On the Russian contribution to the IAWN

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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** - \( \text{MOID} < 0.05 \text{ A.U.} \)

**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 \( L_D = 10^6 \text{ km} \) 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 \( t_w \). \( t_w \sim 30 \) 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 \( \sim 2 \) m class wide field ground based telescopes and/or few \( \sim 1 \) 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 \((t_w)\). \(t_w \sim 5^h\).

- \(V\) typically 20 km/s.

- Limiting magnitude \(V < 18-19\)

- A properly located system of \(~ 0.5 \text{ m}~\) aperture wide field telescopes required (in visual domain). Whole sky should be surveyed in hours!

The mode requires for system of reasonable number of \(~ 0.5 \text{ m}~\) class wide field telescopes. Only including of space telescopes meets requirement of surveying the “whole sky”.

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**

<table>
<thead>
<tr>
<th>Spectral range</th>
<th>400-1100 nm</th>
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</thead>
<tbody>
<tr>
<td>F</td>
<td>5600 mm</td>
</tr>
<tr>
<td>focal ratio</td>
<td>1 : 3.5</td>
</tr>
<tr>
<td>$2\omega$</td>
<td>$2.8^0$</td>
</tr>
<tr>
<td>$2\gamma'$</td>
<td>277 mm</td>
</tr>
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</table>
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

<table>
<thead>
<tr>
<th>№</th>
<th>MPC code</th>
<th>Observations</th>
<th>Objects</th>
<th>Discoveries</th>
<th>Observatory name</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>G96</td>
<td>7575459</td>
<td>1381391</td>
<td>67711</td>
<td>Mt. Lemmon Survey</td>
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<td>2.</td>
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<td>1013872</td>
<td>10390</td>
<td>Catalina Sky Survey</td>
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<td>3.</td>
<td>F51</td>
<td>6037423</td>
<td>1404446</td>
<td>41714</td>
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<td>4.</td>
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<td>5628876</td>
<td>807335</td>
<td>2593</td>
<td>Lincoln Laboratory ETS, New Mexico</td>
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<td>5.</td>
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<td>207099</td>
<td>35037</td>
<td>WISE</td>
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<td>6.</td>
<td>691</td>
<td>3221788</td>
<td>605533</td>
<td>34974</td>
<td>Steward Observatory, Kitt Peak-Spacewatch</td>
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<tr>
<td>7.</td>
<td>E12</td>
<td>867753</td>
<td>199141</td>
<td>1260</td>
<td>Siding Spring Survey</td>
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<tr>
<td>8.</td>
<td>D29</td>
<td>862778</td>
<td>209077</td>
<td>825</td>
<td>Purple Mountain Observatory, XuYi Station</td>
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<td>9.</td>
<td>I41</td>
<td>469350</td>
<td>55688</td>
<td>4097</td>
<td>Palomar Mountain--PTF</td>
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<td>10.</td>
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<td>407501</td>
<td>95277</td>
<td>2000</td>
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<td>11.</td>
<td>H15</td>
<td>406570</td>
<td>97704</td>
<td>1357</td>
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<td>12.</td>
<td>926</td>
<td>343311</td>
<td>101432</td>
<td>1565</td>
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<td>13.</td>
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<td>267461</td>
<td>52934</td>
<td>1653</td>
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<td>14.</td>
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<td>58569</td>
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<td>Apache Point-Sloan Digital Sky Survey</td>
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<td>4160</td>
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<td>19044</td>
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<td>25962</td>
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<td>76584</td>
<td>17745</td>
<td>1495</td>
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<tr>
<td>22.</td>
<td>D00</td>
<td>76152</td>
<td>18253</td>
<td>95</td>
<td>ISON-Kislovodsk Observatory</td>
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<tr>
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<td>69945</td>
<td>12736</td>
<td>502</td>
<td>Astronomical Research Observatory, Westfield</td>
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<tr>
<td>24.</td>
<td>A50</td>
<td>63394</td>
<td>19207</td>
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<tr>
<td>25.</td>
<td>G92</td>
<td>51727</td>
<td>13673</td>
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<tr>
<td>26.</td>
<td>A24</td>
<td>42014</td>
<td>6775</td>
<td>0</td>
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<tr>
<td>27.</td>
<td>A77</td>
<td>39351</td>
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<td>488</td>
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<td>G32</td>
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<td>680</td>
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<td>38209</td>
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<td>1779</td>
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<tr>
<td>30.</td>
<td>807</td>
<td>36346</td>
<td>8026</td>
<td>10</td>
<td>Cerro Tololo Observatory, La Serena</td>
</tr>
</tbody>
</table>
ISON: results on asteroids

Hundreds of light curves were constructed for tens of NEAs
(3122) Florence, (20187) Janapittichova, (25916) 2001 CP44, (162004) 1991 VE,
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

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

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

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 - 18m
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 Control
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
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
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.
Astronomical requirements for NEO detection/monitoring

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:
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!