FLIGHT DYNAMICS SYSTEM API

User Manual V1.2

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For additional support, please contact us at support@digantara.co.in

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Floor 9, Brigade Senate 2,
Hebbal, Bengaluru, India – 560024
info@digantara.co.in | www.digantara.co.in

1. Introduction

Digantara's Flight Dynamics System (FDS) API—is designed to empower you with precise, real-time flight dynamics capabilities to mitigate collision risks and ensure smooth operations in orbit.

The FDS API offers capabilities for:

- **Orbit Propagation:** Accurately track and predict the positions of RSOs up to 14 days in advance.
- **High Accuracy Pass Prediction:** Precisely forecast satellite passes over ground stations.
- **Conjunction Assessment and Screening:** Continuously screen for collision risks, providing timely alerts and detailed risk assessments.
- **Manoeuvre Design:** Design optimal maneuvers for collision avoidance, tailored to mission-specific constraints.
- **First Contact Assistance:** Generate initial orbital predictions and pass predictions for newly launched satellites, supporting early-stage tracking.

Key Benefits:

- **Unified Platform:** Combines essential tools, simplifying workflows and eliminating the need for multiple systems.
- **Real-Time Insights:** Supports confident decision-making with high-speed data processing.
- **Seamless Integration:** Integrates easily into existing systems, breaking down data silos.
- **Scalability and Efficiency:** Scales to meet mission needs and offloads heavy computations, optimizing resources.

Whether you're managing a satellite constellation, planning missions, or conducting space exploration and scientific research, with FDS- you can rely on advanced analytics for safer, more efficient orbital operations.

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2. Authentication

To access the API, you must include an authentication token in the request headers as shown below. The token can be obtained either by registering at fds.digantara.co or by contacting sales@digantara.com.

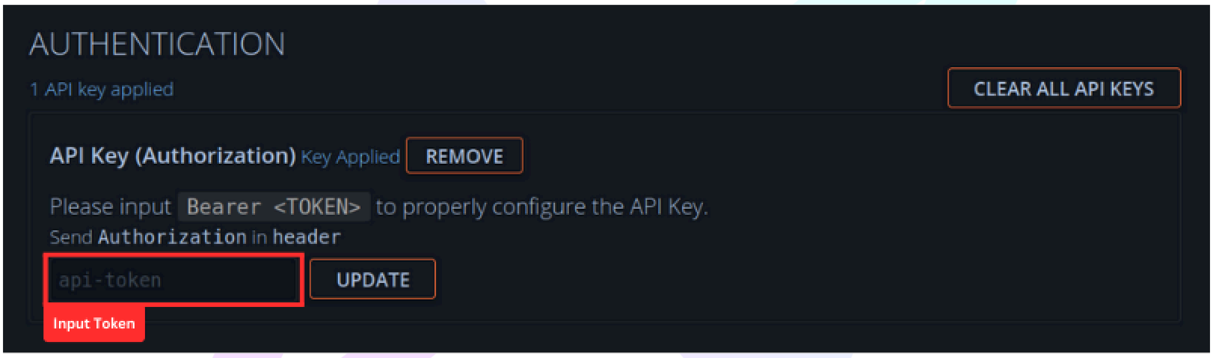
Example Header

```
Bearer <your-token>
```

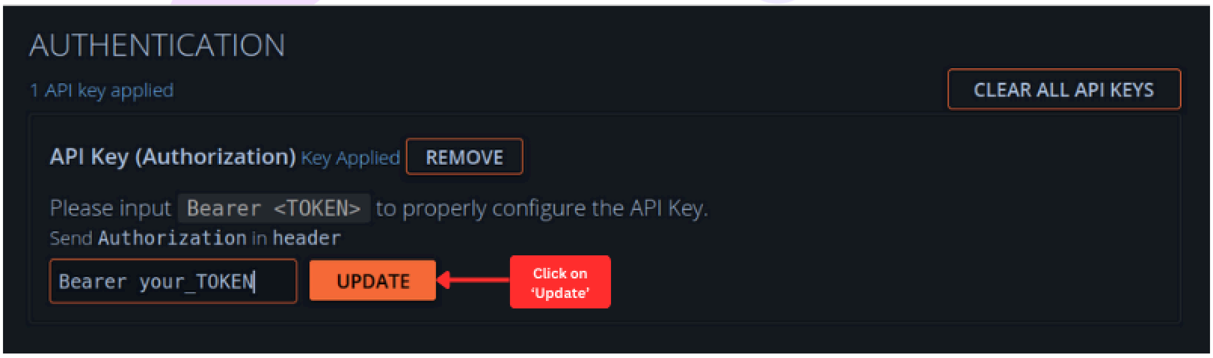
Replace ***<your-token>*** with the actual token provided, where ***Bearer*** has to be mentioned as prefix. The authorization header can also be set under the Authentication section as shown below.

Steps to update Authentication token on web application

1. Click on ***Authentication*** tab on homepage
2. Input ***Authentication token*** with proper format



3. Click on ***UPDATE*** to save Authentication token



3. Orbit Propagation (EPIC)

To initiate an orbit propagation job, navigate to "***POST/epic***" under the Orbit Propagation tab where the required orbit propagation parameters are passed in a ***JSON*** format, described under Request Body. The response will return a unique request ID, which shall be used to retrieve the result using ***GET*** request.

API End-point

```
https://fds.digantara.co/#post-/epic
```

Field Descriptions & Limitations:

1. Object Parameters

Field	Datatype	Description	Constraints	Default choice	Optional
`name`	string	Object Identifier	Any string allowed	-	No
`id`	string	Unique object identifier used in OEM and TLE files.	See ID format section below	-	No
`norad_id`	string	NORAD catalog identifier	Any string allowed	-	No
`position_km`	object	Initial J2000/EME2000 position components (in km)	Magnitude of (x,y,z) must be > 6478.137 km	-	No
`└─x, └─y, └─z`	float	The position components in km	-	-	No
`velocity_kmps`	object	Initial J2000/EME2000 velocity	-	-	No

		components (in kilometers per second)			
└─x_dot, └─y_dot, └─z_dot	float	The velocity components in kilometers per second	-	-	No
mass_kg	float	Mass of the object (in kg)	Valid range: [1, 100000] kg	1 kg	Yes
cross_section_area_m2	float	Cross-sectional area of the object (in square meters)	Valid range: [0.0001, 1000] m^2	1 m^2	Yes
drag_coefficient	float	The drag coefficient (dimensionless)	Valid range: > 0	2.2	Yes
reflectivity_coefficient	float	Reflectivity coefficient for solar radiation pressure	Valid range:[1, 2]	1.1	Yes

`id` format:
For OEM, the identifier has the format YYYY-NNNPPP, where:

- YYYY: Year of launch,
- NNN: Three-digit serial number indicating the launch number in that year.
- PPP: Part specifier (1 to 3 alphabets in capital letters) indicating the part of the object placed in orbit during the launch

For TLE, the identifier has the format YYNNNPPP, where:

- YY: Year of launch (last two digits),
- NNN: Three-digit serial number indicating the launch number
- PPP: Part specifier (1 to 3 alphabets in capital letters) indicating the part of the object placed in orbit during the launch

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2. Covariance Matrix (ECI_J2000)

Field	Datatype	Description	Constraints	Default choice	Optional
cov_diag_pos_xu_km2	float	Variance of the position X in km²	Valid range: ≥ 0	0	Yes
cov_diag_pos_yv_km	float	Variance of the position Y in km²	Valid range: ≥ 0	0	Yes
cov_diag_pos_zw_km2	float	Variance of the position Z in km²	Valid range: ≥ 0	0	Yes
cov_diag_vel_xu_km2ps2	float	Variance of velocity X in (km/s)²	Valid range: ≥ 0	0	Yes
cov_diag_vel_yv_km2ps2	float	Variance of velocity Y in (km/s)²	Valid range: ≥ 0	0	Yes
cov_diag_vel_zw_km2ps2	float	Variance of velocity Z in (km/s)²	Valid range: ≥ 0	0	Yes
off-diagonal elements	float	Covariance matrix off-diagonal elements	-	0	Yes

3. Propagation Settings

Field	Datatype	Description	Constraints	Default choice	Optional
start_time	datetime	Propagation start time	ISO 8601 format: "YYYY-MM-DDThh:mm:ss.sss"	-	No
end_time	datetime	Propagation end time	ISO 8601 format: "YYYY-MM-D		No

			DThh:mm:ss.sss "		
step_size_sec	integer	The step size for propagation, in seconds	Valid range: [1, 86400] seconds	60 seconds	No
geopotential_model	integer	Geopotential model for Earth's perturbation	Values: 1=EGM96, 2=EGM2008, 3=EIGEN-GL04C	3	Yes
geopotential	integer	Degree of the Earth's geopotential perturbations	Valid range: [0 to 360]	70	Yes
atmospheric_model	integer	Atmospheric model used	Values: 1=Exponential, 2=NRLMSISE-00	2	Yes
sun gravity	boolean	Sun gravity perturbation	true/false	true	Yes
moon gravity	boolean	Moon gravity perturbation	true/false	true	Yes
solid_earth_tides	boolean	Solid Earth tides perturbation	true/false	true	Yes
ocean_tides	boolean	Ocean tides perturbation	true/false	true	Yes
solar_radiation_pressure	boolean	Solar radiation pressure perturbation	true/false	true	Yes
earth_albedo	boolean	Earth albedo perturbation	true/false	true	Yes

Covariance-related propagation settings:

Field	Datatype	Description	Constraints	Default choice	Optional
cov_prop_switch	boolean	Enable covariance propagation	true/false	false	Yes
cov_deg_of_geopotential	integer	Geopotential degree for covariance propagation	Valid range: [0 to 360]	4	Yes
cov_atm_drag	boolean	Atmospheric drag for covariance propagation	true/false	false	Yes
cov_pert_sun. cov_pert_moon	boolean	Luni-Solar perturbation for covariance propagation	true/false	false	Yes
cov_pert_srp	boolean	Solar radiation pressure for covariance propagation	true/false	false	Yes
Ephem_integ_abstol	float	Absolute integrator tolerance	Valid range: >0	1e-11	Yes
Ephem_integ_reltol	float	Relative integrator tolerance	Valid range: >0	1e-10	Yes

4. Maneuvers

Field	Datatype	Description	Constraints	Default choice	Optional
maneuvers_uvw	object	List of maneuvers applied to the object	Maneuver fields below	-	Yes
└─ start_time	datetime	The time when the maneuver begins	All times should be specified in ISO	-	No*

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			8601 format. Format: "YYYY-MM-DDTh h:mm:ss.sss"		
└ duration_sec	float	The duration of the maneuver in seconds	Valid range: >0 seconds	-	No*
└ acceleration_kmps2	object	Acceleration components in UVW frame, in kilometers per second squared.	-	-	No
└ acc_u	float	U component acceleration	-	-	No*
└ acc_v	float	V component acceleration	-	-	No*
└ acc_w	float	W component acceleration	-	-	No*
└ eff	float	Efficiency factor for the commanded thrust	Valid range [0, 1.0]	1.0	Yes

* Required only if maneuvers_uvw object is included

5. TLE Generation

Field	**Datatype**	**Description**	**Constraints**	**Default choice**	**Optional**
generate_tle	boolean	Option to generate a TLE from the ephemeris	true/false	false	Yes

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Request Example


```
{
  "covariance_ECI_J2000": {
       "cov_diag_pos_xu_km2": 10000,
       "cov_diag_pos_yv_km2": 10000,
       "cov_diag_pos_zw_km2": 10000,
       "cov_diag_vel_xu_km2ps2": 0.01,
       "cov_diag_vel_yv_km2ps2": 0.01,
       "cov_diag_vel_zw_km2ps2": 0.01,
       "cov_offdiag_km2ps2": {
       "cov_offdiag_21": 0,
       "cov_offdiag_31": 0,
       "cov_offdiag_32": 0,
       "cov_offdiag_41": 0,
       "cov_offdiag_42": 0,
       "cov_offdiag_43": 0,
       "cov_offdiag_51": 0,
       "cov_offdiag_52": 0,
       "cov_offdiag_53": 0,
       "cov_offdiag_54": 0,
       "cov_offdiag_61": 0,
       "cov_offdiag_62": 0,
       "cov_offdiag_63": 0,
       "cov_offdiag_64": 0,
       "cov_offdiag_65": 0
       }
  },
  "maneuvers_uvw": [
       {
       "acceleration_kmps2": {
       "acc_u": 0,
       "acc_v": 0,
       "acc_w": 0
       },
       "duration_sec": 0,
       "eff": 0,
       "start_time": "2023-08-04T01:00:00"
       }
  ],
  "object": {
       "cross_section_area_m2": 0.0452389342,
       "drag_coefficient": 2.2,
       "id": "2012DA14",
       "mass_kg": 23.28,
       "name": "LARETS",
       "norad_id": "27944",
```

```
        "position_km": {
        "x": 1166.3832041214,
        "y": -569.998057629246,
        "z": -6939.59483659417
        },
        "reflectivity_coefficient": 1.2,
        "velocity_kmps": {
        "x_dot": 1.69394028376941,
        "y_dot": -7.26108827784564,
        "z_dot": 0.880941038701065
        }
    },
    "propagation_settings": {
        "atmospheric_drag": true,
        "atmospheric_model": 2,
        "cov_atm_drag": false,
        "cov_deg_of_geopotential": 4,
        "cov_pert_moon": false,
        "cov_pert_srp": false,
        "cov_pert_sun": false,
        "cov_prop_switch": false,
        "earth_albedo": true,
        "end_time": "2023-06-01T00:00:00.000",
        "ephem_integ_abstol": 1e-11,
        "ephem_integ_reltol": 1e-10,
        "geopotential": 70,
        "geopotential_model": 3,
        "moon_gravity": true,
        "ocean_tides": true,
        "solar_radiation_pressure": true,
        "solid_earth_tides": true,
        "start_time": "2023-05-31T00:00:00.000",
        "step_size_sec": 60,
        "sun_gravity": true
    }
```


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4. Conjunction Screening and Assessment (ConjA)

This API endpoint is used for the conjunction assessment between a primary object (satellite) and secondary objects based on provided NORAD IDs or by default with the entire Catalogue. It calculates the Distance of Closest Approach (DCA), Time of Closest Approach (TCA), the Probability of collision (Pc) and Digantara's proprietary confidence metric specifying the reliability of data and the risk associated with the predicted conjunction.

API End-point:

```
https://fds.digantara.dev/#post-/conja
```

Field Descriptions & Limitations:

Field	Datatype	Description	Constraints	Default choice	Optional
`primary_norad_id`	integer	The NORAD ID of the primary object for which the conjunction analysis is being performed.	-	55161	No
`analysis_duration_days`	integer	The number of days over which the conjunction analysis will be carried out	Minimum: 1, Maximum: 5	5	No
`screen_threshold_km`	integer	The screening threshold distance is in kilometers. Objects within a spherical volume with the radius as the specified threshold distance will be considered as potential conjunction.	Minimum: 1, Maximum: 100	25	No
`pc_method`	enum	The method used to calculate the probability of collision.	Allowed: ALFANO-2005, ALFANO-MAX-PROBABILITY, CHAN-1997, FOSTER-1992,	FOSTER -1992	No

			ELROD-2019		
primary_object_span_m	float	Primary object span (maximum dimension) in meters	Minimum: 0.01, Maximum: 100	0.5	Yes
secondary_norad_ids	[integer]	A list of secondary object NORAD IDs to screen for conjunction	List of NORAD IDs	[25544]	Yes

Request Example

1. For entire catalogue analysis

```
{
    "primary_norad_id": 12345,
    "analysis_duration_days": 5,
    "screen_threshold_km": 50,
    "pc_method": "FOSTER-1992",
    "primary_object_span_m": 0.5
}
```

2. For specific secondary object analysis

```
{
    "primary_norad_id": 12345,
    "analysis_duration_days": 5,
    "screen_threshold_km": 25
    "pc_method": "FOSTER-1992",
    "primary_object_span_m": 0.5,
    "secondary_norad_ids": [11111, 22222, 33333]
}
```

5. Collision Avoidance Maneuver (CAM)

This API endpoint calculates and suggests an optimal collision avoidance maneuver (CAM) for the primary satellite based on conjunction data. The maneuver is designed to minimize the probability of collision (Pc) by maneuvering the primary satellite's trajectory to avoid the collision.

API End-point:

```
https://fds.digantara.dev/#post-/cam
```

Field Descriptions & Limitations:

1. CDM Parameters

Field	Datatype	Description	Constraints	Default choice	Optional
`tca_utc`	datetime	Time of close approach	ISO 8601 format: "YYYY-MM-DDT hh:mm:ss.sss"	-	No
`miss_distance_m`	float	Miss distance at close approach	Positive float value	-	No
`collision_probability_method`	string	The method used to calculate the probability of collision.	Allowed: ALFANO-2005, ALFANO-MAX-PROBABILITY, CHAN-1997, FOSTER-1992, ELROD-2019	FOSTER-1992	No
`collision_probability`	float	Probability of collision	Minimum: 0 Maximum: 1	-	No
`relative_speed_mpsz`	float	Relative speed of satellites (in meters per second)	Positive float value	-	No

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relative_states_in_rtn	object	Relative state of secondary object with respect to primary object in RTN frame of reference	-	-	No
└─relative_position_n_m, └─relative_position_r_m, └─relative_position_t_m	float	The Position components in meters	-	-	No
└─relative_velocity_n_mps └─relative_velocity_r_mps └─relative_velocity_t_mps	float	The Velocity components in meters per second	-	-	No
start_screen_period_utc	datetime	Start of conjunction screening	ISO 8601 format: "YYYY-MM-DDT hh:mm:ss.sss"	-	No
stop_screen_period_utc	datetime	End of conjunction screening	ISO 8601 format: "YYYY-MM-DDT hh:mm:ss.sss"	-	No
primary_object_norad_id	integer	NORAD ID of primary object	Minimum: 1 Maximum: 99999	-	No
primary_object_state	object	States of primary object on time of close approach	-	-	No
└─x_km └─y_km └─z_km	float	The Position components in kilometers	-	-	No

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└─x_dot_kmps └─y_dot_kmps └─z_dot_kmps	float	The Velocity components in kilometers per second	-	-	No
primary_object_covariance	object	Covariance of primary object on the time of close approach	-	-	No
cn_n_m2	float	Variance in the cross-track (N) position, measured in square meters	Valid range: ≥ 0	-	No
cr_r_m2	float	Variance in the radial (R) position, measured in square meters	Valid range: ≥ 0	-	No
ct_t_m2	float	Variance in the along-track (T) position, measured in square meters	Valid range: ≥ 0	-	No
cn_r_m2	float	Covariance between cross-track (N) and radial (R) positions, measured in square meters	Valid range: ≥ 0	-	No
cn_t_m2	float	Covariance between cross-track (N) and along-track (T) positions,	Valid range: ≥ 0	-	No

		measured in square meters			
cr_t_m2	float	Covariance between radial (R) and along-track (T) positions, measured in square meters	Valid range: ≥ 0	-	No
cndot_ndot_m2ps2	float	Variance in the cross-track (N) velocity, measured in square meters per second squared	Valid range: ≥ 0	-	No
crdot_rdot_m2ps2	float	Variance in the radial (R) velocity, measured in square meters per second squared	Valid range: ≥ 0	-	No
ctdot_tdot_m2ps2	float	Variance in the along-track (T) velocity, measured in square meters per second squared	Valid range: ≥ 0	-	No
cndot_rdot_m2ps2	float	Covariance between cross-track (N) velocity and radial (R) velocity, measured in square meters per second squared	Valid range: ≥ 0	-	No

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cndot_tdot_m2ps2 crdot_tdot_m2ps2	float	Covariance between cross-track (N) velocity and along-track (T) velocity, measured in square meters per second squared	Valid range: ≥ 0	-	No
cndot_n_m2ps	float	Covariance between cross-track (N) position and cross-track velocity, measured in square meters per second	Valid range: ≥ 0	-	No
cndot_r_m2ps	float	Covariance between cross-track (N) position and radial (R) velocity, measured in square meters per second	Valid range: ≥ 0	-	No
cndot_t_m2ps	float	Covariance between cross-track (N) position and along-track (T) velocity, measured in square meters per second	Valid range: ≥ 0	-	No

`crdot_r_m2ps`	float	Covariance between radial (R) position and radial velocity, measured in square meters per second	Valid range: ≥ 0	-	No
`crdot_n_m2ps`	float	Covariance between radial (R) position and cross-track (N) velocity, measured in square meters per second	Valid range: ≥ 0	-	No
`crdot_t_m2ps`	float	Covariance between radial (R) position and along-track (T) velocity, measured in square meters per second	Valid range: ≥ 0	-	No
`ctdot_n_m2ps`	float	Covariance between along-track (T) position and cross-track (N) velocity, measured in square meters per second	Valid range: ≥ 0	-	No
`ctdot_r_m2ps`	float	Covariance between along-track (T) position and radial (R)	Valid range: ≥ 0	-	No

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		velocity, measured in square meters per second			
ctdot_t_m2ps	float	Covariance between along-track (T) position and along-track (T) velocity, measured in square meters per second	Valid range: ≥ 0	-	No
secondary_object_norad_id	integer	NORAD ID of secondary object	Minimum: 1 Maximum: 99999	-	No
secondary_object_state	object	States of secondary object on time of close approach (Same layout of position and velocity as primary object)	-	-	No
secondary_object_covariance	object	Covariance of secondary object on the time of close approach (Same layout of covariance as primary object)			

2. Custom maneuver parameters (Optional input)

Field	Datatype	Description	Constraints	Default choice	Optional
start_utc	datetime	Maneuver start epoch	ISO 8601 format:	-	Yes

			"YYYY-MM-DDThh:mm:ss.sss"		
duration_s	float	Duration of maneuver from the start_utc in seconds	Valid range: ≥ 0	-	Yes
thrust_direction_rsw	object	Direction of thrust for the maneuver in the RSW frame of reference.	-	-	Yes
└─r └─s └─w	float	Thrust magnitude in RSW component in Newton	-	-	Yes

3. Propulsion system parameters (Optional input)

Field	Datatype	Description	Constraints	Default choice	Optional
specific_impulse_s	float	The specific impulse of the propulsion system in second	Minimum: 100 Maximum: 300	-	Yes
thrust	float	Thrust provided by the propulsion system during the maneuver in Newton	Minimum: $10^{-5>}$ Maximum: 50	-	Yes

4. Post collision avoidance maneuver conjunction analysis parameters

Field	Datatype	Description	Constraints	Default choice	Optional
screen_threshold_km	float	The screening threshold distance is in kilometers. Objects within a spherical volume with the radius as the specified threshold distance	Minimum: 1 Maximum: 100	-	No

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		will be considered as potential conjunction.			

5. Satellite parameter (Optional parameter)

Field	Datatype	Description	Constraints	Default choice	Optional
primary_initial_mass_kg	float	Initial mass of the primary satellite in kilograms. (Note: If the initial mass is not provided, the mass will be retrieved from Digantara's database. If the mass value is not available in the database, it will be assumed to be 5 kg)	Valid range: ≥ 0	-	Yes

Request Example

```
{
  "cdm_parameters": {
      "collision_probability": 0.00008817232570478996,
      "collision_probability_method": "FOSTER-1992",
      "miss_distance_m": 12524.559653287553,
      "primary_object_covariance": {
      "cn_n_m2": 0,
      "cn_r_m2": 0,
      "cn_t_m2": 0,
      "cndot_n_m2ps": 0,
      "cndot_ndot_m2ps2": 0,
      "cndot_r_m2ps": 0,
      "cndot_rdot_m2ps2": 0,
      "cndot_t_m2ps": 0,
      "cndot_tdot_m2ps2": 0,
      "cr_r_m2": 0,
      "crdot_n_m2ps": 0,
      "crdot_r_m2ps": 0,
      "crdot_rdot_m2ps2": 0,
      "crdot_t_m2ps": 0,
      "ct_r_m2": 0,
```


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```
"ct_t_m2": 0,
"ctdot_n_m2ps": 0,
"ctdot_r_m2ps": 0,
"ctdot_rdot_m2ps2": 0,
"ctdot_t_m2ps": 0,
"ctdot_tdot_m2ps2": 0
},
"primary_object_norad_id": 55161,
"primary_object_state": {
"x_dot_kmps": 0,
"x_km": 0,
"y_dot_kmps": 0,
"y_km": 0,
"z_dot_kmps": 0,
"z_km": 0
},
"relative_speed_mps": 7343.659692548911,
"relative_states_in_rtn": {
"relative_position_n_m": 5051.072649367569,
"relative_position_r_m": -7652.210935026668,
"relative_position_t_m": 8531.99433927541,
"relative_velocity_n_mps": 6328.315266198509,
"relative_velocity_r_mps": -7.967524511465651,
"relative_velocity_t_mps": -3725.8153591019
},
"secondary_object_covariance": {
"cn_n_m2": 0,
"cn_r_m2": 0,
"cn_t_m2": 0,
"cndot_n_m2ps": 0,
"cndot_ndot_m2ps2": 0,
"cndot_r_m2ps": 0,
"cndot_rdot_m2ps2": 0,
"cndot_t_m2ps": 0,
"cndot_tdot_m2ps2": 0,
"cr_r_m2": 0,
"crdot_n_m2ps": 0,
"crdot_r_m2ps": 0,
"crdot_rdot_m2ps2": 0,
"crdot_t_m2ps": 0,
"ct_r_m2": 0,
"ct_t_m2": 0,
"ctdot_n_m2ps": 0,
"ctdot_r_m2ps": 0,
"ctdot_rdot_m2ps2": 0,
"ctdot_t_m2ps": 0,
"ctdot_tdot_m2ps2": 0
```


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```
        },
        "secondary_object_norad_id": 48062,
        "secondary_object_state": {
        "x_dot_kmps": 0,
        "x_km": 0,
        "y_dot_kmps": 0,
        "y_km": 0,
        "z_dot_kmps": 0,
        "z_km": 0
        },
        "start_screen_period_utc": "2024-10-20T08:27:54.000Z",
        "stop_screen_period_utc": "2024-10-24T11:05:54.000Z",
        "tca_utc": "2024-10-24T10:25:28.996338Z"
    },
    "custom_maneuver_parameters": [
        {
        "duration_s": 20,
        "start_utc": "2024-07-02T13:10:10.000Z",
        "thrust_direction_rsw": {
        "r": 0,
        "s": 1,
        "w": 0
        }
        }
    ],
    "post_conjunction_analysis_parameters": {
        "screen_threshold_km": 25
    },
    "propulsion_parameters": {
        "specific_impulse_s": 230,
        "thrust_magnitude_N": 1
    }
}
```


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6. High Accuracy Pass Prediction (HAPP)

HAPP provides highly accurate predictions for satellite passes over ground stations. It utilizes sophisticated algorithms and Digantara's proprietary catalogue data to calculate precise pass details of the corresponding set of satellites. By leveraging HAPP, satellite operators can optimize their communication windows and enhance overall mission efficiency.

API End-point:

```
https://fds.digantara.co/#post-/happ
```

Field Descriptions & Limitations:

Field	Datatype	Description	Constraints	Default choice	Optional
`norads`	[string]	List of NORAD IDs for which High Accuracy Pass Prediction has to perform	List of NORAD IDs	["25544"]	No
`ground_stations`		Ground station parameters			No
`latitude`	float	Latitude of ground station for HAPP	Minimum: -90, Maximum: 90	12.9716	No
`longitude`	float	Longitude of ground station for HAPP	Minimum: -180, Maximum: 180	77.5946	No
`name`	string	Name of ground station	-	Bengaluru	No
`propagation_settings`		Propagation Parameters			

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`duration_days`	float	Duration for which HAPP will be performed in days.	Minimum: 0.05, Maximum: 5	1	Yes
`elevation_lower_limit_degrees`	float	Optical elevation lower limit in degrees.	Minimum: 0, Maximum: 30	0	Yes
`step_size_sec`	float	Propagation time step in seconds	Minimum: 0.1, Maximum: 60	5	Yes

Request Example

```
{
  "ground_stations": [
    {
      "latitude": 12.9716,
      "longitude": 77.5946,
      "name": "Bengaluru"
    }
  ],
  "norads": [
    "25544"
  ],
  "propagation_settings": {
    "duration_days": 1,
    "elevation_lower_limit_degrees": 0,
    "step_size_sec": 5
  }
}
```


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7. First Contact Assistance (FCA)

The First Contact Assistance module is designed to support early-stage satellite tracking by generating precise orbital predictions based on the initial state vector of newly launched satellite. Starting with this initial state, the module performs orbit propagation, producing propagated states data and Two-Line Element (TLE). It provides optimal pass predictions for establishing first contact with the satellite by using ground station parameters.

API End-Point:

```
https://fds.digantara.co/#post-/fca
```

Field Descriptions & Limitations:

1. `opm_params` (Orbit Propagation Parameters)

a. Object Parameters

Field	Datatype	Description	Constraints	Default choice	Optional
`name`	string	Object Identifier	Any string allowed	-	No
`id`	string	Unique object identifier used in OEM and TLE files.	See ID format section below	-	No
`norad_id`	string	NORAD catalog identifier	Any string allowed	-	No
`position_km`	object	Initial J2000/EME2000 position components (in km)	Magnitude of (x,y,z) must be > 6478.137 km	-	No
`└─x`, `└─y`, `└─z`	float	The position components in km	-	-	No

velocity_kmps	object	Initial J2000/EME2000 velocity components (in kilometers per second)	-	-	No
└─x_dot, └─y_dot, └─z_dot	float	The velocity components in kilometers per second	-	-	No
mass_kg	float	Mass of the object (in kg)	Valid range: [1, 100000] kg	1 kg	Yes
cross_section_area_m2	float	Cross-sectional area of the object (in square meters)	Valid range: [0.0001, 1000] m^2	1 m^2	Yes
drag_coefficient	float	The drag coefficient (dimensionless)	Valid range: > 0	2.2	Yes
reflectivity_coefficient	float	Reflectivity coefficient for solar radiation pressure	Valid range:[1, 2]	1.1	Yes

id format:

For OEM, the identifier has the format YYYY-NNNPPP, where:

- YYYY: Year of launch,
- NNN: Three-digit serial number indicating the launch number in that year.
- PPP: Part specifier (1 to 3 alphabets in capital letters) indicating the part of the object placed in orbit during the launch

For TLE, the identifier has the format YYNNNPPP, where:

- YY: Year of launch (last two digits),
- NNN: Three-digit serial number indicating the launch number
- PPP: Part specifier (1 to 3 alphabets in capital letters) indicating the part of the object placed in orbit during the launch

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b. Covariance Matrix (ECI_J2000)

Field	Datatype	Description	Constraints	Default choice	Optional
cov_diag_pos_xu_km2	float	Variance of the position X in km²	Valid range: ≥ 0	0	Yes
cov_diag_pos_yv_km	float	Variance of the position Y in km²	Valid range: ≥ 0	0	Yes
cov_diag_pos_zw_km2	float	Variance of the position Z in km²	Valid range: ≥ 0	0	Yes
cov_diag_vel_xu_km2ps2	float	Variance of velocity X in (km/s)²	Valid range: ≥ 0	0	Yes
cov_diag_vel_yv_km2ps2	float	Variance of velocity Y in (km/s)²	Valid range: ≥ 0	0	Yes
cov_diag_vel_zw_km2ps2	float	Variance of velocity Z in (km/s)²	Valid range: ≥ 0	0	Yes
off-diagonal elements	float	Covariance matrix off-diagonal elements	-	0	Yes

c. Propagation Settings

Field	Datatype	Description	Constraints	Default choice	Optional
start_time	datetime	Propagation start time	ISO 8601 format: "YYYY-MM-DD Thh:mm:ss.sss"	-	No
end_time	datetime	Propagation end time	ISO 8601 format: "YYYY-MM-DD Thh:mm:ss.sss"		No
step_size_sec	integer	The step size for propagation, in seconds	Valid range: [1, 86400] seconds	60 seconds	No

geopotential_model	integer	Geopotential model for Earth's perturbation	Values: 1=EGM96, 2=EGM2008, 3=EIGEN-GL04C	3	Yes
geopotential	integer	Degree of the Earth's geopotential perturbations	Valid range: [0 to 360]	70	Yes
atmospheric_model	integer	Atmospheric model used	Values: 1=Exponential, 2=NRLMSISE-00	2	Yes
sun gravity	boolean	Sun gravity perturbation	true/false	true	Yes
moon gravity	boolean	Moon gravity perturbation	true/false	true	Yes
solid_earth_tides	boolean	Solid Earth tides perturbation	true/false	true	Yes
ocean_tides	boolean	Ocean tides perturbation	true/false	true	Yes
solar_radiation_pressure	boolean	Solar radiation pressure perturbation	true/false	true	Yes
earth_albedo	boolean	Earth albedo perturbation	true/false	true	Yes

Covariance-related propagation settings:

Field	Datatype	Description	Constraints	Default choice	Optional
cov_prop_switch	boolean	Enable covariance propagation	true/false	false	Yes

cov_deg_of_geopotential	integer	Geopotential degree for covariance propagation	Valid range: [0 to 360]	4	Yes
cov_atm_drag	boolean	Atmospheric drag for covariance propagation	true/false	false	Yes
cov_pert_sun. cov_pert_moon	boolean	Luni-Solar perturbation for covariance propagation	true/false	false	Yes
cov_pert_srp	boolean	Solar radiation pressure for covariance propagation	true/false	false	Yes
Ephem_integ_abstol	float	Absolute integrator tolerance	Valid range: >0	1e-11	Yes
Ephem_integ_reltol	float	Relative integrator tolerance	Valid range: >0	1e-10	Yes

d. Maneuvers

Field	**Datatype**	**Description**	**Constraints**	**Default choice**	**Optional**
maneuvers_uvw	object	List of maneuvers applied to the object	Maneuver fields below	-	Yes
└─ start_time	datetime	The time when the maneuver begins	All times should be specified in ISO 8601 format. Format: "YYYY-MM-DDT hh:mm:ss.sss"	-	No*
└─ duration_sec	float	The duration of the maneuver in seconds	Valid range: >0 seconds	-	No*

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└─ acceleration_kmps2	object	Acceleration components in UVW frame, in kilometers per second squared.	-	-	No*
└─ acc_u	float	U component acceleration	-	-	No*
└─ acc_v	float	V component acceleration	-	-	No*
└─ acc_w	float	W component acceleration	-	-	No*
└─ eff	float	Efficiency factor for the commanded thrust	Valid range [0, 1.0]	1.0	Yes

e. TLE Generation

Field	Datatype	Description	Constraints	Default choice	Optional
generate_tle	boolean	Option to generate a TLE from the ephemeris	true/false	false	Yes

2. `passes_params` (Pass Prediction Parameters)

Field	Datatype	Description	Constraints	Default choice	Optional
ground_stations		Ground station parameters			No
latitude	float	Latitude of ground station for HAPP	Minimum: -90, Maximum: 90	12.9716	No

longitude	float	Longitude of ground station for HAPP	Minimum: -180, Maximum: 180	77.5946	No
wgs84_elevation_km	string	WGS84 Elevation of ground station in km	Minimum: 0 Maximum: 100	0.9	Yes
name	string	Name of ground station	-	Bengaluru	No
propagation_settings		Propagation Parameters			
duration_days	float	Duration for which HAPP will be performed in days.	Minimum: 0.05, Maximum: 5	1	Yes
elevation_lower_limit_degrees	float	Optical elevation lower limit in degrees.	Minimum: 0, Maximum: 30	0	Yes
step_size_sec	float	Propagation time step in seconds	Minimum: 0.1, Maximum: 60	5	Yes
object_params	object	Parameters associated with object	-	-	-
object_size_m	string	Maximum Diameter/span of the satellite	Minimum: 0.01 Maximum: 100	1.0	Yes

Request Example

```
{
```


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```
"opm_params": {
    "covariance_ECI_J2000": {
    "cov_diag_pos_xu_km2": 10000,
    "cov_diag_pos_yv_km2": 10000,
    "cov_diag_pos_zw_km2": 10000,
    "cov_diag_vel_xu_km2ps2": 0.01,
    "cov_diag_vel_yv_km2ps2": 0.01,
    "cov_diag_vel_zw_km2ps2": 0.01,
    "cov_offdiag_km2ps2": {
    "cov_offdiag_21": 0,
    "cov_offdiag_31": 0,
    "cov_offdiag_32": 0,
    "cov_offdiag_41": 0,
    "cov_offdiag_42": 0,
    "cov_offdiag_43": 0,
    "cov_offdiag_51": 0,
    "cov_offdiag_52": 0,
    "cov_offdiag_53": 0,
    "cov_offdiag_54": 0,
    "cov_offdiag_61": 0,
    "cov_offdiag_62": 0,
    "cov_offdiag_63": 0,
    "cov_offdiag_64": 0,
    "cov_offdiag_65": 0
    }
    },
    "generate_tle": false,
    "maneuvers_uvw": [
    {
    "acceleration_kmps2": {
    "acc_u": 0,
    "acc_v": 0,
    "acc_w": 0
    },
    "duration_sec": 0,
    "eff": 1,
    "start_time": "2023-08-04T01:00:00"
    }
    ],
    "object": {
    "cross_section_area_m2": 0.0452389342,
    "drag_coefficient": 2.2,
    "id": "2012DA14",
    "mass_kg": 23.28,
    "name": "LARETS",
    "norad_id": "27944",
    "position_km": {
```

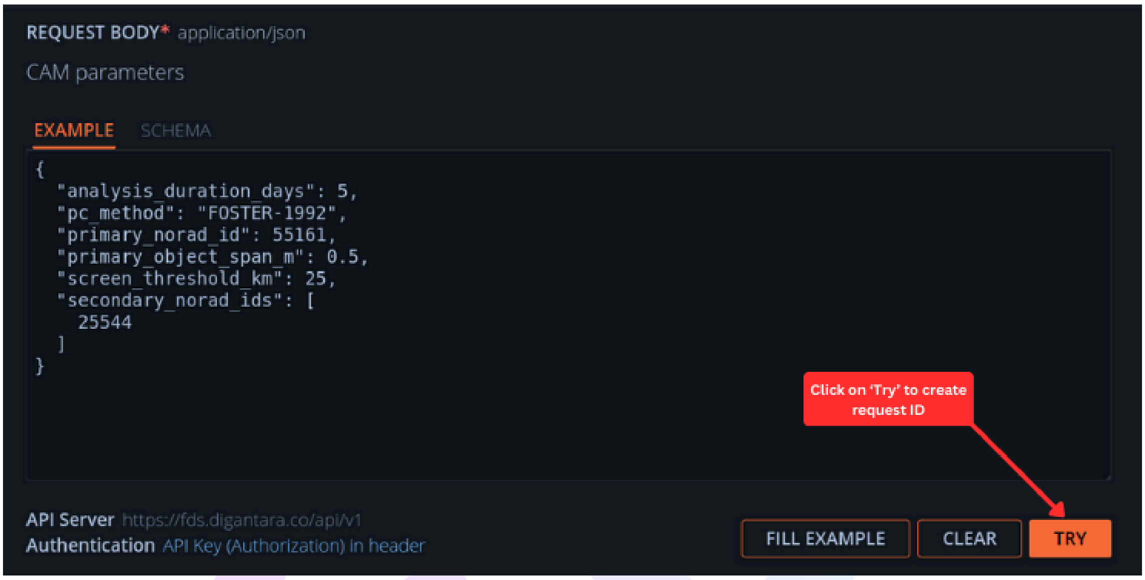
```
      "x": 1166.3832041214,
      "y": -569.998057629246,
      "z": -6939.59483659417
      },
      "reflectivity_coefficient": 1.2,
      "velocity_kmps": {
      "x_dot": 1.69394028376941,
      "y_dot": -7.26108827784564,
      "z_dot": 0.880941038701065
      }
      },
      "propagation_settings": {
      "atmospheric_drag": true,
      "atmospheric_model": 2,
      "cov_atm_drag": false,
      "cov_deg_of_geopotential": 4,
      "cov_pert_moon": false,
      "cov_pert_srp": false,
      "cov_pert_sun": false,
      "cov_prop_switch": false,
      "earth_albedo": true,
      "end_time": "2023-06-01T00:00:00.000",
      "ephem_integ_abstol": 1e-11,
      "ephem_integ_reltol": 1e-10,
      "geopotential": 70,
      "geopotential_model": 3,
      "moon_gravity": true,
      "ocean_tides": true,
      "solar_radiation_pressure": true,
      "solid_earth_tides": true,
      "start_time": "2023-05-31T00:00:00.000",
      "step_size_sec": 60,
      "sun_gravity": true
      }
  },
  "passes_params": {
      "ground_stations": [
      {
      "latitude": 12.9716,
      "longitude": 77.5946,
      "name": "Bengaluru"
      }
      ],
      "object_params": {
      "object_size_m": [
      0
      ]
```

```
      },
      "propagation_settings": {
      "duration_days": 1,
      "elevation_lower_limit_degrees": 0,
      "step_size_sec": 5
      }
  }
}
```

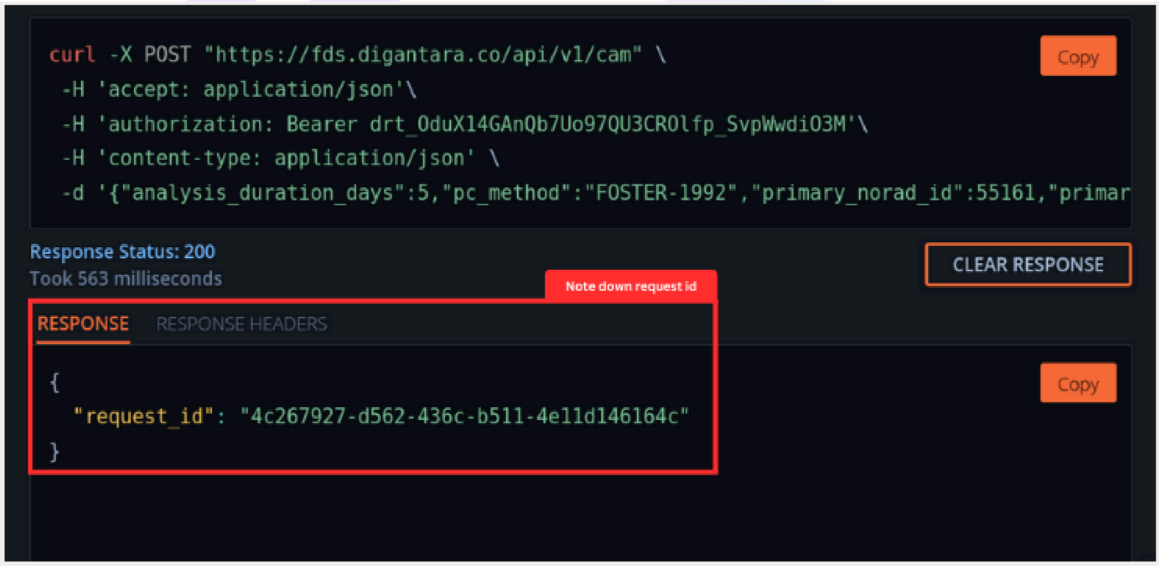
8. API Usage Guide

Creating Back-end Request ID

- Using the web-based application
  1. Click on ***POST/cam, POST/conja, POST/epic, POST/happ, POST/fca*** from the home page.
  2. Input the proper parameters from the ***Example*** tab.
  3. To create a request id click on ***Try***.



  4. Note ***request id*** for further use.



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- Using the ***curl*** format (Inputs have to be updated):

You can interact with the API using `curl` commands. Here's how to use `curl` to make requests to the API, including authentication and POST requests. Base URL would be the API end-point of a particular module.

Header	Value	Description
`accept`	application/json	Specifies the expected response format
`authorization`	Bearer `API_TOKEN`	Authentication token (replace `API_TOKEN` with your actual token)
`content-type`	application/json	Specifies the request body format

1. For entire catalogue analysis

```
curl -X POST "<https://fds.digantara.co/api/v1/cam>" \\
-H "accept: application/json"\\
-H "authorization: Bearer API_TOKEN"\\
-H "content-type: application/json" \\
-d'{"primary_norad_id":12345,"analysis_duration_days":5,"screen_threshold_km":50
,"pc_method":"FOSTER-1992"}' \\
```

2. For specific secondary object analysis

```
curl -X POST "<https://fds.digantara.co/api/v1/cam>" \\
-H "accept: application/json"\\
-H "authorization: Bearer API_TOKEN"\\
-H "content-type: application/json" \\
-d{"primary_norad_id":12345,"analysis_duration_days":5,"screen_threshold_km":25,
"pc_method":"FOSTER-1992","secondary_norad_ids":[11111,22222,33333]}' \\
```

Response

The response will contain the conjunction results including potential conjunction events, computed Pc values, and details of the closest approaches between the primary and secondary objects in form of .csv files and CCSDS conjunction data messages (CDM) in zip folder.

Response code

Code	Type	Message	Description
200	Status	REQUEST_IN_PROGRESS or REQUEST_COMPLETE	-

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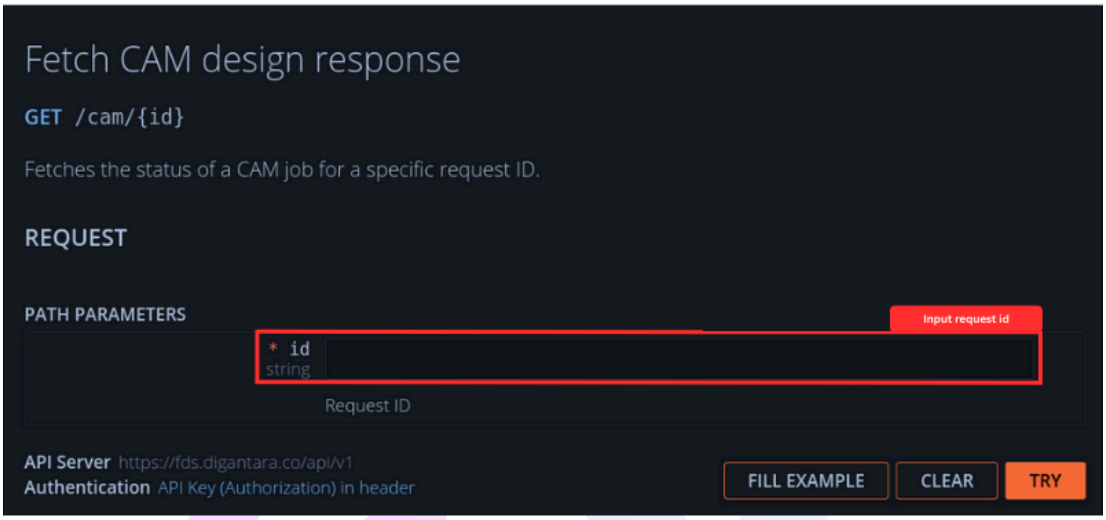
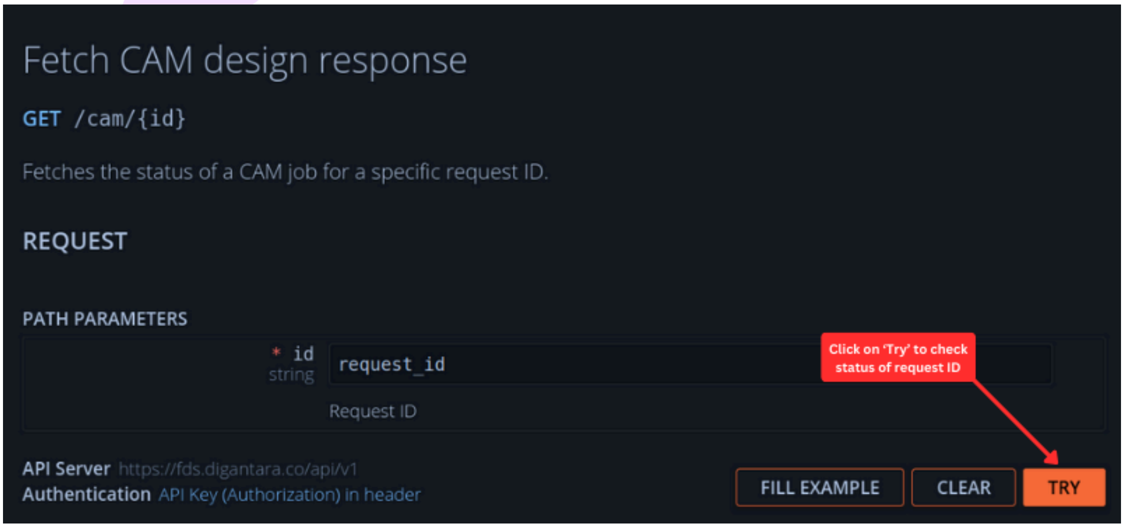
400	Error	INVALID_INPUT	Check request body parameters
422	Error	VALIDATION ERROR	Contact support@digantara.co.in
500	Error	SERVER_ERROR	Contact support@digantara.co.in

Checking response

1. Click on ***GET/cam/{id}, GET/epic/{id} & GET/happ/{id}*** from the home page.
2. Input ***request id*** under heading of ***PATH PARAMETERS***.

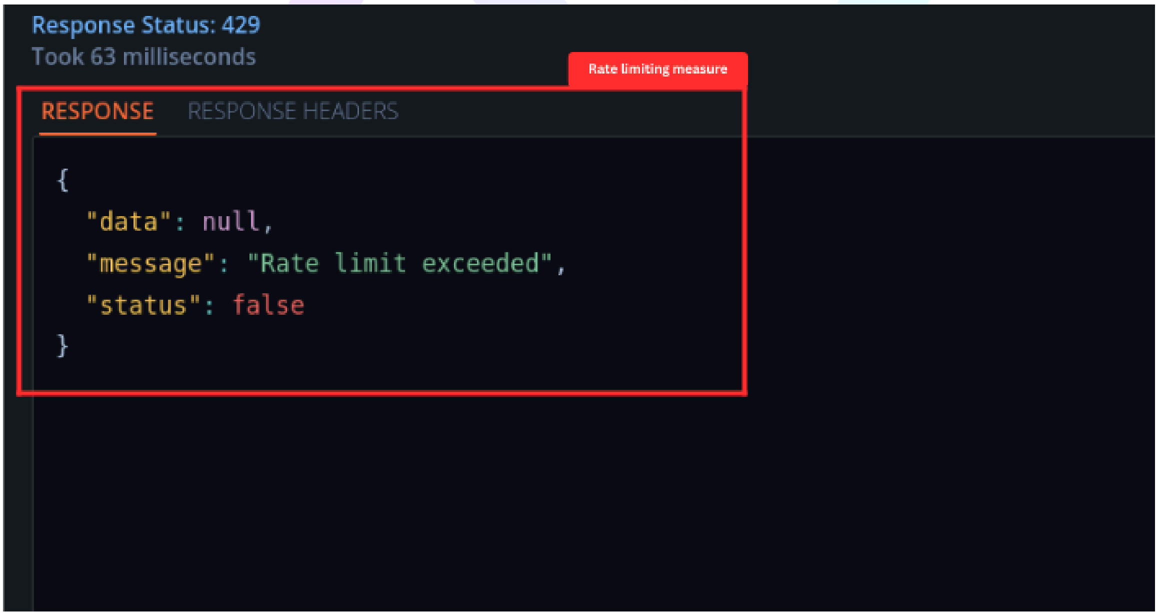


3. To check the status of the request click on ***Try***. To check for updates on the response status, click ***Try*** periodically until the status changes from "In Progress" to "Completed". Clicking too frequently may surpass the rate limit.



4. Request-in-progress response. The duration of the run will vary depending on the module and your inputs.

5. Rate limiting measure: If requests surpass the average rate of three per second, the system identifies this as a potential denial-of-service (DoS) attempt and dynamically enforces rate-limiting measures. Additionally, it adjusts the reset interval based on the severity and persistence of the excess traffic.



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6. Request completed: Module output file link will appear here-

Example Response


```
{
  "status": "REQUEST_COMPLETED",
  "message": "Request completed successfully.",
  "data": {
    "cdms_zip_filepath": "https://downloadable_link_cdms_zip_filepath.com",
    "conjunction_analysis_report_csv":
"https://downloadable_link_conjunction_analysis_report_csv.com",
  },
  "params": {
    "primary_norad_id": 12345,
    "analysis_duration_days": 5,
    "screen_threshold_km": 50,
    "pc_method": "FOSTER-1992"
  }
}
```


Note: For High Accuracy Pass Prediction, there are two more output points

PASS SUMMARY

- After request generation, wait for 30-40 seconds and paste the same ***request_id*** in the ***id*** box of the ***GET /happ/{id}/summary*** tab.
- To check for updates on the response status, click ***Try*** periodically. Once the simulation is done, the ***pass summary*** and ***pass details*** outputs are ready.
- The status of the simulation will be available in the ***RESPONSE*** window below the same page

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PASS DETAILS

- Copy the same ***request_id*** in the ***GET /happ/{id}/summary/{pass_id}*** tab
- Enter the ***pass_id*** from the ***GET /happ/{id}/summary*** tab above, the pass details of that corresponding pass can be seen in the ***RESPONSE*** window in ***JSON*** format.
