Minor Planet Center overview

CENTER FOR ASTROPHYSICS HARVARD & SMITHSONIAN

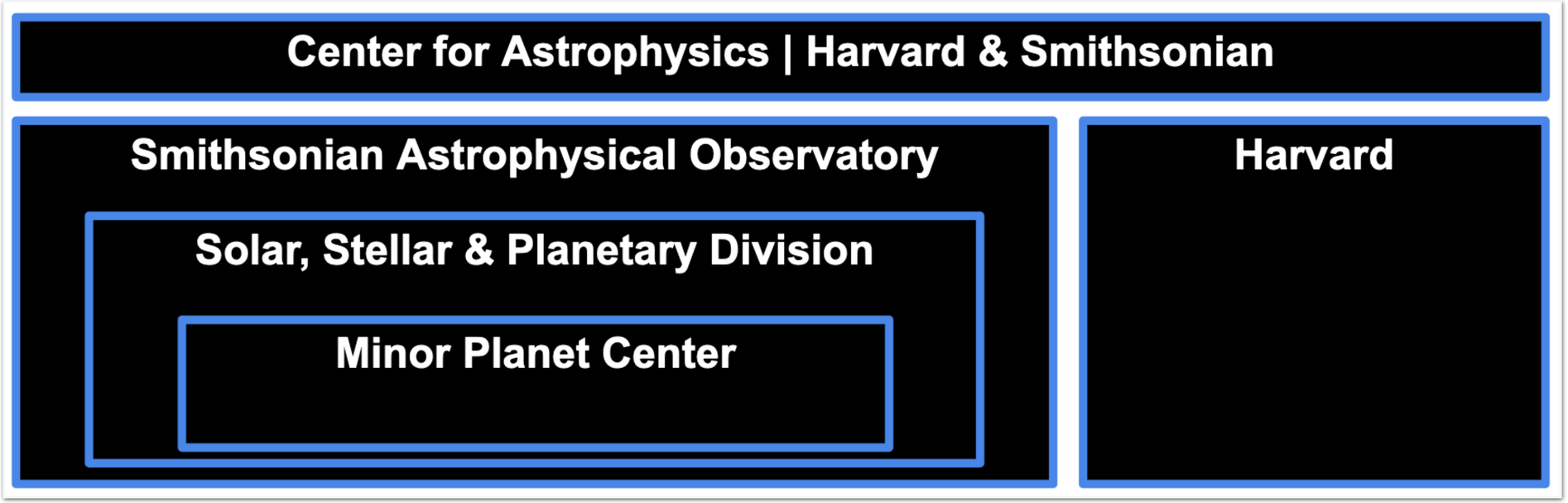
Federica Spoto, **Matthew Payne** & the MPC team
Center for Astrophysics, Harvard & Smithsonian

54th DPS Meeting - October 6th, 2022
SBN Users Meeting

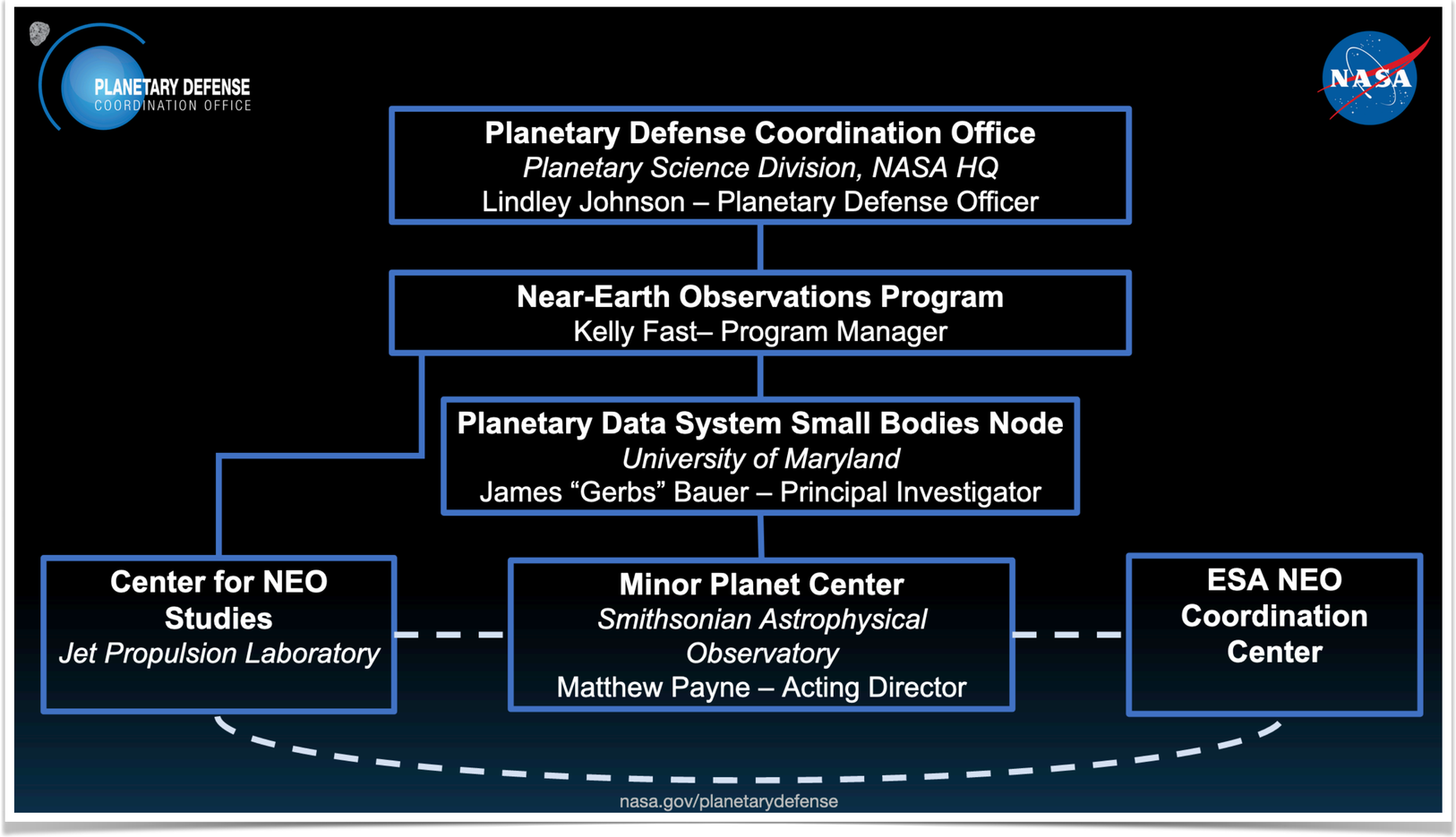
MPC: an overview

The International Astronomical Union
Minor Planet Center

- **Single world wide location** for receipt and distribution of positional measurements of minor planets, comets and outer irregular satellites of planets
- Granted **authority for operations** by the **International Astronomical Union** (IAU)
- Part of the **Smithsonian Astrophysical Observatory (1978)**
  - Center for Astrophysics, SSP Division



MPC: an overview

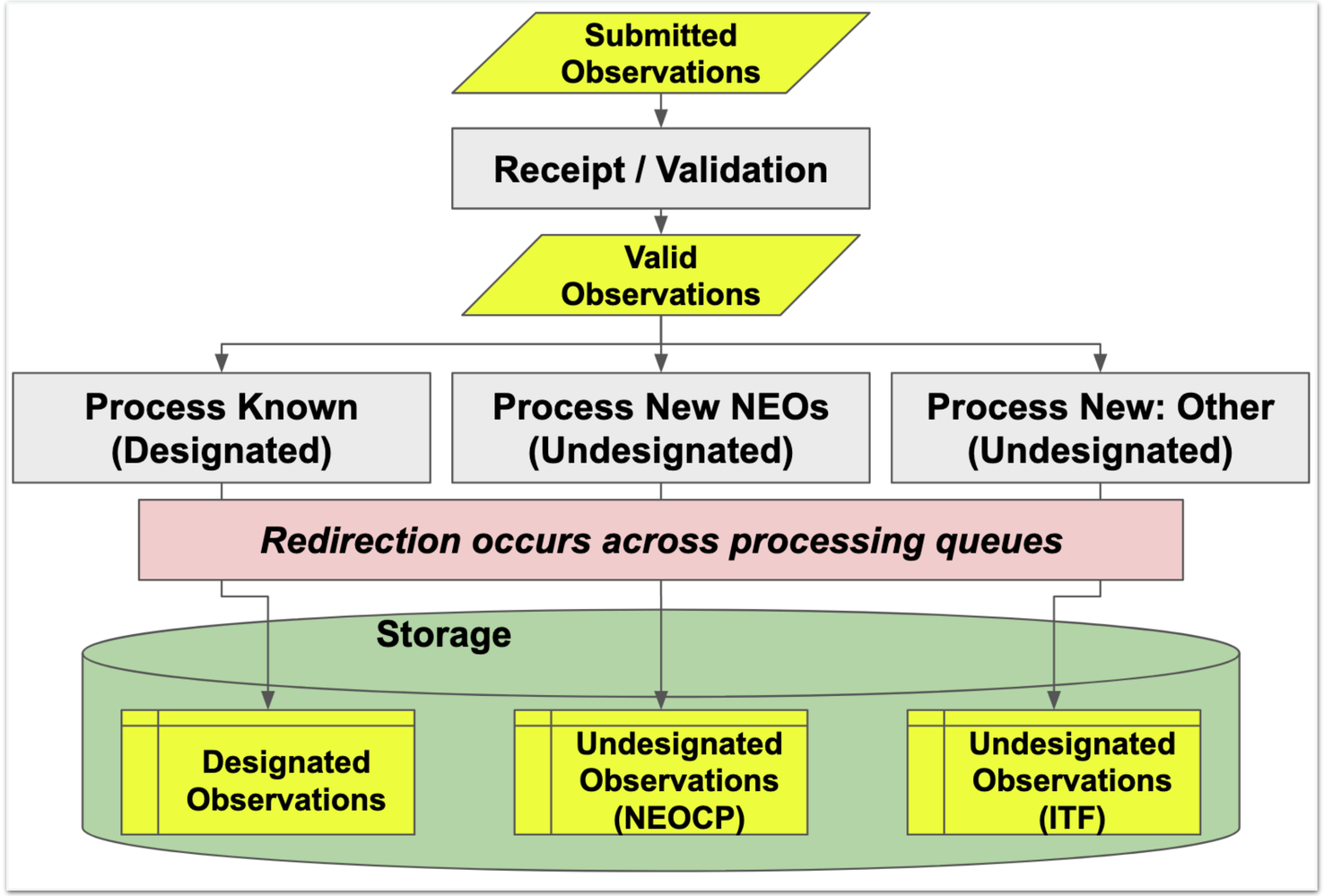


- **Sub-node of the Small Body Node** (SBN) of the NASA Planetary Data System @ U. Maryland
- **Founded 100% by NASA** through a cooperative agreement via a sub-award from U. Maryland
  - SBN is responsible for oversight of the sub-award
    - **Evaluated in 2021 Senior Review** as part of NASA Planetary Data System/ Small Body Node

MPC: staff

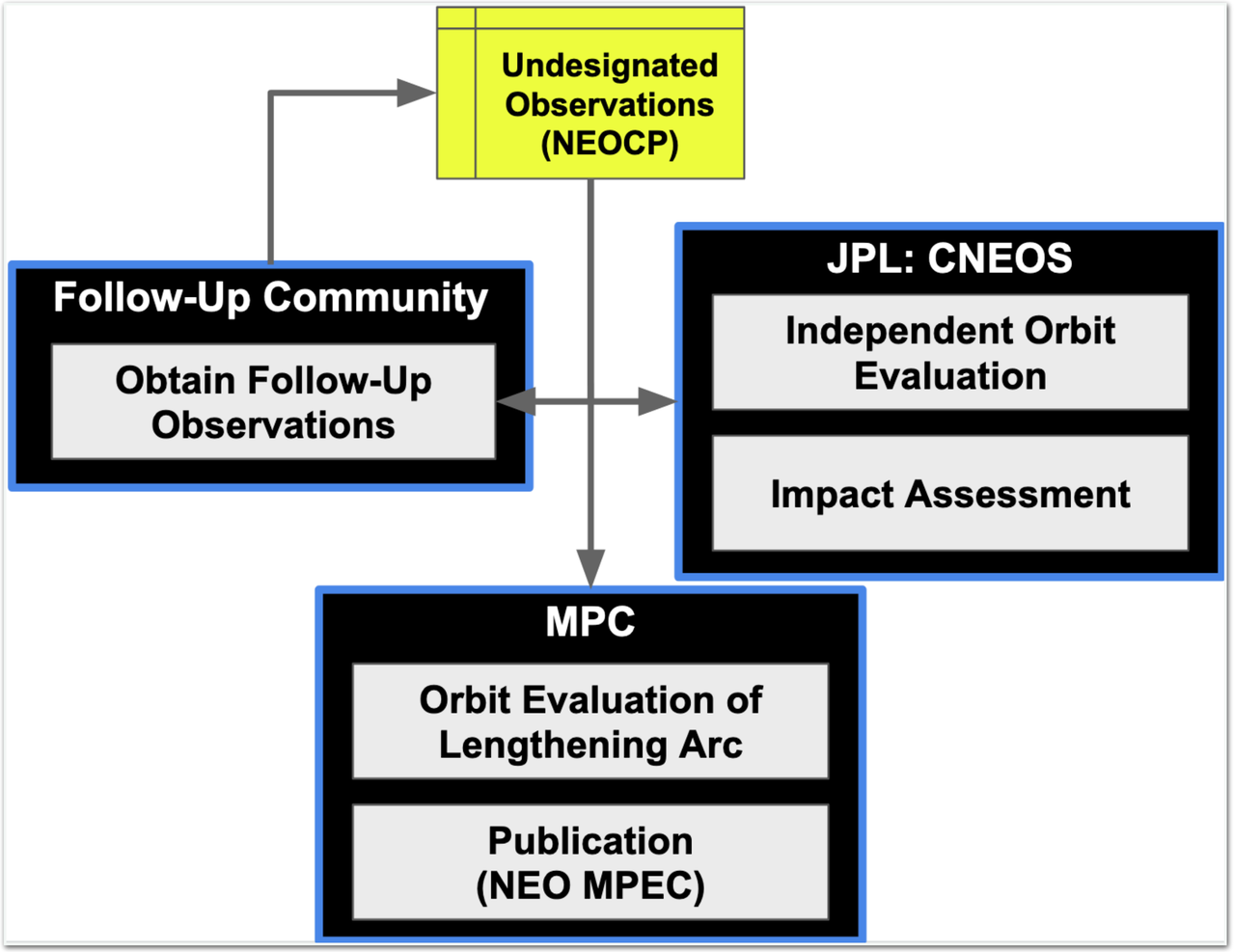
Name	FTE	Role
Matthew Payne	1.00	Director
Michael Rudenko	1.00	Software & Sys-Admin; Comets
Peter Veres	1.00	NEOCP operations; Identifications; Pipeline Automation
Dave Bell	1.00	Software & DB-Dev; NEOCP; ADES
Paresh Prema	1.00	Software & Web-Dev; Identifications;
Margaret Pan	0.80	Pipeline Migration; Orbit-Fitting
Federica Spoto	1.00	Project Scientist
Rosemary Pike	0.42	TNOs, Natural Satellites
Mike Alexandersen	1.00	TNOs, Natural Satellites
Chris Moriarty	0.75	Technical Manager
N Casale	0.75	Software Developer
Michael Lackner	1.00	Contractor: Database migration
Ben Gafford	**1.00**	**Software Developer** - starting on Tuesday Oct 11

MPC simplified process flow



- **Observation ingestion**
  - Top-level validation of format and basic physical plausibility
- **Submitted designations or unknown objects**
  - Submitted labels and designation-guide process-path
  - Redirection can occur
- **Attempt linking of unknown/ unattributed**
- **Orbit fitting of known designations**
- **Suspected new NEOs**
  - NEOCP for follow up

NEO Confirmation Page



- **Facilitate follow up and observations of new NEOs**
  - Survey and follow up community
- **MPC filter the observations**
  - Linking
  - Identifications
- **MPECs**
  - New NEOs are published through the Minor Planet Electronic Circulars once the orbits are confirmed

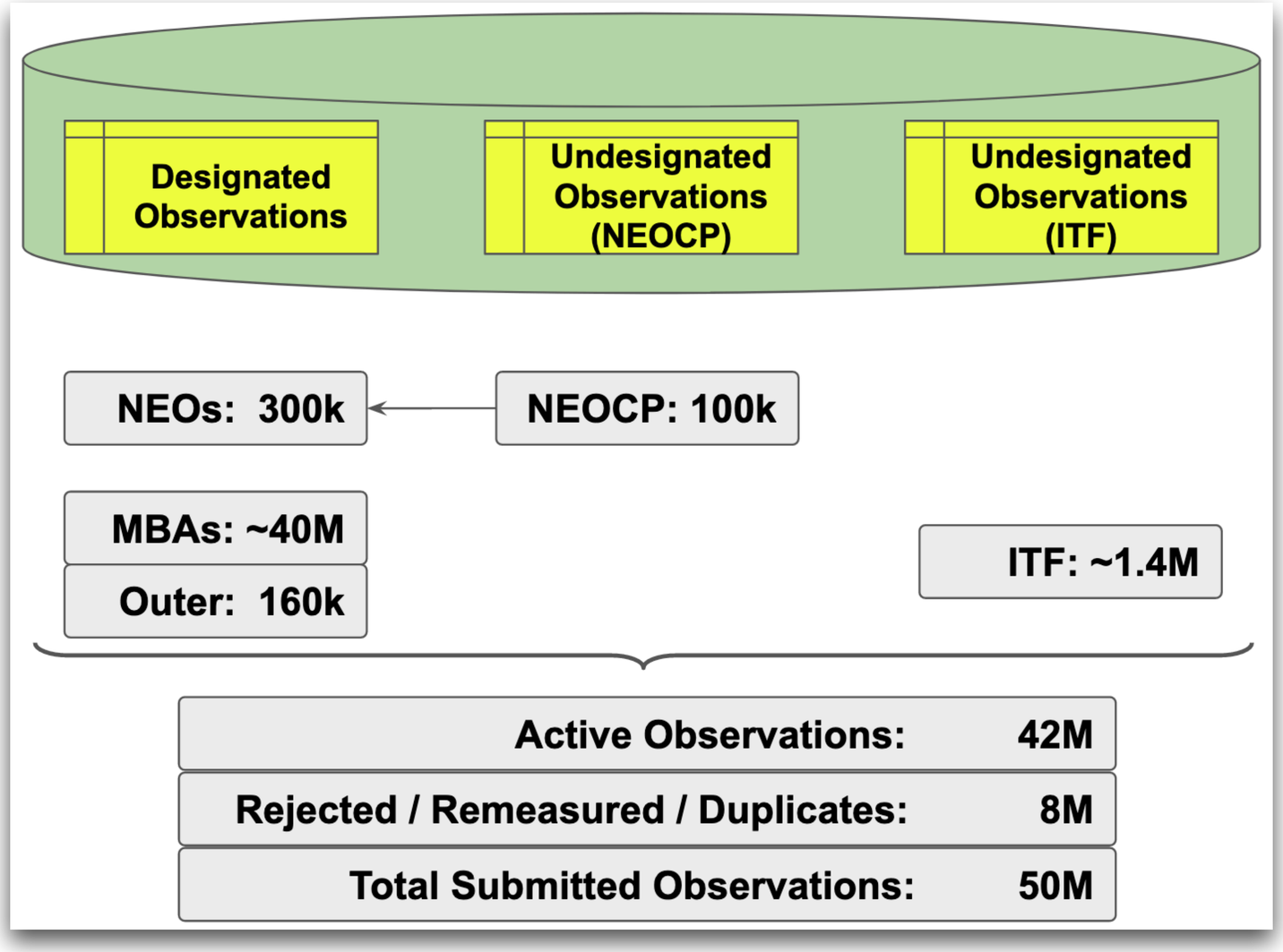
MPC Indicative Statistics on Obs

The International Astronomical Union Minor Planet Center

- **Submitted observations during 2022**
  - ~ 50 M
- **Total observations data archive**
  - ~ 360M
- **NEOs and new NEOs**
  - ~ 100k NEOCP (new NEOs)

A **large fraction** of the MPC work is required to do **linking and attribution** of submitted data and to **establish the quality of the data we receive**.

A small fraction of the MPC work is actually Planetary Defense related.



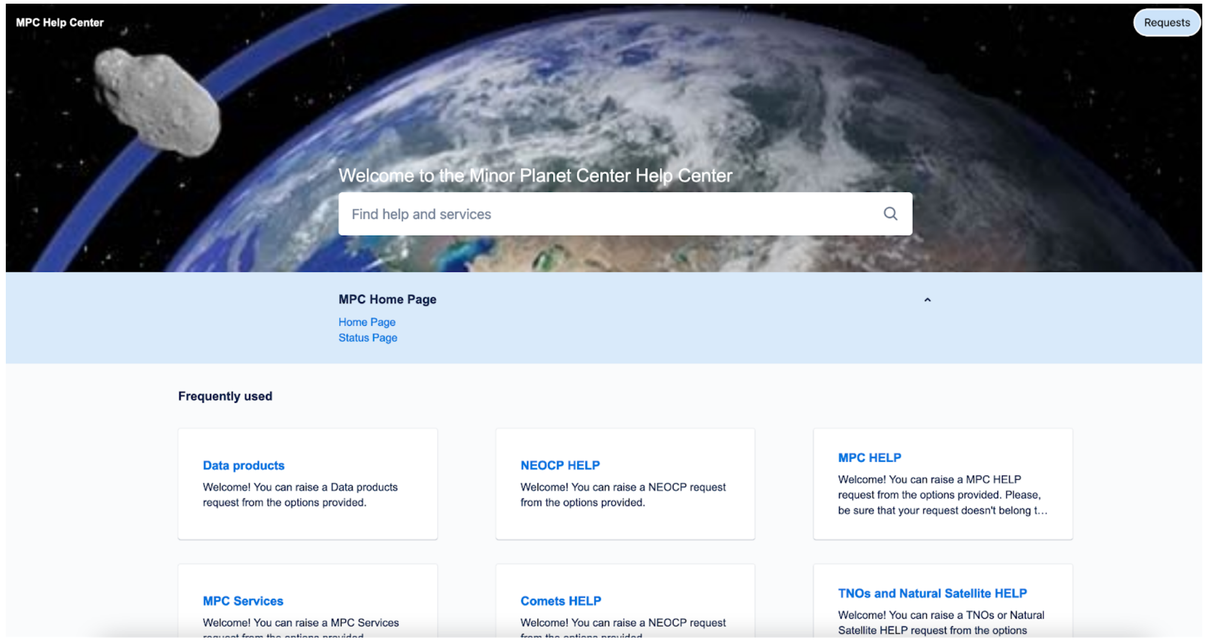
Jira - helpdesk

The International Astronomical Union Minor Planet Center

The MPC is currently working on a large number of projects to improve the current system and to get ready for the next years

Known problems

- **Reliability** of the old code
- **Outstanding problems**
- System based on **flat files**
- **Communication and community needs**



Please use Jira to:

- Report problems
- Suggest features
- Ask questions

… **Talk to us**!

How we handle the Helpdesk:

- Automatic assignments
- Weekly meetings
- Move to development

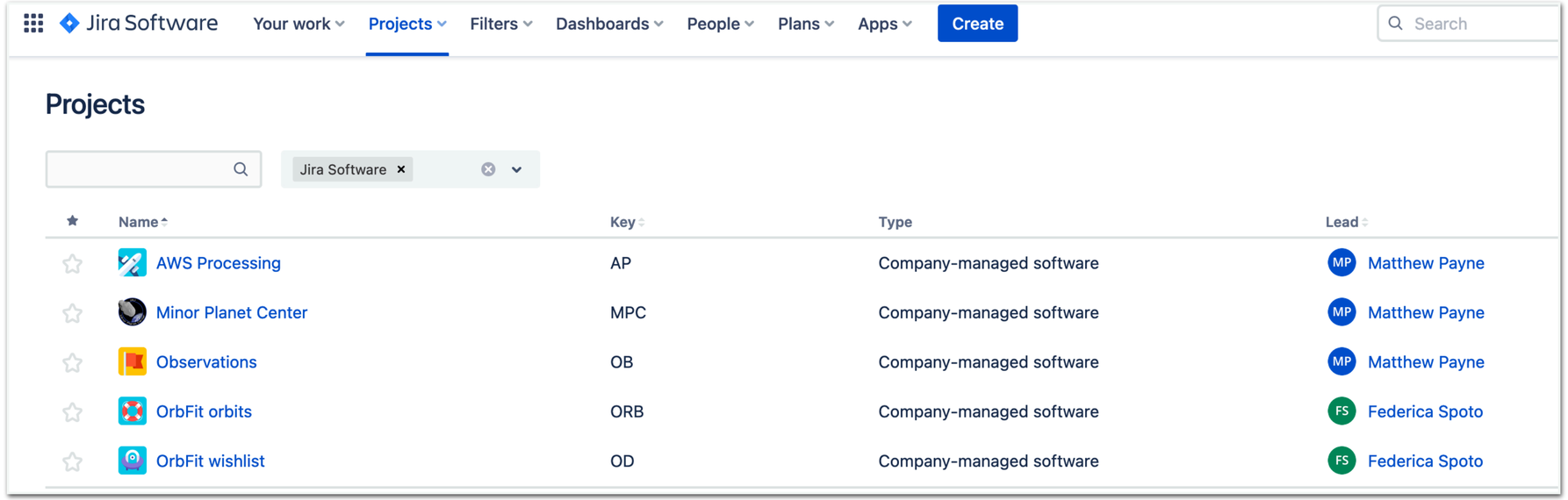
https://mpc-service.atlassian.net/servicedesk/customer/portals

Jira - software

The MPC is currently working on a large number of projects to improve the current system and to get ready for the next years

Known problems

- **Reliability** of the old code
- **Outstanding problems**
- System based on **flat files**
- **Communication and community needs**



Jira software project

- Weekly meetings
- Monthly status
- Priorities
- Estimated due date
- Testing and documentation

The Minor Planet Center
&
SBN

Replicated tables @ SBN

The International Astronomical Union Minor Planet Center

MariaDB table

ITF

Table	Count	Created_at	Updated_at
close_approaches	223366	2019-05-23 19:22:13	2019-05-23 19:22:13
comet_names	4586	2017-03-15 16:46:33	2017-03-15 16:46:33
comet_orbit_uncertainties	1015	2019-06-04 12:15:27	2019-06-04 12:15:27
comet_orbits	11830	2021-06-01 05:25:44	2022-10-05 05:31:03
identifications	605719	2022-10-05 12:25:47	2022-10-05 12:25:47
isolated_tracklets	38868710	2022-10-05 16:02:13	2022-10-05 16:02:13
mpc_indices	396	2022-10-05 18:30:05	2022-10-05 18:30:05
numbered_identifications	999025	2022-09-17 06:29:26	2022-09-17 06:29:26
numbered_mps	619150	2017-11-07 13:09:45	2022-10-03 18:41:57
obs_request_observers	52	2019-07-24 16:57:48	2019-07-24 16:57:48
obs_request_users	7	2015-12-04 00:25:22	2015-12-04 00:25:22
observations	348446132	2022-10-05 17:34:21	2022-10-05 17:34:21
orbit_uncertainties	787168	2019-06-03 12:14:44	2022-09-17 06:39:59
orbits	1240236	2022-10-05 18:14:11	2022-10-05 18:31:05
perturbed_orbits	175724170	2018-09-27 17:20:33	2018-09-27 17:20:33
radar_observations	1507	2019-05-30 03:12:41	2019-05-30 03:12:41

https://sbnmpc.astro.umd.edu/MPC_database/statusDB.shtml

Observation database table

NEOCP related tables

Identifications

Observations

Postgres mpc_sbn:

Table	Count	Created_at	Updated_at
neocp_events	151611	2022-09-30 16:49:29.151633	2022-09-30 16:49:29.151633
neocp_obs_archive	404558	2022-09-30 15:47:20.622626	2022-09-30 15:47:20.622626
neocp_obs	1399	2022-09-30 15:47:20.617271	2022-09-30 15:47:20.617271
neocp_prev_des	50091	2022-09-30 16:06:18.85224	2022-09-30 16:06:18.85224
neocp_var	167224	2022-09-30 16:49:29.116213	2022-09-30 16:49:29.116213
current_identifications	1768308	2022-09-30 16:50:41.483548	2022-09-30 16:51:14.854191
numbered_identifications	619761	2022-09-16 18:46:46.323085	2022-09-16 18:46:46.323085
primary_objects	0	1970-01-01 00:00:00.0	1970-01-01 00:00:00.0
obs_sbn	357666156	2022-09-27 11:44:31.971596-04	2022-09-30 12:50:42.56431-04

https://sbnmpc.astro.umd.edu/MPC_database/statusDB.shtml

Database Status: RED

5 Oct 2022

The replication is temporary out of service due to **SBN** hardware failure.

Observation table

The International Astronomical Union Minor Planet Center

Currently replicating the entire observation table through SBN

- Beta-release
  - Tables can still be added, removed or modified
- SBN MPC Wiki
  - https://sbnwiki.astro.umd.edu/wiki/SBN_MPC_Wiki
- Caveats
  - **There are still small differences between the database and the flat files**
  - *Flat files* are still the *primary source of data*
  - **Additional flat files** have been recently added to the MPC webpage to keep into account **redesignations** and **deletions**

https://minorplanetcenter.net/data

Alterations to Observations (unpublished)

The following files are provisional files that detail the observations that will be altered and published during the next set of MPCs. Note that the files will be updated daily even if the content has not changed.

File	Description	Update frequency	Last Update (UT)	Documentation
redesigs.dat	Observations that are to be redesignated	Daily	2022/09/30 12:29	Documentation to come...
todelete.dat	Observations that are to be deleted			

Additional tables

The MPC is currently working on a number of tables that we want to be able to replicate to SBN in the next months

- **Orbit table**
  - Real-time fit of the incoming observations
  - Orbital elements
  - **Uncertainties**
  - Additional parameters (e.g. non-gravs)
  - Dynamical model description
  - Magnitude
  - *New mpc_orb json format*
- **Obs alteration table**
  - Deletions
  - Redesignations
  - Remeasurements
- **Residual table**
  - Residuals, weights, flags for each observation
- **Comets**


```
"system_data": {
    "eph": "JPLDE431",
    "refsys": "ECLM J2000"
},
"designation_data": {
    "permid": "",
    "packed_primary_provisional_designation": "K03A23F",
    "unpacked_primary_provisional_designation": "2003 AF23",
    "orbfit_name": "2003AF23",
    "iau_name": ""
},
"nongrav_data": {
    "non_gravs": true,
    "booleans": {
        "yarkovski": true,
        "srp": true,
        "marsden": false,
        "yc": false,
        "yabushita": false,
        "A1": false,
        "A2": false,
        "A3": false,
        "DT": false
    },
    "coefficients": {
        "yarkovski": -0.000706670561734636,
        "srp": -0.0130026086159011,
        "A1": null,
        "A2": null,
        "A3": null,
        "DT": null
    }
},
"magnitude_data": {
    "h": 20.943,
    "g": 0.15
},
"epoch_data": {
    "timesystem": "TDT",
    "epoch": 59200.0
}
```

Future development

Decadal survey

MPC related findings

- "The **Minor Planet Center** and the Center for Near-Earth Object Studies provide **crucial data for identifying NEOs** and evaluating their impact probabilities, and therefore, are **vital components for an effective planetary defense response**. "

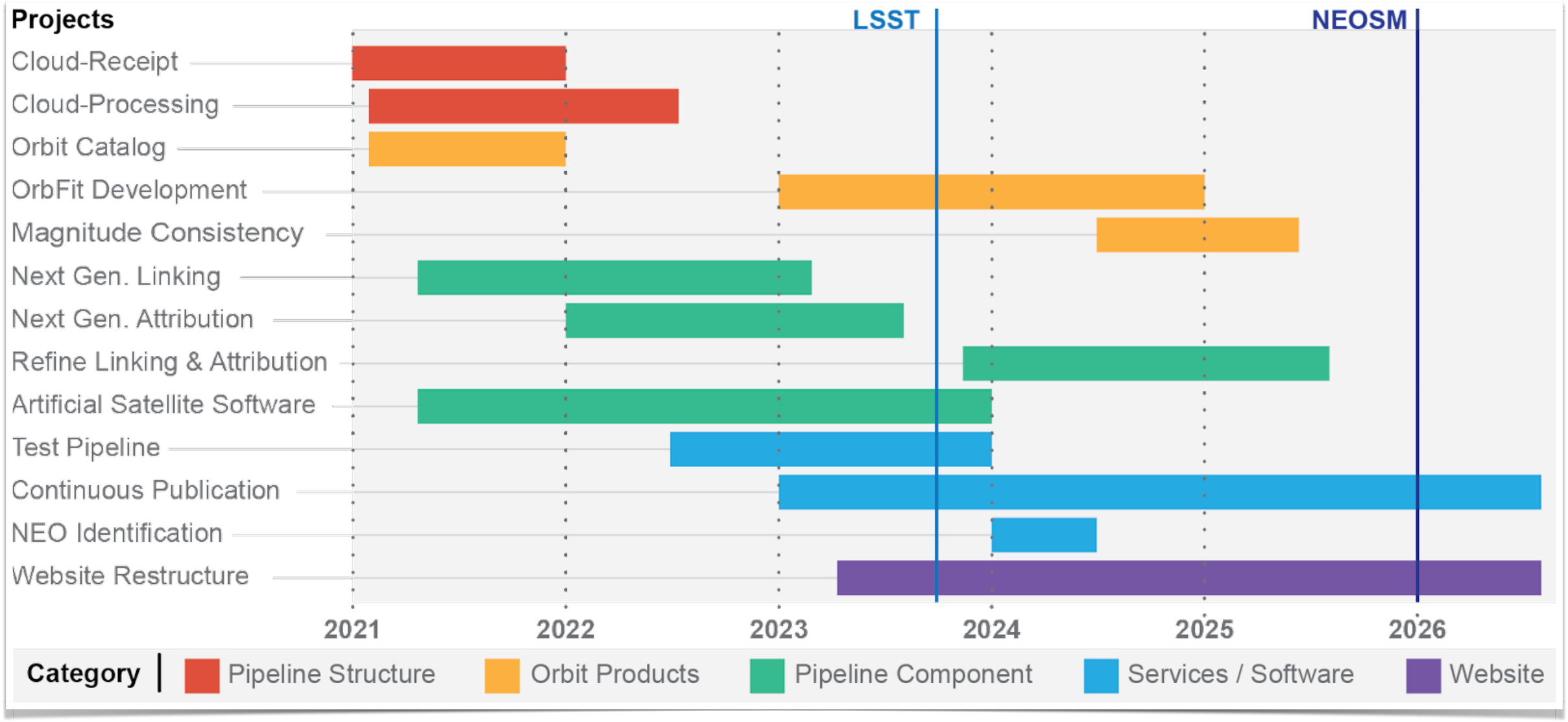
- "The IAU Minor Planet Center's (MPC) role as the worldwide repository for positional measurements of small bodies and responsibility for their initial orbit computation is **crucial for planetary defense efforts to identify and track NEOs**."

- "**The data pipeline for detection, tracking, impact assessment, and reporting to the public will be tested by the ten-fold increase in NEO detection rates** when VCRO and NEO Surveyor become operational. Both facilities will benefit from coordinated rehearsals and operational readiness reviews well-prior to achieving their full operational capabilities."

- " … a **well-coordinated data pipeline between VCRO, the Minor Planet Center, and the Center for Near-Earth Object Studies, would provide optimal benefits for planetary defense**. "

Key development projects

The International Astronomical Union
Minor Planet Center



MUG (MPC User Group) priorities

The International Astronomical Union Minor Planet Center

- **Communication**
  - **“The MPC should continue to foster and emphasize a deep institutional culture of openness and transparency”**

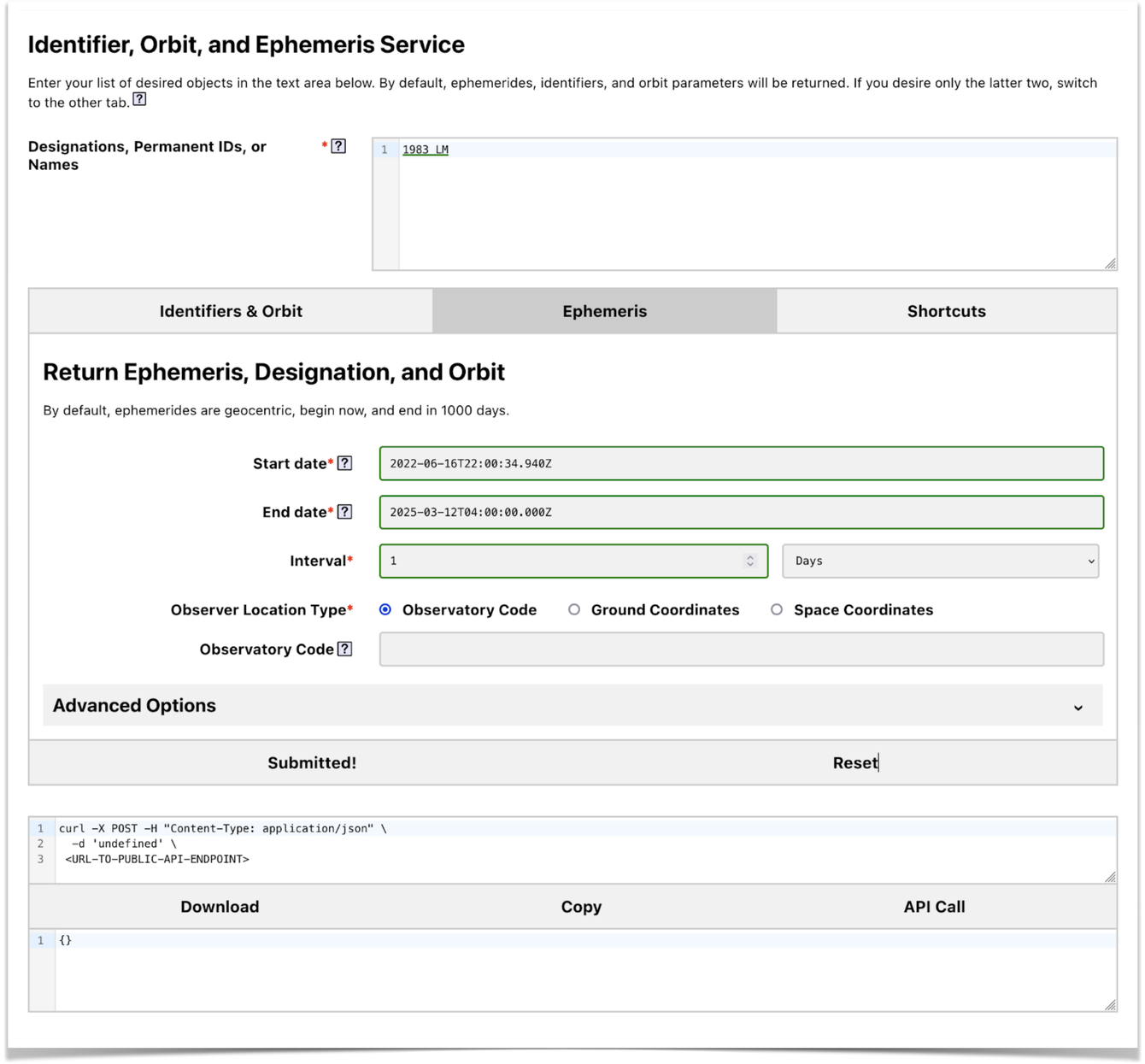
  - Implemented standardized workflows for task managements across both Jira Helpdesk and Jira software
  - Implemented weekly reviews of all Helpdesk and development tasks
  - *Long and short term prioritization and release planning*

- **“Quality control of ongoing services”**

  - Working on testing and documentation
  - Added monitoring on back-end data and front-end results
  - Improving the main services used by the community, while working on new releases

Ephemeris Service and MPChecker

The International Astronomical Union Minor Planet Center

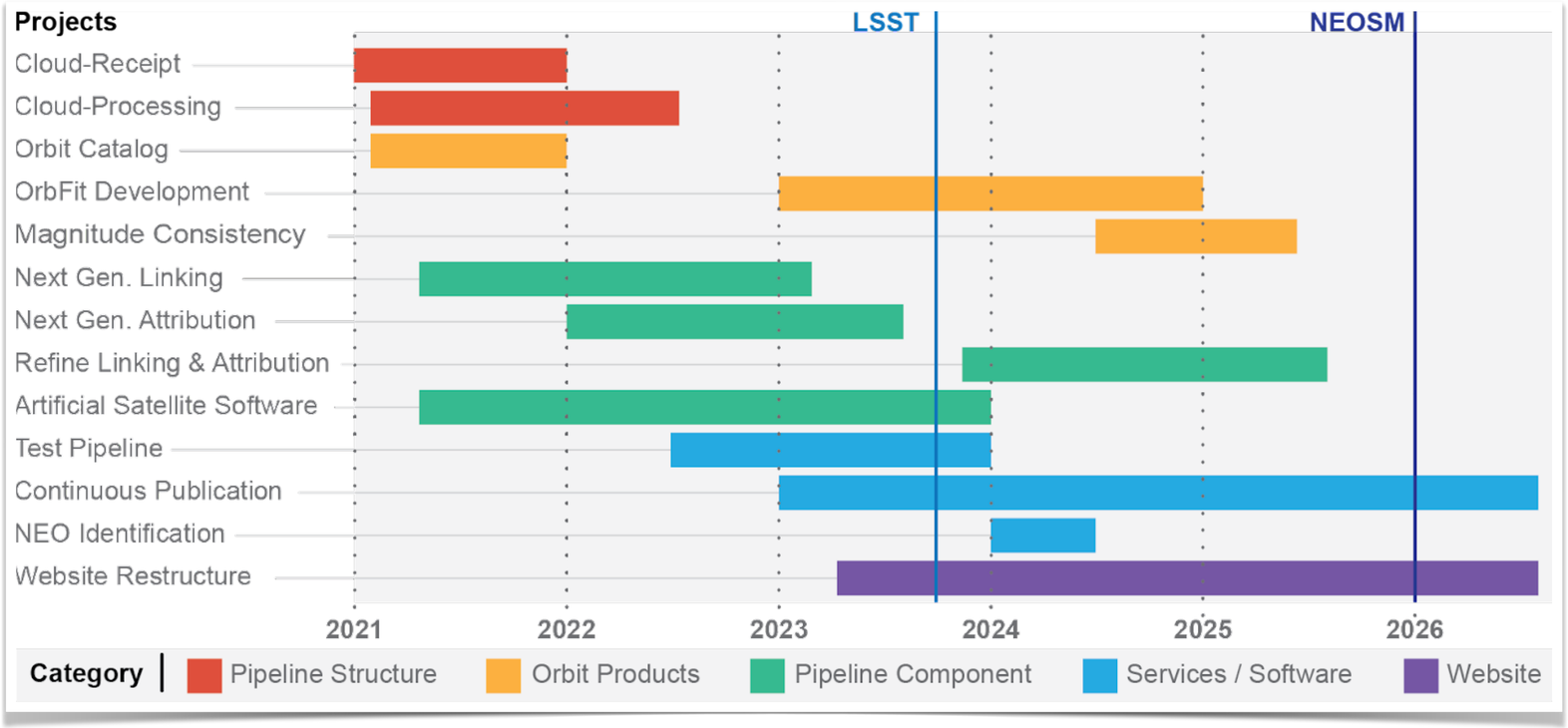


- Ephemeris Service
  - New APIs
    - Ephemeris API
    - Designation API
  - Faster and more accurate

- MPChecker
  - Use of the new mpc-orb.json format
  - Pre-calculation of the cheby polynomial
  - Check of pre-fit residuals

AWS and VCRO LSST test

The International Astronomical Union Minor Planet Center



Data forecast

- 2020-2021
  - 50 M obs/y
- VRO LSST Operations - 2024
  - 225 M obs/y
- NEOSM Operations - 2026
  - ~ 30 M obs/y

To-scale exercise MPC-VCRO LSST and NEOSM

- Goal
  - Assess *MPC's current and expected future ability to ingest VCRO LSST-size submissions using AWS* (Amazon Web Services) queues and Aurora database
  - Exercise and testing the new submission process
  - Test the MPC's capability to fit large sample of orbits and the new orbit exchange format
  - Preparing the same exercise with the NEO Surveyor team

Conclusions: MPC priorities

The International Astronomical Union Minor Planet Center

- **AWS Pipeline Development**
  - *Migration*: receipt and processing
- **Orbits**
  - *New mpc_orb json format*
  - Improve automated decisions
  - Comets
- **NEOCP**
  - New code
  - *Fully perturbed orbits*

- **VCRO and NEO Surveyor**
  - *Readiness* testing
- **Processing Queues**
  - Reorganization
  - *Logging* and *testing*
  - Simplification
- **Service Deployment**
  - Identification APIs
  - *Ephemeris and MPChecker*