NEODyS (and AstDyS and Priority List) Data Provision

Fabrizio Bernardi

CEO of SpaceDyS

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What is **NEODyS**

- **NEODyS** is a web based service and stands for Near Earth Objects Dynamic Site: http://newton.dm.unipi.it/neodys
- **NEODyS** provides information on the **IMPACT PROBABILITY** of Near Earth Objects (NEOs), typically for an horizon of 100 years
- The most important output is the **Risk Page**: http://newton.dm.unipi.it/neodys2/index.php?pc=4.0 where a list of NEOs (**459** on Nov 17th) with some chances of hitting the Earth within the next century is posted for the public
- Only **JPL@NASA** provides a similar service with **SENTRY**
- **NEODyS** team has a technological leadership in Europe (and world)

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NEODyS background

- **NEODyS** was born in 1999 at the Dep. of Mathematics of the University of Pisa (Italy), within the Celestial Mechanics Group (**CMG**) lead by Prof. **Andrea Milani**
- The main motivation was the absence of a rigorous and systematic method for computing on a daily basis the probability that an asteroid is hitting the Earth
- The **1997XF11** case was a PR disaster, just for the lack of a well established system to perform such computations

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NEODyS daily activities

- Since 1999 **NEODyS** is processing astrometric data of Near Earth Objects (NEOs) provided by the ***Minor Planet Center***, the official entity supported by the International Astronomical Union (***IAU***) that manages all the asteroids observations and the official catalog of asteroids
- The data are sent to **NEODyS** either by email or via web, through the Minor Planet Electronic Circulars (MPECs)
- MPECs:
  - DOU → Daily Orbit Update: new observations (and orbits) of already known NEOs
  - Discovery MPEC → Certifies the discovery of a new NEO
  - Recovery MPEC → When a single opposition NEO is reobserved at a following apparition

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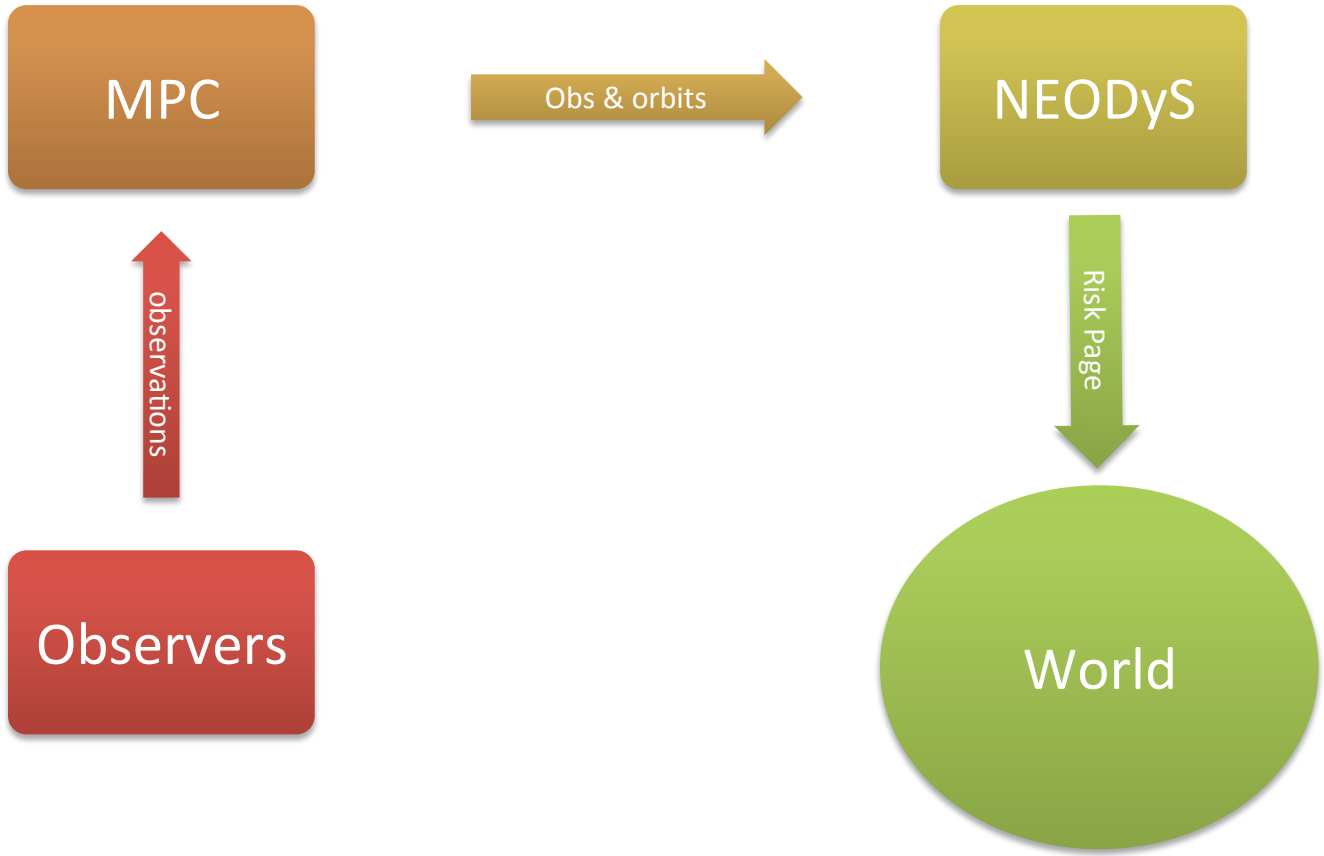
NEODyS daily activities



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What NEODyS actually does

- When the NEODyS system receive new data from MPC, they will be processed by the software robot called **CLOMON2**
- **CLOMON2** is based on the libraries of the **OrbFit** (ver.4.2) software package developed and maintained by UniPi and SpaceDyS, written in Fortran 90
- **CLOMON2** has a very high level of automation. When new data are available, it automatically starts to process them
- When the **CLOMON2** output (the risk file) is ready, a qualified operator checks the output and posts it to the web

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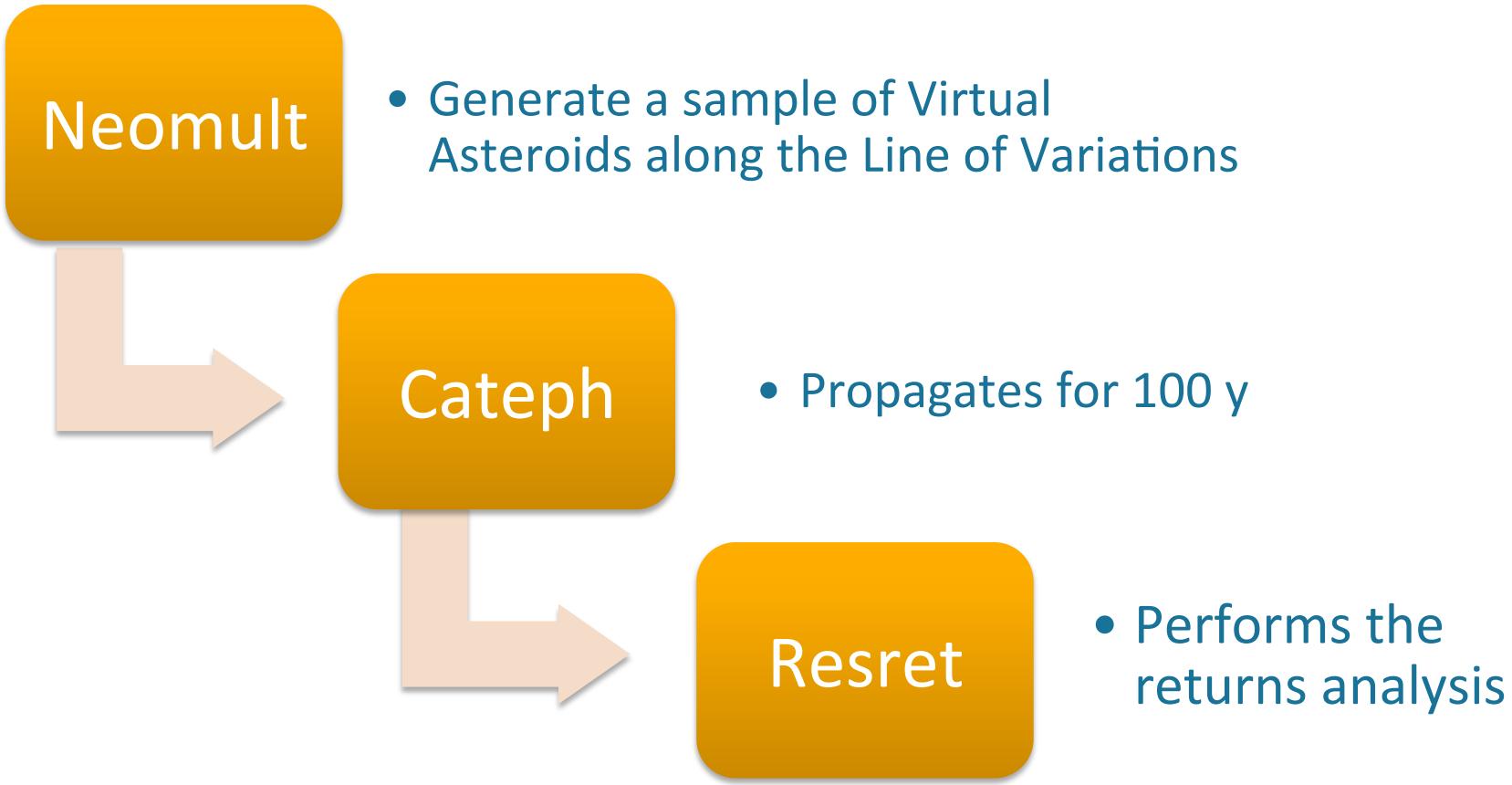
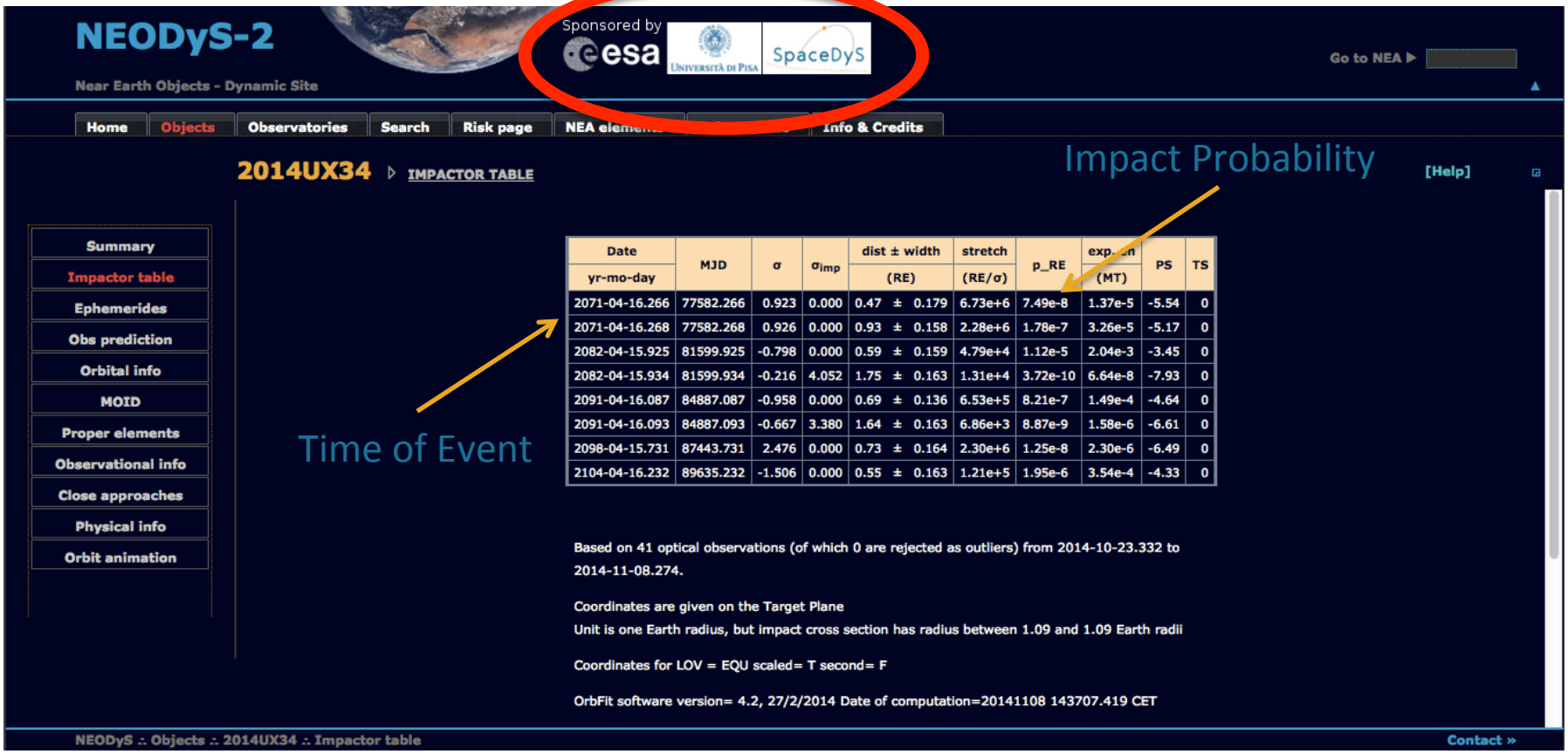
CLOMON2 processes chart

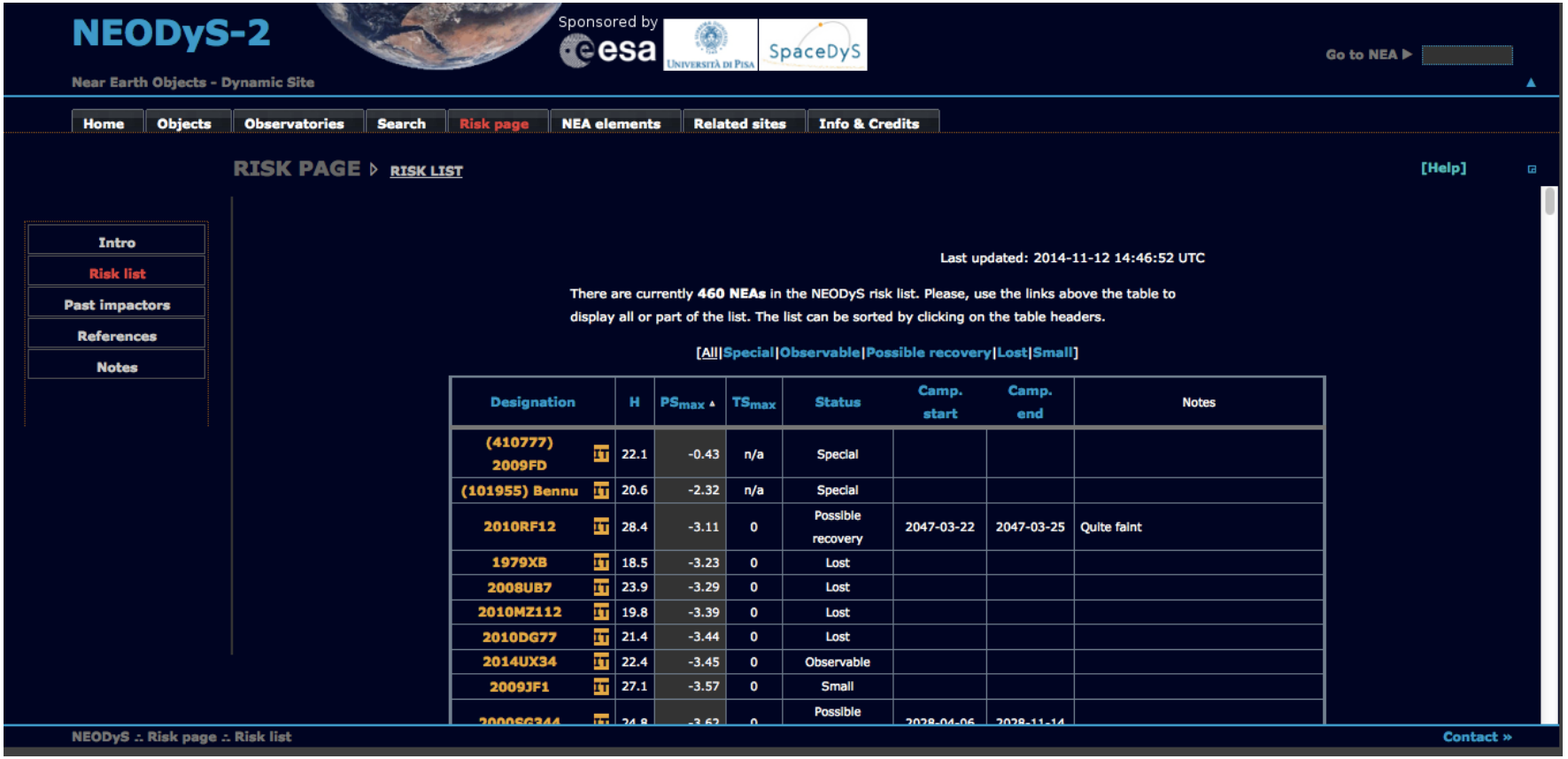


NEODyS output example – Risk File



Date yr-mo-day	MJD	σ	σ_{imp}	dist ± width (RE)	stretch (RE/σ)	p_RE	exp…n (MT)	PS	TS
2071-04-16.266	77582.266	0.923	0.000	0.47 ± 0.179	6.73e+6	7.49e-8	1.37e-5	-5.54	0
2071-04-16.268	77582.268	0.926	0.000	0.93 ± 0.158	2.28e+6	1.78e-7	3.26e-5	-5.17	0
2082-04-15.925	81599.925	-0.798	0.000	0.59 ± 0.159	4.79e+4	1.12e-5	2.04e-3	-3.45	0
2082-04-15.934	81599.934	-0.216	4.052	1.75 ± 0.163	1.31e+4	3.72e-10	6.64e-8	-7.93	0
2091-04-16.087	84887.087	-0.958	0.000	0.69 ± 0.136	6.53e+5	8.21e-7	1.49e-4	-4.64	0
2091-04-16.093	84887.093	-0.667	3.380	1.64 ± 0.163	6.86e+3	8.87e-9	1.58e-6	-6.61	0
2098-04-15.731	87443.731	2.476	0.000	0.73 ± 0.164	2.30e+6	1.25e-8	2.30e-6	-6.49	0
2104-04-16.232	89635.232	-1.506	0.000	0.55 ± 0.163	1.21e+5	1.95e-6	3.54e-4	-4.33	0

NEODyS output example – Risk List



NEODyS-2

Near Earth Objects - Dynamic Site

Sponsored by esa, Università di Pisa, SpaceDyS

Go to NEA ▶

Home | Objects | Observatories | Search | Risk page | NEA elements | Related sites | Info & Credits

RISK PAGE ▷ RISK LIST [Help]

- Intro
- Risk list
- Past impactors
- References
- Notes

Last updated: 2014-11-12 14:46:52 UTC

There are currently **460 NEAs** in the NEODyS risk list. Please, use the links above the table to display all or part of the list. The list can be sorted by clicking on the table headers.

[All|Special|Observable|Possible recovery|Lost|Small]

Designation	H	PS$_{max}$ ▲	TS$_{max}$	Status	Camp. start	Camp. end	Notes
(410777) 2009FD	22.1	-0.43	n/a	Special			
(101955) Bennu	20.6	-2.32	n/a	Special			
2010RF12	28.4	-3.11	0	Possible recovery	2047-03-22	2047-03-25	Quite faint
1979XB	18.5	-3.23	0	Lost			
2008UB7	23.9	-3.29	0	Lost			
2010MZ112	19.8	-3.39	0	Lost			
2010DG77	21.4	-3.44	0	Lost			
2014UX34	22.4	-3.45	0	Observable			
2009JF1	27.1	-3.57	0	Small			
2000SG344	24.8	-3.62	0	Possible	2028-04-06	2028-11-14	

NEODyS ∴ Risk page ∴ Risk list

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NEODyS Services

- Risk Page and Impactor Tables
- Orbits DB, with covariance matrices for all NEOs (11621 on Nov 17th) in Keplerian and Equinoctal parameters
- Observations DB (1.3 millions of obs)
- Ephemerides and observation prediction for observers
- List of close approaches
- Proper elements
- List of observatories
- Scientific Expertise and Consultancy

- **AstDyS** stands for Asteroids Dynamic Site
- It has the same NEODyS interface, with some differences
- **AstDyS** is a database of all numbered and multi-opposition asteroids (on Nov 17th it counts 415688 numbered asteroids and 114888 multi-opposition asteroids
- **AstDyS** manages (Nov 17th) 108 millions of observations of numbered objects and more than 9 millions of observations of multi-opposition objects
- **AstDyS** is updated on a monthly basis according to MPC data release for all asteroids

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AstDyS Services

- ~~Risk Page and Impactor Tables~~
- Orbits DB, with covariance matrices for all numbered and multi opposition asteroids in Keplerian and Equinoctal parameters
- Observations data
- Ephemerides and observation prediction for observers
- ~~List of close approaches~~
- Proper elements and families
- List of observatories and performance statistics
- Scientific Expertise and Consultancy

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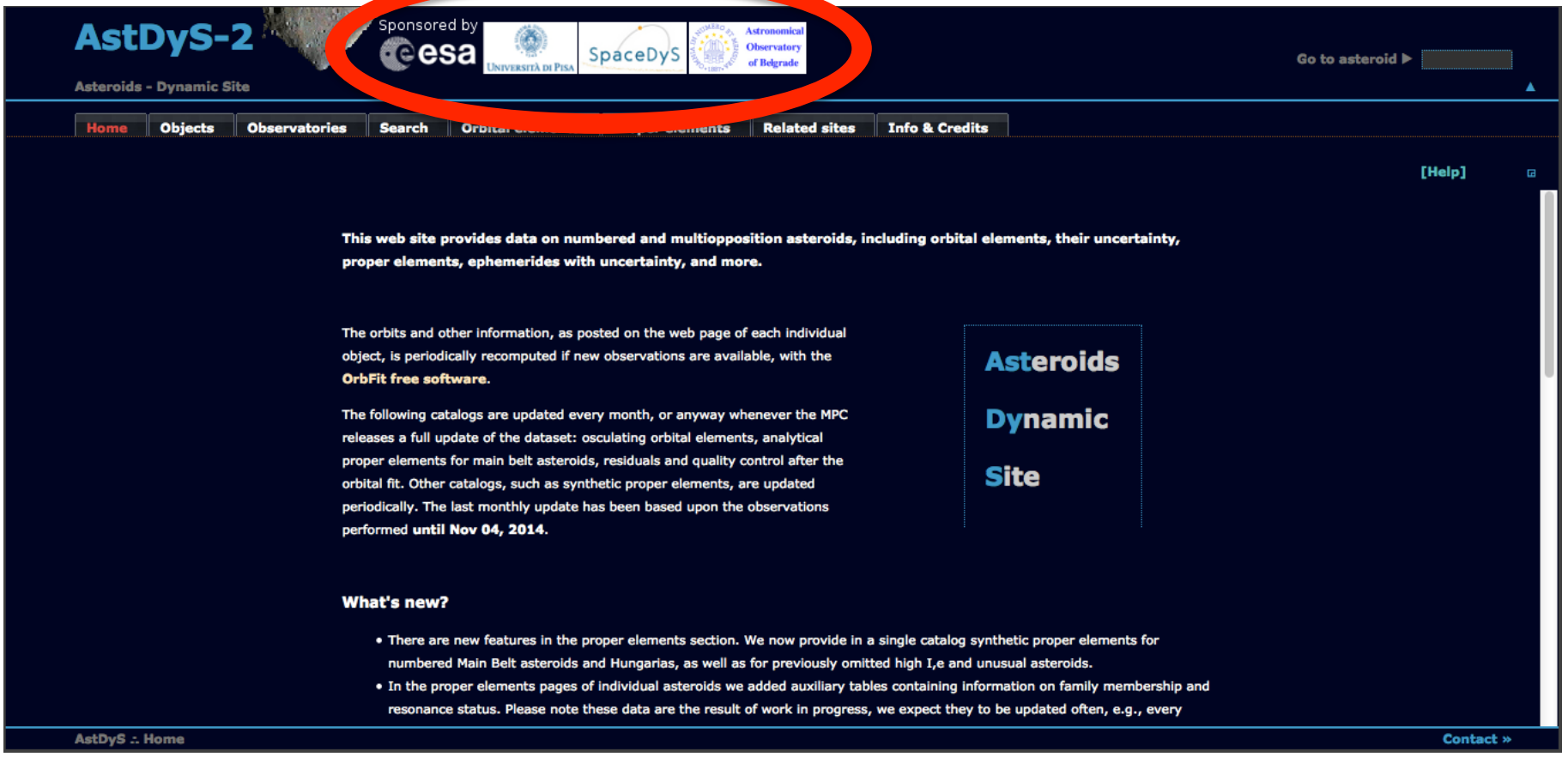
AstDyS web page



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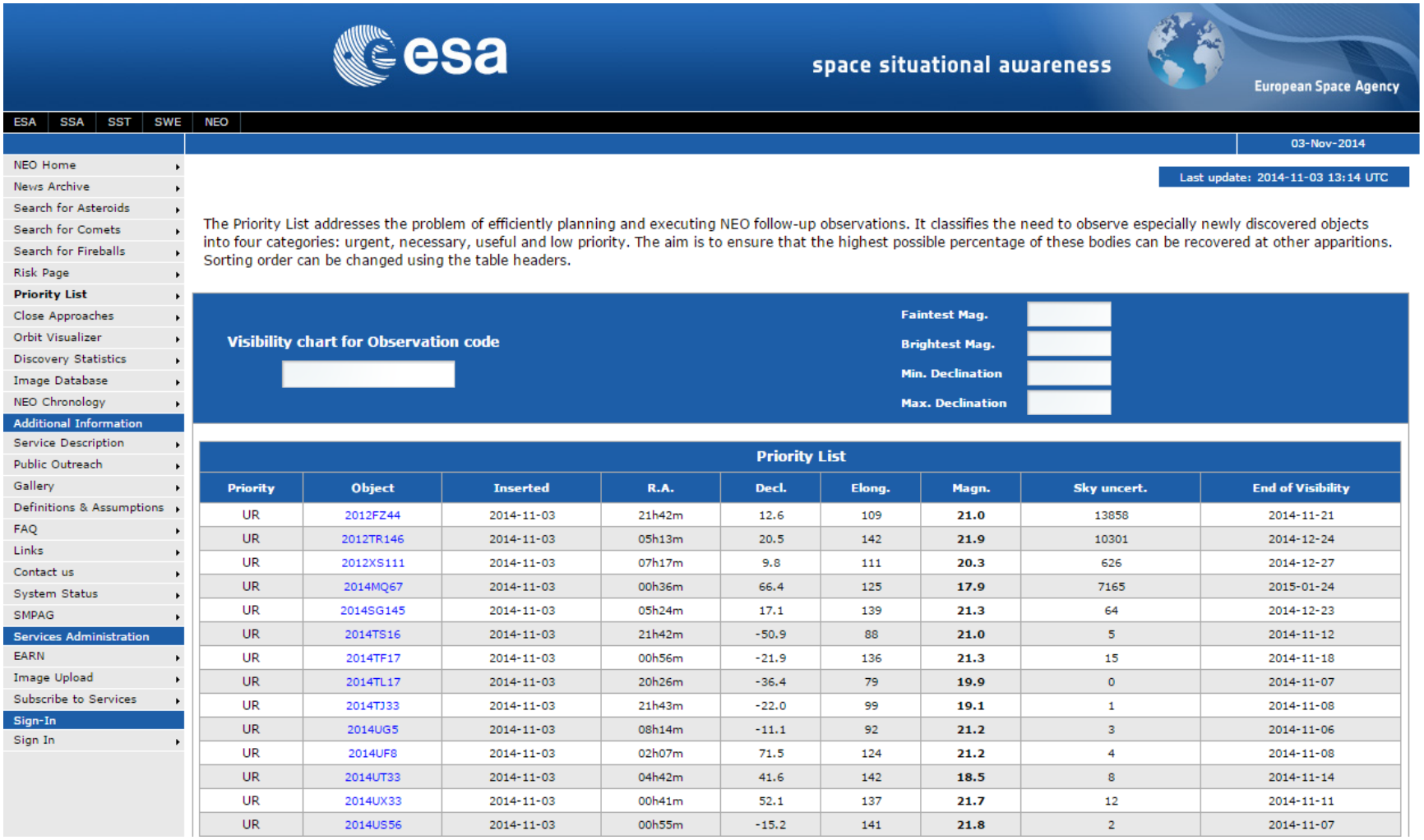
Priority List

- The **Priority List** classifies the need to observe NEOs
- The protocol is based on the algorithm implemented in the activities of the **Spaceguard Central Node** (SCN, a facility of the Spaceguard Foundation, established with the support of ESA)
- The PL inventors were Andrea Boattini, Germano D'Abramo, Andrea Carusi and Giovanni B. Valsecchi
- The objective of the software is to improve the **efficiency of astrometric follow-up observations** of NEOs for the accurate determination of their orbits.
- The priority list reports a list of NEAs classified into four categories: **urgent, necessary, useful and low priority**

Priority List at the NEOCC

- The Priority list software has been moved to the ESA NEO Coordination Centre in 2012 and it is currently under the maintenance of SpaceDyS
- It is automatically updated on a daily basis using data coming from the **NEODyS** database.
- The NEOCC FDOs perform maintenance procedures two times a month.
- Currently, the NEO Web portal reports the objects in need of observations through two lists: **a priority list and a faint NEO list:**
  - The first one contains NEAs brighter than V magnitude 22.0 and at least 40 degrees of solar elongation,
  - The second one reports objects with highest magnitudes.
- The PL supports the observations taken with ESA OGS telescope

Priority List at the NEOCC



esa space situational awareness European Space Agency

ESA | SSA | SST | SWE | NEO

03-Nov-2014

Last update: 2014-11-03 13:14 UTC

- NEO Home
- News Archive
- Search for Asteroids
- Search for Comets
- Search for Fireballs
- Risk Page
- **Priority List**
- Close Approaches
- Orbit Visualizer
- Discovery Statistics
- Image Database
- NEO Chronology

Additional Information

- Service Description
- Public Outreach
- Gallery
- Definitions & Assumptions
- FAQ
- Links
- Contact us
- System Status
- SMPAG

Services Administration

- EARN
- Image Upload
- Subscribe to Services

Sign-In

- Sign In

The Priority List addresses the problem of efficiently planning and executing NEO follow-up observations. It classifies the need to observe especially newly discovered objects into four categories: urgent, necessary, useful and low priority. The aim is to ensure that the highest possible percentage of these bodies can be recovered at other apparitions. Sorting order can be changed using the table headers.

Visibility chart for Observation code

Faintest Mag.
Brightest Mag.
Min. Declination
Max. Declination

Priority List

Priority	Object	Inserted	R.A.	Decl.	Elong.	Magn.	Sky uncert.	End of Visibility
UR	2012FZ44	2014-11-03	21h42m	12.6	109	**21.0**	13858	2014-11-21
UR	2012TR146	2014-11-03	05h13m	20.5	142	**21.9**	10301	2014-12-24
UR	2012XS111	2014-11-03	07h17m	9.8	111	**20.3**	626	2014-12-27
UR	2014MQ67	2014-11-03	00h36m	66.4	125	**17.9**	7165	2015-01-24
UR	2014SG145	2014-11-03	05h24m	17.1	139	**21.3**	64	2014-12-23
UR	2014TS16	2014-11-03	21h42m	-50.9	88	**21.0**	5	2014-11-12
UR	2014TF17	2014-11-03	00h56m	-21.9	136	**21.3**	15	2014-11-18
UR	2014TL17	2014-11-03	20h26m	-36.4	79	**19.9**	0	2014-11-07
UR	2014TJ33	2014-11-03	21h43m	-22.0	99	**19.1**	1	2014-11-08
UR	2014UG5	2014-11-03	08h14m	-11.1	92	**21.2**	3	2014-11-06
UR	2014UF8	2014-11-03	02h07m	71.5	124	**21.2**	4	2014-11-08
UR	2014UT33	2014-11-03	04h42m	41.6	142	**18.5**	8	2014-11-14
UR	2014UX33	2014-11-03	00h41m	52.1	137	**21.7**	12	2014-11-11
UR	2014US56	2014-11-03	00h55m	-15.2	141	**21.8**	2	2014-11-07

- **SpaceDyS – Space Dynamics Services**, is a spin-off of the team of Andrea Milani, of the Dep. Of Mathematics of the University of Pisa
- Since its birth, on May 2011, **SpaceDyS** has been deeply involved in many SSA activities, specifically for the NEO and SST segments (SN-III, SN-V, CO-II, P2-NEO-I, P2-SST-IV)
- **SpaceDyS** major expertise is obviously the NEO dynamics, but in general it is developing advanced tools for the orbit determination problem applied for Solar System objects and objects orbiting around the Earth

- **SpaceDyS** is now managing, maintaining and developing all the activities related to **NEODyS**, **AstDyS** and **PL**
- The two presently Front Desk Operators at the NEOCC are both **SpaceDyS** employees
- At **SpaceDyS** HQ there are three employees fully devoted to the SSA NEO activities
- Scientific consultancy from the senior **SpaceDyS** partners who are among the worldwide experts for this matter

Service Level Agreements with ESA

- Since **SpaceDyS** birth in 2011 Service Level Agreements with **ESA** were in place for the following **ESA** needs:
  - Provide to the ESA-SSA precursor services at the NEOCC the **NEODyS** data (orbits with covariance matrices, the **Risk List** and **Impactor Tables**, the list of close approaches, NEOs ephemerides of the Orbit Visualization Tool,...
  - Provide to the ESA-SSA precursor services at the NEOCC the **AstDyS** data (orbits, proper elements,...)
  - Maintain the **Priority List** at the **NEOCC**
  - Scientific consultancy to ESA staff and general users
  - Support for the precursor services activities

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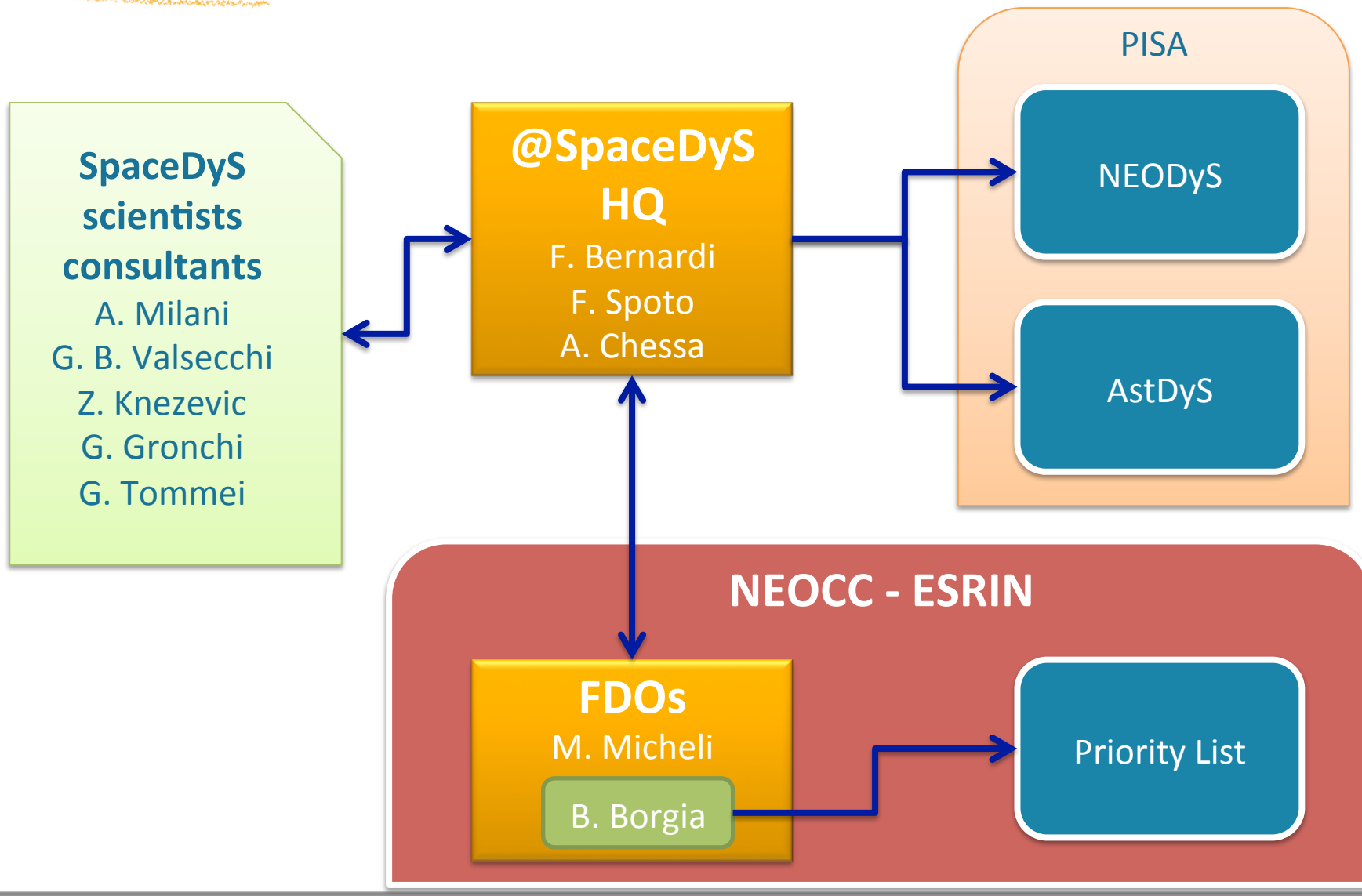
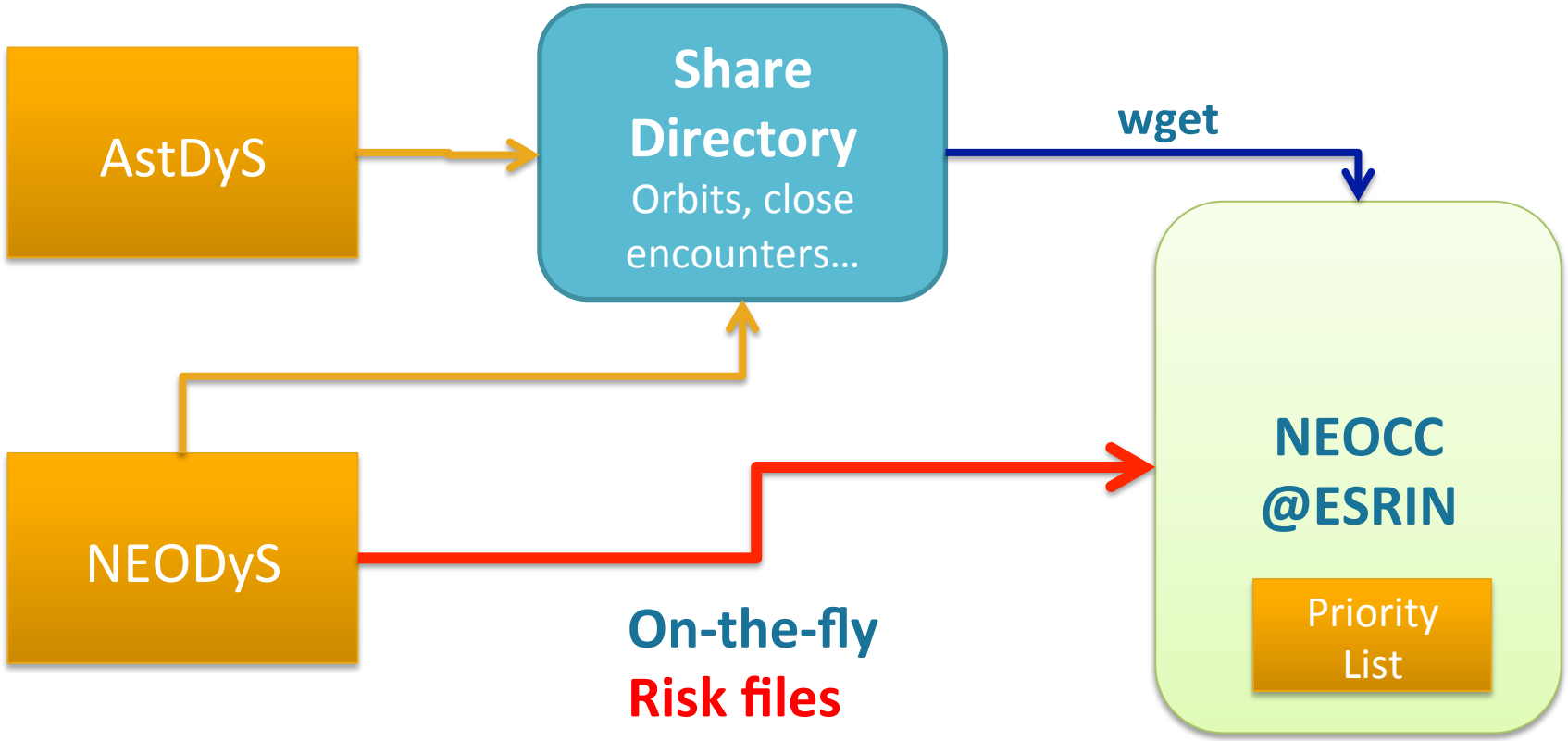
SLA - Timeline

- **SLA-1**: 01 Sep 2011 → 31 Mar 2012 (only **NEODyS**)
- **SLA-2**: 01 Apr 2012 → 30 Jun 2013
- **SLA-3**: 01 Jul 2013 → 30 Jun 2014
  - CCN-1: 01 Jul 2014 → 30 Jun 2015
  - CCN-2: 01 Jul 2015 → 30 Jun 2016

SpaceDyS team for SSA-NEO



Provision of data to the NEOCC system



Reliability of the service

- **SpaceDyS** is committed to provide the service to **ESA** 24/7/365
- Occasionally, during the SLAs period, there were some downtimes due to
  - Maintenance of the systems (O.S. upgrade, network maintenance…), which was necessary
  - Planned power outages, for electricity network maintenance
  - Unplanned and sudden power outages or internet failures
- When possible, ESA was informed as well as the asteroid observers community
- Out of services lasted only few hours and SpaceDyS personnel was always available, even during week-ends and holidays
- Automated systems alert through email the SpaceDyS operators when the services are experiencing troubles

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…maintaining the leadership

- The **NEO-SpaceDyS** team is committed to continue the research activity in the NEO dynamics science:
  - Introduction of non-grav. Parameters (Yarkovsky, rad. Press.,…)
  - Improved error models
  - Improved dynamical models
  - Imminent Impactors computation: a new system that computes the IP after processing data which are still in the NEO Confirmation Page
- New and improved services:
  - Graphic representation of the LOV behavior for 100 y and for all the NEOs on the Risk Page
  - Asteroids families computation and graphic representation
- Publishing papers, participating to international conferences, training young personnel

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The future

- The ESA Work Plan 2014 foresees that the NEODyS and AstDyS services will migrate to the NEOCC
- The "**Migration**" process will last **three years** and will include all the Orbit Determination and Impact Monitoring activities
- Training of personnel is foreseen
- SpaceDyS will take the lead and responsibility for this activity
- SpaceDyS will ensure the maintenance of the ESA system for the OD and IM functions for the following years

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Conclusions

- SpaceDyS has a well established leadership in the NEO business
- SpaceDyS is providing continuously the data to ESA-NEOCC
- Fast reaction in case of failures
- Prompt answer to ESA or general user requests for consultancy
- Support for the NEOCC precursor services development
- Continuous research and developments
- The main goal is the **Migration** of the services to ESA