Minor Planet Center Activities

CENTER FOR ASTROPHYSICS HARVARD & SMITHSONIAN

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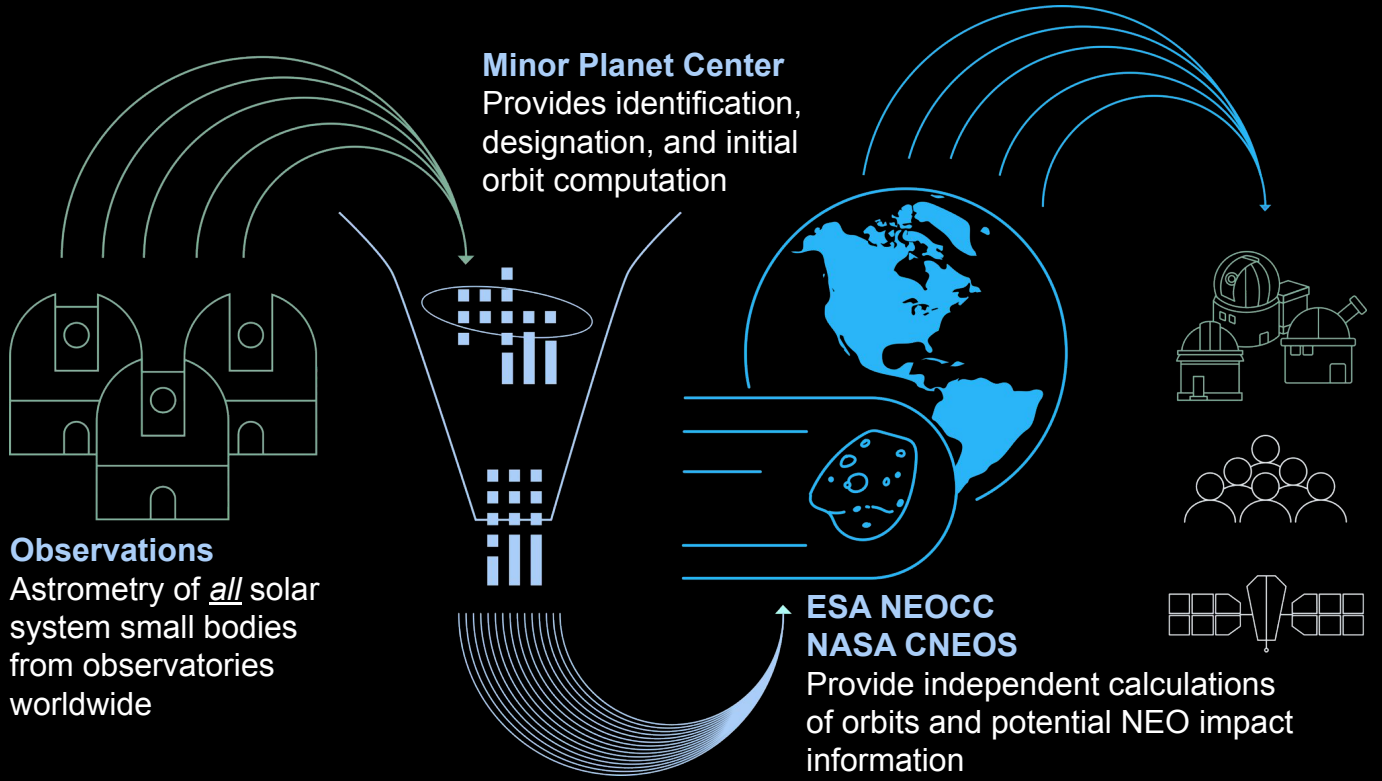
Center for Astrophysics | Harvard & Smithsonian

October 8nd, 2025: SMPAG

The International Astronomical Union
Minor Planet Center

Astrometric Data Flow



Observations
Astrometry of *all* solar system small bodies from observatories worldwide

Minor Planet Center
Provides identification, designation, and initial orbit computation

ESA NEOCC
NASA CNEOS
Provide independent calculations of orbits and potential NEO impact information

Information made available to the public and to support follow-on observations by Earth-based and space-based facilities

NEOCC – Near-Earth Object Coordination Centre
CNEOS – Center for Near Earth Object Studies

Staffing & Funding

Staffing

- 6 PhD Astronomers
  - 1 of whom is part-time
- 5 Software & Systems Specialists

Funding

- 100% Funded by NASA's Planetary Defense Coordination Office (PDCO).
- The MPC operates as a sub-node of the University of Maryland's Small Bodies Node (SBN) of NASA's Planetary Data System (PDS).
- Funding from the PDCO flows to the MPC via an cooperative agreement with the University of Maryland.
- Current funding agreement runs from Dec 2021 to Nov 2026;

Planetary Defense

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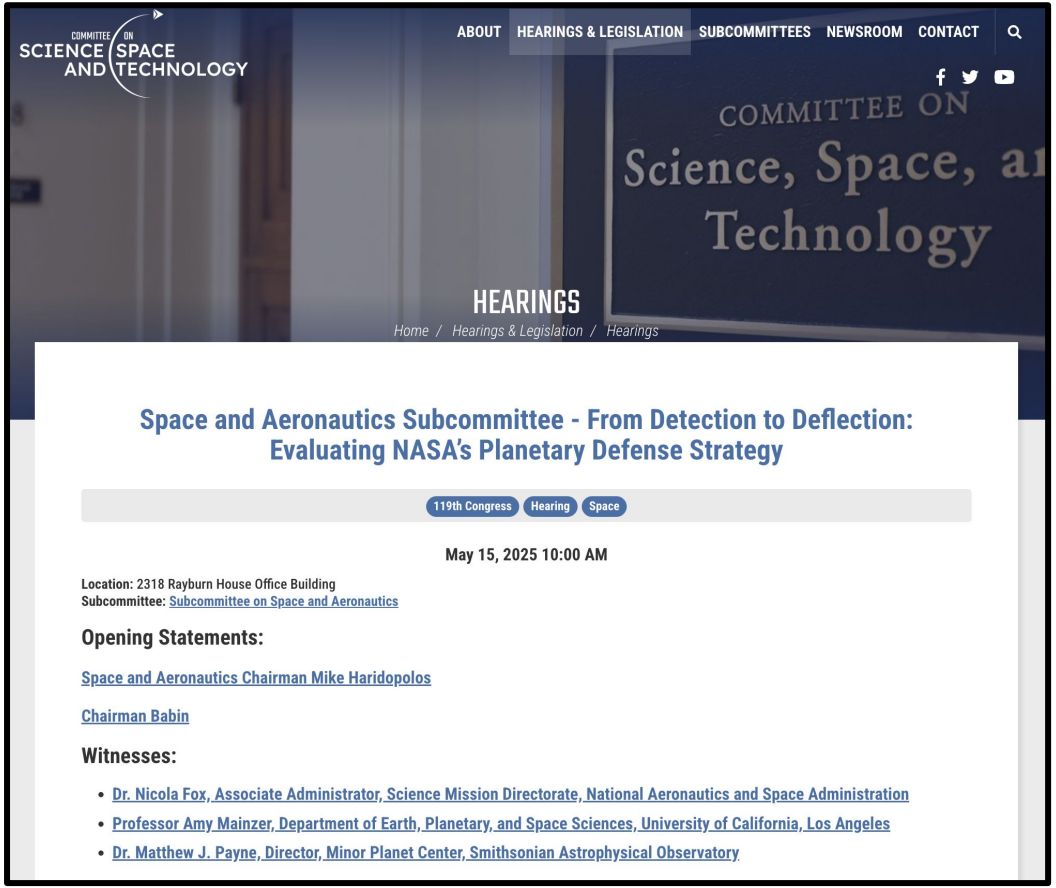
Congressional Subcommittee on Space and Aeronautics

Witnesses

- Dr. Nicola Fox
- Prof. Amy Mainzer
- Dr. Matthew Payne

Links

- https://science.house.gov/2025/5/from-detection-to-deflection-evaluating-nasa-s-planetary-defense-strategy
- https://www.youtube.com/watch?v=5SamCKEOoeQ&t=1s

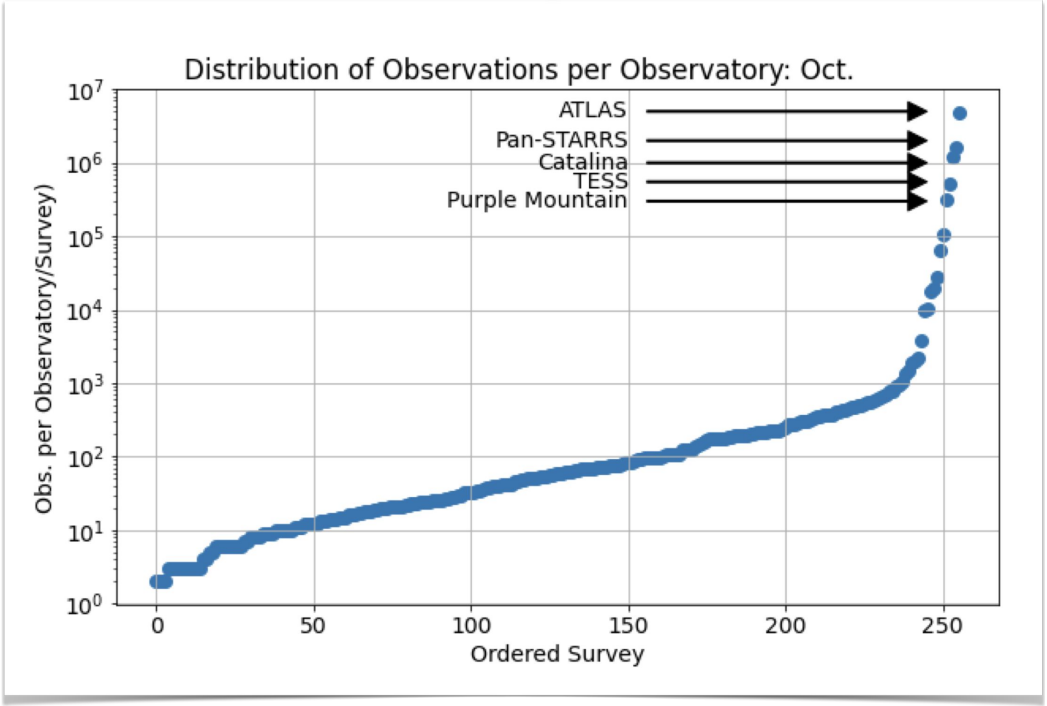


Forecasting Data Volumes

Data Volumes

Monthly Submissions

- Over 2,600 registered observatories
- A few hundred observatories submit data to the MPC on a monthly basis.
- Small unfunded observers through to large professional groups.
- A handful of observatories dominate the volume of data submitted.
- Primarily PDCO funded surveys
    - PanSTARRS, ATLAS, Catalina, …
- 99% of these data are of MBAs

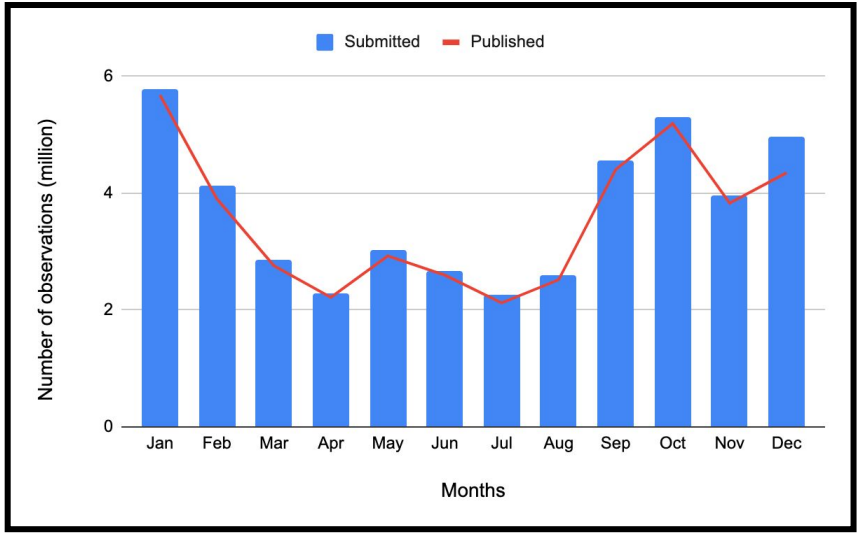


Data Volumes

Annual Volumes

- The MPC currently receives ~40M - 50M observations per year.
- Average ~125k per night

2024 Submissions



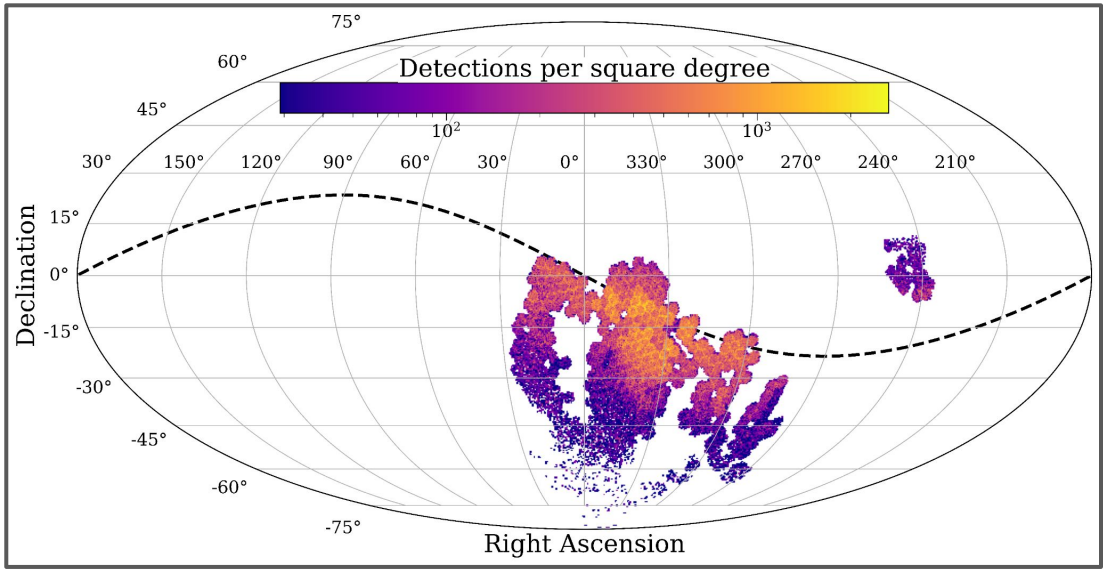
Data Volumes

Rubin Forecasts

- Kurlander et al. 2025 https://iopscience.iop.org/article/10.3847/1538-3881/add685

- Single Night Average:
  - Rubin: 300,000
  - Current MPC: 125,000

Single Night Detections

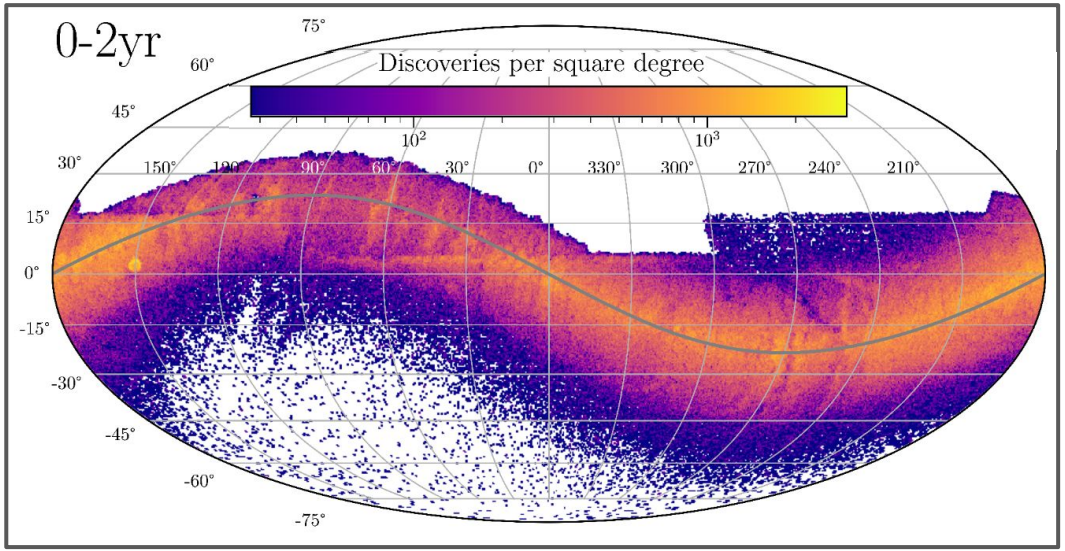


Data Volumes

Rubin Forecasts

- Kurlander et al. 2025
- Single Night Average:
  - Rubin: 300,000
  - Current MPC: 125,000
- Yearly Average:
  - Rubin: 110 M
  - Current MPC: 45 M
- With remeasurement:
  - Rubin → ~220M
  - (Uncertain if/when remeasurements might occur)

Annual Discoveries



Data Volumes

Rubin Forecasts

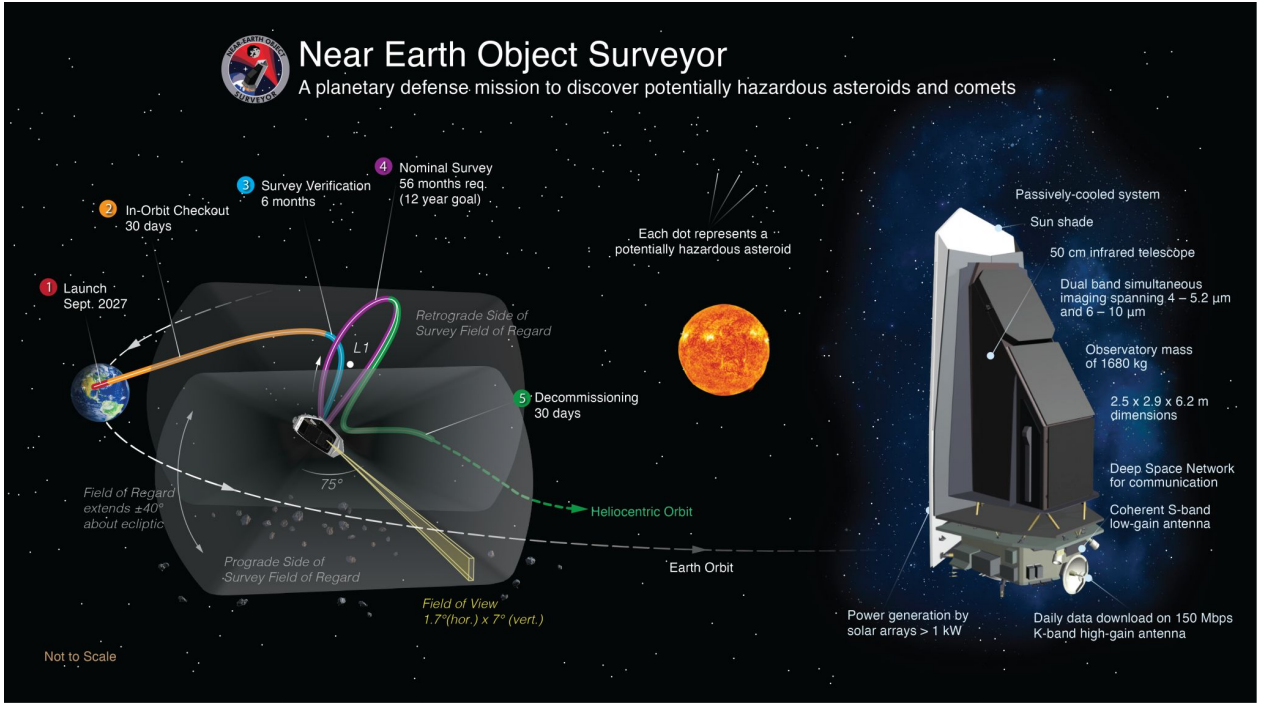
- Kurlander et al. 2025
- Rubin 10-Year Detections: 1.1 B
  (Current MPC ~ 475 M)
- Rubin 10-Year Objects Observed: 5.4 M
  (Current MPC ~ 1.5 M)
  ⇒
  Rubin 10-Year Objects *Discovered*: 3.9 M

Component	Currently Known	Objects observed	Median Arc	Median Number of Detections
NEOs	37,932	$127,040 \pm 557$	96 d	23
MBAs	1,380,217	$5,087,541 \pm 1,661$	9.0 yr	160
Jupiter Trojans	15,134	$109,367 \pm 331$	9.0 yr	193
TNOs	5,246	$37,002 \pm 192$	9.5 yr	234

Data Volumes

NEO Surveyor

- Scheduled to launch 2028
- Survey cadence is still being optimised
  ⇒
- Predicted yields remain approximate
- Forecast ~150 - 200 M observations / year to the MPC



Data Volumes

Summary Forecasts

- Yearly Averages:
  - *Rubin*: 110 M - 220 M
  - *NEO Surveyor*: 150 M - 200 M
  - *Other*: 50 M - 75 M
  - **Total: 310 M - 475 M**
  - *Current MPC: 45 M*
- Total Observation Database in 2035
  - **Total: 3 B - 5 B**
  - *Current MPC: ~475 M*
- MPC will need to deal with
  - ~10× data flow
  - ~10× data volume

Preparing for this deluge of data has been the focus of MPC development activity for the past few years

MPC Developments

Observation Ingest

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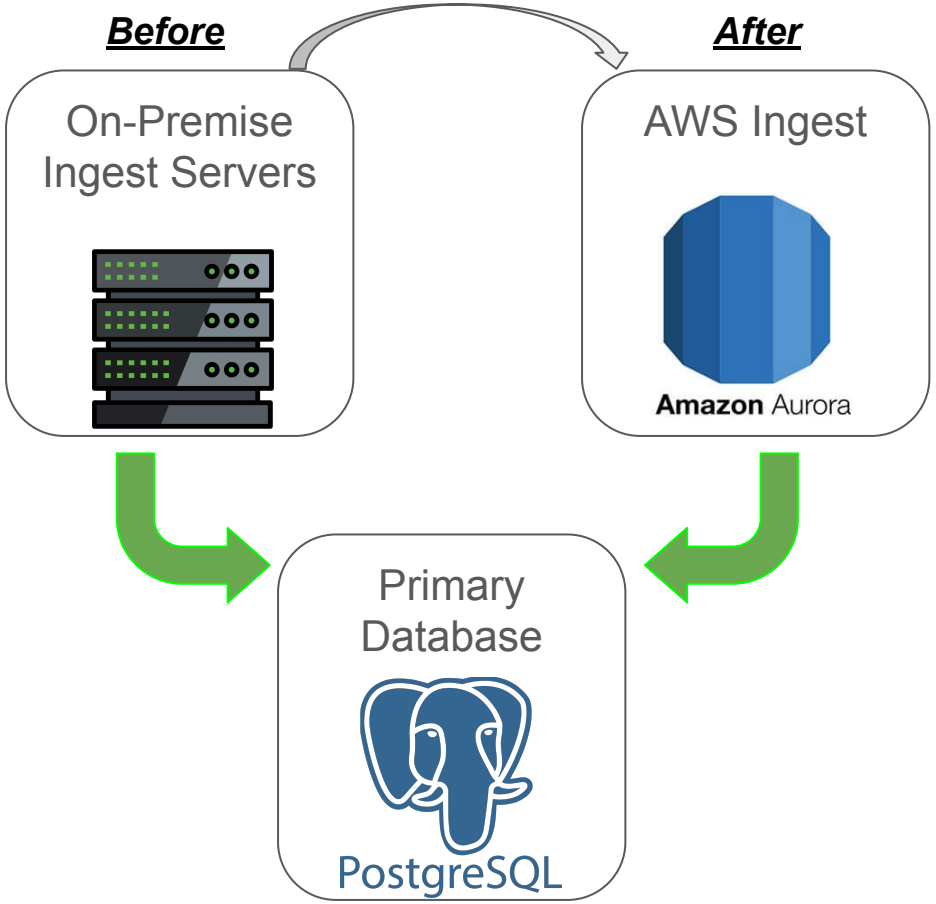
Migrate Ingest Route

- Migrate to AWS Aurora-based system
- Increased resilience against power outages
- Submission routes (e.g. https://minorplanetcenter.net/submit_xml) will be repointed
- Submitters/Observers unaffected.

Status

- Test version of AWS -to- Primary-DB is flowing
- On-premise server is current ingest route
- Switch-over: *October 28th*



Pipeline Processing

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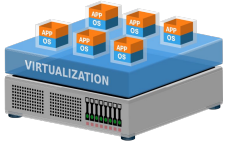
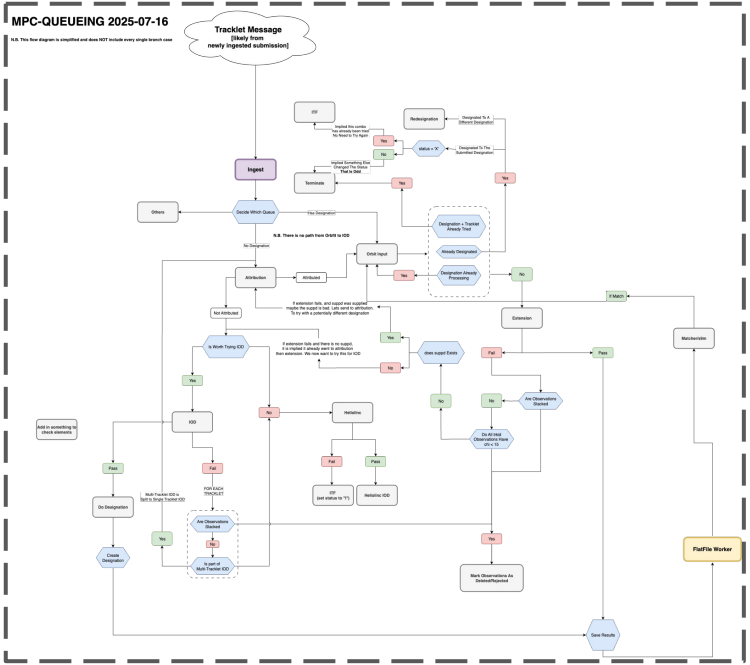
Infrastructure

- Local Hardware
- Virtual Machine Cluster
- Docker Swarm
- RabbitMQ Job-Queue Management
- PostgreSQL Databases
- Key Functionalities Containerized and deployed as microservices:
  - IOD
  - Orbit Fitting
  - Attribution
  - Precovery Search
  - Designation
  - Publication
- Failover Infrastructure



PostgreSQL

docker



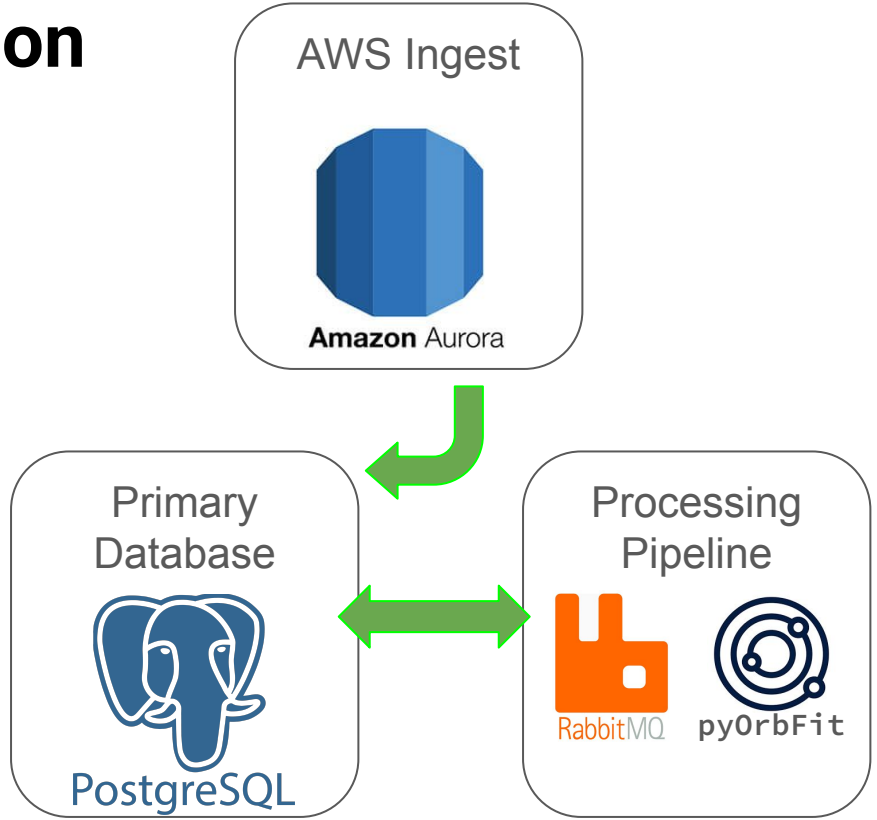
RabbitMQ

HelioLinc

pyOrbFit

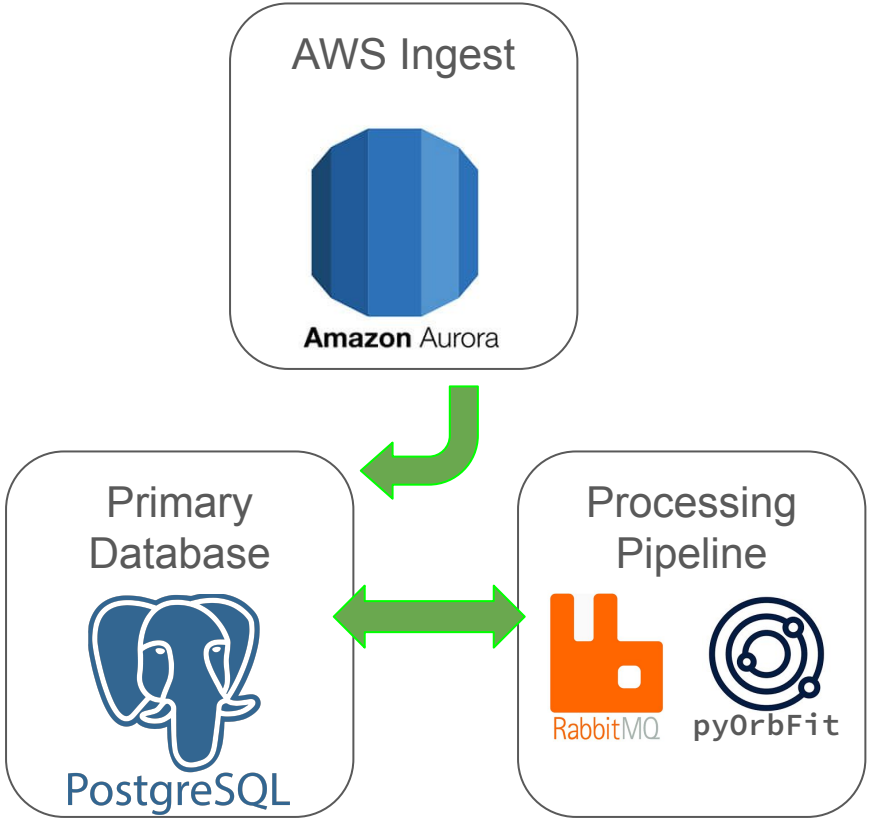
Infrastructure Reproduction

- Clone AWS components
  - Database
  - Compute Instances
  - Codebase
- Clone Internal System components
  - Static Database Snapshot
  - Processing Pipeline Components



Isolated Testing

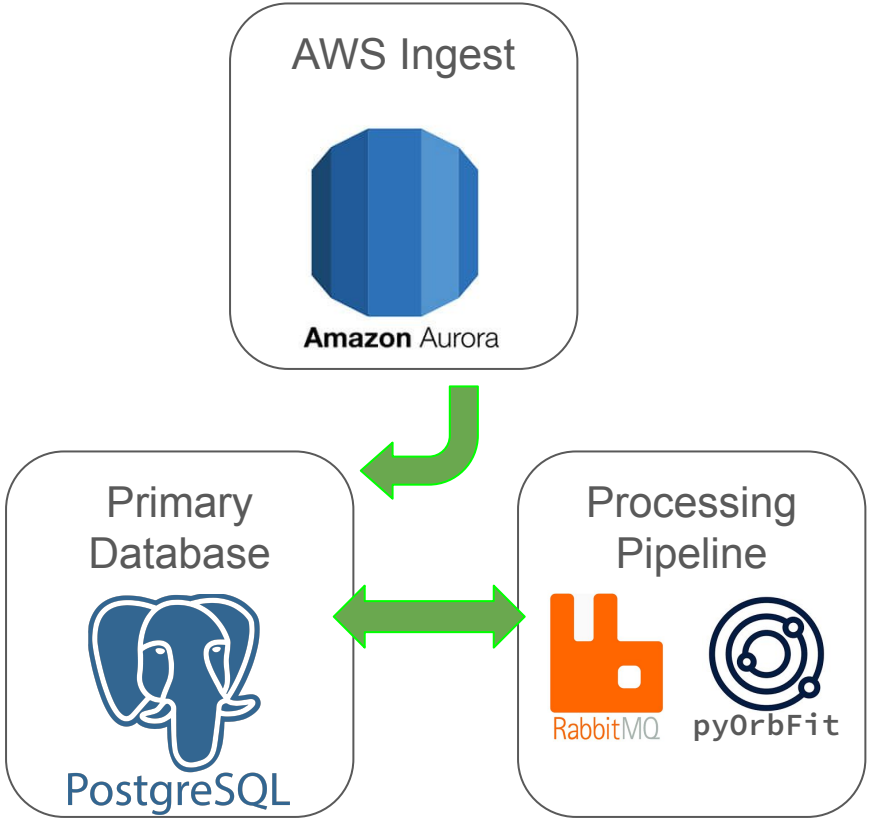
- Submitters can test-at-scale
  - Repeated submission of millions of observations
- Test & Develop Quickly & Safely
  - Submitter data preparation
  - MPC process capabilities & routing
- Available for Multiple Teams
  - Rubin
  - NEO Surveyor



SandBox Systems

Isolated Testing

- Pre-Publication Rubin Solar System
  - Nov. ComCam Data
  - Apr/May/Jun: LSSTCam Commissioning
- NEO Surveyor
  - At-scale heliolinc tests: Efficiency of performance; Completeness of recovery
- Other Possibilities
  - Testing at-scale *remeasurement* processes
  - Open to suggestions



LSST Commissioning Data

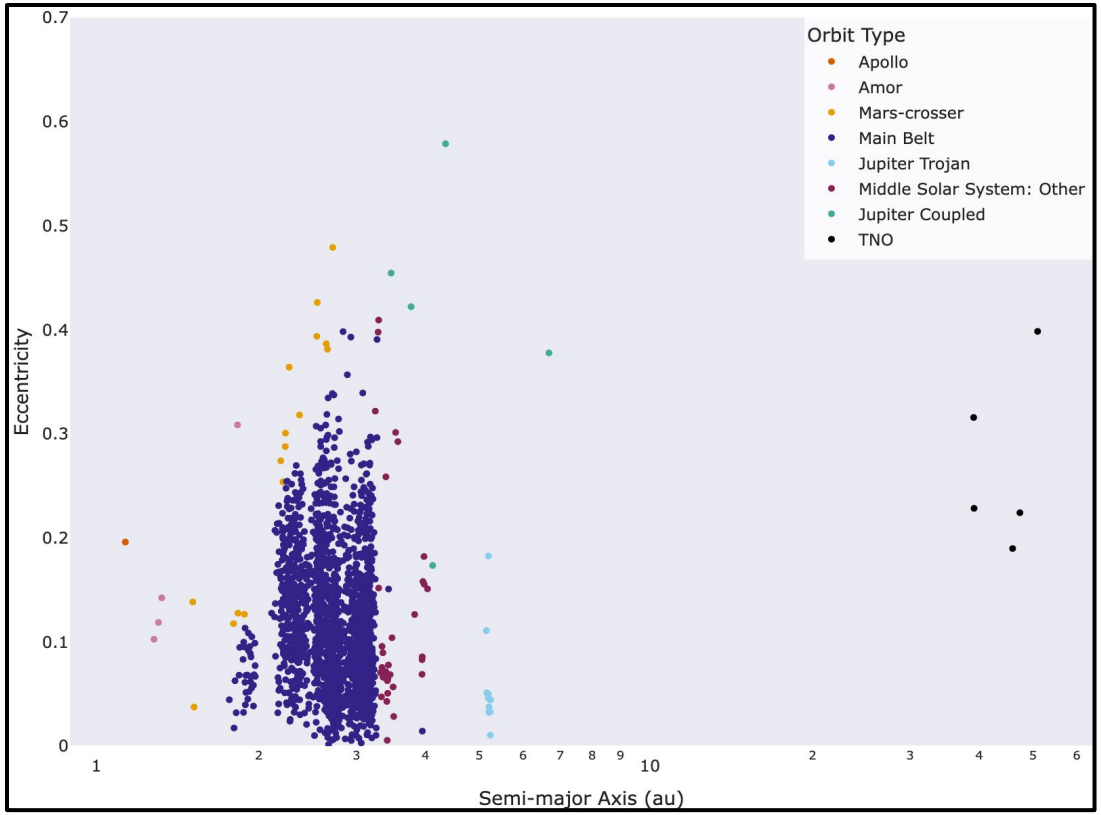
LSST: First Public Submissions

The International Astronomical Union Minor Planet Center

June 23rd

- Observatory Code X05
- 343,760 Submitted Observations
- 2,103 unique objects

Orbit type	Number of objects
NEOs	7
Mars-crossers	16
Main Belt	1830
Jupiter Trojans	11
Jupiter Coupled	5
Middle Solar System: Other	35
TNOs	5

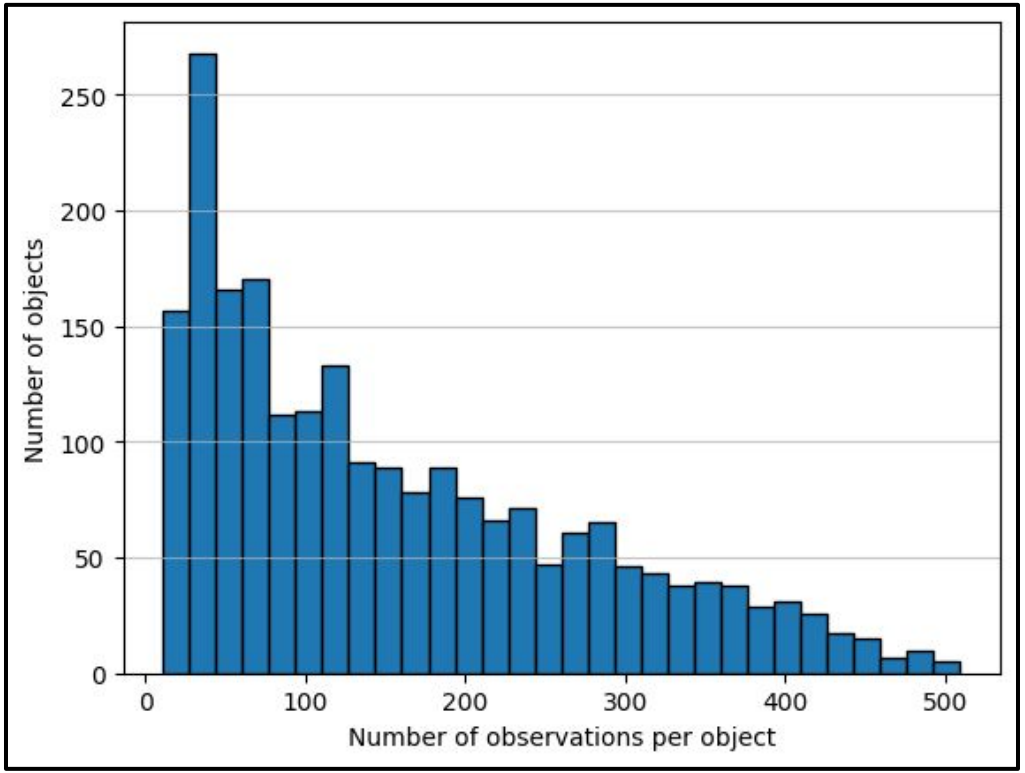


LSST: First Public Submissions

The International Astronomical Union Minor Planet Center

June 23rd

- Observatory Code X05
- 343,760 Submitted Observations
  - Coincidentally close to expected nightly average
- 2,103 unique objects
- Median: 132 observations per object
  - Rather different to expected profile during operations



LSST: Imminent Data Deluge

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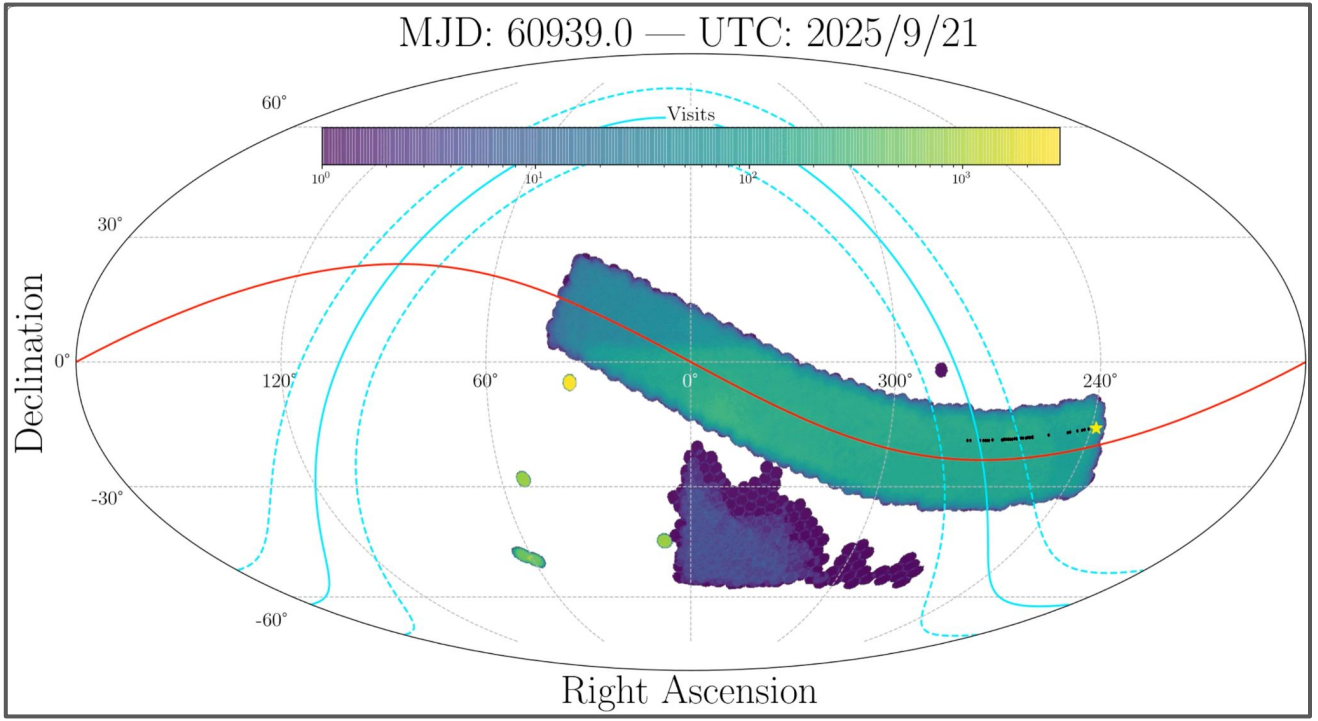
SV Survey

- Started June - Sept 2025 Sept.
- ~1,400 deg^2
- ~⅓ ecliptic band, ±10°

⇒

- ~ ⅓ of ***known*** MBAs observed:
  I.e. **~500k**
- Similar number of ***new*** MBAs likely awaiting discovery
- Millions of Rubin Solar System observations are about to pour out!



Improving Services & Communication

MPC Explorer

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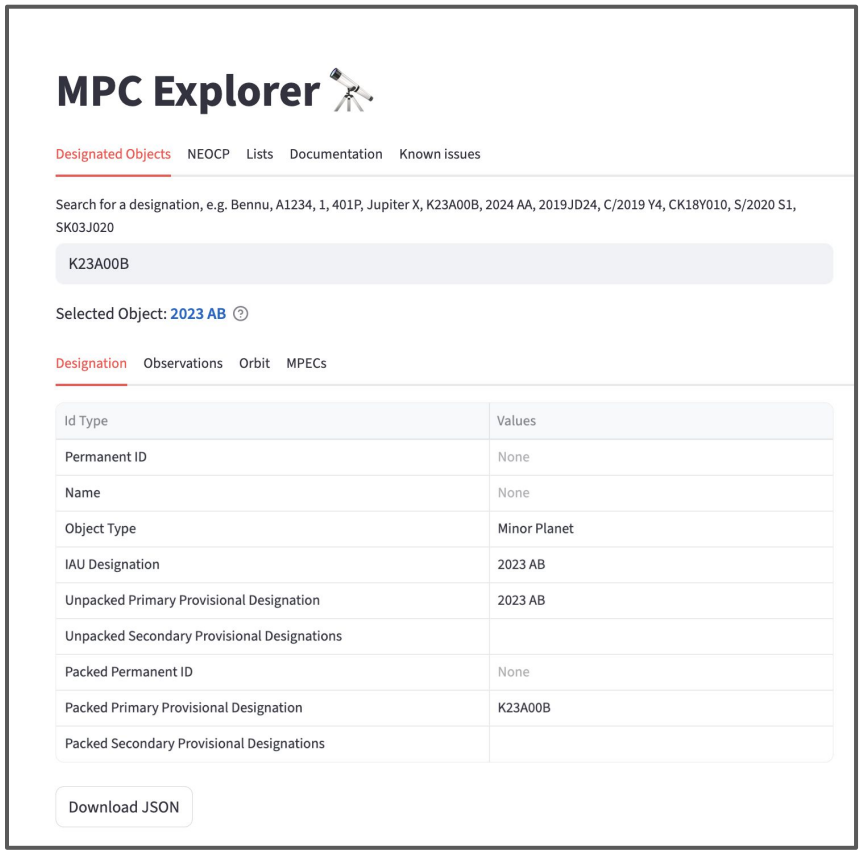


Database centric functionality that will work as a replacement for our legacy *db_search*

Available Now: Data is continuously updated

- Designations and Identifications
- Observations
- NEOCP
- Orbits
- MPECs

Access Methods

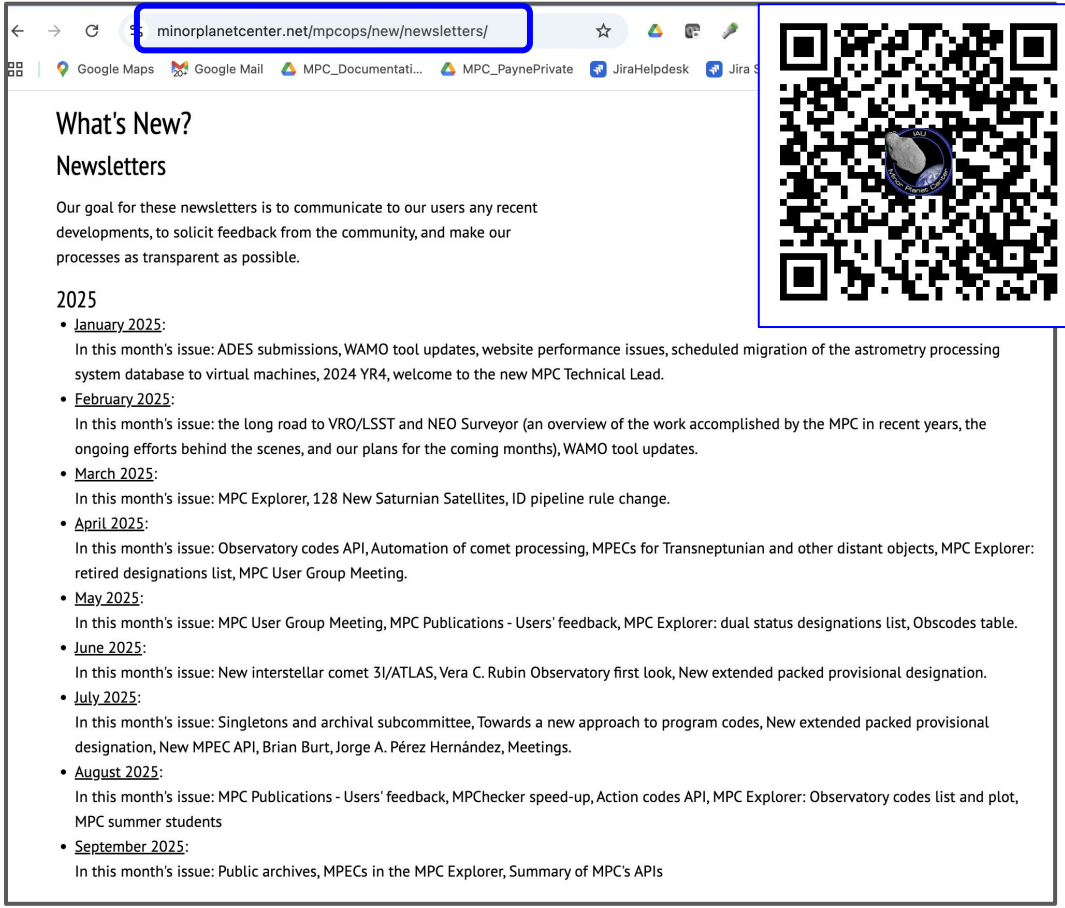
- Web-forms
- API

URL & QR-Code

- https://data.minorplanetcenter.net/explorer/

Communications

The International Astronomical Union Minor Planet Center



Monthly Newsletter:

- Always available on the MPC website
- Contains information about recent developments, recommendations for the community, updates on MPC staff, recent resolved issues or recurring problems and future plans
- Setting up a subscription list

Helpdesk

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

Summary

- Preparations for Rubin LSST & NEO Surveyor Missions have dominated recent MPC activities
  - Well-planed to handle the forecast 10× increase in data volume by 2028

- Modern, robust pipeline deployed on redundant hardware.
  - Further developments will continue.

- Future: focus attention and effort on improving user services and documentation.