IAWN Steering Group Meeting

Minor Planet Center & Harvard-Smithsonian Center for Astrophysics
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On the Russian contribution to the IAWN

Boris Shustov

Institute of Astronomy, RAS

INASAN
Institute of Astronomy, RAS

Plan of the talk

- The need for a national NEO program
- Astronomical requirements for NEO detection/ monitoring
- Existing premises and recent activities
- What we plan to do
- How to contribute to the IAWN

Arguments pro national program in Russia (NEO aspects)

1. The NEO problem is a multi-problem. Various organizations (ministries) are to be involved (coordinated);

2. The expensive technologies of massive detection of NEO, preventing collisions and mitigation can be proposed but cannot be realized under the responsibility of individual research institution;

3. Cooperation of countries on the NEO problem implies the involvement of Russia Government (or authorized body);

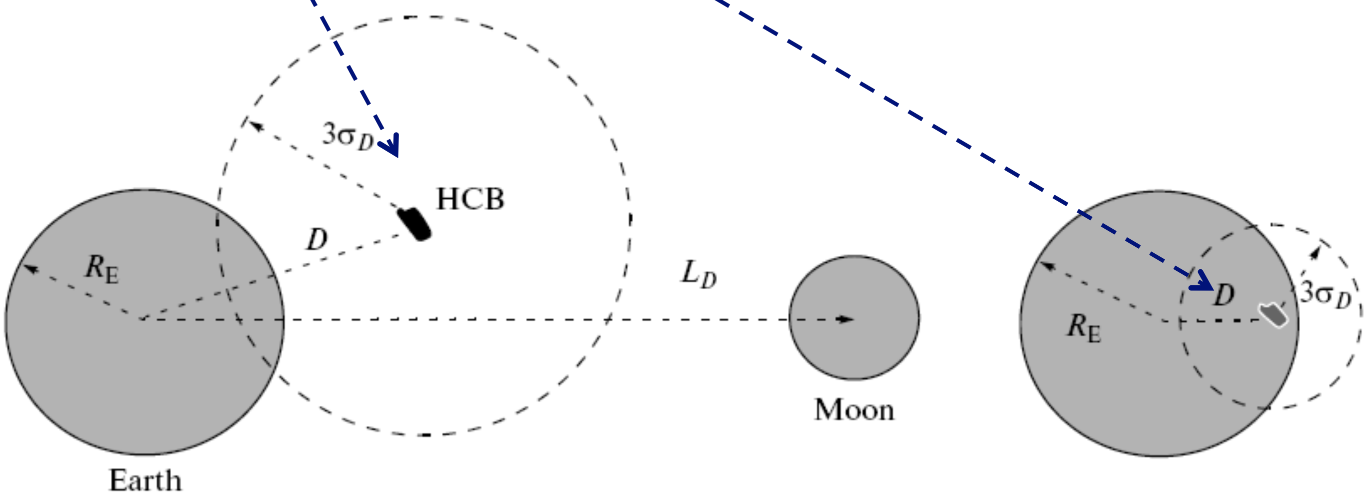
4. Regular funding is vitally important for real progress.

Suggestion to the definitions of hazardous celestial bodies (HCB)

PHO - $MOID < 0.05$ A.U.

Threatening object (TO) $D < L_D,\ D - 3\sigma_D < R_E$

Collisional object (CO) $D < R_E,\ 3\sigma_D < R_E$



NB: In the definition of PHO limiting size (or H) is not included!
For TO collision probability $>\sim 10^{-3}$, (if $L_D = 10^6$ km then $>\sim 10^{-4}$)
For CO collision probability $>\sim 0.5$

Two tasks and modes of detection

Large Distant Detection (LDD). Major goal is to detect "all" PHO larger than ~ 50 m well beforehand (to ensure possibility of active counteraction).

Near Earth Detection (NED). Major goal – to detect "all" PHO larger than ~ 5 m in the near space ($D < L_D$). This makes possible warning.

"all" means > 90%

LDD mode: NEO detection

(general requirements and other inputs for design of detection instrument)

- Time interval between detection+characterisation and rendez-vous must be not less than warning time (t_w). t_w ~ **30** days.
- *V* at approach < **40** km/s.
- For the object (at 1 A.U. from the Earth) an observational time interval of **7** days is sufficient for classification as PHO or TO.
- Limiting magnitude *V* < **23 - 24**

This mode requires some **~2** m class wide field ground based telescopes and/or few **~1** m class wide field space telescopes. Only including of space telescopes meets requirement of surveying the “whole sky” in t_w.

NED mode: NEO detection
(general requirements and other inputs for design of detection instrument)

- Time interval between detection and rendez-vous must be not less than warning time (t_w). t_w ~ **5**^{h}.
- *V* typically **20** km/s .
- Limiting magnitude *V* < **18-19**
- A properly located system of ~ **0.5 m** aperture wide field telescopes required (in visual domain). Whole sky should be surveyed in hours!

The mode requires for system of reasonable number of ~ **0.5 m** class wide field telescopes. Only including of space telescopes meets requirement of surveying the “whole sky”.

See for more details : **B.Shustov et al. Astronomical Aspects of Building a System for Detecting and Monitoring Hazardous Space Objects,** *Solar System Research, 2013, Vol. 47, No. 4, pp. 288–295.*

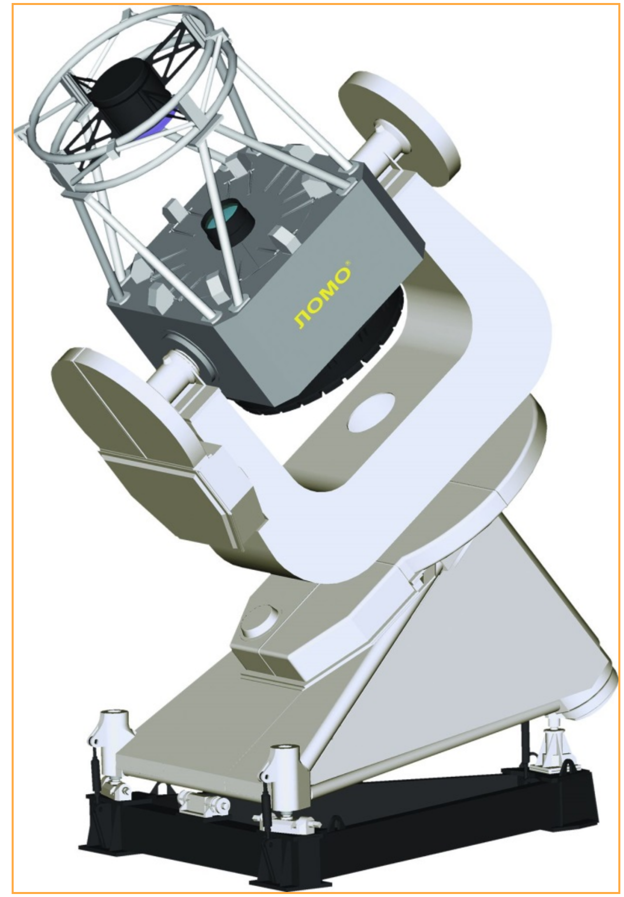
Detection and follow-up observation require for different technologies!

NEO detection: Technical Premises

The only instrument for massive detection in LDD mode telescope AZT-33VM (∅ 1.6 m) is under construction.

Wide-angle 1.6 m telescope AZT-33VM

Spectral range	400-1100 nm
F	5600 mm
focal ratio	1 : 3.5
2ω	2.8^0
$2y'$	277 mm



There exist a number of telescopes for follow up observations.

NEO monitoring and detection in NED mode: Technical Premises.

Optical instruments (networks)

ISON - partially supported by Roscosmos. Major goal – space surveillance (especially – space debris).

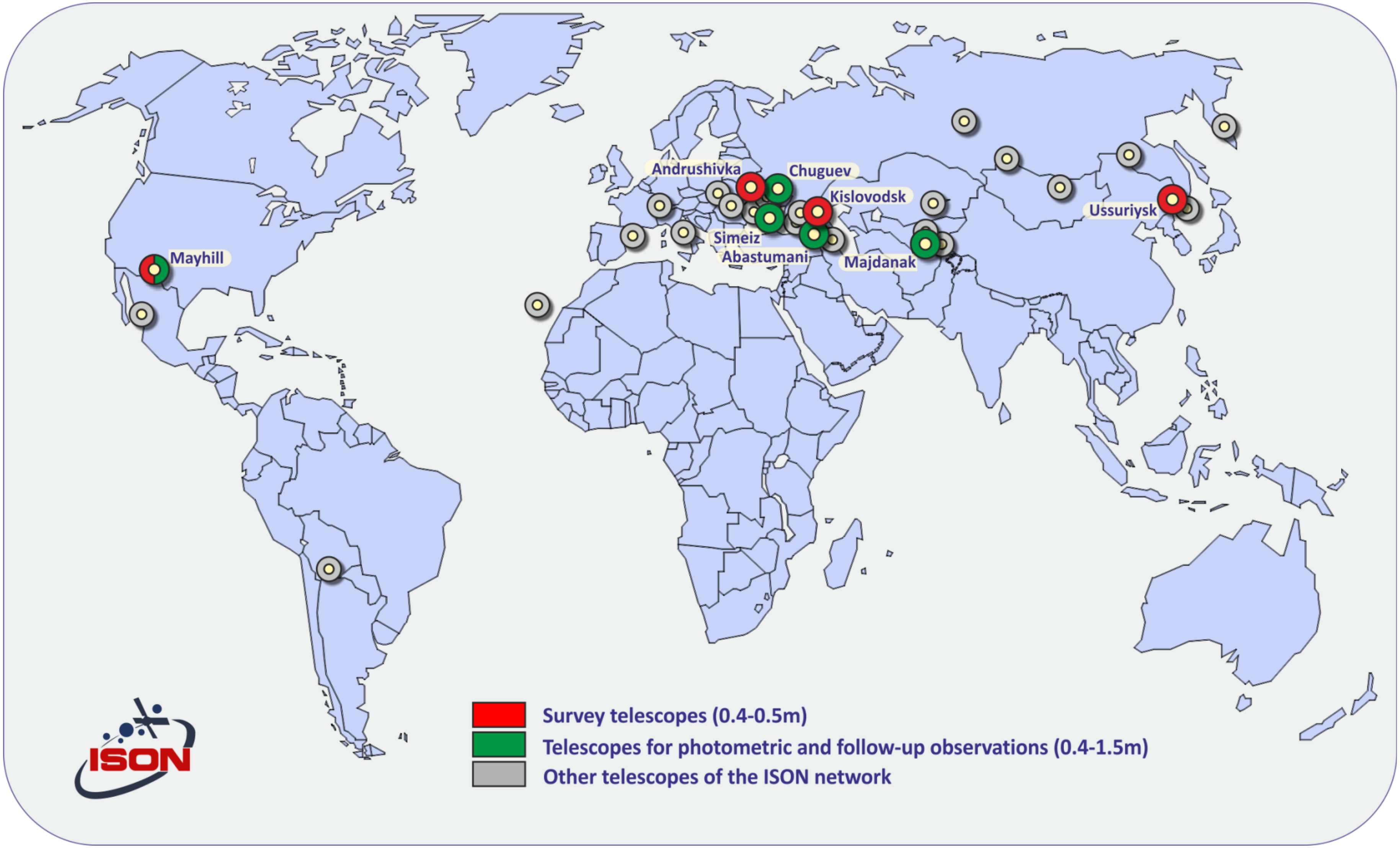
MASTER – robotic network supported by Moscow University. Major goal – alert observations of GRB.

INASAN network – just first experiments on cooperative NEO observations.

Radio experiments

Radars

ISON telescopes for NEO surveys and follow-up observations



Top 30. Number of observations in 2010-2013

№	MPC code	Observations	Objects	Discoveries	Observatory name
1.	G96	7575459	1381391	67711	Mt. Lemmon Survey
2.	703	6186338	1013872	10390	Catalina Sky Survey
3.	F51	6037423	1404446	41714	Pan-STARRS 1, Haleakala
4.	704	5628876	807335	2593	Lincoln Laboratory ETS, New Mexico
5.	C51	4008160	207099	35037	WISE
6.	691	3221788	605533	34974	Steward Observatory, Kitt Peak-Spacewatch
7.	E12	867753	199141	1260	Siding Spring Survey
8.	D29	862778	209077	825	Purple Mountain Observatory, XuYi Station
9.	I41	469350	55688	4097	Palomar Mountain--PTF
10.	J75	407501	95277	2000	OAM Observatory, La Sagra
11.	H15	406570	97704	1357	ISON-NM Observatory, Mayhill
12.	926	343311	101432	1565	Tenagra II Observatory, Nogales
13.	J43	267461	52934	1653	Oukaimeden Observatory, Marrakech
14.	645	245718	58569	7	Apache Point-Sloan Digital Sky Survey
15.	106	204623	49178	309	Crni Vrh
16.	291	180787	47795	1562	LPL/Spacewatch II
17.	J04	140559	36365	1474	ESA Optical Ground Station, Tenerife
18.	W84	110213	8518	4160	Cerro Tololo-DECam
19.	644	95804	19044	1766	Palomar Mountain/NEAT
20.	A14	92556	25962	311	Les Engarouines Observatory
21.	461	76584	17745	1495	University of Szeged, Piszkesteto Stn. (Konkoly)
22.	D00	76152	18253	95	ISON-Kislovodsk Observatory
23.	H21	69945	12736	502	Astronomical Research Observatory, Westfield
24.	A50	63394	19207	113	Andrushivka Astronomical Observatory
25.	G92	51727	13673	107	Jarnac Observatory, Vail
26.	A24	42014	6775	0	New Millennium Observatory, Mozzate
27.	A77	39351	9729	488	Observatoire Chante-Perdrix, Dauban
28.	G32	38997	5086	680	Elena Remote Observatory, San Pedro de Atacama
29.	695	38209	8149	1779	Kitt Peak
30.	807	36346	8026	10	Cerro Tololo Observatory, La Serena

ISON : results on asteroids

Hundreds of light curves were constructed for tens of NEAs

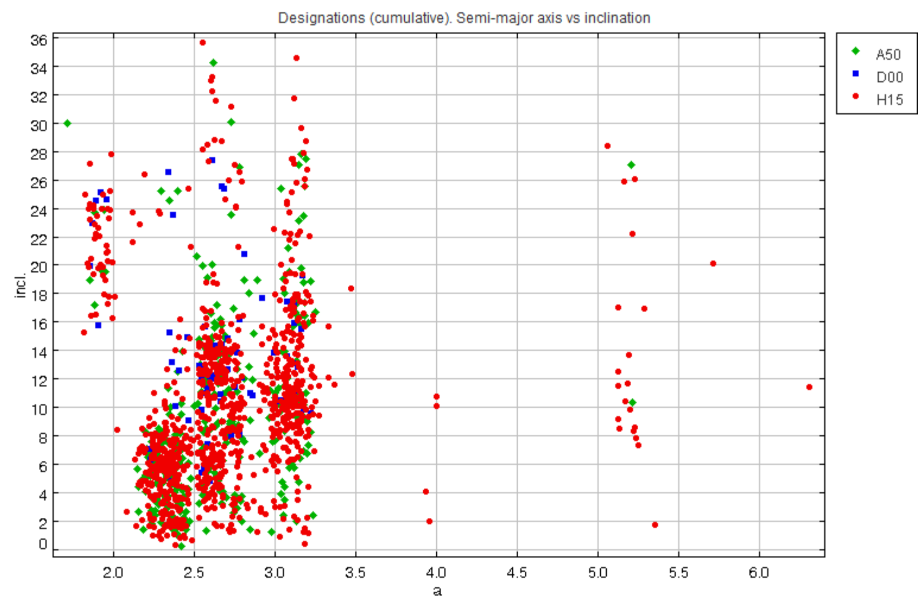
(3122) Florence, (20187) Janapittichova, (25916) 2001 CP44, (162004) 1991 VE, (7888) 1993 UC, 1998 VO, (47035) 1998 WS, 2000 WN22, 2001 WC47, 2002 GT, 2012 EG5, 2012 DX75, 2012 KP24, 2012 KT42, 2012 LZ1, 2012 QG42, 2012 TC4, 2012 DA14…

YORP-effects is estimated: (2100) Ra-Shalom и (88710) 2001 SL9

Binarity of asteroids:

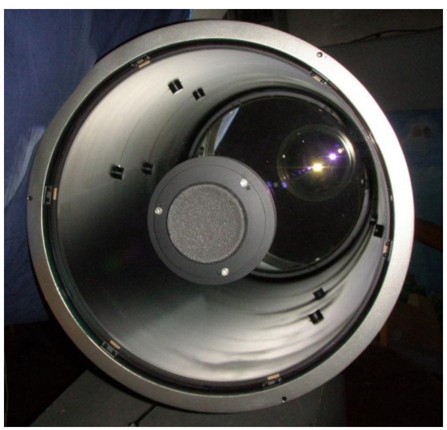
(3352) McAuliffe, (8373) Stephengould, (7888) 1993 UC, (68216) 2001 CV26, (137170) 1999 HF1, (329437) 2002 OA22, (8306) SHOKO

Discoveries: 6 comets - C/2010 X1 (Elenin), P/2011 NO1 (Elenin), **C/2012 S1 (ISON)**, C/2013 V3 (Nevski), C/2013 N4 (Borisov), C/2013 V2 (Borisov),
8 NEAs, 1500+ asteroids



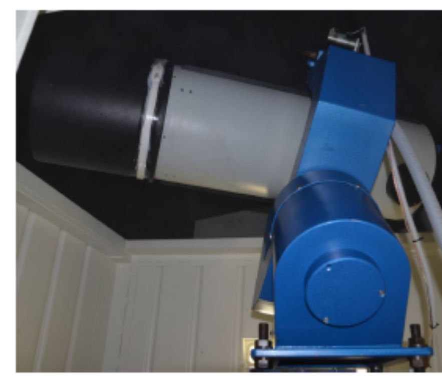
ISON : some instruments implemented for the project

ISON-NM: SANTEL-400AN, D=400 mm, f/3, FOV 106’x106’
CCD – FLI ML09000-65



50-cm telescope ORI-50 in Andrushivka (Ukraine)

Kislovodsk observatory
(25-cm, 2x20 cm and 40-cm telescopes)



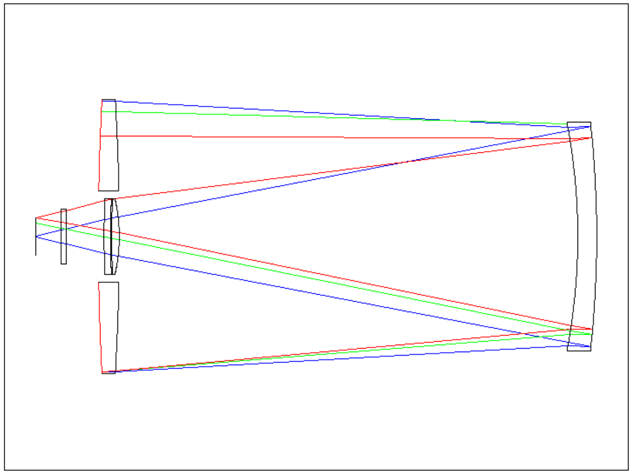
SANTEL-400AN, D=400 mm, f/3, FOV 106’x106’
CCD – FLI ML09000-65

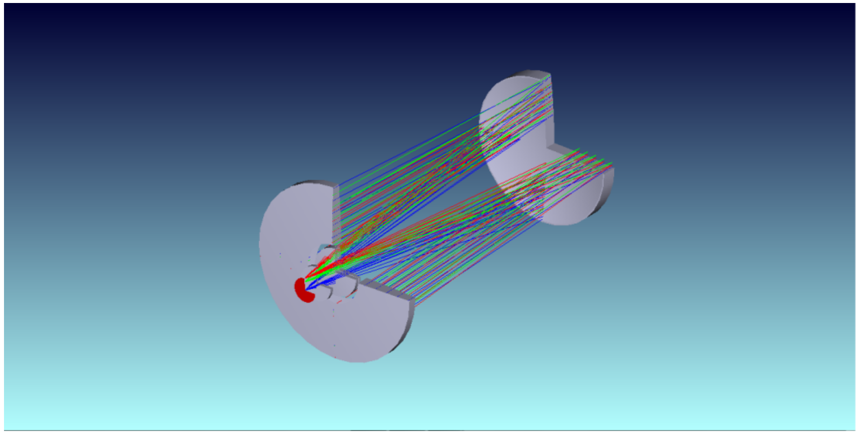
New telescopes

SANTEL-650A
(Ussuriisk)

0.65-m f/2 + FLI PL4301

FOV 2.2° x 2.2°





Perspective very large field survey system

4 x VT78e (Genon)

0.19-m f/1.54

Overall FOV - 14° x 14°
Limiting mag. in survey mode - 18^m

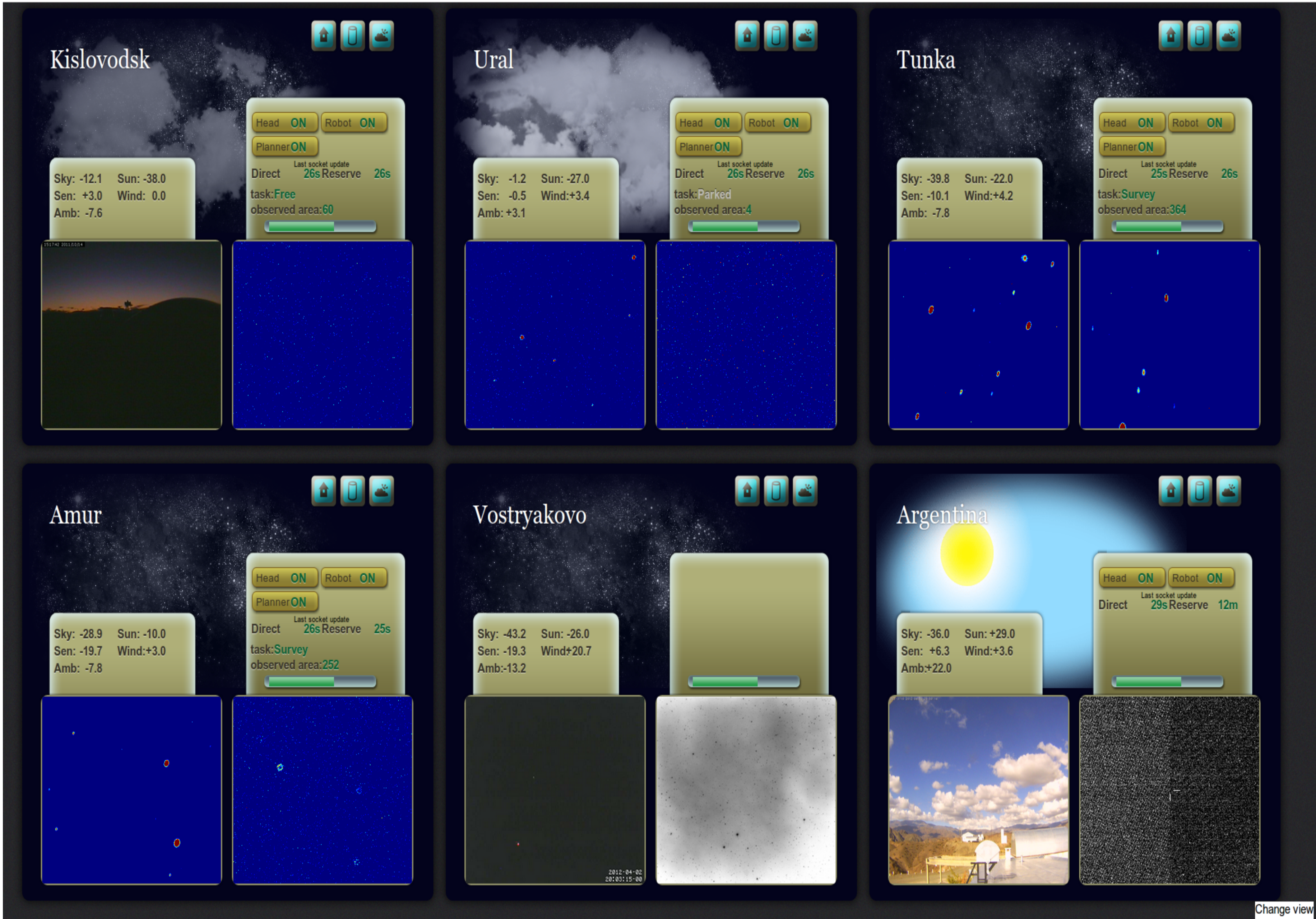
MASTER Robotic Net

Moscow State University

Total FOV= 32 Square Degrees up to 20 mag, 1500 square degrees per night

D=400 mm, D/F = 1:2.5

Master: Real Time Video Conrol



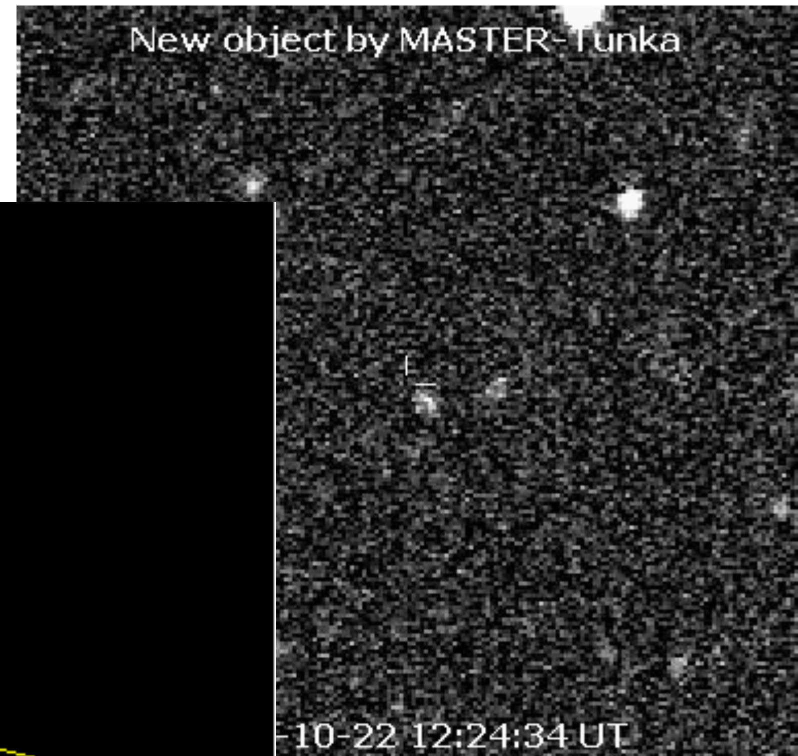
After Chelyabinsk event MASTER changed the survey strategy.

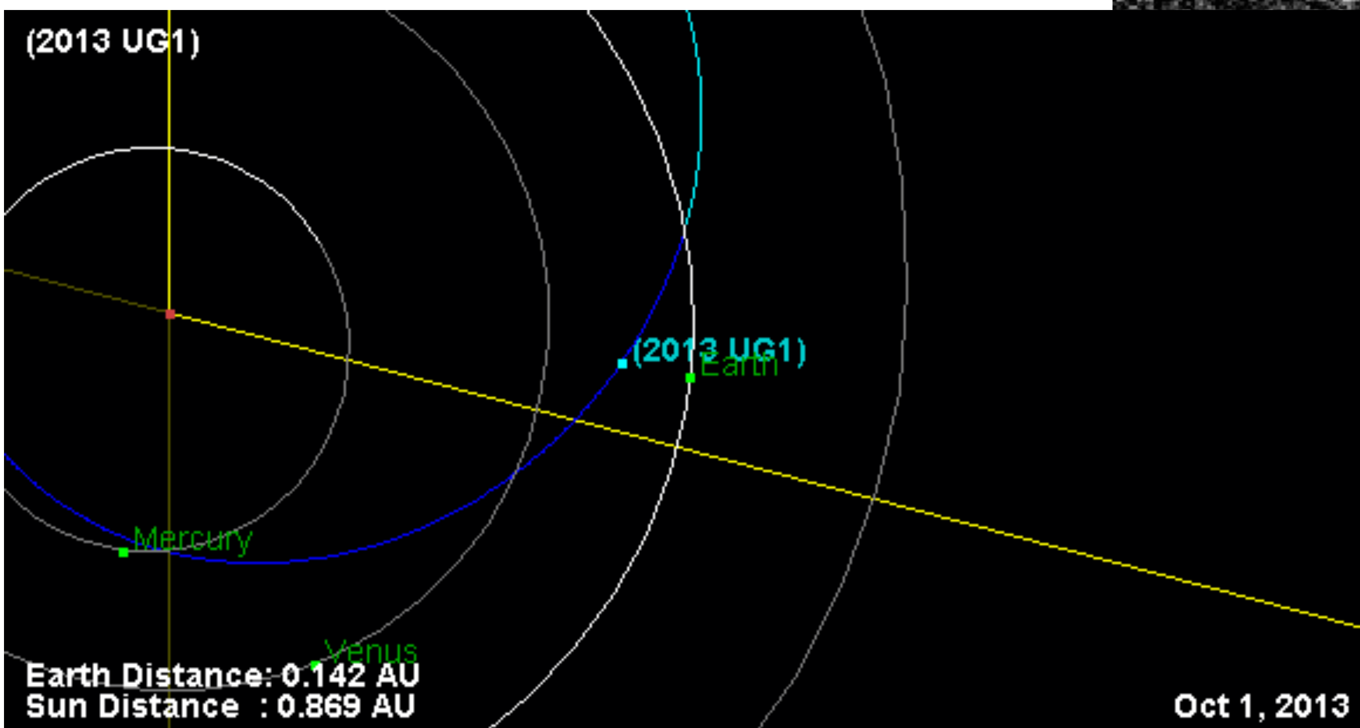
13928 minor planet observations by MASTER have been reported to MPC.

2 Potentially Hazardous Asteroids (PHAs)
have been discovered since September 2013

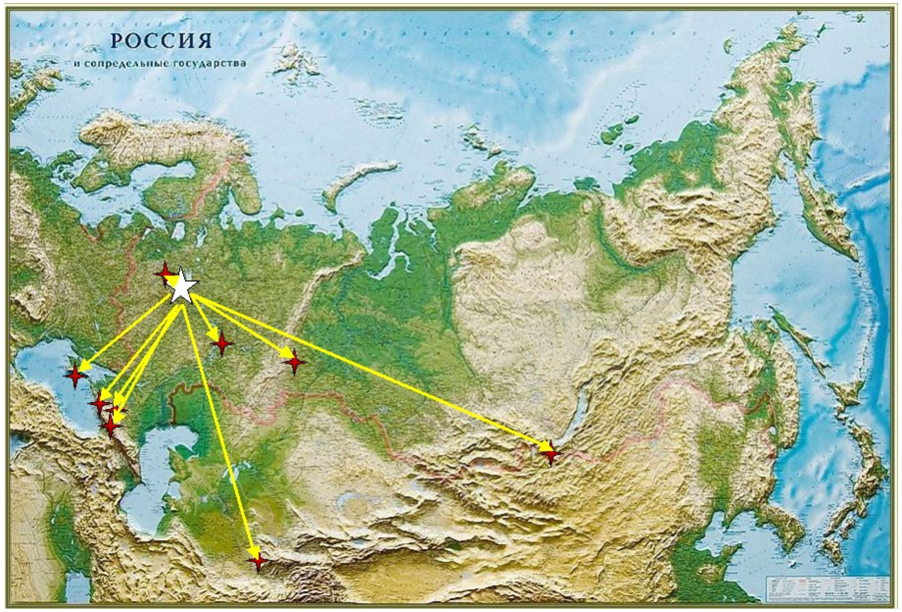
PHA 2013 UG1 was discovered by MASTER-Tunka 22 Oct 2013.

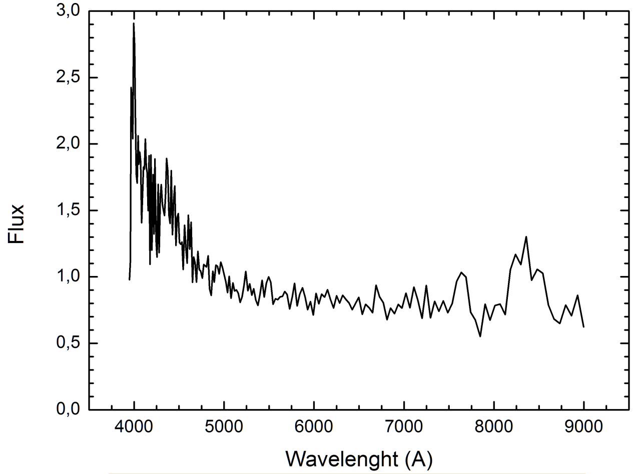
H~ 22.3, Diameter ~ 135 m





INASAN cooperation of observatories of Russia and near countries

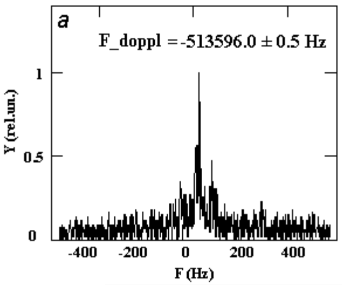


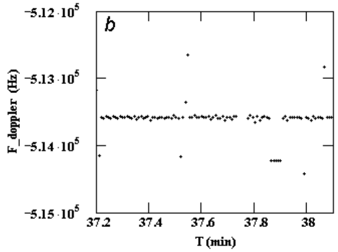


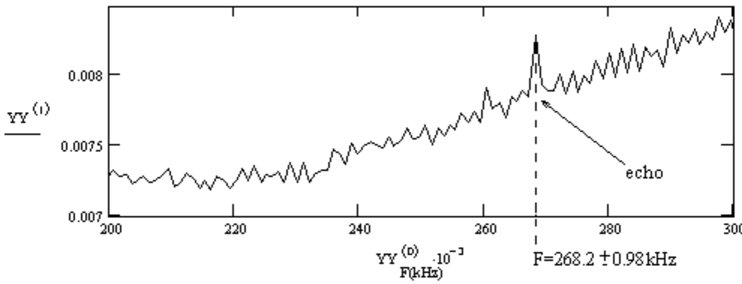
Two campaigns were completed in 2013 with 0.5 – 6 m telescopes of 11 observatories

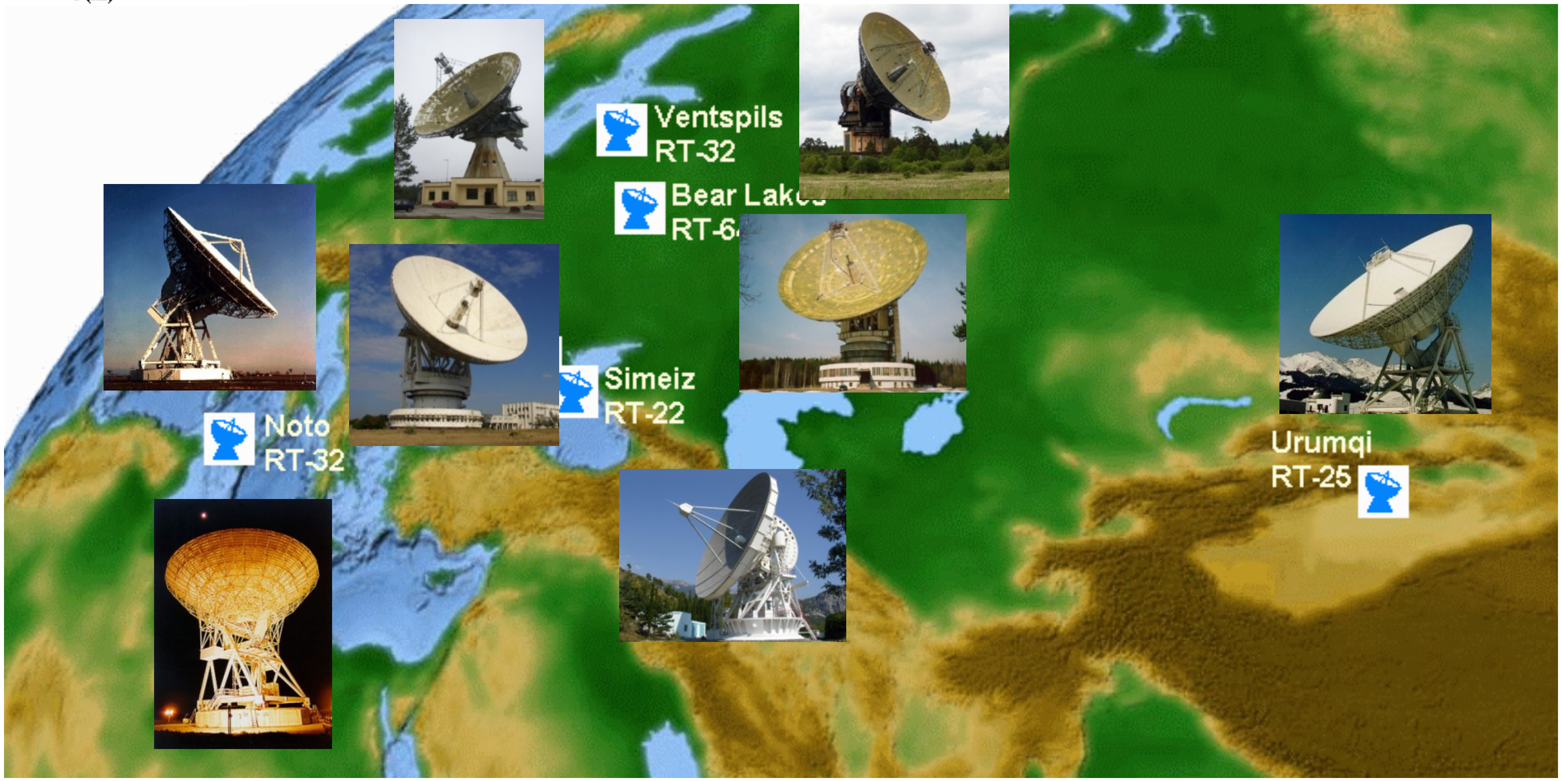
Spectrum of asteroid 2010 CF19 was obtained with Zeiss-2000 (TF INASAN)

Radiolocation of asteroid with RT-70









Premises: data centers

There work local data centers on NEO topic

- Institute of applied astronomy RAS
- Main (Pulkovo) Observatory RAS
- Institute of applied mathematics RAS
- Institute of astronomy RAS
- Tomsk University

Premises: organizational issues

In November 2012 Roscosmos gave start of systemic approach to elaboration of program of construction the **system of detection and monitoring** of dangerous objects (space debris and NEOs).

Two major partners:

- Roscosmos - for space debris
- RAS & universities - for ground based facilities for detection and studies of NEOs.

Roscosmos is considered either to be in charge for all the NEO related space missions. This seems to be the first and most important step to the construction of a national system.

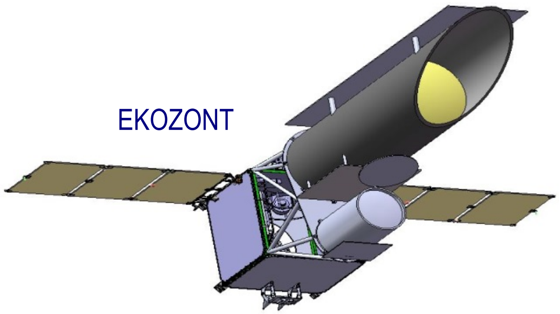
Plans

1. To complete AZT 33 VM – 2017

2. To establish National (sub)Center for NEO research - 2017

3. To have a series of new ground based instrument, Including multi-aperture systems - 2019

4. To implement Space telescope for NEO search program - 2021



See for details :
B.Shustov et al., A Concept of a Space Hazard Counteraction System: Astronomical Aspects, *Solar System Research, 2013, Vol. 47, No. 4, pp. 302–314.*

How to contribute to the IAWN

1. To establish national NEO center.
2. National center will work as intellectual node of MPC and NEODyS. It is required to determine interoperability standards.
3. To move from international recommendations to agreements on IAWN.
4. more

IAWN: time to work together!