29th IADC Meeting, Apr 11-14, 2011

Berlin, Germany

Automation of development of GEO and HEO region survey strategies - implementation for faint space debris surveys

Presentation of the Roscosmos delegation to the IADC WG1

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Instruments for GEO Surveys

- Typical 22 cm and 25 cm aperture telescopes
  FOV – from 2.8°x2.8° to 5.5°x5.5°

- Facilities having survey instruments

  Blagoveshchensk, Collepardo, Milkovo, Nauchny, Pulkovo, Tarija, Ussuriysk

- New instruments with 40 and 50 cm aperture

- Different strategies are required due to different performances of telescopes

First step – analysis of observation circumstances and selection of fields

Observation constrains:

- night time only (defined by the Sun elevation)
- minimal acceptable observing objects elevation
- Moon phase and Moon/Jupiter angular distance
- shadow position
- phase angle or/and estimated brightness
- Milky Way position

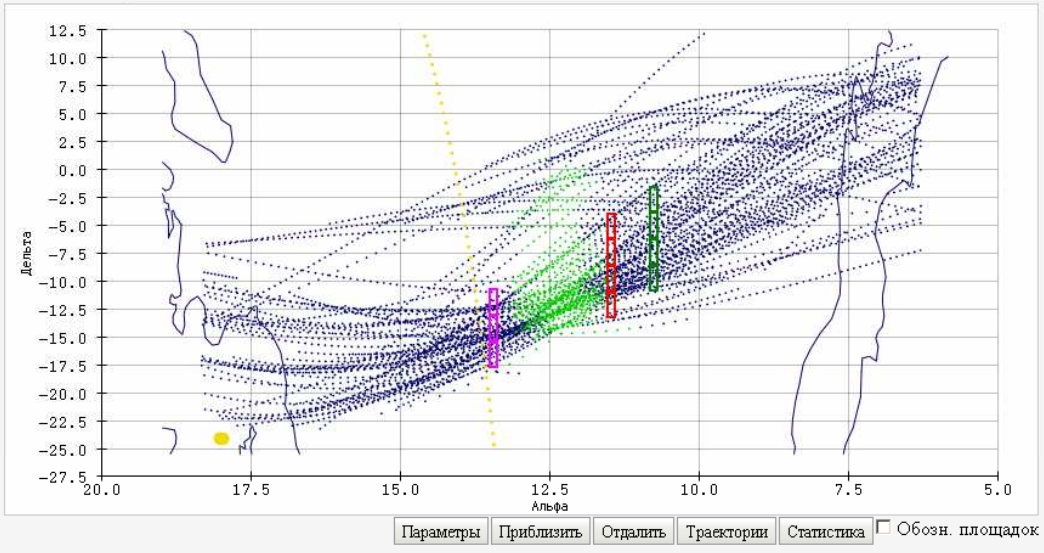
Fields selection:

- selection of groups with the same RA, defining range of DECL, defining field overlapping (%) within one group
- defining relative positions of the groups
- rise/set check
- expected number of known of objects crossing each field during the night

First step – analysis of observation circumstances and selection of fields

Обзор на интервале: 25/03/2011 12:00:00 - 26/03/2011 12:00:00 ИП: 10533 KRRS220_AT

Альфа/Дельта



Параметры | Приблизить | Отдалить | Траектории | Статистика | Обозн. площадок

Начало ночи (-12°):	25/03/2011 17:03:53 UTC
Полночь:	25/03/2011 21:47:53 UTC
Конец ночи (-12°):	26/03/2011 02:31:53 UTC
Длительность ночи, ч:	9.47
Восход луны (0°):	25/03/2011 23:04:15 UTC
Заход луны (0°):	Над горизонтом
Фаза Луны:	56%

Альфа:	07:34:52
Дельта:	-06:31:18
Восход:	Над горизонтом
Заход:	25/03/2011 21:41:32
Расст. до Луны,°:	141
Расст. до Юпитера,°:	101
Расст. до Венеры,°:	139
ЧУ,ч	

Группы | Площадки | Порядок обхода

	#	ID	Об.	RA	DEC	vRA	vDEC	sVRA	sVDEC	Разм.	Восход	Заход	d.Л.
	1	0::0	15/14%	11.455	-12.174	16.230	-2.460	4.229	1.407	2.4x2.4	Над гор.	26-01:07:41	91
	2	0::1	38/35%	11.455	-9.798	15.150	-2.771	2.424	0.978	2.4x2.4	Над гор.	26-01:19:05	92
	3	0::2	16/15%	11.455	-7.422	14.541	-3.685	3.322	0.782	2.4x2.4	Над гор.	26-01:29:58	93
	4	0::3	12/11%	11.455	-5.046	14.603	-3.754	1.076	1.263	2.4x2.4	Над гор.	26-01:40:26	94
	1	1::0	20/19%	13.427	-16.630	14.914	-2.817	1.763	0.540	2.4x2.4	25-19:10:13	Над гор.	62
	2	1::1	38/35%	13.427	-14.254	15.863	-2.093	2.877	1.182	2.4x2.4	25-18:57:30	Над гор.	63
	3	1::2	18/17%	13.427	-11.878	14.971	-2.194	2.465	1.533	2.4x2.4	25-18:45:33	Над гор.	64
	1	2::0	25/23%	10.744	-9.783	15.393	-2.475	3.160	1.167	2.4x2.4	Над гор.	26-00:36:29	101
	2	2::1	26/24%	10.744	-7.407	15.540	-3.181	3.474	0.851	2.4x2.4	Над гор.	26-00:47:21	102
	3	2::2	16/15%	10.744	-5.031	13.662	-3.709	1.636	0.543	2.4x2.4	Над гор.	26-00:57:49	103
	4	2::3	10/9%	10.744	-2.655	14.257	-3.574	1.754	1.484	2.4x2.4	Над гор.	26-01:07:56	104

Second step – definition of fields observation order and start/end conditions

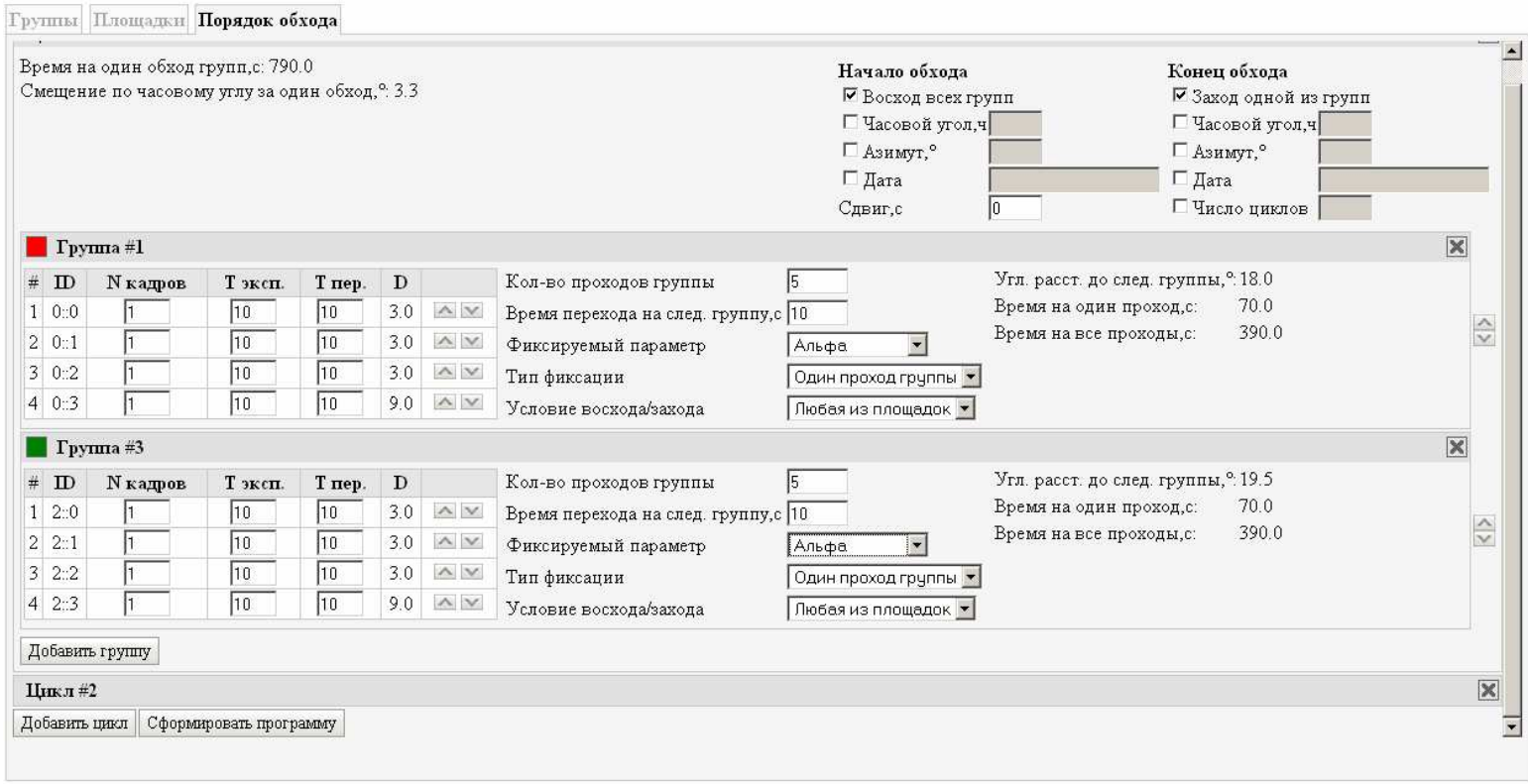
Fields observation order:

- groups ordering and fields ordering within each group
- rules of fields imaging (RA fixed, HA fixed, number of images per field)
- definition of a cycle and a sequence

Start/end conditions:

- one specific (or any) field of some (or any) group violates predefined elevation, RA, HA, Az or Moon distance constraint
- start/end of the night
- number of cycles

Second step – definition of fields observation order and start/end conditions (cont.)



Third step – program calculation and visualization of calculated survey strategy

Results of program calculation:

- formalized description of a survey using special scripting language

```
BEGIN LOOP SUN=-12 OFFSET=0 ELV=10
BLOCK=1 SETNUM=5 FIXPRM=HA RA=11.1158(15.04107) DECL=-5.000
BLOCK=3 SETNUM=5 FIXPRM=HA RA=10.0211(15.04107) DECL=-3.448
END LOOP SUN=-12 ELV=10
BEGIN LOOP SUN=-12 OFFSET=0 ELV=10
BLOCK=2 SETNUM=15 FIXPRM=HA RA=13.4526(15.04107) DECL=-6.724
END LOOP SUN=-12 ELV=10
```

- detailed description of complete sequence of imaging fields
- program for the mount and CCD control software
- visualization of developed survey strategy

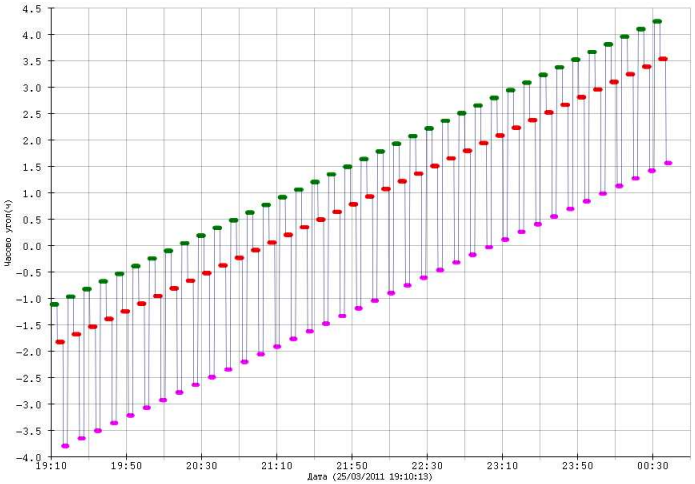
Third step – program calculation and visualization of calculated survey strategy (cont.)

Описание | **Программа** | Программа(Хаос) | Часовой угол/Время | Альфа/Время | Дельта/Время | Часовой угол/Дельта | Альфа/Дельта | Угол места/Азимут

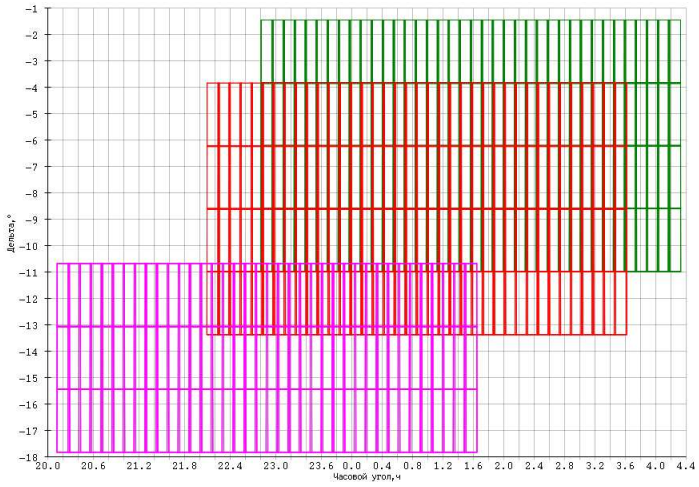
#	пл.	ч.у.	альфа	дельта	у.м.	азимут	эксп.	начало	конец	Vальфа	Vдельта	SVальфа	SVдельта	Р.Лун.	Р.[illegible]
00000	0::0	202414.64	110656.84	-045960.00	020.8	120.5	01x10	25/03/2011 17:03:53	25/03/2011 17:04:03	00014.773	-0001.226	00000.613	00001.805	098.3	15
00001	0::1	202414.64	110716.90	-015960.00	023.2	118.5	01x10	25/03/2011 17:04:13	25/03/2011 17:04:23	00014.572	-0002.507	00000.680	00001.775	099.5	15
00002	0::2	202414.64	110736.95	+010000.00	025.5	116.5	01x10	25/03/2011 17:04:33	25/03/2011 17:04:43	00014.897	-0002.001	00000.328	00001.376	100.6	15
00003	0::3	202414.64	110757.01	+040000.00	027.8	114.3	01x10	25/03/2011 17:04:53	25/03/2011 17:05:03	00014.956	-0001.909	00000.708	00000.715	101.8	15
00004	0::0	202534.86	110656.84	-045960.00	021.0	120.8	01x10	25/03/2011 17:05:13	25/03/2011 17:05:23	00014.773	-0001.226	00000.613	00001.805	098.3	15
00005	0::1	202534.86	110716.90	-015960.00	023.4	118.8	01x10	25/03/2011 17:05:33	25/03/2011 17:05:43	00014.572	-0002.507	00000.680	00001.775	099.5	15
00006	0::2	202534.86	110736.95	+010000.00	025.7	116.8	01x10	25/03/2011 17:05:53	25/03/2011 17:06:03	00014.897	-0002.001	00000.328	00001.376	100.6	15
00007	0::3	202534.86	110757.01	+040000.00	028.0	114.6	01x10	25/03/2011 17:06:13	25/03/2011 17:06:23	00014.956	-0001.909	00000.708	00000.715	101.8	15
00008	0::0	202655.07	110656.84	-045960.00	021.2	121.1	01x10	25/03/2011 17:06:33	25/03/2011 17:06:43	00014.773	-0001.226	00000.613	00001.805	098.3	15
00009	0::1	202655.07	110716.90	-015960.00	023.6	119.1	01x10	25/03/2011 17:06:53	25/03/2011 17:07:03	00014.572	-0002.507	00000.680	00001.775	099.5	15
00010	0::2	202655.07	110736.95	+010000.00	025.9	117.0	01x10	25/03/2011 17:07:13	25/03/2011 17:07:23	00014.897	-0002.001	00000.328	00001.376	100.6	15
00011	0::3	202655.07	110757.01	+040000.00	028.3	114.9	01x10	25/03/2011 17:07:33	25/03/2011 17:07:43	00014.956	-0001.909	00000.708	00000.715	101.8	15
00012	0::0	202815.29	110656.84	-045960.00	021.4	121.4	01x10	25/03/2011 17:07:53	25/03/2011 17:08:03	00014.773	-0001.226	00000.613	00001.805	098.3	15
00013	0::1	202815.29	110716.90	-015960.00	023.8	119.4	01x10	25/03/2011 17:08:13	25/03/2011 17:08:23	00014.572	-0002.507	00000.680	00001.775	099.5	15
00014	0::2	202815.29	110736.95	+010000.00	026.2	117.3	01x10	25/03/2011 17:08:33	25/03/2011 17:08:43	00014.897	-0002.001	00000.328	00001.376	100.6	15
00015	0::3	202815.29	110757.01	+040000.00	028.5	115.2	01x10	25/03/2011 17:08:53	25/03/2011 17:09:03	00014.956	-0001.909	00000.708	00000.715	101.8	15
00016	0::0	202935.51	110656.84	-045960.00	021.7	121.7	01x10	25/03/2011 17:09:13	25/03/2011 17:09:23	00014.773	-0001.226	00000.613	00001.805	098.3	15
00017	0::1	202935.51	110716.90	-015960.00	024.0	119.7	01x10	25/03/2011 17:09:33	25/03/2011 17:09:43	00014.572	-0002.507	00000.680	00001.775	099.5	15
00018	0::2	202935.51	110736.95	+010000.00	026.4	117.6	01x10	25/03/2011 17:09:53	25/03/2011 17:10:03	00014.897	-0002.001	00000.328	00001.376	100.6	15
00019	0::3	202935.51	110757.01	+040000.00	028.7	115.5	01x10	25/03/2011 17:10:13	25/03/2011 17:10:23	00014.956	-0001.909	00000.708	00000.715	101.8	15
00020	2::0	213636.78	100115.79	-032653.79	032.2	136.4	01x10	25/03/2011 17:10:33	25/03/2011 17:10:43	00014.648	-0001.906	00000.758	00001.923	113.6	13
00021	2::1	213636.78	100135.84	-002653.79	034.8	134.6	01x10	25/03/2011 17:10:53	25/03/2011 17:11:03	00014.809	-0001.547	00000.493	00001.878	114.9	13
00022	2::2	213636.78	100155.90	+023306.21	037.4	132.7	01x10	25/03/2011 17:11:13	25/03/2011 17:11:23	00014.900	-0002.040	00000.367	00001.568	116.2	13
00023	2::3	213636.78	100215.95	+053306.21	039.9	130.6	01x10	25/03/2011 17:11:33	25/03/2011 17:11:43	00015.090	-0001.572	00000.376	00000.889	117.4	13
00024	2::0	213757.00	100115.79	-032653.79	032.4	136.7	01x10	25/03/2011 17:11:53	25/03/2011 17:12:03	00014.648	-0001.906	00000.758	00001.923	113.6	13
00025	2::1	213757.00	100135.84	-002653.79	035.0	134.9	01x10	25/03/2011 17:12:13	25/03/2011 17:12:23	00014.809	-0001.547	00000.493	00001.878	114.9	13
00026	2::2	213757.00	100155.90	+023306.21	037.5	133.0	01x10	25/03/2011 17:12:33	25/03/2011 17:12:43	00014.900	-0002.040	00000.367	00001.568	116.2	13
00027	2::3	213757.00	100215.95	+053306.21	040.1	131.0	01x10	25/03/2011 17:12:53	25/03/2011 17:13:03	00015.090	-0001.572	00000.376	00000.889	117.4	13
00028	2::0	213917.22	100115.79	-032653.79	032.5	137.1	01x10	25/03/2011 17:13:13	25/03/2011 17:13:23	00014.648	-0001.906	00000.758	00001.923	113.6	13
00029	2::1	213917.22	100135.84	-002653.79	035.1	135.3	01x10	25/03/2011 17:13:33	25/03/2011 17:13:43	00014.809	-0001.547	00000.493	00001.878	114.9	13
00030	2::2	213917.22	100155.90	+023306.21	037.7	133.4	01x10	25/03/2011 17:13:53	25/03/2011 17:14:03	00014.900	-0002.040	00000.367	00001.568	116.2	13
00031	2::3	213917.22	100215.95	+053306.21	040.3	131.3	01x10	25/03/2011 17:14:13	25/03/2011 17:14:23	00015.090	-0001.572	00000.376	00000.889	117.4	13
00032	2::0	214037.44	100115.79	-032653.79	032.7	137.4	01x10	25/03/2011 17:14:33	25/03/2011 17:14:43	00014.648	-0001.906	00000.758	00001.923	113.6	13
00033	2::1	214037.44	100135.84	-002653.79	035.3	135.6	01x10	25/03/2011 17:14:53	25/03/2011 17:15:03	00014.809	-0001.547	00000.493	00001.878	114.9	13
00034	2::2	214037.44	100155.90	+023306.21	037.9	133.7	01x10	25/03/2011 17:15:13	25/03/2011 17:15:23	00014.900	-0002.040	00000.367	00001.568	116.2	13

Third step – program calculation and visualization of calculated survey strategy (cont.)

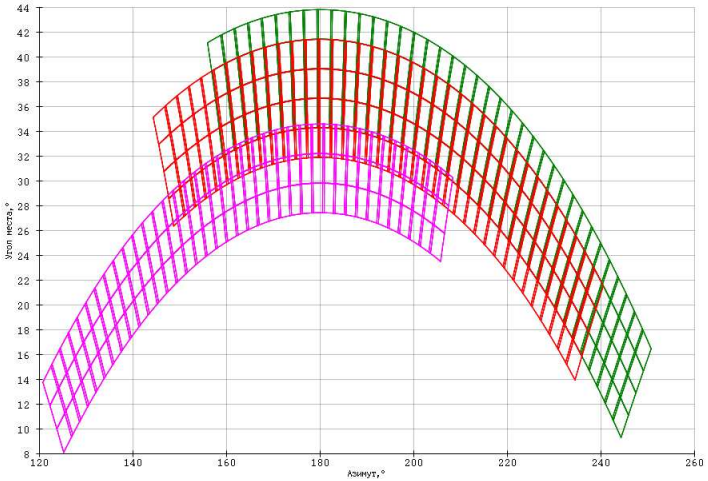
HA vs. Time



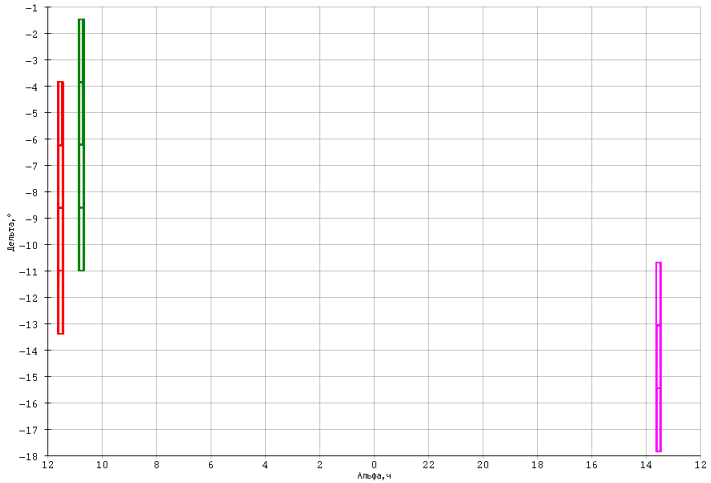
DECL vs. HA



Elev vs. Az

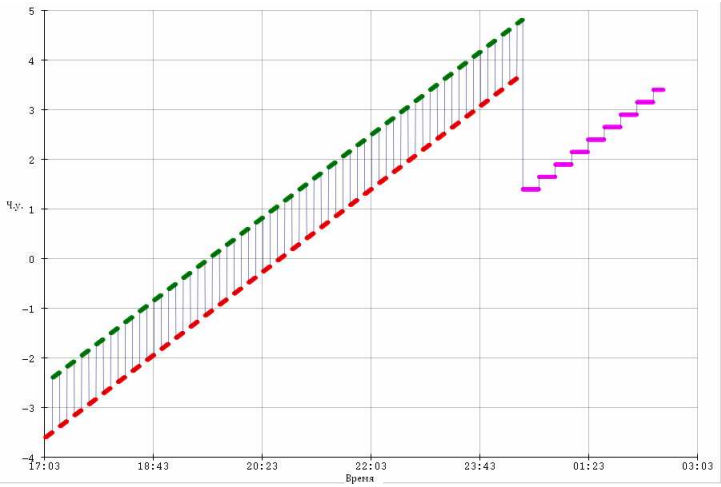


RA vs. Time

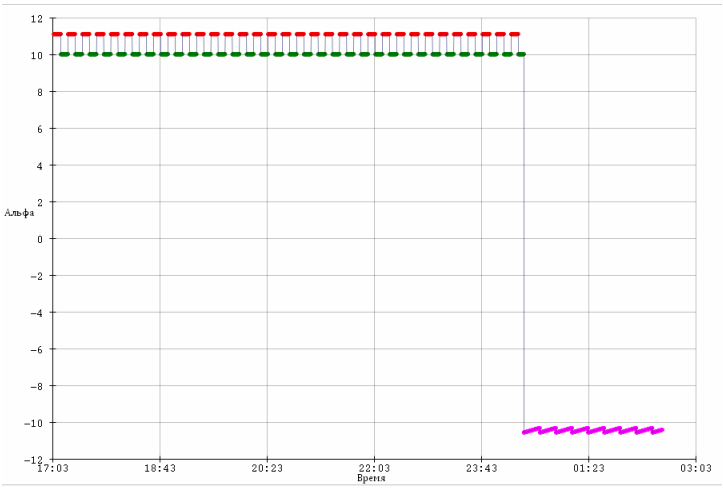


Third step – program calculation and visualization of calculated survey strategy (cont.)

HA vs. Time

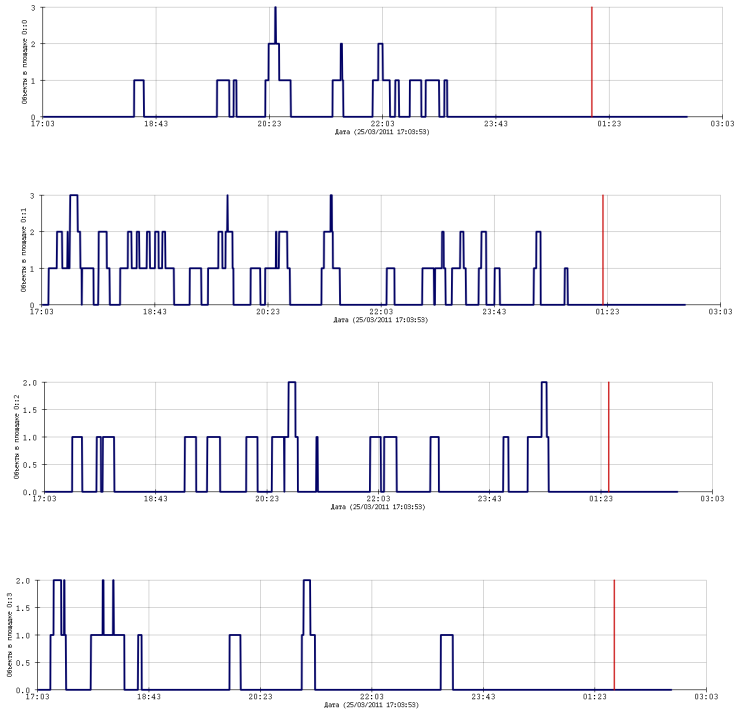


RA vs. Time

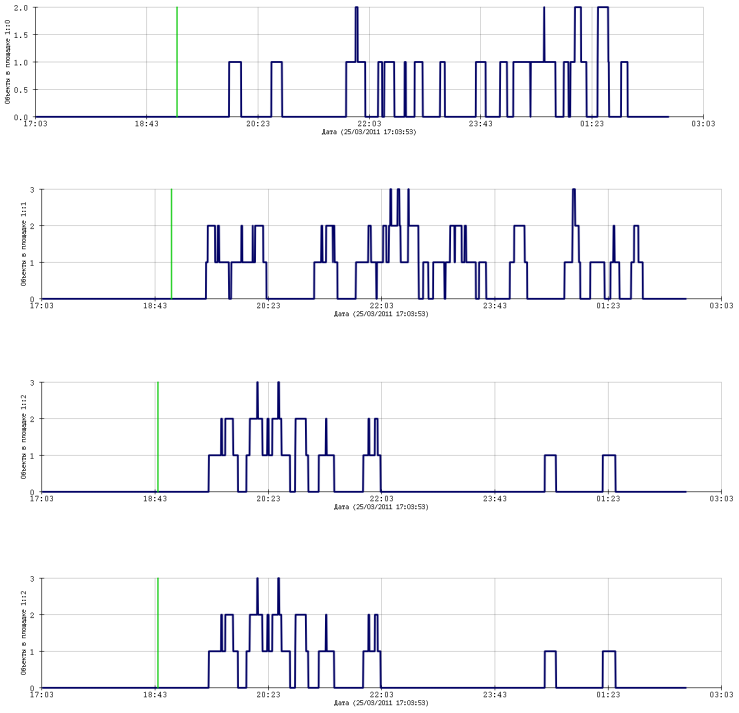


Third step – program calculation and visualization of calculated survey strategy (cont.)

Number of know objects expected to appear in the FOV. Group 0



Number of know objects expected to appear in the FOV. Group 1



Fourth step – estimation of expected formal accuracy of orbits using obtained tracks

Grouping ‘measurements’ for known objects ‘detected’ in the fields

Making OD for each orbit

Estimation of formal accuracy of orbits at the time of the last measurement (using covariance)

Propagation of the covariance to the next night

Conclusions

A powerful software tool in support of GEO and HEO surveys planning is developed.

Strategies on any level of complexity can be checked from the different points of view.

Observers do not need anymore to constrain themselves with just some ‘traditional’ approaches and are capable to develop own strategies better taking into account peculiarities of a specific observation instrument or specific group of studied objects.

Different strategies can be compared in terms of accuracy of orbit.