Prediction of motion

To perform the service "Prediction of satellites motion", the user must prepare the input file ("TLE_ini.txt") containing the TLE set for a previous time interval.

Example of such file is as follows:

```
1 35865U 09049A   09263.18836766 .00000176 00000-0 10000-3 0    50
2 35865 098.8007 313.3591 0003564 077.3801 282.7795 14.21824067   353
1 35865U 09049A   09263.68096973 +.00000176 +00000-0 +10000-3 0 00075
2 35865 098.8007 313.8501 0003584 074.1254 286.0304 14.21824264000428
1 35865U 09049A   09264.66617459 .00000176 00000-0 10000-3 0    61
2 35865 098.8010 314.8326 0003553 071.4378 288.7185 14.21824773   567
1 35865U 09049A   09265.58100732 +.00000176 +00000-0 +10000-3 0 00097
2 35865 098.8005 315.7444 0003490 068.8840 291.2717 14.21825238000697
1 35865U 09049A   09266.00323756 .00000176 00000-0 10000-3 0    76
2 35865 098.8004 316.1656 0003476 067.7453 292.4070 14.21825238   750
1 35865U 09049A   09266.77732717 +.00000176 +00000-0 +10000-3 0 00105
2 35865 098.8003 316.9374 0003459 066.1413 294.0126 14.21825459000861
1 35865U 09049A   09267.76253122 .00000176 00000-0 10000-3 0    80
2 35865 098.8003 317.9196 0003392 063.6114 296.5400 14.21825734  1005
1 35865U 09049A   09268.74773547 +.00000176 +00000-0 +10000-3 0 00111
2 35865 098.8001 318.9020 0003361 059.7753 300.3748 14.21826020001144
```

In this case the file contains 8 TLE sets. The last TLE set relates to the initial time of prediction. The user should understand, to which calendar time these data relate. Of course, the number of TLE sets should be not less than 1. As a rule, the number of TLE sets should be not more than 40.

In the simplest mode, the last TLE set is used as the initial data, and the SGP4 model of motion is applied. It is this mode that is implemented currently. In the future we plan to add the mode "Determination of initial data with using previous TLE" and to use the numerical model of motion.

The forecast is performed for future instants with time intervals not longer than a month. The data on these instants consist of three user's values: the data about the start and end time, as well as about the step.

1.	Start time: YMDHMS (time unit) or the revolution number counted from the last TLE set
2.	End time: YMDHMS (time unit) or the revolution number counted from the last TLE set.
3.	Step: in time (min) or in revolutions.

At this stage of the site designing the listed initial data are included into the text of user's letter.

Two forms are provided for representation of results:

- Components of the 6-dimensional state vector ("RV") in the Geocentric Equatorial Coordinate (true-equator, mean-equinox) System;

- Set of orbital elements ("EL").

The first form ("RV") is applied for representing the results at this stage of site designing. The example of prediction results is presented in table 1. Explanations are given in italics.

Table 1. Content of the output file "RVoutput.dat"

№	*Время*	*x km*	*y km*	*z km*	*Vx km/sec*	*Vy km/sec*	*Vz km/sec*
0	14946.94175175	-7158.1895	1490.9296	0.0212	-1.50433621	-6.06500788	3.82053864
1	14946.94869619	-6753.1431	-2195.9768	2157.6940	2.78145515	-5.85651001	3.15927290
2	14946.95564064	-4035.3032	-5137.7216	3578.7051	6.00665199	-3.66698463	1.44157331
3	14946.96258508	45.9664	-6340.9499	3785.8792	7.20196399	-0.21094418	-0.78091742
4	14946.96952953	4100.7455	-5346.3772	2678.8501	5.88695183	3.45867544	-2.81445117
5	14946.97647397	6643.4346	-2406.5563	597.3226	2.27091241	6.04975021	-3.90904816
6	14946.98341841	6594.5798	1455.2221	-1707.5889	-2.47009870	6.37812444	-3.50296394
7	14946.99036286	3852.8736	4712.6193	-3307.4013	-6.34982683	4.08298202	-1.63286181
8	14946.99730730	-488.6314	6016.6511	-3532.6734	-7.59859829	0.12742749	0.89665102
9	14947.00425175	-4646.9437	4890.9270	-2326.0359	-5.80655352	-3.71362960	2.96736202
10	14947.01119619	-7043.6527	1886.7480	-220.7666	-1.96821823	-5.95482540	3.81530287

, ...

The time is presented in the form of the Modified Julian Date counted from 00h 00m 00s of January 01, 1958.

Based on the TLE data set, the accuracy of results is also estimated. Using each of TLE sets as the initial data, the software program performs forecasting for the "future" TLE time instants and calculates time errors of forecasting. The values of time errors are averaged: the mean value (E), the standard deviation (SD) and the root mean square (RMS) are calculated as a function of prediction interval. The example of these results is presented in table 2 below. Explanations are given in italics. Here N is the forecast interval in revolutions, n is the number of implementations. The dimensional representation of errors is seconds.

Table 2. Errors with using the SGP4 model

N	RMS	M	SD	n
0	0.07	-0.017	0.063	38
10	0.13	-0.031	0.127	37
20	0.22	-0.041	0.211	36
30	0.32	-0.047	0.321	35
40	0.47	-0.045	0.465	34
50	0.64	-0.026	0.641	33
60	0.83	0.008	0.835	32
70	1.07	0.059	1.073	31
80	1.37	0.122	1.363	30
90	1.69	0.228	1.670	29

At the next stage of site designing it is planned to perform the motion prediction in a more complex mode, based on TLE processing with using the modified least square technique (the maximum likelihood method) and the numerical prediction model. This mode is possible, when we have several TLE sets with the time interval of about a week. This requirement is caused by the constraint on the fit span used for determination of initial data. When the number of TLE sets is small (less than 4), the initial data cannot be updated. The considered mode provides more accurate prediction of motion.