Known Solar System Object Association (SSOID)

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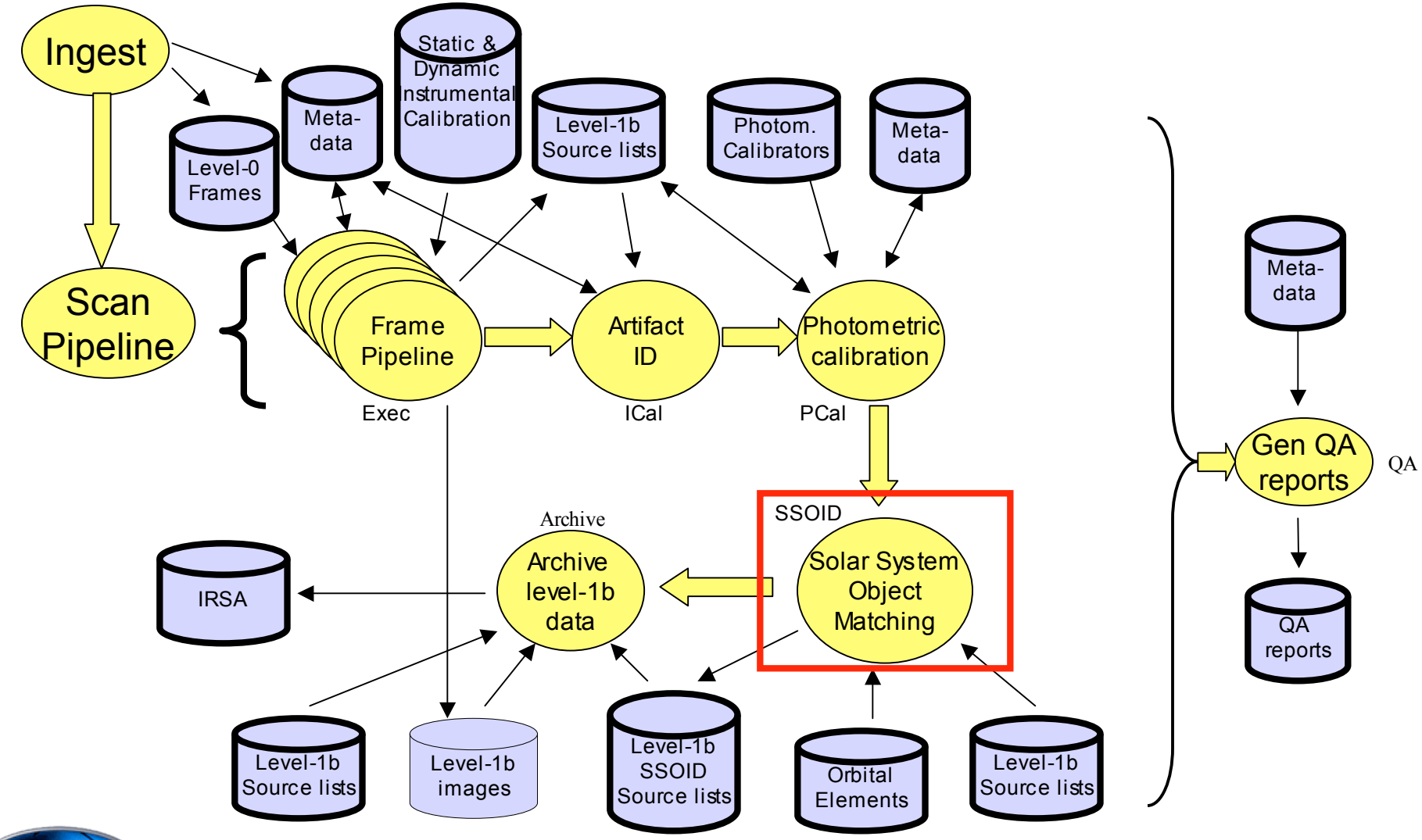
WSDS Scan Pipeline



Driving Requirements

L4WSDC-027	The WSDC shall identify and compile a listing of known solar system objects that are positionally associated with source extractions in the WISE single-epoch image frames.
L4WSDC-028	The solar system objects associated with WISE single-epoch extractions shall include asteroids, comets, planets, and planetary satellites.

Object Association - 1

- Basic design involves a comparison of WISE source coordinates with ephemerides of solar system objects
  - Ephemerides referred to mean equator and equinox of J2000, thus compatible with WISE source positions
  - Ephemeris positions accompanied by two-dimensional error estimates; numbered asteroids good to an arcsecond, while unnumbered asteroids have orbits of variable quality
  - Use contemporary orbits for comets (where available) to avoid the effect of non-gravitational forces
  - Ephemeris positions accompanied by plane-of-sky velocities so that small time deltas can be handled without recomputing ephemeris
  - Non-detection of known objects predicted to be in the field of view are of potential interest

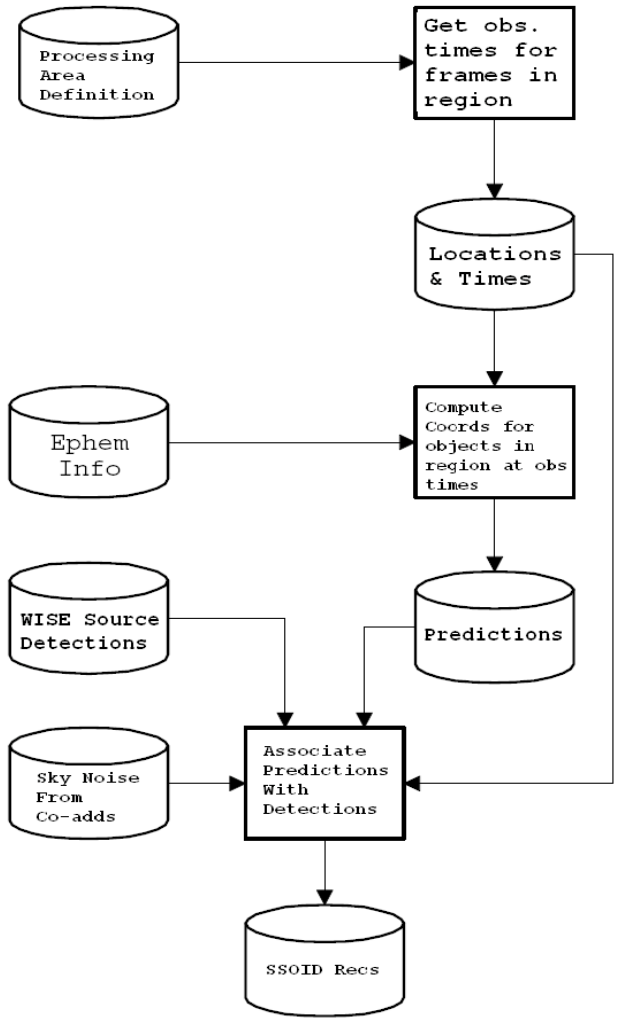
Object Association - 2

- Can be rapidly implemented by relying on code developed for 2MASS project
  - 2MASS restricted attention to objects with reasonably reliable ephemerides (numbered asteroids, multi-opposition unnumbered asteroids, comets, planets; most single-opposition asteroids were excluded; planetary satellites were not considered)
  - Current orbit catalogs include over 330,000 such objects, approximately four times the number of objects that 2MASS considered
  - Catalogs updated on a monthly basis from orbits published by the Minor Planet Center
  - Orbits integrated to epochs of osculation at 100-day intervals, thus never more than 50 days from an epoch

Object Association - 3

- Efficiency of 2MASS approach can be improved
  - Candidate list prepared by finding all known objects that fell within a scan region (plus buffer), specified by the coordinates of its corners
  - Involved computing ephemeris position for every object in the catalog at every input time (one per record)
  - Detected source positions compared with ephemeris position and estimated error ellipse (9 arcseconds maximum error allowed)
  - First pass can be use to compute solar elongation of all objects and eliminate those far from the region of interest that cannot possibly move into it
  - Requires picking the "natural" time scale of a processing batch

SSOID Prediction/Detection Association



Processing Area Definition file defines the sky region to process.

WISE frames in this region are found, and obs times for all frames are supplied to the ephemeris program.

Ephemeris program computes positions and proper motions for each object in the region at frame times, with uncertainty ellipse axes aligned with line of variation.

Predictions are associated with WISE detections via 2-D χ^2 test (same method as that used in PRex subsystem). Source parameters, SSO parameters, and local sky noise are output.

Code Modifications - 1

- Existing code designed to work with two fixed terrestrial observatory sites utilized by 2MASS
  - Will be necessary to provide position of WISE spacecraft to ephemeris routine or compute it from frequently updated two-body elements
  - Parallax about 10 arcseconds per inverse topocentric distance in AU, so main-belt asteroids can have 3 to 5 arcseconds of ephemeris error if parallax ignored, more for near-Earth asteroids, less for distant objects
  - Easiest to implement if spacecraft ephemeris also referred to mean equator and equinox of J2000

Code Modifications - 2

- Existing code written for 2MASS used fixed-size arrays to conform to FORTRAN 77 standard
  - Required updating of source code as object catalogs increased in size (or wasted memory)
  - Wide availability of Fortran 90/95 compilers now allows use of memory allocation (variable-size arrays), thus eliminating the need to update source code and recompile

Code Modifications - 3

- Existing code not designed to deal with planetary satellites
  - Satellite associations were handled in off-line analyses for 2MASS
  - Uses two-body computations for speed
  - Outer satellites of Jupiter and Saturn experience significant solar perturbations, rendering two-body ephemerides of unacceptable accuracy once time from epoch of osculation exceeds about two weeks, depending on the object
  - Requires three-body numerical integrations

Development Schedule - 1

- May 2008: make design decisions
  - Method for computing spacecraft ephemeris
  - "Natural" time scale for processing batches
- June 2008: update SIS used for 2MASS
- July 17, 2008: WSDS v1 (supports MOS end-to-end testing)
- January 2009: implement code to handle parallax for a moving observer
- January 2009: implement code to allocate orbital element arrays based on size of catalogs
- February 2009: first ephemeris code delivery

Development Schedule - 2

- February 28, 2009: WSDS v2 (supports MOS/WSDC load volume tests)
- July 2009: deliver three-body code to handle outer satellites of giant planets
- August 4, 2009: WSDS v3 (supports ops readiness reviews, launch IOC), orbit database
- January 26, 2010: WSDS v3.5 (supports preliminary data processing, mission ops), orbit database update
- October 18, 2010: WSDS v4 (supports final data processing, final products), orbit database update

Issues/Concerns

- Will need synthetic spacecraft ephemeris positions or orbital elements to permit testing of code modifications
- Will need synthetic input data to permit testing (already part of the test plan)
- Unclear how trailed (nearby) objects will be handled
- How many updates to the orbital element catalog will be desired?
- WISE will detect many previously unknown moving objects; will special handling of these be required?