapi/schemas/extent.yaml
  itemType:
    description: indicator about the type of the items in the collection
    type: string
    default: movingfeature
  crs:
    description: the list of coordinate reference systems supported by the service
    type: array
    items:
      type: string
    default:
      - https://www.opengis.net/def/crs/OGC/1.3/CRS84
    example:
      - https://www.opengis.net/def/crs/OGC/1.3/CRS84
      - https://www.opengis.net/def/crs/EPSG/0/4326
  updateFrequency:
    description: a time interval of sampling location. The unit is millisecond.
```

```
    type: number
```

The following JSON payload is an example of a response to an OGC API Moving Features `Collection` GET operation.

Collection Information Example

```
{
  "id": "mfc-1",
  "title": "moving_feature_collection_sample",
  "itemType": "movingfeature",
  "updateFrequency": 1000,
  "extent": {
    "spatial": {
      "bbox": [
        -180, -90, 190, 90
      ],
      "crs": [
        "http://www.opengis.net/def/crs/OGC/1.3/CRS84"
      ]
    },
    "temporal": {
      "interval": [
        "2011-11-11T12:22:11Z","2012-11-24T12:32:43Z"
      ],
      "trs": [
        "http://www.opengis.net/def/uom/ISO-8601/0/Gregorian"
      ]
    }
  },
  "links": [
    {
      "href": "https://data.example.org/collections/mfc-1",
      "rel": "self",
      "type": "application/json"
    }
  ]
}
```

Replace

A successful response to the `Collection` PUT operation is an HTTP status code.

Requirement 10	/req/mf-collection/collection-put-success
A	The API implementation SHALL comply with the API-Feature `PUT` response requirement `/req/create-replace-delete/update-put-response`.

Requirement 10	/req/mf-collection/collection-put-success
B	The API implementation SHALL comply with the API-Feature `PUT` exception requirement `/req/create-replace-delete/update-put-rid-exception`.

Delete

A successful response to the `Collection` DELETE operation is an HTTP status code.

Requirement 11	/req/mf-collection/collection-delete-success
A	The API implementation SHALL comply with the API-Feature `DELETE` response requirement `/req/create-replace-delete/delete/response`.
B	If no resource with the identifier exists in the collection, the server SHALL respond with a not-found exception (`404`).

7.4.3. Error situations

The requirements for handling unsuccessful requests are provided in HTTP Response. General guidance on HTTP status codes and how they should be handled is provided in HTTP Status Codes.

Chapter 8. Requirements Class "MovingFeatures"

8.1. Overview

Requirements Class	
http://www.opengis.net/spec/ogcapi-movingfeatures-1/1.0/req/movingfeatures	
Target type	Web API
Dependency	http://www.opengis.net/spec/ogcapi-features-1/1.0/req/core
Dependency	http://www.opengis.net/spec/ogcapi-features-4/1.0/req/create-replace-delete
Dependency	http://www.opengis.net/spec/movingfeatures/json/1.0/req/trajectory
Dependency	http://www.opengis.net/spec/movingfeatures/json/1.0/req/prism

The `MovingFeatures` requirements class defines the requirements for a moving feature. A moving feature is an object that provide information about and access to a TemporalGeometryCollection and TemporalPropertyCollection.

8.2. Information Resources

The five resources defined in this Requirements Class are summarized in Table 7.

Table 7. MovingFeatures Resources

Resource	URI	HTTP Method
MovingFeatures	`{root}/collections/{collectionId}/items`	GET, POST
MovingFeature	`{root}/collections/{collectionId}/items/{mfeatureId}`	GET, DELETE
TemporalGeometryCollection	`{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries`	GET, POST
TemporalGeometry	`{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}`	DELETE
TemporalGeometryQuery	`{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/{queryType}`	GET
TemporalPropertyCollection	`{root}/collections/{collectionId}/items/{mFeatureId}/tproperties`	GET, POST

Resource	URI	HTTP Method
TemporalProperty	{root}/collections/{collectionId}/items/{mFeatureId}/tproperties/{tPropertiesName}	GET, POST

8.3. Resource MovingFeatures

The MovingFeatures resource supports retrieving and creating operations via GET and POST HTTP methods respectively.

1. Retrieving operation returns a set of features which describes the moving feature available from this API.
2. Creating operation post a new MovingFeature resource instance to a specific Collection (specified by {collectinoId} with this API.

The OGC API-MF Items query is an OGC API-Features endpoint that may be used to catalog pre-existing moving features. If a mFeatureID is not specified, the query will return a list of the available moving features. The list of moving features returned to the response can be limited using the bbox, datetime, and limit parameters. This behavior is specified in OGC API-Features. All parameters for use with the Items query are defined by OGC API-Features.

8.3.1. Operation

Retrieve

This operation is defined in the MovingFeatures conformance class of API-Features. No modifications are needed to support MovingFeature resources.

1. Issue a GET request on {root}/collections/{collledctionID}/items path

Support for GET on the {root}/collections/{collledctionID}/items path is required by API-Features.

Requirement 12	/req/movingfeatures/features-get
A	The API implementation SHALL comply with the API-Features Features operation requirement /req/core/fc-op.

Create

This operation is defined in the CREATE conformance class of API-Features. This operation targeted MovingFeature resource.

1. Issue a POST request on {root}/collections/{collledctionID}/items path

Support for HTTP POST method is required by API-Features.

Requirement 13	/req/movingfeatures/features-post
A	The API implementation SHALL comply with the API-Feature CREATE operation requirement /req/create-replace-delete/insert-post-op.
B	The API implementation SHALL comply with the API-Feature CREATE request body requirements /req/create-replace-delete/insert-body and /req/create-replace-delete/insert-content-type.
C	The content of the request body SHALL be based upon the MovingFeature object and MovingFeatureCollection object in OGC Moving Features JSON encoding standard schema.

The following example adds a new feature (MovingFeature object in MF-JSON) to the specific Collection. The feature is represented as MovingFeature object (or MovingFeatureCollection object) in MF-JSON, which is a kind of extension of the GeoJSON. A pseudo-sequence diagram notation is used to illustrate the details of the HTTP communication between the client and the server.

Create a New MovingFeature Object Example

```
Client                                                                  Server
  |                                                                       |
  | POST /collections/mfc_1/items   HTTP/1.1                              |
  | Content-Type: application/geo+json                                    |
  |                                                                       |
  | {                                                                     |
  |   "type": "Feature",                                                  |
  |   "id": "mf_1",                                                       |
  |   "properties": {                                                     |
  |      "name": "car1",                                                  |
  |      "state": "test1",                                                |
  |      "video": "http://.../example/video.mpeg"                         |
  |   },                                                                  |
  |   "crs": {                                                            |
  |      "type": "Name",                                                  |
  |      "properties": {                                                  |
  |         "name": "urn:ogc:def:crs:OGC:1.3:CRS84"                       |
  |      }                                                                |
  |   },                                                                  |
  |   "trs": {                                                            |
  |      "type": "Link",                                                  |
  |      "properties": {                                                  |
  |         "type": "ogcdef",                                             |
  |         "href": "http://www.opengis.net/def/uom/ISO-8601/0/Gregorian" |
  |      }                                                                |
  |   },                                                                  |
  |   "temporalGeometry": {                                               |
  |      "type": "MovingPoint",                                           |
  |      "datetimes": [                                                   |
  |         "2011-07-14T22:01:01.000Z",                                   |
```

```
|         "2011-07-14T22:01:02.000Z",                                                                  |
|         "2011-07-14T22:01:03.000Z",                                                                  |
|         "2011-07-14T22:01:04.000Z",                                                                  |
|         "2011-07-14T22:01:05.000Z"                                                                   |
|      ],                                                                                              |
|      "coordinates": [                                                                                |
|         [139.757083,35.627701,0.5],                                                                  |
|         [139.757399,35.627701,2.0],                                                                  |
|         [139.757555,35.627688,4.0],                                                                  |
|         [139.757651,35.627596,4.0],                                                                  |
|         [139.757716,35.627483,4.0]                                                                   |
|      ],                                                                                              |
|      "interpolation": "Linear",                                                                      |
|      "base": {                                                                                       |
|         "type": "glTF",                                                                              |
|         "href": "http://.../example/car3dmodel.gltf"                                                 |
|      },                                                                                              |
|      "orientations": [                                                                               |
|          {"scales": [1,1,1],"angles": [0,0,0]},                                                      |
|          {"scales": [1,1,1],"angles": [0,355,0]},                                                    |
|          {"scales": [1,1,1],"angles": [0,0,330]},                                                    |
|          {"scales": [1,1,1],"angles": [0,0,300]},                                                    |
|          {"scales": [1,1,1],"angles": [0,0,270]},                                                    |
|      ]                                                                                               |
|   },                                                                                                 |
|   "temporalProperties": [                                                                            |
|      {                                                                                               |
|         "datetimes": [                                                                               |
|            "2011-07-14T22:01:01.450Z",                                                               |
|            "2011-07-14T23:01:01.450Z",                                                               |
|            "2011-07-15T00:01:01.450Z"                                                                |
|            ],                                                                                        |
|         "length": {                                                                                  |
|            "type": "Measure",                                                                        |
|            "form": "http://www.qudt.org/qudt/owl/1.0.0/quantity/Length",                             |
|            "values": [1,2.4,1],                                                                      |
|            "interpolation": "Linear",                                                                |
|            "description": "description1"                                                             |
|         },                                                                                           |
|         "discharge": {                                                                               |
|            "type": "Measure",                                                                        |
|            "form": "MQS",                                                                            |
|            "values": [3,4,5],                                                                        |
|            "interpolation": "Step"                                                                   |
|         }                                                                                            |
|      },                                                                                              |
|      {                                                                                               |
|         "datetimes": [                                                                               |
|            "2011-07-15T23:01:01.450Z",                                                               |
|            "2011-07-16T00:01:01.450Z"                                                                |
|         ],                                                                                           |
```

```
|         "camera": {                                                    |
|            "type": "Image",                                            |
|            "values": [                                                 |
|               "http://.../example/image1",                             |
|               "VBORw0KGgoAAAANSUhEU......"                             |
|            ],                                                          |
|            "interpolation": "Discrete"                                 |
|         },                                                             |
|         "labels": {                                                    |
|            "type": "Text",                                             |
|            "values": ["car","human"],                                  |
|            "interpolation": "Discrete"                                 |
|         }                                                              |
|      }                                                                 |
|   ]                                                                    |
| }                                                                      |
|----------------------------------------------------------------------->|
|                                                                        |
| HTTP/1.1 201 Created                                                   |
| Location: /collections/mfc_1/items/mf_1                                |
|<-----------------------------------------------------------------------|
```

8.3.2. Response

Retrieve

A successful response to the `MovingFeatures` GET operation is a document that contains the static data of moving features. In a typical API deployment, the `MovingFeatures` GET response will list features of all offered resource types.

Requirement 14	/req/movingfeatures/features-get-success
A	The API implementation SHALL comply with the API-Features `Features` response requirement `/req/core/fc-response`.
B	The response SHALL only include moving features selected by the request with parameters.
C	Each moving feature in the response SHALL include the mandatory properties listed in Table 8.

MovingFeatures GET Response Schema (movingFeatureCollection.yaml)

```yaml
type: object
required:
  - type
  - features
properties:
  type:
    type: string
    enum:
```

```
      - FeatureCollection
  features:
    type: array
    items:
      $ref: movingFeature.yaml
  crs:
    $ref: crs.yaml
  trs:
    $ref: trs.yaml
  links:
    type: array
    items:
      $ref:
https://schemas.opengis.net/ogcapi/features/part1/1.0/openapi/schemas/link.yaml
  timeStamp:
    type: string
    format: date-time
  numberMatched:
    type: integer
    minimum: 0
  numberReturned:
    type: integer
    minimum: 0
```

crs.yaml


```
type: object
required:
  - type
  - properties
properties:
  oneOf:
    - - type:
          type: string
          enum:
            - "Name"
      - properties:
          type: object
          required:
            - name
          properties:
            - name:
                type: string
                default: "urn:ogc:def:crs:OGC:1.3:CRS84"
    - - type:
          type: string
          enum:
            - "Link"
      - properties:
          type: object
```

```
          required:
            - href
            - type
          properties:
            - href:
                type: string
                format: uri
            - type:
                type: string
```

trs.yaml

```
type: object
required:
  - type
  - properties
properties:
  oneOf:
    - - type:
          type: string
          enum:
            - "Name"
      - properties:
          type: object
          required:
            - name
          properties:
            - name:
                type: string
                default: "urn:ogc:data:time:iso8601"
    - - type:
          type: string
          enum:
            - "Link"
      - properties:
          type: object
          required:
            - href
            - type
          properties:
            - href:
                type: string
                format: uri
            - type:
                type: string
```

The following JSON payload is an example of a response to an OGC API Moving Features `MovingFeatures` GET operation.

MovingFeatures GET Example


```
{
  "type": "FeatureCollection",
  "features":[
    {
      "id": "mf-1",
      "type": "Feature",
      "geometry":{
        "type": "LineString",
        "coordinates": [
          [139.757083, 35.627701, 0.5],
          [139.757399, 35.627701, 2.0],
          [139.757555, 35.627688, 4.0],
          [139.757651, 35.627596, 4.0],
          [139.757716, 35.627483, 4.0]
        ]
      },
      "properties":{
        "label": "car",
        "state": "test1",
        "video":
"http://www.opengis.net/spec/movingfeatures/json/1.0/prism/example/video.mpeg"
      },
      "bbox":[
        139.757083, 35.627483, 0.0,
        139.757716, 35.627701, 4.5
      ],
      "time":[
        "2011-07-14T22:01:01Z",
        "2011-07-15T01:11:22Z"
      ],
      "crs": {
        "type": "Name",
        "properties": "urn:ogc:def:crs:OGC:1.3:CRS84"
      },
      "trs": {
        "type": "Name",
        "properties": "urn:ogc:data:time:iso8601"
      }
    }
  ],
  "crs": {
    "type": "Name",
    "properties": "urn:ogc:def:crs:OGC:1.3:CRS84"
  },
  "trs": {
    "type": "Name",
    "properties": "urn:ogc:data:time:iso8601"
  },
  "links":[
```

```
    {
      "href": "https://data.example.org/collections/mfc-1/items",
      "rel": "self",
      "type": "application/geo+json"
    },
    {
      "href": "https://data.example.org/collections/mfc-1/items&offset=1&limit=1",
      "rel": "next",
      "type": "application/geo+json"
    }
  ],
  "timeStamp": "2020-01-01T12:00:00Z",
  "numberMatched": 100,
  "numberReturned": 1
}
```


Create

A successful response to the `MovingFeatures` POST operation is an HTTP status code.

Requirement 15	/req/movingfeatures/features-post-success
A	The API implementation SHALL comply with the API-Feature `CREATE` response requirement `/req/create-replace-delete/insert-response` and `/req/create-replace-delete/insert-response-rid`.

8.3.3. Error situations

The requirements for handling unsuccessful requests are provided in HTTP Response. General guidance on HTTP status codes and how they should be handled is provided in HTTP Status Codes.

8.4. Resource MovingFeature

8.4.1. Overview

A MovingFeature object consists of the set of static information that describes a single moving feature and the set of temporal object information, such as temporal geometry and temporal property. An abbreviated copy of this information is returned for each `MovingFeature` in the `{root}/collections/{collectionId}/items` GET response.

The schema for the moving feature object presented in this clause is an extension of the `GeoJSON Feature Object` defined in GeoJSON. Table 8 defines the set of properties that may be used to describe a moving feature.

Table 8. Table of the properties related to the moving feature

Property	Requirement	Description
id	M	A unique record identifier assigned by the server.
type	M	A feature type of GeoJSON (i.e., one of 'Feature' or 'FeatureCollection').
geometry	M	A projective geometry of the moving feature.
properties	M	A set of property of GeoJSON.
bbox	O	A bounding box information for the moving feature.
time	O	A life span information for the moving feature.
crs	O	A coordinate reference system information for the moving feature.
trs	O	A temporal reference system information for the moving feature.
temporalGeometries	O	A set of temporal geometry of the moving feature.
temporalPropertiesCollection	O	A set of temporalProperty of the moving feature.

NOTE The properties *id*, *type*, *geometry*, *properties*, and *bbox* were inherited from GeoJSON.

Requirement 16	/req/movingfeatures/mf-mandatory
A	A moving feature object SHALL contain all the mandatory properties listed in Table 8.

8.4.2. Operation

Retrieve

This operation is defined in the `Feature` conformance class of API-Features. No modifications are needed to support MovingFeature resources.

1. Issue a `GET` request on the `{root}/collections/{collectionId}/items/{mFeatureId}` path

The {mFeatureId} parameter is the unique identifier for a single moving feature offered by the API. The list of valid values for `{mFeatureId}` is provided in the `{root}/collections/{collectionId}/items` GET response.

Support for GET on the `{root}/collections/{collledctionID}/items/{mFeatureId}` path is required by API-Features.

Requirement 17	/req/movingfeatures/mf-get
A	The API implementation SHALL comply with the API-Features `Feature` operation requirement `/req/core/f-op`.
B	For every moving feature in a moving feature collection (path `{root}/collections/{collectionId}`), the server SHALL support the HTTP GET operation at the path `{root}/collections/{collectionId}/items/{mFeatureId}`
C	The path parameter `collectionId` is each `id` property in the `Collection` GET operation response where the value of the `itemType` property is specified as `movingfeature`. The path parameter `mFeatureId` is an `id` property of the moving feature.

Delete

This operation is defined in the `DELETE` conformance class of API-Features.

1. Issue a `DELETE` request on `{root}/collections/{collectionId}/items/{mFeatureId}` path

Support for HTTP DELETE method is required by API-Features.

Requirement 18	/req/movingfeatures/mf-delete
A	The API implementation SHALL comply with the API-Feature `DELETE` operation requirement `req/create-replace-delete/delete/delete-op`.
B	For every moving feature in a moving feature collection (path `{root}/collections/{collectionId}`), the server SHALL support the HTTP DELETE operation at the path `{root}/collections/{collectionId}/items/{mFeatureId}`
C	The path parameter `collectionId` is each `id` property in the `Collection` GET operation response where the value of the `itemType` property is specified as `movingfeature`. The path parameter `mFeatureId` is an `id` property of the moving feature.

8.4.3. Response

Retrieve

A successful response to the `MovingFeature` GET operation is a set of metadata that describes the moving feature identified by the `{mFeatureId}` parameter. This response does not include a set of temporal object information. The temporal object information may be accessed using TemporalGeometries and TemporalPropertiesCollection operations.

Requirement 19	/req/movingfeatures/mf-get-success
A	A successful execution of the operation SHALL be reported as a response with an HTTP status code `200`.

Requirement 19	/req/movingfeatures/mf-get-success
B	The content of that response SHALL include the set of moving feature's metadata that defined in the response schema.

MovingFeature GET Response Schema (movingFeature.yaml)

```
type: object
required:
  - id
  - type
  - geometry
  - properties
properties:
  id:
    type: string
  type:
    type: string
    enum:
      - Feature
  geometry:
    $ref:
https://schemas.opengis.net/ogcapi/features/part1/1.0/openapi/schemas/geometryGeoJSON.
yaml
  properties:
    type: object
    nullable: true
  bbox:
    type: array
    minItems: 1
    items:
      type: array
      oneOf:
        - minItems: 4
          maxItems: 4
        - minItems: 6
          maxItems: 6
      items:
        type: number
  time:
    type: array
    minItems: 1
    items:
      type: array
      minItems: 2
      maxItems: 2
      items:
        type: string
        format: date-time
        nullable: true
  crs:
```

```
    $ref: crs.yaml
  trs:
    $ref: trs.yaml
  links:
    type: array
    items:
      $ref:
https://schemas.opengis.net/ogcapi/features/part1/1.0/openapi/schemas/link.yaml
```

The `interval` property of the `MovingFeature` response represents a particular period of moving feature existence.

The following JSON payload is an example of a response to an OGC API MovingFeatures `MovingFeature` operation.

MovingFeature Example

```
{
  "id": "mf-1",
  "type": "Feature",
  "geometry":{
    "type": "LineString",
    "coordinates": [
      [139.757083, 35.627701, 0.5],
      [139.757399, 35.627701, 2.0],
      [139.757555, 35.627688, 4.0],
      [139.757651, 35.627596, 4.0],
      [139.757716, 35.627483, 4.0]
    ]
  },
  "properties":{
    "name": "car1",
    "state": "test1",
    "video":
"http://www.opengis.net/spec/movingfeatures/json/1.0/prism/example/video.mpeg"
  },
  "bbox":[
    139.757083, 35.627483, 0.0,
    139.757716, 35.627701, 4.5
  ],
  "time":[
    "2011-07-14T22:01:01Z",
    "2011-07-15T01:11:22Z"
  ],
  "crs": {
    "type": "Name",
    "properties": "urn:ogc:def:crs:OGC:1.3:CRS84"
  },
  "trs": {
    "type": "Name",
```

```
    "properties": "urn:ogc:data:time:iso8601"
  }
}
```

Delete

A successful response to the `Collection` DELETE operation is an HTTP status code.

Requirement 20	/req/movingfeatures/mf-delete-success
A	The API implementation SHALL comply with the API-Feature `DELETE` response requirement `/req/create-replace-delete/delete/response`.
B	If no resource with the identifier exists in the collection, the server SHALL respond with a not-found exception (`404`).

8.4.4. Error situations

The requirements for handling unsuccessful requests are provided in HTTP Response. General guidance on HTTP status codes and how they should be handled is provided in HTTP Status Codes.

8.5. Resource TemporalGeometryCollection

The `TemporalGeometryCollection` resource supports retrieving and creating operations via GET and POST HTTP methods respectively.

1. Retrieving operation returns a set of temporal geometry object which is included in the `MovingFeature` that specified by {mFeatureId}. The set of temporal geometry object returned to the response can be limited using the `limit`, `bbox`, `datetime`, and `leaf` parameters.
2. Creating operation post a new TemporalGeometry resource to the `MovingFeature` that specified by {mFeatureId}.

8.5.1. Parameters

Parameter leaf

The `leaf` parameter is a sequence of monotonic increasing instants with date-time strings (ex. "2018-02-12T23:20:50Z") that adheres to RFC3339. It consists of a list of the date-time format string, different from `datetime` parameter. The array does not allow the same element.

Example 1. Leaf valid (and invalid) Examples

(O) "2018-02-12T23:20:50Z"

(O) "2018-02-12T23:20:50Z", "2018-02-12T23:30:50Z"

(O) "2018-02-12T23:20:50Z", "2018-02-12T23:30:50Z", "2018-02-12T23:40:50Z"

(X) "2018-02-12T23:20:50Z", "2018-02-12T23:20:50Z"

(X) "2018-02-12T23:20:50Z", "2018-02-12T22:20:50Z"

If `leaf` parameter is provided by the client, the endpoint returns only geometry coordinate (or temporal property value) with the leaf query at each time included in the `leaf` parameter, similar to ***pointAtTime*** operation in the OGC Moving Feature Access standard. And `interpolation` property in the response SHALL be 'Discrete'.

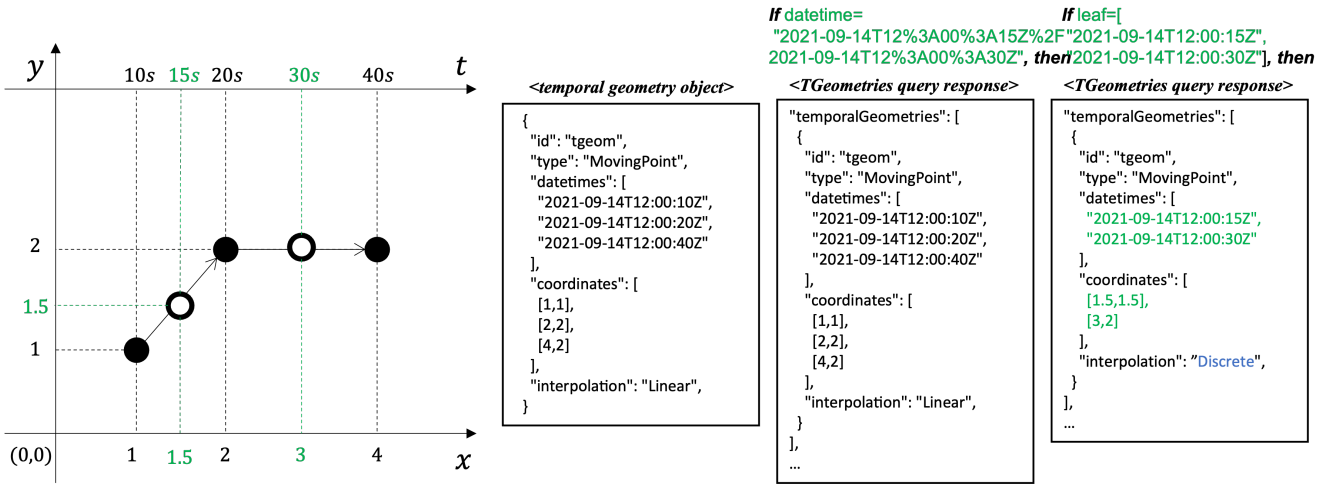

Figure 2. Example of response result with `leaf` parameter

Requirement 21	**/req/movingfeatures/param-leaf-definition**

A	The operation SHALL support a parameter `leaf` with the following characteristics (using an OpenAPI Specification 3.0 fragment):
	`name: leaf`
	`in: query`
	`required: false`
	`schema:`
	`  type: array`
	`  uniqueItems: true,`
	`  minItems: 1`
	`  items:`
	`  type: string`
	`  format: date-time`
	`style: form`
	`explode: false`

B	The `leaf` parameter SHALL be a sequence of monotonic increasing instants with `date-time` strings.
C	The syntax of `date-time` is specified by RFC 3339, 5.6.

Requirement 22	/req/movingfeatures/param-leaf-response
A	If the `leaf` parameter is provided by the client and supported by the server, then only resources that have a temporal information (i.e., `datetimes` property) that intersects the temporal information in the `leaf` parameter SHALL be part of the result set.
B	The `leaf` parameter SHALL match all resources in the moving feature that are associated with temporal information.
C	If `leaf` parameter is provided by the client and supported by the server, the endpoint SHALL return only temporal geometry coordinate (or temporal property value) with the ***PointAtTime*** query at each time included in the `leaf` parameter, using interpolated trajectory according to the `interpolation` property.
D	If `leaf` parameter is provided by the client and supported by the server, the `interpolation` property in the response SHALL be 'Discrete'.

8.5.2. Operation

Retrieve

1. Issue a `GET` request on the `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries` path

Requirement 23	/req/movingfeatures/tgeometries-get
A	For every moving feature identified in the MovingFeatures GET response (path `{root}/collections/{collectionId}/items`), the server SHALL support the HTTP GET operation at the path `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries`
B	The path parameter `collectionId` is each `id` property in the `Collection` GET response where the value of the `itemType` property is specified as `movingfeature`. The path parameter `mFeatureId` is each `id` property in the `MovingFeatures` GET response.

Create

This operation is defined in the `CREATE` conformance class of API-Features. This operation targeted TemporalGeometry resource.

1. Issue a `POST` request on `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries` path

Support for HTTP POST method is required by API-Features.

Requirement 24	/req/movingfeatures/tgeometries-post
A	The API implementation SHALL comply with the API-Feature CREATE operation requirement /req/create-replace-delete/insert-post-op.
B	The API implementation SHALL comply with the API-Feature CREATE request body requirements /req/create-replace-delete/insert-body and /req/create-replace-delete/insert-content-type.
C	The content of the request body SHALL be based upon the TemporalGeometry object in OGC Moving Features JSON encoding standard schema.
D	The latest date-time instance in the temporal geometry object in MovingFeature, determined by mFeatureId, SHALL be faster than the beginning date-time instance in the temporal geometry object in the request body.

The following example adds a new feature (TemporalGeometry object in MF-JSON) to the feature created by the Creation a MovingFeature Example. The feature is represented as TemporalGeometry object in MF-JSON, which is a kind of extension of the JSON. A pseudo-sequence diagram notation is used to illustrate the details of the HTTP communication between the client and the server.

Create a New TemporalGeometry Object Example

```
Client                                                                  Server
  |                                                                       |
  | POST /collections/mfc_1/items/mf_1/tgeometries   HTTP/1.1             |
  | Content-Type: application/json                                        |
  |                                                                       |
  | {                                                                     |
  |    "id": "tg_1",                                                      |
  |    "type": "MovingPoint",                                             |
  |    "datetimes": [                                                     |
  |       "2011-07-14T22:01:06.000Z",                                     |
  |       "2011-07-14T22:01:07.000Z",                                     |
  |       "2011-07-14T22:01:08.000Z"                                      |
  |    ],                                                                 |
  |    "coordinates": [                                                   |
  |       [139.757716,35.627483,4.0],                                     |
  |       [139.757782,35.627483,4.0],                                     |
  |       [139.757843,35.627483,4.0]                                      |
  |    ],                                                                 |
  |    "interpolation": "Linear",                                         |
  |    "base": {                                                          |
  |       "type": "glTF",                                                 |
  |       "href": "http://.../example/car3dmodel.gltf"                    |
  |    },                                                                 |
  |    "orientations": [                                                  |
```

```
    |        {"scales": [1,1,1],"angles": [0,0,270]},                          |
    |        {"scales": [1,1,1],"angles": [0,0,270]},                          |
    |        {"scales": [1,1,1],"angles": [0,0,270]}                           |
    |    ]                                                                     |
    | }                                                                        |
    |------------------------------------------------------------------------->|
    |                                                                          |
    | HTTP/1.1 201 Created                                                     |
    | Location: /collections/mfc_1/items/mf_1/tgeometries/tg_1                 |
    |<-------------------------------------------------------------------------|
```

8.5.3. Response

Retrieve

A successful response to the `TemporalGeometryCollection` GET operation is a document that contains the set of temporal geometry of the moving feature identified by the `{mFeatureId}` parameter.

Requirement 25	/req/movingfeatures/tgeometries-get-success
A	The API implementation SHALL comply with the API-Features `Features` response requirement `/req/core/fc-response`.
B	The response SHALL only include temporal geometries selected by the request with `limit`, `bbox`, `datetime`, and `leaf` parameters.
C	Each temporal geometry in the response SHALL include the mandatory properties listed in Table 9.

TemporalGeometries GET Response Schema (temporalGeometryCollection.yaml)

```yaml
type: object
required:
  - type
  - prisms
properties:
  type:
    type: string
    default: MovingGeometryCollection
  prisms:
    type: array
    items:
      $ref: temporalGeometry.yaml
  crs:
    $ref: crs.yaml
  trs:
    $ref: trs.yaml
  links:
    type: array
    items:
      $ref:
```

```
https://schemas.opengis.net/ogcapi/features/part1/1.0/openapi/schemas/link.yaml
  timeStamp:
    type: string
    format: date-time
  numberMatched:
    type: integer
    minimum: 0
  numberReturned:
    type: integer
    minimum: 0
```

TemporalGeometry Schema (temporalGeometry.yaml)

```
type: object
required:
  - id
  - type
  - coordinates
  - datetimes
  - interpolation
properties:
  id:
    type: string
  type:
    type: string
    enum:
      - MovingPoint
      - MovingLineString
      - MovingPolygon
      - MovingPointCloud
  coordinates:
    type: array
    minItems: 2
    items:
      oneOf:
        - $ref: pointCoordinates.yaml
        - $ref: lineStringCoordinates.yaml
        - $ref: polygonCoordinates.yaml
        - $ref: multiPointCoordinates.yaml
  datetimes:
    type: array
    uniqueItems: true,
    minItems: 2
    items:
      type: string
      format: date-time
  interpolation:
    type: string
    enum:
      - Discrete
```

```
      - Step
      - Linear
      - Quadratic
      - Cube
  base:
    type: object
    required:
      - href
      - type
    properties:
      href:
        type: string
        format: uri
      type:
        type: string
  orientations:
    type: array
    minItems: 2
    items:
      type: object
      required:
        - scales
        - angles
      properties:
        scales:
          type: array
          oneOf:
            - minItems: 2
              maxItems: 2
            - minItems: 3
              maxItems: 3
          items:
            type: number
        angles:
          type: array
          oneOf:
            - minItems: 2
              maxItems: 2
            - minItems: 3
              maxItems: 3
          items:
            type: number
```

The following JSON payload is an example of a response to an OGC API Moving Features `TemporalGeometryCollection` GET operation.

TemporalGeometryCollection GET Example

```
{
  "type": "MovingGeometryCollection",
```

```
  "prisms": [
    {
      "id": "tg-1",
      "type": "MovingPoint",
      "datetimes": [
        "2011-07-14T22:01:02Z",
        "2011-07-14T22:01:03Z",
        "2011-07-14T22:01:04Z"
      ],
      "coordinates": [
        [139.757399, 35.627701, 2.0],
        [139.757555, 35.627688, 4.0],
        [139.757651, 35.627596, 4.0]
      ],
      "interpolation": "Linear",
      "base": {
        "type": "glTF",
        "href":
"https://www.opengis.net/spec/movingfeatures/json/1.0/prism/example/car3dmodel.gltf"
      },
      "orientations":[
        {
          "scales": [1,1,1],
          "angles": [0,355,0]
        },
        {
          "scales": [1,1,1],
          "angles": [0,0,330]
        },
        {
          "scales": [1,1,1],
          "angles": [0,0,300]
        }
      ]
    }
  ],
  "crs": {
    "type": "Name",
    "properties": "urn:ogc:def:crs:OGC:1.3:CRS84"
  },
  "trs": {
    "type": "Name",
    "properties": "urn:ogc:data:time:iso8601"
  },
  "links": [
    {
      "href": "https://data.example.org/collections/mfc-1/items/mf-1/tgeometries",
      "rel": "self",
      "type": "application/json"
    },
    {
```

```
      "href": "https://data.example.org/collections/mfc-1/items/mf-
1/tgeometries&offset=10&limit=1",
      "rel": "next",
      "type": "application/json"
    }
  ],
  "timeStamp": "2021-09-01T12:00:00Z",
  "numberMatched": 100,
  "numberReturned": 1
}
```


Create

A successful response to the `TemporalGeometryCollection` POST operation is an HTTP status code.

Requirement 26	/req/movingfeatures/tgeometries-post-success
A	The API implementation SHALL comply with the API-Feature `CREATE` response requirement `/req/create-replace-delete/insert-response` and `/req/create-replace-delete/insert-response-rid`.

8.5.4. Error situations

The requirements for handling unsuccessful requests are provided in HTTP Response. General guidance on HTTP status codes and how they should be handled is provided in HTTP Status Codes.

8.6. Resource TemporalGeometry

A temporal geometry object represents the movement of a moving feature with various types of moving geometry, i.e., `MovingPoint`, `MovingLineString`, `MovingPolygon`, and `MovingPointCloud`. It can also represent the movement of a 3D object with its orientation.

The schema for the temporal geometry object presented in this clause is an extension of the `TemporalGeometry Object` defined in MF-JSON standard. Table 9 defines the set of properties that may be used to describe a temporal geometry.

Table 9. Table of the properties related to the temporal geometry

Property	Requirement	Description
id	O	An identifier for the resource assigned by an external entity.
type	M	A primitive geometry type of MF-JSON (i.e., one of 'MovingPoint', 'MovingLineString', 'MovingPolygon', 'MovingPointCloud', or 'MovingGeometryCollection').
datetimes	M	A sequence of monotonic increasing instants.
coordinates	M	A sequence of leaf geometries of a temporal geometry, having the same number of elements as "datetimes".

Property	Requirement	Description
interpolation	M	A predefined type of motion curve (i.e., one of 'Discrete', 'Step', 'Linear', 'Quadratic' or 'Cubic').
base.type	O	A type of 3D file format, such as 'STL', 'OBJ', 'PLY', and 'glTF'.
base.href	O	A URL to address a 3D model data which represents a base geometry of a 3D shape.
orientations.scales	O	An array value of numbers along the x, y, and z axis in order as three scale factors.
orientations.angles	O	An array value of numbers along the x, y, and z axis in order as Euler angles in degree.

NOTE The detailed information and requirements for each property are described in the OGC Moving Feature JSON encoding standard.

Requirement 27	/req/movingfeatures/tgeometry-mandatory
A	A temporal geometry object SHALL contain all the mandatory properties listed in Table 9.

8.6.1. Operation

Delete

This operation is defined in the DELETE conformance class of API-Features.

1. Issue a DELETE request on {root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId} path

The {tGeometryId} parameter is the unique identifier for a single temporal geometry offered by the API. The list of valid values for {tGeometryId} is provided in the {root}/collections/{collectionId}/items/{mFeatureId}/tgeometries GET response.

Support for HTTP DELETE method is required by API-Features.

Requirement 28	/req/movingfeatures/tgeometry-delete
A	The API implementation SHALL comply with the API-Feature DELETE operation requirement /req/create-replace-delete/delete/delete-op.
B	For every temporal geometry in a moving feature (path {root}/collections/{collectionId}/items/{mFeatureId}), the server SHALL support the HTTP DELETE operation at the path {root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}

Requirement 28	/req/movingfeatures/tgeometry-delete
C	The path parameter `collectionId` is each `id` property in the `Collection` GET operation response where the value of the `itemType` property is specified as `movingfeature`. The path parameter `mFeatureId` is an `id` property of the moving feature. The path parameter `tGeometryId` is an `id` property of the temporal geometry.

8.6.2. Response

Delete

A successful response to the `TemporalGeometry` DELETE operation is an HTTP status code.

Requirement 29	/req/movingfeatures/tgeometry-delete-success
A	The API implementation SHALL comply with the API-Feature `DELETE` response requirement `/req/create-replace-delete/delete/response`.
B	If no resource with the identifier exists in the collection, the server SHALL respond with a not-found exception (`404`).

8.6.3. Error situations

The requirements for handling unsuccessful requests are provided in HTTP Response. General guidance on HTTP status codes and how they should be handled is provided in HTTP Status Codes.

8.7. TemporalGeometry Query Resources

TemporalGeometry Query resources are spatio-temporal queries which support operation of the API for the access TemporalGeometry resources. The OGC API-MF has identified an initial set of common query types to implement, described in this clause. This list may change as the standard is used and experience is gained.

Query resources related to the TemporalGeometry resource can be exposed using the path templates:

- `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/{queryType}`

Where:

- `{root}` = Base URI for the API server
- `{collectionId}` = An identifier for a specific Collection of data
- `{mFeatureId}` = An identifier for a specific MovingFeature of a specific Collection of data
- `{tGeometryId}` = An identifier for a specific TemporalGeometry of a specific MovingFeatures of data

- {quertyType} = An identifier for the query pattern performed by the API.

Table 10 provides a mapping of the initial query types proposed for the OGC API-MF.

Table 10. Table of the query resources

Path Template	Query Type	Description
{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/distance	Distance	Return a graph of the time to distance function as a form of the TemporalProperty.
{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/velocity	Velocity	Return a graph of the time to velocity function as a form of the TemporalProperty.
{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/acceleration	Acceleration	Return a graph of the time to acceleration function as a form of the TemporalProperty.

8.7.1. Shared query parameters

Query parameters are used in URLs to define the resources which are returned on a GET request. The following are defined as standard shared parameters for use.

Parameter datetime

For datetime parameter, see Clause 10.1.3.

8.7.2. Distance Query

The Distance query returns a time to distance curve of the TemporalGeometry object as a form of the TemporalProperty. Figure 3 shows an example of time to distance curve.

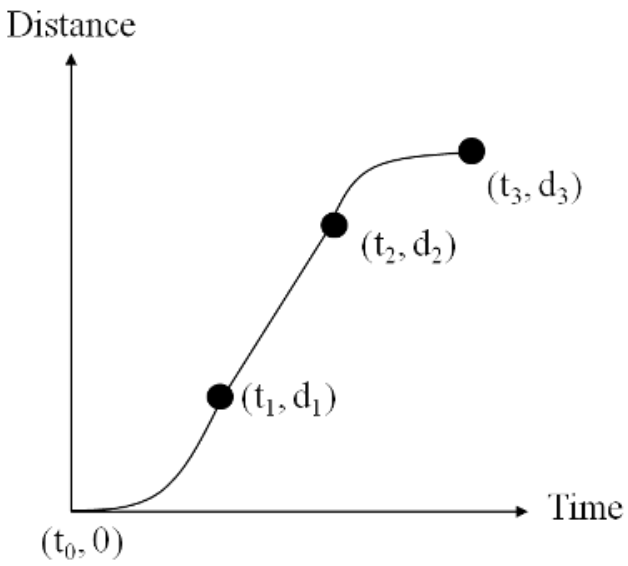

Figure 3. Example of time to distance curve [OGC 16-120r3, OGC Moving Features Access]

The filter constraints are defined by the following query parameter:

Parameter datetime

Define the specified datetime to return the distance value from the time to distance graph. When 'datetime' is not specified, the API MUST return data from all available times of the specified TemporalGeometry resource.

8.7.3. Velocity Query

The Velocity query returns a time to velocity curve of the TemporalGeometry object as a form of the TemporalProperty.

The filter constraints are defined by the following query parameter:

Parameter datetime

Define the specified datetime to return the velocity value from the time to velocity graph. When 'datetime' is not specified, the API MUST return data from all available times of the specified TemporalGeometry resource.

8.7.4. Acceleration Query

The Acceleration query returns a time to acceleration curve of the TemporalGeometry object as a form of the TemporalProperty.

The filter constraints are defined by the following query parameter:

Parameter datetime

Define the specified datetime to return the acceleration value from the time to acceleration graph. When 'datetime' is not specified, the API MUST return data from all available times of the specified TemporalGeometry resource.

8.7.5. Operation Requirements

Requirement 30	/req/movingfeatures/tgeometry-query
A	For every temporal geometry identified in the TemporalGeometryCollection GET response (path `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries`), the server SHALL support the HTTP GET operation at the path `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/{queryType}`

Requirement 30	/req/movingfeatures/tgeometry-query
B	The path parameter `collectionId` is each `id` property in the `Collection` GET operation response where the value of the `itemType` property is specified as `movingfeature`. The path parameter `mFeatureId` is an `id` property of the moving feature. The path parameter `tGeometryId` is an `id` property of the temporal geometry.
C	The path parameter `queryType` SHALL be one of the predefined query type (**distance, velocity**, and **acceleration**)

Permission 1	/per/movingfeatures/tgeometry-query
A	A distance query GET operation MAY include a `datetime` query parameter.
B	A velocity query GET operation MAY include a `datetime` query parameter.
C	An acceleration query GET operation MAY include a `datetime` query parameter.

8.7.6. Response Requirements

Requirement 31	/req/movingfeatures/tgeometry-query-success
A	A successful execution of the operation SHALL be reported as a response with an HTTP status code `200`.
B	The content of that response SHALL include the parametric value that defined in the response schema.
C	The `type` property SHALL be **TFloat**

8.8. Resource TemporalPropertyCollection

A `TemporalPropertyCollection` object consists of the set of TemporalProperty which is included in the `MovingFeature` that specified by {mFeatureId}. The `TemporalPropertyCollection` resource supports retrieving and creating operations via GET and POST HTTP methods respectively.

1. Retrieving operation returns a list of the available abbreviated copy of TemporalProperty object in the specified moving feature.
2. Creating operation post a new TemporalProperty object to the `MovingFeature` that specified by {mFeatureId}.

8.8.1. Operation

Retrieve

1. Issue a `GET` request on the `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties` path

Requirement 32	/req/movingfeatures/tproperties-collection-get
A	For every moving feature identified in the MovingFeatures GET response (path `{root}/collections/{collectionId}/items`), the server SHALL support the HTTP GET operation at the path `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties`
B	The path parameter `collectionId` is each `id` property in the `Collection` GET response where the value of the `itemType` property is specified as `movingfeature`. The path parameter `mFeatureId` is each `id` property in the `MovingFeatures` GET response.

Create

This operation is defined in the `CREATE` conformance class of API-Features. This operation targeted TemporalProperty resource.

1. Issue a `POST` request on `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties` path

Support for HTTP POST method is required by API-Features.

Requirement 33	/req/movingfeatures/tproperties-collection-post
A	The API implementation SHALL comply with the API-Feature `CREATE` operation requirement `/req/create-replace-delete/insert-post-op`.
B	The API implementation SHALL comply with the API-Feature `CREATE` request body requirements `/req/create-replace-delete/insert-body` and `/req/create-replace-delete/insert-content-type`.
C	The content of the request body SHALL be based upon the TemporalProperties or ParametricValues object schema.

TemporalPropertyCollection Request Body Schema (temporalProperty.yaml)

```
type: object
required:
  - name
  - type
properties:
  name:
    type: string
  type:
    type: string
```

```
    enum:
      - TBoolean
      - TText
      - TInteger
      - TReal
      - TImage
  form:
    oneOf:
      - type: string
        format: uri
      - type: string
        minLength: 3
        maxLength: 3
  description:
    type: string
```

The following example adds a new feature (TemporalProperty Object and ParametricValues object in MF-JSON) to the feature created by the Creation a MovingFeature Example. The feature is represented as JSON. A pseudo-sequence diagram notation is used to illustrate the details of the HTTP communication between the client and the server.

Create a New TemporalProperty Object Example

```
  Client                                                                  Server
    |                                                                       |
    | POST /collections/mfc_1/items/mf_1/tproperties   HTTP/1.1             |
    | Content-Type: application/json                                        |
    |                                                                       |
    | {                                                                     |
    |    "name": "speed",                                                   |
    |    "type": "TFloat",                                                  |
    |    "form": "KMH"                                                      |
    | }                                                                     |
    |---------------------------------------------------------------------->|
    |                                                                       |
    | HTTP/1.1 201 Created                                                  |
    | Location: /collections/mfc_1/items/mf_1/tproperties/speed             |
    |<----------------------------------------------------------------------|
```

Create a New TemporalProperty Object Example with ParametricValues in MF-JSON

```
  Client                                                                  Server
    |                                                                       |
    | POST /collections/mfc_1/items/mf_1/tproperties   HTTP/1.1             |
    | Content-Type: application/json                                        |
    |                                                                       |
    | {                                                                     |
    |    "datetimes": [                                                     |
    |       "2011-07-14T22:01:06.000Z",                                     |
    |       "2011-07-14T22:01:07.000Z",                                     |
```

```
|       "2011-07-14T22:01:08.000Z",                                          |
|    ],                                                                      |
|    "speed": {                                                              |
|       "type": "Measure",                                                    |
|       "form": "KMH",                                                       |
|       "values": [65.0, 70.0, 80.0],                                        |
|       "interpolation": "Linear"                                            |
|    }                                                                       |
| }                                                                          |
|--------------------------------------------------------------------------->|
|                                                                            |
| HTTP/1.1 201 Created                                                       |
| Location: /collections/mfc_1/items/mf_1/tproperties/speed                  |
|<---------------------------------------------------------------------------|
```

8.8.2. Response

Retrieve

A successful response to the `TemporalPropertyCollection` GET is a document that contains the set of TemporalProperty of the moving feature identified by the `{mFeatureId}` parameter.

Requirement 34	/req/movingfeatures/tproperties-collection-get-success
A	The API implementation SHALL comply with the API-Features `Features` response requirement `/req/core/fc-response`.
B	Each temporal properties object in the response SHALL include the mandatory properties listed in Table 11.

TemporalPropertyCollection GET Response Schema (temporalPropertyCollection.yaml)

```
type: object
required:
  - temporalProperties
properties:
  temporalProperties:
    type: array
    items:
      oneOf:
        - $ref: temporalProperty.yaml
        - $ref: temporalValue.yaml
  links:
    type: array
    items:
      $ref:
https://schemas.opengis.net/ogcapi/features/part1/1.0/openapi/schemas/link.yaml
  timeStamp:
    type: string
    format: date-time
  numberMatched:
```

```
    type: integer
    minimum: 0
  numberReturned:
    type: integer
    minimum: 0
```

The following JSON payload is an example of a response to an OGC API Moving Features `TemporalPropertyCollection` GET operation.

TemporalPropertyCollection GET Example

```
{
  "temporalProperties": [
    {
      "name": "length",
      "type": "TReal",
      "form": "http://www.qudt.org/qudt/owl/1.0.0/quantity/Length"
    },
    {
      "name": "speed",
      "type": "TReal",
      "form": "KHM"
    }
  ],
  "links": [
    {
      "href": "https://data.example.org/collections/mfc-1/items/mf-1/tproperties",
      "rel": "self",
      "type": "application/json"
    },
    {
      "href": "https://data.example.org/collections/mfc-1/items/mf-
1/tproperties&offset=2&limit=2",
      "rel": "next",
      "type": "application/json"
    }
  ],
  "timeStamp": "2021-09-01T12:00:00Z",
  "numberMatched": 10,
  "numberReturned": 2
}
```

Create

A successful response to the `TemporalPropertyCollection` POST operation is an HTTP status code.

Requirement 35	/req/movingfeatures/tproperties-collection-post-success
A	The API implementation SHALL comply with the API-Feature CREATE response requirement /req/create-replace-delete/insert-response and /req/create-replace-delete/insert-response-rid.

8.8.3. Error situations

The requirements for handling unsuccessful requests are provided in HTTP Response. General guidance on HTTP status codes and how they should be handled is provided in HTTP Status Codes.

8.9. Resource TemporalProperty

8.9.1. Overview

The TemporalProperty resource supports retrieving and creating operations via GET and POST HTTP methods respectively.

1. Retrieving operation returns a TemporalProperty resource which is included in the TemporalPropertyCollection that specified by {tPropertyName}. The TemporalProperty resource returned to the response can be limited using the limit, datetime, and leaf parameters.
2. Creating operation post a new temporal value object to the TemporalPropertyCollection that specified by {tPropertyName}.

A temporal property object is a collection of dynamic non-spatial attributes and their temporal values with time. An abbreviated copy of this information is returned for each TemporalProperty in the {root}/collections/{collectionId}/items/{mFeatureId}/tproperties response.

The schema for the temporal property object presented in this clause is an extension of the TemporalProperty Object defined in MF-JSON standard. Table 11 defines the set of property that may be used to describe a temporal property.

Table 11. Table of the properties related to the temporal property

Property	Requirement	Description
name	M	An identifier for the resource assigned by an external entity.
type	M	A predefined temporal property type (i.e., one of 'TBoolean', 'TText', 'TInteger', 'TReal', and 'TImage').
values	O	A sequence of temporal value
form	O	A unit of measure.
description	O	A short description.

Table 12. Table of the properties related to the temporal value

Property	Requirement	Description
datetimes	M	A sequence of monotonic increasing instants.
values	M	A sequence of dynamic value, having the same number of elements as "datetimes".
interpolation	M	A predefined type for a dynamic value (i.e., one of 'Discrete', 'Step', 'Linear', or 'Regression').

NOTE The detailed information and requirements for each property are described in the OGC Moving Feature JSON encoding standard.

Requirement 36	/req/movingfeatures/tproperties-mandatory
A	A temporal property object SHALL contain all the mandatory properties listed in Table 11 and Table 12.

8.9.2. Operation

Retrieve

1. Issue a `GET` request on the `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties/{tPropertyName}` path

The `{tPropertyName}` parameter is the unique identifier for a single temporal property value offered by the API. The list of valid values for `{tPropertyName}` is provided in the `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties` GET response.

Requirement 37	/req/movingfeatures/tproperties-get
A	For every temporal properties in a moving feature (path `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties`), the server SHALL support the HTTP GET operation at the path `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties/{tPropertiesName}`
B	The path parameter `collectionId` is each `id` property in the `Collection` GET response where the value of the `itemType` property is specified as `movingfeature`. The path parameter `mFeatureId` is each `id` property in the `MovingFeatures` GET response. `tPropertiesName` is a local identifier of the temporal properties.

Create

This operation is defined in the `CREATE` conformance class of API-Features. This operation targeted TemporalValue object.

1. Issue a `POST` request on `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties/{tPropertyName}` path

Support for HTTP POST method is required by API-Features.

Requirement 38	/req/movingfeatures/tproperties-post
A	The API implementation SHALL comply with the API-Feature `CREATE` operation requirement `/req/create-replace-delete/insert-post-op`.
B	The API implementation SHALL comply with the API-Feature `CREATE` request body requirements `/req/create-replace-delete/insert-body` and `/req/create-replace-delete/insert-content-type`.
C	The content of the request body SHALL be based upon the TemporalValue schema.
D	The latest date-time instance in the temporal value object in TemporalProperty, determined by `tPropertyName`, SHALL be faster than the beginning date-time instance in the temporal value object in the request body.

TemporalProperty Request Body Schema (temporalValue.yaml)

```yaml
type: object
required:
  - datetimes
  - values
  - interpolation
properties:
  datetimes:
    type: array
    uniqueItems: true,
    minItems: 2
    items:
      type: string
      format: date-time
  values:
    oneOf:
      - type: number
      - type: string
      - type: boolean
  interpolation:
    type: string
    enum:
      - Discrete
      - Step
      - Linear
      - Regression
```

The following example adds a new feature (TemporalValue object) to the feature created by the Creation a New TemporalProperty Object Example. The feature is represented as JSON. A pseudo-

sequence diagram notation is used to illustrate the details of the HTTP communication between the client and the server.

Create a New TemporalValue Object Example

```
   Client                                                                  Server
     |                                                                       |
     | POST /collections/mfc_1/items/mf_1/tproperties/speed   HTTP/1.1       |
     | Content-Type: application/json                                        |
     |                                                                       |
     | {                                                                     |
     |    "datetimes": [                                                     |
     |       "2011-07-14T22:01:09.000Z",                                     |
     |       "2011-07-14T22:01:010.000Z",                                    |
     |    ],                                                                 |
     |    "values": [                                                        |
     |       90.0,                                                           |
     |       95.0,                                                           |
     |    ],                                                                 |
     |    "interpolation": "Linear"                                          |
     | }                                                                     |
     |---------------------------------------------------------------------->|
     |                                                                       |
     | HTTP/1.1 201 Created                                                  |
     | Location: /collections/mfc_1/items/mf_1/tproperties/speed             |
     |<----------------------------------------------------------------------|
```


8.9.3. Response

Retrieve

A successful response to the `TemporalProperty` GET operation is a temporal property identified by the `{tPropertyName}` parameter.

Requirement 39	/req/movingfeatures/tproperties-get-success
A	A successful execution of the operation SHALL be reported as a response with an HTTP status code `200`.
B	The response SHALL only include temporal properties selected by the request with `limit`, `datetime`, and `leaf` parameters.
C	The content of that response SHALL include the parametric value that defined in the response schema.

The following JSON payload is an example of a response to an OGC API Moving Features `TemporalProperty` GET operation.

TemporalProperty GET Example

```
{
```

```
  "temporalProperties": [
    {
      "datetimes":[
        "2011-07-14T22:01:02Z",
        "2011-07-14T22:01:03Z",
        "2011-07-14T22:01:04Z"
      ],
      "values":[
        65.0,
        70.0,
        80.0
      ],
      "interpolation": "Linear"
    },
    {
      "datetimes":[
        "2011-07-15T08:00:00Z",
        "2011-07-15T08:00:01Z",
        "2011-07-15T08:00:02Z"
      ],
      "values":[
        0.0,
        20.0,
        50.0
      ],
      "interpolation": "Linear"
    }
  ],
  "links": [
    {
      "href": "https://data.example.org/collections/mfc-1/items/mf-
1/tproperties/speed",
      "rel": "self",
      "type": "application/json"
    },
    {
      "href": "https://data.example.org/collections/mfc-1/items/mf-
1/tproperties/speed&offset=2&limit=2",
      "rel": "next",
      "type": "application/json"
    }
  ],
  "timeStamp": "2021-09-01T12:00:00Z",
  "numberMatched": 20,
  "numberReturned": 2
}
```


Create

A successful response to the `TemporalProperty` POST operation is an HTTP status code.

Requirement 40	/req/movingfeatures/tproperties-post-success
A	The API implementation SHALL comply with the API-Feature `CREATE` response requirement `/req/create-replace-delete/insert-response` and `/req/create-replace-delete/insert-response-rid`.

8.9.4. Error situations

The requirements for handling unsuccessful requests are provided in HTTP Response. General guidance on HTTP status codes and how they should be handled is provided in HTTP Status Codes.

Chapter 9. Common Requirements

9.1. Parameters

The query parameters `bbox`, `datetime` and `limit` are inherited from API-Common. All requirements and recommendations in API-Common regarding these parameters also apply for API-MF. No modifications are required.

9.1.1. Parameter limit

Requirement 41	**/req/common/param-limit**
A	OGC API-MF SHALL support the Limit parameter for the operation.
B	Requests which include the Limit parameter SHALL comply with API-Common requirement `/req/collections/rc-limit-definition`.
C	Responses to Limit requests SHALL comply with API-Common requirements `/req/collections/rc-limit-response`

9.1.2. Parameter bbox

Requirement 42	**/req/common/param-bbox**
A	OGC API-MF SHALL support the Bounding Box (`bbox`) parameter for the operation.
B	Requests which include the Bounding Box parameter SHALL comply with OGC API-Common requirement `/req/collections/rc-bbox-definition`.
C	Responses to Bounding Box requests SHALL comply with OGC API-Common requirement `/req/collections/rc-bbox-response`.

9.1.3. Parameter datetime

Requirement 43	**/req/common/param-datetime**
A	OGC API-MF SHALL support the DateTime (`datetime`) parameter for the operation.
B	Requests which include the DateTime parameter SHALL comply with OGC API-Common requirement `/req/collections/rc-time-definition`.
C	Responses to DateTime requests SHALL comply with OGC API-Common requirement `/req/collections/rc-time-response`.

9.2. HTTP Response

Each HTTP request shall result in a response that meets the following requirement.

Requirement 44	/req/common/http-response
A	An HTTP operation SHALL return a response which includes a `status code` and an optional `description` elements.
B	If the `status code` is not equal to 200, then the `description` element SHALL be populated.

The YAML schema for these results is provided in HTTP Response Schema.

HTTP Response Schema

```
title: Exception Schema
description: JSON schema for exceptions based on RFC 7807
type: object
required:
  - type
properties:
  type:
    type: string
  title:
    type: string
  status:
    type: integer
  detail:
    type: string
  instance:
    type: string
```

9.3. HTTP Status Codes

Table 13 lists the main HTTP status codes that clients should be prepared to receive. This includes support for specific security schemes or URI redirection. In addition, other error situations may occur in the transport layer outside of the server.

Table 13. Typical HTTP status codes

Status code	Description
`200`	A successful request.
`201`	The server has been fulfilled the operation and a new resource has been created.
`202`	A successful request, but the response is still being generated. The response will include a `Retry-After` header field giving a recommendation in seconds for the client to retry.

Status code	Description
204	A successful request, but the resource has no data resulting from the request. No additional content or message body is provided.
304	An entity tag was provided in the request and the resource has not been changed since the previous request.
308	The server cannot process the data through a synchronous request. The response includes a `Location` header field which contains the URI of the location the result will be available at once the query is complete Asynchronous queries.
400	The server cannot or will not process the request due to an apparent client error. For example, a query parameter had an incorrect value.
401	The request requires user authentication. The response includes a `WWW-Authenticate` header field containing a challenge applicable to the requested resource.
403	The server understood the request, but is refusing to fulfill it. While status code `401` indicates missing or bad authentication, status code `403` indicates that authentication is not the issue, but the client is not authorised to perform the requested operation on the resource.
404	The requested resource does not exist on the server. For example, a path parameter had an incorrect value.
405	The request method is not supported. For example, a POST request was submitted, but the resource only supports GET requests.
406	Content negotiation failed. For example, the `Accept` header submitted in the request did not support any of the media types supported by the server for the requested resource.
413	Request entity too large. For example the query would involve returning more data than the server is capable of processing, the implementation should return a message explaining the query limits imposed by the server implementation.
500	An internal error occurred in the server.

Annex A: Conformance Class Abstract Test Suite (Normative)

A.1. Introduction

The Abstract Test Suite (ATS) is a compendium of test assertions applicable to implementations of the OGC API-MF. An ATS provides a basis for developing an Executable Test Suite to verify that the implementation under test conforms to all the relevant functional specifications.

The abstract test cases (assertions) are organized into test groups that correspond to distinct conformance test classes defined in the OGC API-MF specification.

OGC APIs are not Web Services in the traditional sense. Rather, they define the behavior and content of a set of Resources exposed through a Web Application Programming Interface (Web API). Therefore, an API may expose resources in addition to those defined by the standard. A test engine must be able to traverse the API, identify and validate test points, and ignore resource paths which are not to be tested.

The Conformance Classes addressed by this Abstract Test Suite are the:

- MovingFeature Collection Catalog Conformance Class
- MovingFeature Conformance Class

A.2. Conformance Class MovingFeature Collection Catalog

Conformance Class	
http://www.opengis.net/spec/ogcapi-movingfeatures-1/1.0/conf/mf-collection	
Target type	Web API
Requirements Class	http://www.opengis.net/spec/ogcapi-movingfeatures-1/1.0/req/mf-collection
Dependency	http://www.opengis.net/spec/ogcapi-common-1/1.0/conf/html
Dependency	http://www.opengis.net/spec/ogcapi-common-1/1.0/conf/json
Dependency	http://www.opengis.net/spec/ogcapi-common-2/1.0/conf/collections
Dependency	http://www.opengis.net/spec/ogcapi-features-1/1.0/conf/geojson
Dependency	http://www.opengis.net/spec/ogcapi-features-4/1.0/conf/create-replace-delete

A.2.1. MovingFeature Collections

HTTP GET Operation

Abstract Test 1	**/conf/mf-collection/collections-get**
Requirement	/req/mf-collection/collections-get /req/mf-collection/collections-get-success
Test purpose	Validate that the MovingFeature Collections can be retrieved from the expected location.
Test method	1. Issue an HTTP GET request to the URL `{root}/collections` 2. Validate that a document was returned with a status code `200` 3. Validate the contents of the returned document using test `/conf/mf-collection/collections-get-success`

Abstract Test 2	**/conf/mf-collection/collections-get-success**
Requirement	/req/mf-collection/collections-get-success
Test purpose	Validate that the MovingFeature Collections complies with the required structure and contents.
Test method	1. Validate that all response documents complies with OGC API-Common /conf/collections/rc-md-success 2. Validate the Collections resource for all supported media types using the resources and tests identified in Table 14 3. Verify that the response document contains a `itemType` property and its value is 'movingfeature'

The Collections content may be retrieved in a number of different formats. The following table identifies the applicable schema document for each format and the test to be used to validate the against that schema. All supported formats should be exercised.

Table 14. Schema and Tests for MovingFeature Collections content

Format	Schema Document	Test ID
HTML	collections.yaml	/conf/html/content
JSON	collections.yaml	/conf/json/content

HTTP POST Operation

Abstract Test 3	**/conf/mf-collection/collections-post**
Requirement	/req/mf-collection/collections-post /req/mf-collection/collections-post-success
Test purpose	Validate that the MovingFeature Collections can be created to the expected location.

Test method	1. Validate that the server comply with OGC API-Features POST operation requirements 2. Validate that a body of a POST request using for all supported media types using the resources and tests identified in Table 15 3. Validate that the request body complies OGC API-Features POST request body requirements 4. Issue an HTTP POST request to the URL `{root}/collections` 5. Validate the contents of the response using test `/conf/mf-collection/collections-post-success`

Table 15. Schema and Tests for Request Body of `{root}/collections` POST

Format	Schema Document	Test ID
HTML	collection_requestbody.yaml	/conf/html/content
JSON	collection_requestbody.yaml	/conf/json/content

Abstract Test 4	**/conf/mf-collection/collections-post-success**
Requirement	/req/mf-collection/collections-post-success
Test purpose	Validate that the response of `{root}/collections` POST request complies with the required structure and contents.
Test method	1. Validate that a document was returned with a status code `201` or `202` 2. Validate that all response documents complies with OGC API-Features POST response requirements

A.2.2. MovingFeature Collection

HTTP GET Operation

Abstract Test 5	**/conf/mf-collection/collection-get**
Requirement	/req/mf-collection/collection-get /req/mf-collection/collection-get-success
Test purpose	Validate that the MovingFeature Collection can be retrieved from the expected location.
Test method	For every Collection described in the Collections content, issue an HTTP GET request to the URL `{root}/collections/{collectionId}` where `{collectionId}` is the id property for the collection 1. Validate that a Collection was returned with a status code `200` 2. Validate the contents of the returned document using test `/conf/mf-collection/collection-get-success`

Abstract Test 6	**/conf/mf-collection/collection-get-success**
Requirement	/req/mf-collection/collection-get-success /req/mf-collection/mandatory-collection

Test purpose	Validate that the MovingFeature Collection complies with the required structure and contents.
Test method	1. Validate that all response documents complies with OGC API-Common /conf/collections/src-md-success 2. Validate the Collections resource for all supported media types using the resources and tests identified in Table 16 and Table 6

Table 16. Schema and Tests for MovingFeature Collection content

Format	Schema Document	Test ID
HTML	collection.yaml	/conf/html/content
JSON	collection.yaml	/conf/json/content

HTTP PUT Operation

Abstract Test 7	**/conf/mf-collection/collection-put**
Requirement	/req/mf-collection/collection-put /req/mf-collection/collection-put-success
Test purpose	Validate that the MovingFeature Collection can be replaced to the expected location.
Test method	1. Validate that the server comply with OGC API-Features PUT operation requirements 2. Validate that a body of a PUT request using for all supported media types using the resources and tests identified in Table 15 3. Validate that the request body complies OGC API-Features PUT request body requirements 4. Issue an HTTP PUT request to the URL `{root}/collections/{collectionId}` 5. Validate the contents of the response using test `/conf/mf-collection/collections-put-success`

Abstract Test 8	**/conf/mf-collection/collections-put-success**
Requirement	/req/mf-collection/collection-put-success
Test purpose	Validate that the response of `{root}/collections/{collectionId}` PUT request complies with the required structure and contents.
Test method	1. Validate that a document was returned with a status code `200`, `202`, or `204` 2. Validate that all response documents complies with OGC API-Features PUT response requirements

HTTP DELETE Operation

Abstract Test 9	**/conf/mf-collection/collection-delete**
Requirement	/req/mf-collection/collection-delete /req/mf-collection/collection-delete-success

Test purpose	Validate that the MovingFeature Collection can be deleted to the expected location.
Test method	1. Validate that the server comply with OGC API-Features DELETE operation requirements 2. Issue an HTTP DELETE request to the URL `{root}/collections/{collectionId}` 3. Validate the contents of the response using test `/conf/mf-collection/collections-put-success`

Abstract Test 10	**/conf/mf-collection/collections-delete-success**
Requirement	/req/mf-collection/collection-delete-success
Test purpose	Validate that the response of `{root}/collections/{collectionId}` DELETE request complies with the required structure and contents.
Test method	1. Validate that a document was returned with a status code `200`, `202`, or `204` 2. Validate that all response documents complies with OGC API-Features DELETE response requirements

A.3. Conformance Class MovingFeatures

Conformance Class	
http://www.opengis.net/spec/ogcapi-movingfeatures-1/1.0/conf/movingfeatures	
Target type	Web API
Requirements Class	http://www.opengis.net/spec/ogcapi-movingfeatures-1/1.0/req/movingfeatures
Dependency	http://www.opengis.net/spec/ogcapi-common-1/1.0/conf/html
Dependency	http://www.opengis.net/spec/ogcapi-common-1/1.0/conf/json
Dependency	http://www.opengis.net/spec/ogcapi-common-2/1.0/conf/collections
Dependency	http://www.opengis.net/spec/ogcapi-common-2/1.0/conf/simple-query
Dependency	http://www.opengis.net/spec/ogcapi-features-1/1.0/conf/core
Dependency	http://www.opengis.net/spec/ogcapi-features-1/1.0/conf/geojson
Dependency	http://www.opengis.net/spec/ogcapi-features-4/1.0/conf/create-replace-delete

A.3.1. MovingFeatures

HTTP GET Operation

Abstract Test 11	**/conf/movingfeatures/features-get**
Requirement	/req/movingfeatures/features-get /ref/movingfeatures/features-get-success

Test purpose	Validate that MovingFeatures can be identified and extracted from a MovingFeature Collection using query parameters.
Test method	For every MovingFeature Collection identified in MovingFeature Collections, issue an HTTP GET request to the URL `{root}/collections/{collectionId}/items` where `{collectionId}` is the id property for a MovingFeature Collection described in the MovingFeature Collections content 1. Validate that a document was returned with a status code `200` 2. Validate the contents of the returned document using test `/conf/movingfeatures/features-get-success` Repeat these tests using the following parameter tests that defined in the OGC API-Common: - Bounding Box: Bounding Box Tests - Limit: Limit Tests - Date-Time: Date-Time Tests Execute requests with combinations of the `"bbox"` and `"datetime"` query parameters and verify that only features are returned that match both selection criteria.

Abstract Test 12	**/conf/movingfeatures/features-get-success**
Requirement	/ref/movingfeatures/features-get-success
Test purpose	Validate that the MovingFeatures complies with the required structure and contents.
Test method	1. Validate that all response documents complies with OGC API-Features /conf/core/fc-response 2. Validate the Collections resource for all supported media types using the resources and tests identified in Table 17

The MovingFeatures content may be retrieved in a number of different formats. The following table identifies the applicable schema document for each format and the test to be used to validate the against that schema. All supported formats should be exercised.

Table 17. Schema and Tests for MovingFeatures content

Format	Schema Document	Test ID
HTML	movingFeatureCollection.yaml	/conf/html/content
GeoJSON	movingFeatureCollection.yaml	/conf/geojson/content

HTTP POST Operation

Abstract Test 13	**/conf/movingfeatures/features-post**

Requirement	/req/movingfeatures/mf-mandatory /req/movingfeatures/features-post /req/movingfeatures/features-post-success
Test purpose	Validate that the MovingFeature can be created to the expected location.
Test method	1. Validate that the server comply with OGC API-Features POST operation requirements 2. Validate that a body of a POST request using for all supported media types using the resources and tests identified in Table 18 and Table 8 3. Validate that the request body complies OGC API-Features POST request body requirements 4. Issue an HTTP POST request to the URL `{root}/collections/{collectionId}/items` 5. Validate the contents of the response using test `/conf/movingfeatures/features-post-success`

Table 18. Schema and Tests for Request Body of `{root}/collections/{collectionId}/items` POST

Format	Schema Document	Test ID
JSON	MF-JSON_Prism.schema.json	/conf/json/content

Abstract Test 14	**/conf/movingfeatures/features-post-success**
Requirement	/req/movingfeatures/features-post-success
Test purpose	Validate that the response of `{root}/collections/{collectionId}/items` POST request complies with the required structure and contents.
Test method	1. Validate that a document was returned with a status code `201` or `202` 2. Validate that all response documents complies with OGC API-Features POST response requirements

A.3.2. MovingFeature

HTTP GET Operation

Abstract Test 15	**/conf/movingfeatures/mf-get**
Requirement	/req/movingfeatures/mf-get /ref/movingfeatures/mf-get-success
Test purpose	Validate that the MovingFeature can be retrieved from the expected location.

Test method	For every MovingFeature identified in MovingFeature Collection, issue an HTTP GET request to the URL `{root}/collections/{collectionId}/items/{mFeaturesId}` where `{collectionId}` is the id property for a MovingFeature Collection described in the MovingFeature Collections content and `{mFeatureId}` is the id property for the MovingFeature 1. Validate that a document was returned with a status code `200` 2. Validate the contents of the returned document using test `/conf/movingfeatures/features-get-success`

Abstract Test 16	**/conf/movingfeatures/mf-get-success**
Requirement	/ref/movingfeatures/mf-get-success
Test purpose	Validate that the MovingFeature complies with the required structure and contents.
Test method	1. Validate that all response documents complies with OGC API-Features /conf/core/f-success 2. Validate the Collections resource for all supported media types using the resources and tests identified in Table 19

The MovingFeature content may be retrieved in a number of different formats. The following table identifies the applicable schema document for each format and the test to be used to validate the against that schema. All supported formats should be exercised.

Table 19. Schema and Tests for MovingFeature content

Format	Schema Document	Test ID
HTML	movingFeature.yaml	/conf/html/content
GeoJSON	movingFeature.yaml	/conf/geojson/content

HTTP DELETE Operation

Abstract Test 17	**/conf/movingfeatures/mf-delete**
Requirement	/req/movingfeatures/mf-delete /req/movingfeatures/mf-delete-success
Test purpose	Validate that the MovingFeature can be deleted to the expected location.
Test method	1. Validate that the server comply with OGC API-Features DELETE operation requirements 2. Issue an HTTP DELETE request to the URL `{root}/collections/{collectionId}/items/{mFeatureId}` 3. Validate the contents of the response using test `/conf/mf-collection/collections-put-success`

Abstract Test 18	**/conf/movingfeatures/mf-delete-success**
Requirement	/req/movingfeatures/mf-delete-success

Test purpose	Validate that the response of `{root}/collections/{collectionId}/items/{mFeatureId}` DELETE request complies with the required structure and contents.
Test method	1. Validate that a document was returned with a status code `200`, `202`, or `204` 2. Validate that all response documents complies with OGC API-Features DELETE response requirements

A.3.3. Parameter Leaf

Abstract Test 19	**/conf/movingfeatures/param-leaf-definition**
Requirement	/req/movingfeatures/param-leaf-definition
Test purpose	Validate that the `leaf` query parameter is constructed correctly.
Test method	Verify that the `leaf` query parameter complies with the definition (using an OpenAPI Specification 3.0 fragment)

Abstract Test 20	**/conf/movingfeatures/param-leaf-response**
Requirement	/req/movingfeatures/param-leaf-definition /req/movingfeatures/param-leaf-response
Test purpose	Validate that the `leaf` query parameter is processed correctly.
Test method	DO FOR each Resource which have `datetimes` property: 1. Calculate a temporal geometry coordinate (or temporal property value) with the ***PointAtTime*** query at each time included in the `leaf` parameter, using interpolated trajectory according to the `interpolation` property 2. Verify that the temporal geometry coordinate (or temporal property value) intersects the interpolated trajectory according to the `interpolation` property, using datetime value defined by the `leaf` parameter

A.3.4. TemporalGeometryCollection

HTTP GET Operation

Abstract Test 21	**/conf/movingfeatures/tgeometries-get**
Requirement	/req/movingfeatures/tgeometries-get /req/movingfeatures/tgeometries-get-success
Test purpose	Validate that the TemporalGeometryCollection can be identified and extracted from a MovingFeature using query parameters.

Test method	For every TemporalGeometry identified in MovingFeature, issue an HTTP GET request to the URL `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries` where `{collectionId}` is the id property for a MovingFeature Collection described in the MovingFeature Collections content and `{mFeatureId}` is the id property for the MovingFeature 1. Validate that a document was returned with a status code `200` 2. Validate the contents of the returned document using test `/conf/movingfeatures/tgeometries-get-success` Repeat these tests using the following parameter tests that defined in the OGC API-Common and API-MF: - Bounding Box: Bounding Box Tests - Limit: Limit Tests - Date-Time: Date-Time Tests - Leaf: Leaf Definition Test and Leaf Response Test Execute requests with combinations of the `"bbox"`, `"datetime"`, and `"leaf"` query parameters and verify that only features are returned that match both selection criteria.

Abstract Test 22	**/conf/movingfeatures/tgeometries-get-success**
Requirement	/req/movingfeatures/tgeometries-get-success
Test purpose	Validate that the TemporalGeometryCollection complies with the required structure and contents.
Test method	1. Validate that the `type` property is present and has a value of `MovingGeometryCollection` 2. Validate the `prism` property is present and that it is populated with an array of TemporalGeometry items 3. Validate that only TemporalGeometries which match the selection criteria are included in the MovingFeature 4. If the `links` property is present, validate that all entries comply with OGC API-Features /conf/core/fc-links 5. If the `timeStamp` property is present, validate that it complies with OGC API-Features /conf/core/fc-timeStamp 6. If the `numberMatched` property is present, validate that it complies with OGC API-Features /conf/core/fc-numberMatched 7. If the `numberReturned` property is present, validate that it complies with OGC API-Features /conf/core/fc-numberReturned 8. Validate the TemporalGeometryCollection resource for all supported media types using the resources and tests identified in Table 20

The TemporalGeometryCollection content may be retrieved in a number of different formats. The following table identifies the applicable schema document for each format and the test to be used to validate the against that schema. All supported formats should be exercised.

Table 20. Schema and Tests for TemporalGeometryCollection content

Format	Schema Document	Test ID
HTML	temporalGeometryCollection.yaml	/conf/html/content
JSON	temporalGeometryCollection.yaml	/conf/json/content

HTTP POST Operation

Abstract Test 23	**/conf/movingfeatures/tgeometries-post**
Requirement	/req/movingfeatures/tgeometries-mandatory /req/movingfeatures/tgeometries-post /req/movingfeatures/tgeometries-post-success
Test purpose	Validate that the TemporalGeometry can be created to the expected location.
Test method	1. Validate that the server comply with OGC API-Features POST operation requirements 2. Validate that a body of a POST request using for all supported media types using the resources and tests identified in Table 21 and Table 9 3. Validate that the request body complies OGC API-Features POST request body requirements 4. Issue an HTTP POST request to the URL `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries` 5. Validate the contents of the response using test `/conf/movingfeatures/tgeometries-post-success`

Table 21. Schema and Tests for Request Body of `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries` *POST*

Format	Schema Document	Test ID
JSON	MF-JSON_Prism.schema.json	/conf/json/content

Abstract Test 24	**/conf/movingfeatures/tgeometries-post-success**
Requirement	/req/movingfeatures/tgeometries-post-success
Test purpose	Validate that the response of `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries` POST request complies with the required structure and contents.
Test method	1. Validate that a document was returned with a status code `201` or `202` 2. Validate that all response documents complies with OGC API-Features POST response requirements

A.3.5. TemporalGeometry

HTTP DELETE Operation

Abstract Test 25	**/conf/movingfeatures/tgeometry-delete**
Requirement	/req/movingfeatures/tgeometry-delete /req/movingfeatures/tgeometry-delete-success
Test purpose	Validate that the MovingFeature Collection can be deleted to the expected location.
Test method	1. Validate that the server comply with OGC API-Features DELETE operation requirements 2. Issue an HTTP DELETE request to the URL `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tgeometryId}` 3. Validate the contents of the response using test `/conf/mf-collection/collections-put-success`

Abstract Test 26	**/conf/mf-collection/collections-delete-success**
Requirement	/req/movingfeatures/tgeometry-delete-success
Test purpose	Validate that the response of `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tgeometryId}` DELETE request complies with the required structure and contents.
Test method	1. Validate that a document was returned with a status code `200`, `202`, or `204` 2. Validate that all response documents complies with OGC API-Features DELETE response requirements

A.3.6. TemporalGeometryQuery

HTTP GET Operation

Abstract Test 27	**/conf/movingfeatures/tgeometry-query-distance**
Requirement	/req/movingfeatures/tgeometry-query /req/movingfeatures/tgeometry-query-success
Test purpose	Validate that resources can be identified and extracted from a TemporalGeometry with a `Distance` query using query parameters.

Test method	IF a query parameter `datatime` is not empty, validate that the query parameter `datatime` with the following parameter tests that defined in the OGC API-Common: - **Date-Time**: Date-Time Tests 1. Issue an HTTP GET request to the URL `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/distance` 2. Validate that a document was returned with a status code `200` 3. Verify the `type` is `"TFloat"` IF a query parameter `datatime` is not empty: Execute requests with `datatime` query parameter and verify the correctly calculated value is returned. IF a query parameter `datatime` is empty: Verify that a time-to-distance curve is correctly returned according to the specified TemporalGeometry resource by {tgeometryId}.

Abstract Test 28	**/conf/movingfeatures/tgeometry-query-velocity**
Requirement	/req/movingfeatures/tgeometry-query /req/movingfeatures/tgeometry-query-success
Test purpose	Validate that resources can be identified and extracted from a TemporalGeometry with a `Velocity` query using query parameters.
Test method	IF a query parameter `datatime` is not empty, validate that the query parameter `datatime` with the following parameter tests that defined in the OGC API-Common: - **Date-Time**: Date-Time Tests 1. Issue an HTTP GET request to the URL `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/velocity` 2. Validate that a document was returned with a status code `200` 3. Verify the `type` is `"TFloat"` IF a query parameter `datatime` is not empty: Execute requests with `datatime` query parameter and verify the correctly calculated value is returned. IF a query parameter `datatime` is empty: Verify that a time-to-velocity curve is correctly returned according to the specified TemporalGeometry resource by {tgeometryId}.

Abstract Test 29	**/conf/movingfeatures/tgeometry-query-acceleration**

Requirement	/req/movingfeatures/tgeometry-query /req/movingfeatures/tgeometry-query-success
Test purpose	Validate that resources can be identified and extracted from a TemporalGeometry with a `Acceleration` query using query parameters.
Test method	IF a query parameter `datatime` is not empty, validate that the query parameter `datatime` with the following parameter tests that defined in the OGC API-Common: - **Date-Time**: Date-Time Tests 1. Issue an HTTP GET request to the URL `{root}/collections/{collectionId}/items/{mFeatureId}/tgeometries/{tGeometryId}/acceleration` 2. Validate that a document was returned with a status code `200` 3. Verify the `type` is `"TFloat"` IF a query parameter `datatime` is not empty: Execute requests with `datatime` query parameter and verify the correctly calculated value is returned. IF a query parameter `datatime` is empty: Verify that a time-to-acceleration curve is correctly returned according to the specified TemporalGeometry resource by {tgeometryId}.

A.3.7. TemporalPropertyCollection

HTTP GET Operation

Abstract Test 30	**/conf/movingfeatures/tproperties-collection-get**
Requirement	/req/movingfeatures/tproperties-collection-get /req/movingfeatures/tproperties-collection-get-success
Test purpose	Validate that the TemporalPropertyCollection can be identified and extracted from a MovingFeature using query parameters.

Test method	For every TemporalProperty identified in MovingFeature, issue an HTTP GET request to the URL `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties` where `{collectionId}` is the id property for a MovingFeature Collection described in the MovingFeature Collections content and `{mFeatureId}` is the id property for the MovingFeature 1. Validate that a document was returned with a status code `200` 2. Validate the contents of the returned document using test `/conf/movingfeatures/tproperties-collection-get-success` Repeat these tests using the following parameter tests that defined in the OGC API-Common: - Limit: Limit Tests - Date-Time: Date-Time Tests Execute requests with combinations of the `"datetime"` query parameters and verify that only features are returned that match both selection criteria.

Abstract Test 31	**/conf/movingfeatures/tproperties-collection-get-success**
Requirement	/req/movingfeatures/tproperties-collection-get-success
Test purpose	Validate that the TemporalPropertyCollection complies with the required structure and contents.
Test method	1. Validate the `temporalProperties` property is present and that it is populated with an array of TemporalProperty items 2. Validate that the `name` and `type` property is present 3. Validate the `type` property is present and its value is one of the predefined value (i.e., one of 'TBoolean', 'TText', 'TInteger', 'TReal', and 'TImage') 4. If the `links` property is present, validate that all entries comply with OGC API-Features /conf/core/fc-links 5. If the `timeStamp` property is present, validate that it complies with OGC API-Features /conf/core/fc-timeStamp 6. If the `numberMatched` property is present, validate that it complies with OGC API-Features /conf/core/fc-numberMatched 7. If the `numberReturned` property is present, validate that it complies with OGC API-Features /conf/core/fc-numberReturned 8. Validate the TemporalPropertyCollection resource for all supported media types using the resources and tests identified in Table 22

The TemporalPropertyCollection content may be retrieved in a number of different formats. The following table identifies the applicable schema document for each format and the test to be used to validate the against that schema. All supported formats should be exercised.

Table 22. Schema and Tests for TemporalPropertyCollection content

Format	Schema Document	Test ID
HTML	temporalPropertyCollection.yaml	/conf/html/content
JSON	temporalPropertyCollection.yaml	/conf/json/content

HTTP POST Operation

Abstract Test 32	**/conf/movingfeatures/tproperties-collection-post**
Requirement	/req/movingfeatures/tproperties-mandatory /req/movingfeatures/tproperties-collection-post /req/movingfeatures/tproperties-collection-post-success
Test purpose	Validate that the TemporalProperty can be created to the expected location.
Test method	1. Validate that the server comply with OGC API-Features POST operation requirements 2. Validate that a body of a POST request using for all supported media types using the resources and tests identified in Table 23 and Table 11 3. Validate that the request body complies OGC API-Features POST request body requirements 4. Issue an HTTP POST request to the URL `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties` 5. Validate the contents of the response using test `/conf/movingfeatures/tproperties-collection-post-success`

Table 23. Schema and Tests for Request Body of `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties` POST

Format	Schema Document	Test ID
HTML	tproperty_requestbody.yaml	/conf/html/content
JSON	tproperty_requestbody.yaml	/conf/json/content
JSON	MF-JSON_Prism.schema.json	/conf/json/content

Abstract Test 33	**/conf/movingfeatures/tproperties-collection-post-success**
Requirement	/req/movingfeatures/tproperties-collection-post-success
Test purpose	Validate that the response of `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties` POST request complies with the required structure and contents.
Test method	1. Validate that a document was returned with a status code `201` or `202` 2. Validate that all response documents complies with OGC API-Features POST response requirements

A.3.8. TemporalProperty

HTTP GET Operation

Abstract Test 34	**/conf/movingfeatures/tproperties-get**
Requirement	/req/movingfeatures/tproperties-get /req/movingfeatures/tproperties-get-success
Test purpose	Validate that the TemporalProperty can be identified and extracted from a TemporalPropertyCollection using query parameters.
Test method	For every TemporalProperty identified in MovingFeature, issue an HTTP GET request to the URL `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties/{tpropertyName}` where `{collectionId}` is the id property for a MovingFeature Collection described in the MovingFeature Collections content, `{mFeatureId}` is the id property for the MovingFeature, `{tpropertyName}` is the name property for the TemporalProperty 1. Validate that a document was returned with a status code `200` 2. Validate the contents of the returned document using test `/conf/movingfeatures/tproperties-get-success` Repeat these tests using the following parameter tests that defined in the OGC API-Common and API-MF: - Limit: Limit Tests - Date-Time: Date-Time Tests - Leaf: Leaf Definition Test and Leaf Response Test Execute requests with combinations of the `"datetime"` and `"leaf"` query parameters and verify that only features are returned that match both selection criteria.

Abstract Test 35	**/conf/movingfeatures/tproperties-get-success**
Requirement	/req/movingfeatures/tproperties-get-success
Test purpose	Validate that the TemporalProperty complies with the required structure and contents.
Test method	1. Validate the `temporalProperties` property is present and that it is populated with an array of TemporalValue items 2. If the `links` property is present, validate that all entries comply with OGC API-Features /conf/core/fc-links 3. If the `timeStamp` property is present, validate that it complies with OGC API-Features /conf/core/fc-timeStamp 4. If the `numberMatched` property is present, validate that it complies with OGC API-Features /conf/core/fc-numberMatched 5. If the `numberReturned` property is present, validate that it complies with OGC API-Features /conf/core/fc-numberReturned 6. Validate the TemporalProperty resource for all supported media types using the resources and tests identified in Table 24

The TemporalProperty content may be retrieved in a number of different formats. The following table identifies the applicable schema document for each format and the test to be used to validate the against that schema. All supported formats should be exercised.

Table 24. Schema and Tests for TemporalProperty content

Format	Schema Document	Test ID
HTML	temporalPropertyCollection.yaml	/conf/html/content
JSON	temporalPropertyCollection.yaml	/conf/json/content

HTTP POST Operation

Abstract Test 36	**/conf/movingfeatures/tproperties-post**
Requirement	/req/movingfeatures/tproperties-mandatory /req/movingfeatures/tproperties-post /req/movingfeatures/tproperties-post-success
Test purpose	Validate that the TemporalValue can be created to the expected location.
Test method	1. Validate that the server comply with OGC API-Features POST operation requirements 2. Validate that a body of a POST request using for all supported media types using the resources and tests identified in Table 25 and Table 12 3. Validate that the request body complies OGC API-Features POST request body requirements 4. Issue an HTTP POST request to the URL `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties/{tPropertyName}` 5. Validate the contents of the response using test `/conf/movingfeatures/tproperties-post-success`

Table 25. Schema and Tests for Request Body of `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties/{tPropertyName}` *POST*

Format	Schema Document	Test ID
HTML	tvalue_requestbody.yaml	/conf/html/content
JSON	tvalue_requestbody.yaml	/conf/json/content

Abstract Test 37	**/conf/movingfeatures/tproperties-post-success**
Requirement	/req/movingfeatures/tproperties-post-success
Test purpose	Validate that the response of `{root}/collections/{collectionId}/items/{mFeatureId}/tproperties/{tPropertyName}` POST request complies with the required structure and contents.

Test method	1. Validate that a document was returned with a status code `201` or `202` 2. Validate that all response documents complies with OGC API-Features POST response requirements

Annex B: Relationship with other OGC/ISO standards (Informative)

This specification is built upon the following OGC/ISO standards. The geometry concept is presented first, followed by the feature concept. Note that a feature is *not* a geometry, but a feature often contains a geometry as one of its attributes. However, it is legal to build features without geometry attribute, or with more than one geometry attributes.

B.1. Static geometries, features and accesses

The following standards define static objects, without time-varying properties.

B.1.1. Geometry (ISO 19107)

The ISO 19107, *Geographic information — Spatial schema* standard defines a `GM_Object` base type which is the root of all geometric objects. Some examples of `GM_Object` subtypes are `GM_Point`, `GM_Curve`, `GM_Surface` and `GM_Solid`. A `GM_Object` instance can be regarded as an infinite set of points in a particular coordinate reference system. The standard provides a `GM_CurveInterpolation` code list to identify how those points are computed from a finite set of points. Some interpolation methods listed by ISO 19107 are (non-exhaustive list):

linear

Positions on a straight line between each consecutive pair of control points.

geodesic

Positions on a geodesic curve between each consecutive pair of control points. A geodesic curve is a curve of shortest length. The geodesic shall be determined in the coordinate reference system of the curve.

circularArc3Points

For each set of three consecutive control points, a circular arc passing from the first point through the middle point to the third point. Note: if the three points are co-linear, the circular arc becomes a straight line.

elliptical

For each set of four consecutive control points, an elliptical arc passing from the first point through the middle points in order to the fourth point. Note: if the four points are co-linear, the arc becomes a straight line. If the four points are on the same circle, the arc becomes a circular one.

cubicSpline

The control points are interpolated using initial tangents and cubic polynomials, a form of degree 3 polynomial spline.

The UML below shows the `GM_Object` base type with its operations (e.g. `distance(⋯)` for computing the distance between two geometries). `GM_Curve` (not shown in this UML) is a subtype of

GM_Primitive. All operations assume static objects, without time-varying coordinates or attributes.

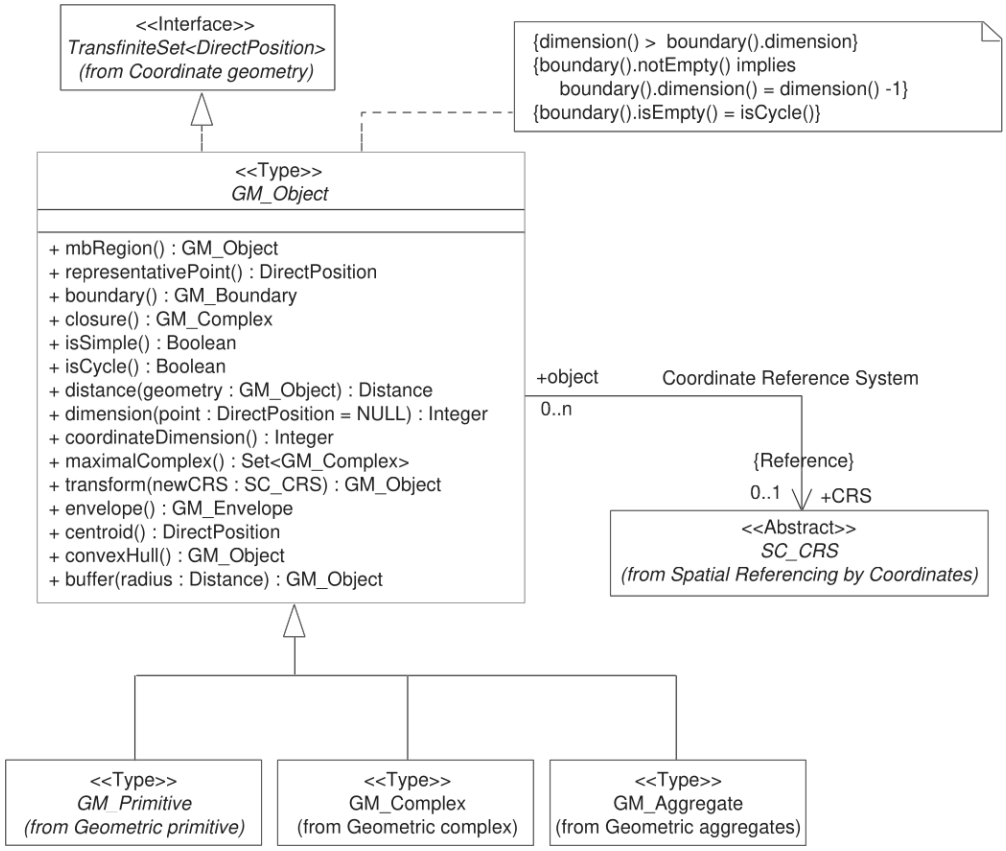

Figure 4. GM_Object from ISO 19107:2003 figure 6

Geometry, topology and temporal objects (GM_Object, TP_Object, TM_Object) are not abstractions of real-world phenomena. These types can provide types for feature properties as described in the next section, but cannot be specialized to features.

B.1.2. Features (ISO 19109)

The ISO 19109, *Geographic information — Rules for application schema* standard defines types for the definition of features. A feature is an abstraction of a real-world phenomena. The terms “feature type” and “feature instance” are used to separate the following concepts of “feature”:

Feature type

The whole collection of real-world phenomena classified in a concept. For example the “bridge” feature type is the abstraction of the collection of all real-world phenomena that is classified into the concept behind the term “bridge”.

Feature instance

A certain occurrence of a feature type. For example “Tower Bridge” feature instance is the abstraction of a certain real-world bridge in London.

In object-oriented modelling, feature types are equivalent to classes and feature instances are equivalent to objects,

The UML below shows the General Feature Model. FeatureType is a metaclass that is instantiated as classes that represent individual feature types. A FeatureType instance contains the list of properties (attributes, associations and operations) that feature instances of that type can contain. Geometries

are properties like any other, without any special treatment. All properties are static, without time-varying values.

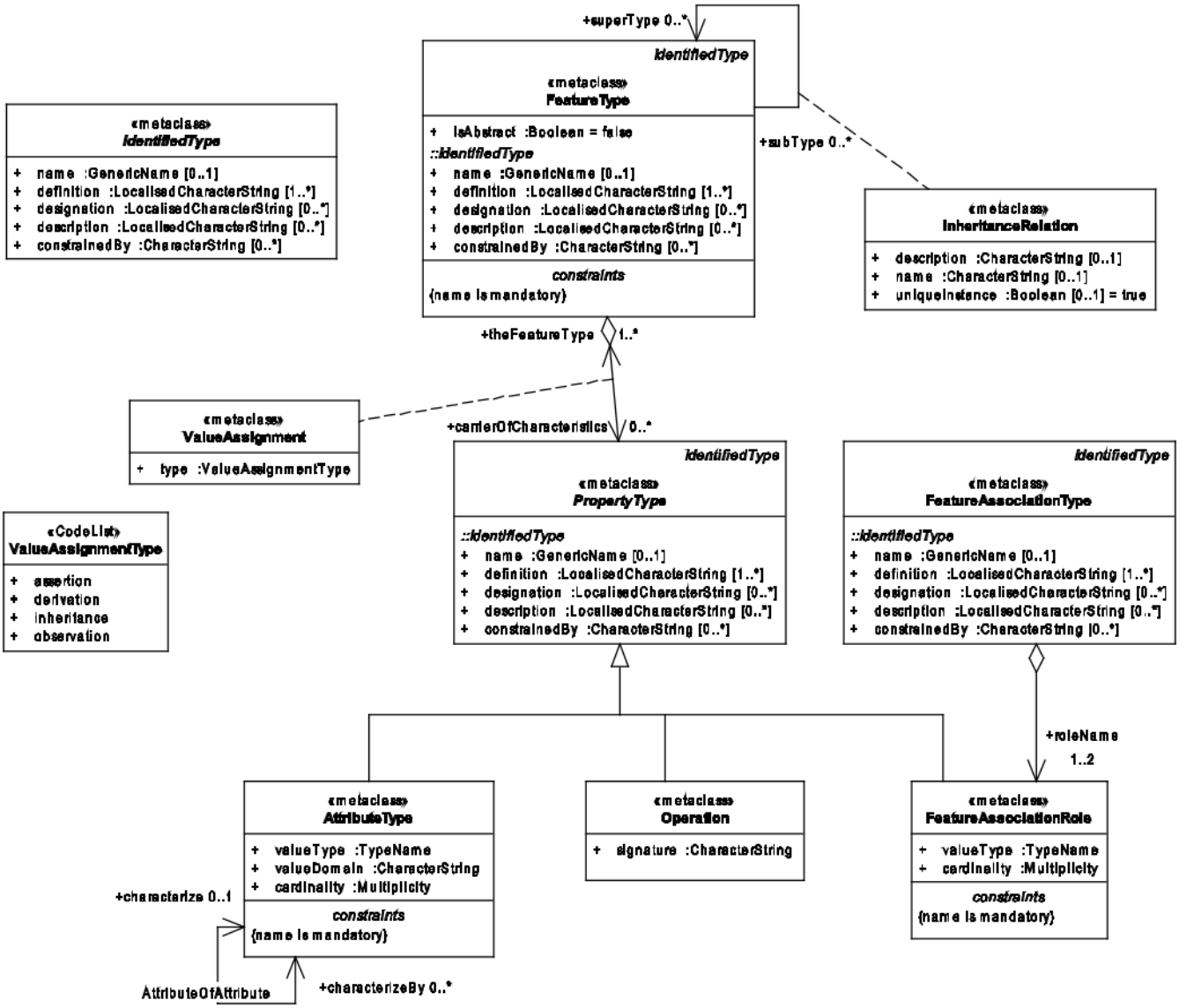

Figure 5. General Feature Model from ISO 19109:2009 figure 5

B.1.3. Simple Features SQL

The Simple Feature Access — Part 2: SQL Option standard describes a feature access implementation in SQL based on a profile of ISO 19107. This standard defines *feature table* as a table where the columns represent feature attributes, and the rows represent feature instances. The geometry of a feature is one of its feature attributes.

B.1.4. Filter Encoding (ISO 19143)

The ISO 19143, *Geographic information — Filter encoding* standard (also OGC standard) provides types for constructing queries. These objects can be transformed into a SQL “SELECT … FROM … WHERE … ORDER BY …” statement to fetch data stored in a SQL-based relational database. Similarly, the same objects can be transformed into an XQuery expression in order to retrieve data from XML document. The UML below shows the objects used for querying a subset based on spatial operations such as “contains” or “intersects”.

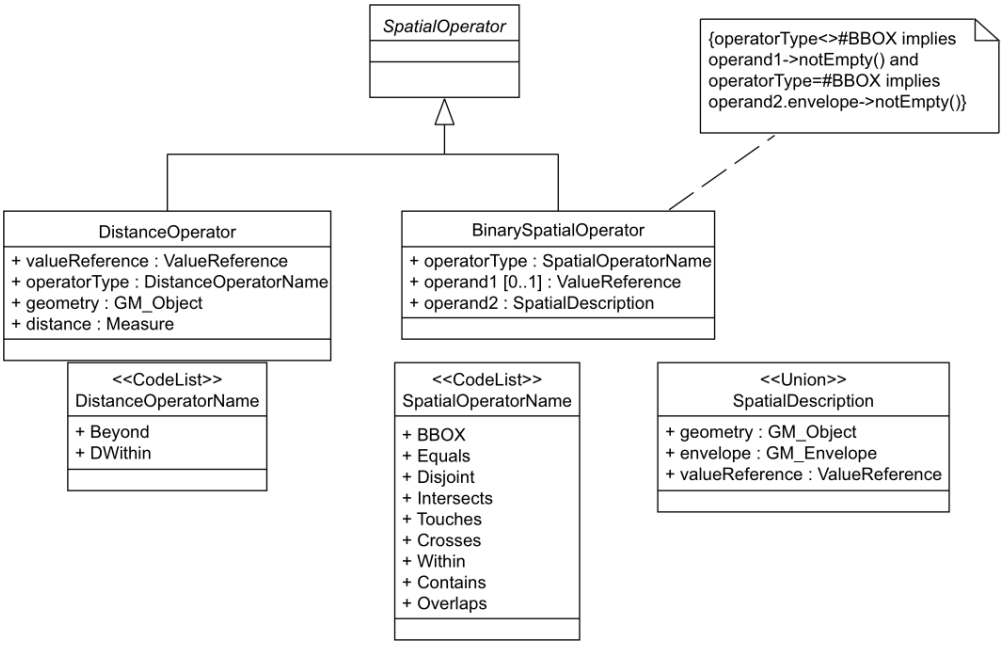

Figure 6. Spatial operators from ISO 19143 figure 6

B.1.5. Features web API

The OGC 17-069, *Features — Part 1: Core* standard specifies the fundamental building blocks for interacting with features using Web API. This base standards allow to get all features available on a server, or to get feature instances by their identifier.

B.1.6. Features Filtering web API

The OGC TBD, *Features — Part 3: Filtering and the Common Query Language (CQL)* standard extends the Feature web API with capabilities to encode more sophisticated queries. The conceptual model is close to ISO 19143.

B.2. Temporal geometries and moving Features

B.2.1. Moving Features (ISO 19141)

The ISO 19141, *Geographic information — Schema for moving features* standard extends the ISO 19107 spatial schema for addressing features whose locations change over time. Despite the “Moving Features” name, that standard is more about “Moving geometries”. The UML below shows how the `MF_Trajectory` type extends the “static” types from ISO 19107.

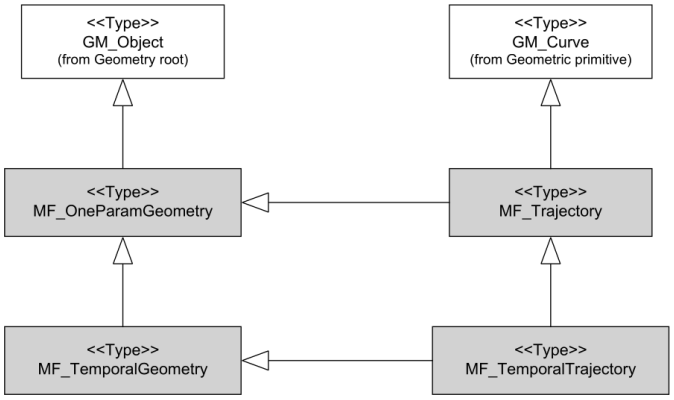

Figure 7. Trajectory type from ISO 19141 figure 3

Trajectory inherits some operations shown below. Those operations are in addition to the operations inherited from `GM_Object`. For example the `distance(⋯)` operation from ISO 19107 is now completed by a `nearestApproach(⋯)` operation.

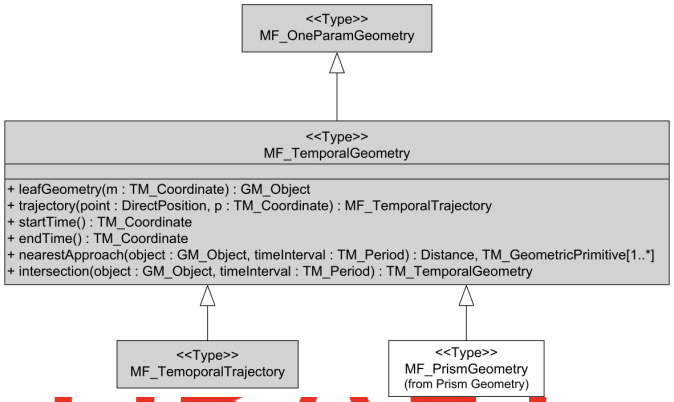

Figure 8. Temporal geometry from ISO 19141 figure 6

B.2.2. Moving Features XML encoding (OGC 18-075)

The OGC 18-075 *Moving Features Encoding Part I: XML Core* standard takes a subset of ISO 19141 specification and encodes it in XML format. But that standard also completes ISO 19141 by allowing to specify attributes whose value change over time. This extension to above *General Feature Model* is shown below:

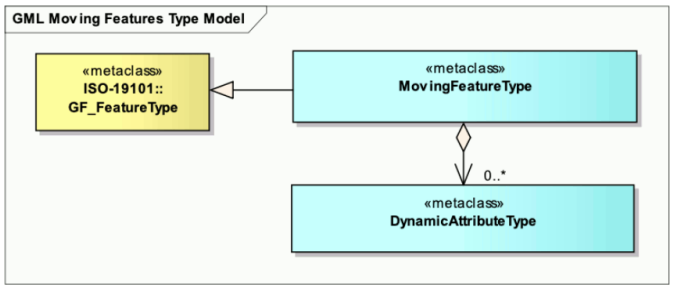

Figure 9. Dynamic attribute from OGC 18-075 figure 3

B.2.3. Moving Features JSON encoding (OGC 19-045)

The OGC 19-045 *Moving Features Encoding Extension — JSON* standard takes a subset of ISO 19141 specification and encodes it in JSON format. The specification provides various UML diagrams summarizing ISO 19141.

Annex C: Revision History

Date	Release	Editor	Primary clauses modified	Description
2021-09-14	0.1	Taehoon Kim, Kyoung-Sook Kim, and Martin Desruisseaux	all	first draft version
2022-03-01	0.2	Taehoon Kim, Kyoung-Sook Kim	all	revised sections related to resources to add CRUD operations
2022-10-09	0.3	Taehoon Kim, Kyoung-Sook Kim	all	added TemporalGeometry Query resources
2023-02-21	0.9	Taehoon Kim, Kyoung-Sook Kim, Mahmoud, and Esteban	all	finalize draft version
2023-05-19	0.9.9	Taehoon Kim, Kyoung-Sook Kim, Mahmoud, and Esteban	all	finalize draft version

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