

# Trajectory Prediction For Deep Space Debris Object WT1190F

A news article by Traci Watson dated 23 October 2015<sup>i</sup> describes deep space debris catalogued as object WT1190F after its discovery earlier that month. This article reports WT1190F will likely be incinerated high above the Indian Ocean 65 km from the southern tip of Sri Lanka on 13 November 2015 at 06:20 UT. The latest heliocentric epoch J2000.0 ecliptic elements for WT1190F available as of 26 October 2015 appear in Table 1, along with the associated square root covariance (SRC) matrix. These data are as posted to the Jet Propulsion Laboratory's (JPL's) *Horizons* ephemeris server.<sup>ii</sup> Note pre-discovery observations as early as 19 September 2015 are being used in this Solution #29.

**Table 1. *Horizons* Solution #29 for WT1190F is summarized with its heliocentric epoch J2000.0 elements followed by its SRC matrix. Parameters in the record following SRC data govern how *Horizons* will model non-gravitational accelerations during WT1190F trajectory generation. The final record specifies how *Horizons* will model WT1190F apparent brightness.**

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Revised: Oct 22, 2015                               WT1190F                               999787

Test case object, solution #29.
Data fit: 85 measurements 2015 Sep 19 - Oct 22
Source: Davide Farnocchia (JPL)

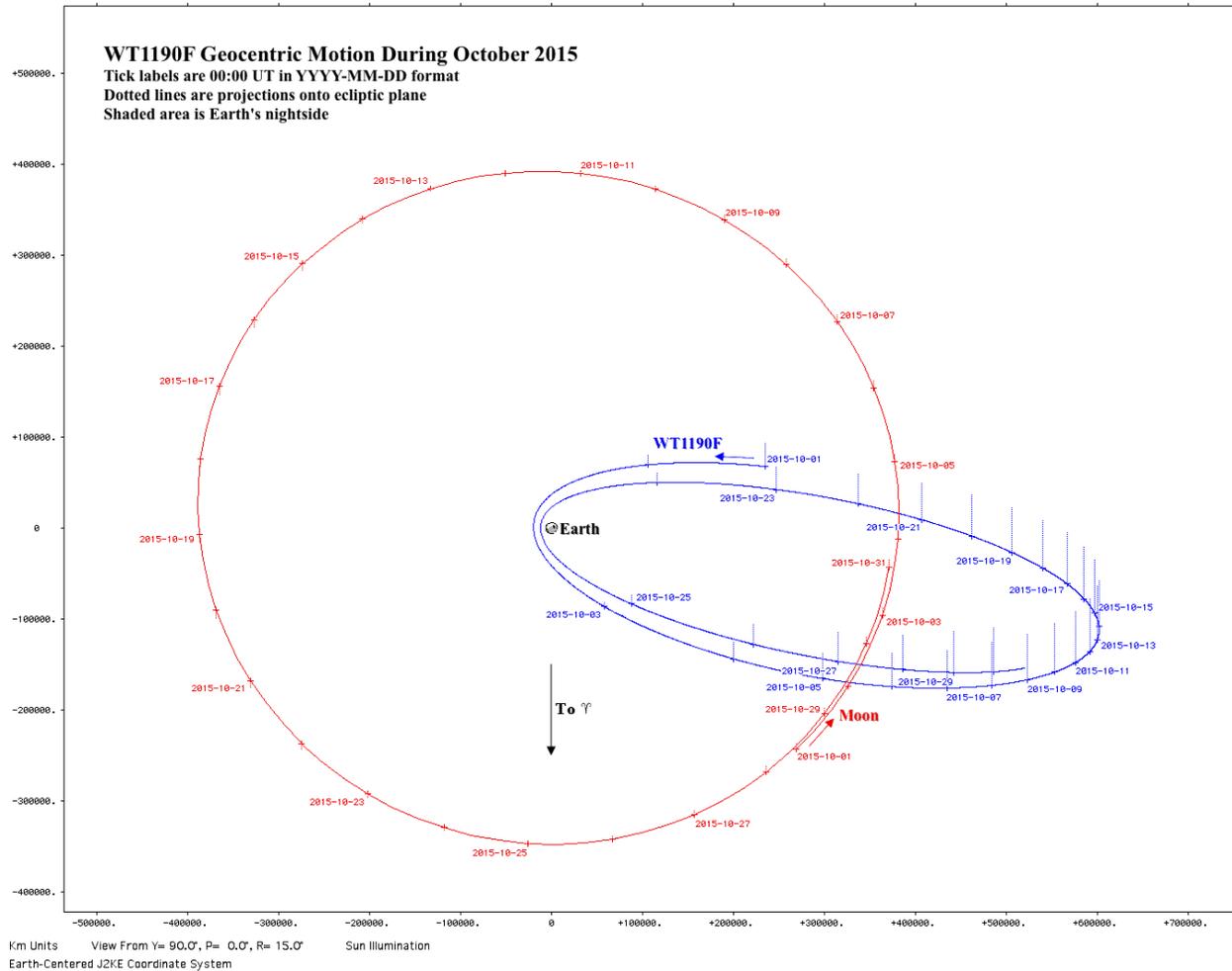
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OM= 188.5637556209191  W = 181.0259108116186  IN= .923567328294445
SRC= -1.368021424147169E-8 +2.701898868062974E-8 -1.277944096063512E-9
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      -5.637992133425217E-8 +8.062914312517092E-8 -1.757022206856501E-9
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      -1.969512506261888E-7 +4.86074639628473E-9 +4.671538301935545E-5
      -1.799414197971456E-7 +1.020694595116957E-6 -4.41557718769756E-8
      +2.272005534541633E-7 -7.27463336166616E-9 -9.153055871079531E-5
      +1.976173903515159E-7 -1.840561417738115E-6 +4.261404432301204E-8
      -8.166509866229103E-11
A1= 2.318742843757473E-9  R0= 1.  ALN= 1.  NM= 2.  NK= 0.
H= 31.194  G= 0.15
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<sup>i</sup> Reference <http://www.nature.com/news/incoming-space-junk-a-scientific-opportunity-1.18642> (accessed 26 October 2015).

<sup>ii</sup> *Horizons* data, including user instructions, are available at <http://ssd.jpl.nasa.gov/?horizons> (accessed 27 October 2015). The telnet user interface was used in preparing this report.

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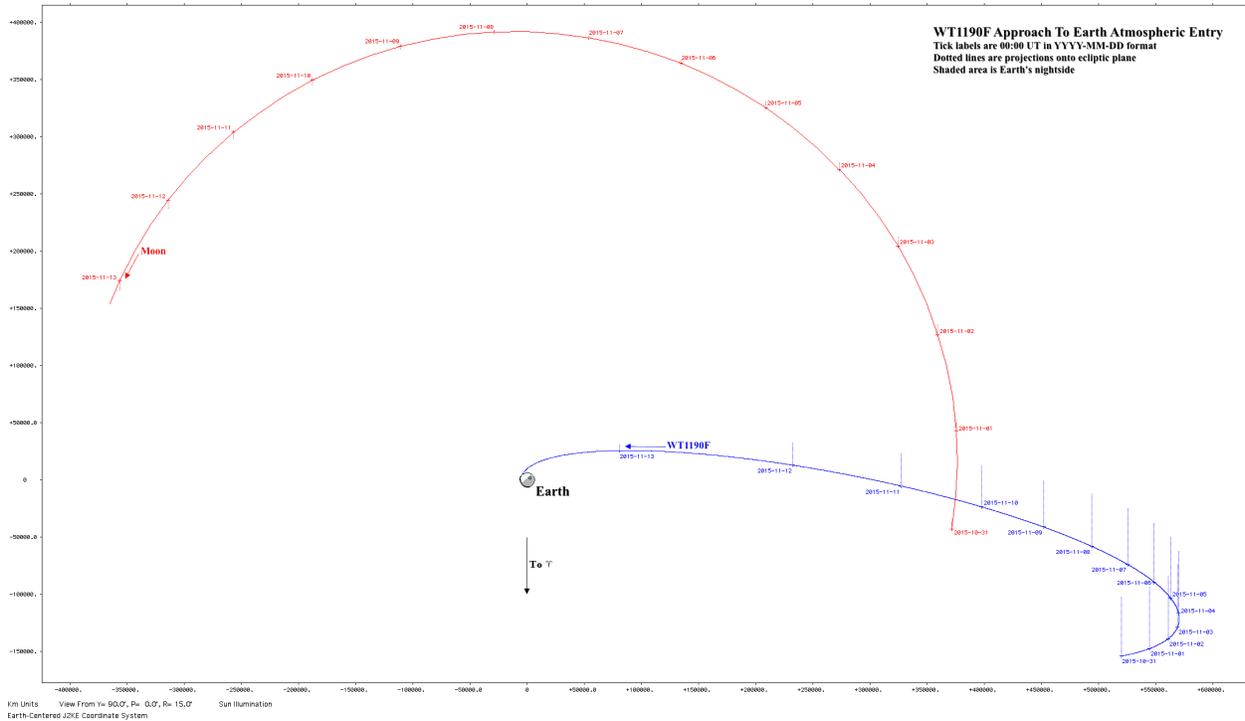
The Solution #29 ephemeris available on *Horizons* 26 October 2015 only extends from 1.0 to 31.0 October 2015 UT. Figure 1 plots this trajectory, together with that for the Moon, relative to the geocentric ecliptic plane.



**Figure 1. Geocentric motion of *Horizons'* Solution #29 ephemeris for WT1190F (blue) is plotted with that of the Moon (red) during October 2015.**

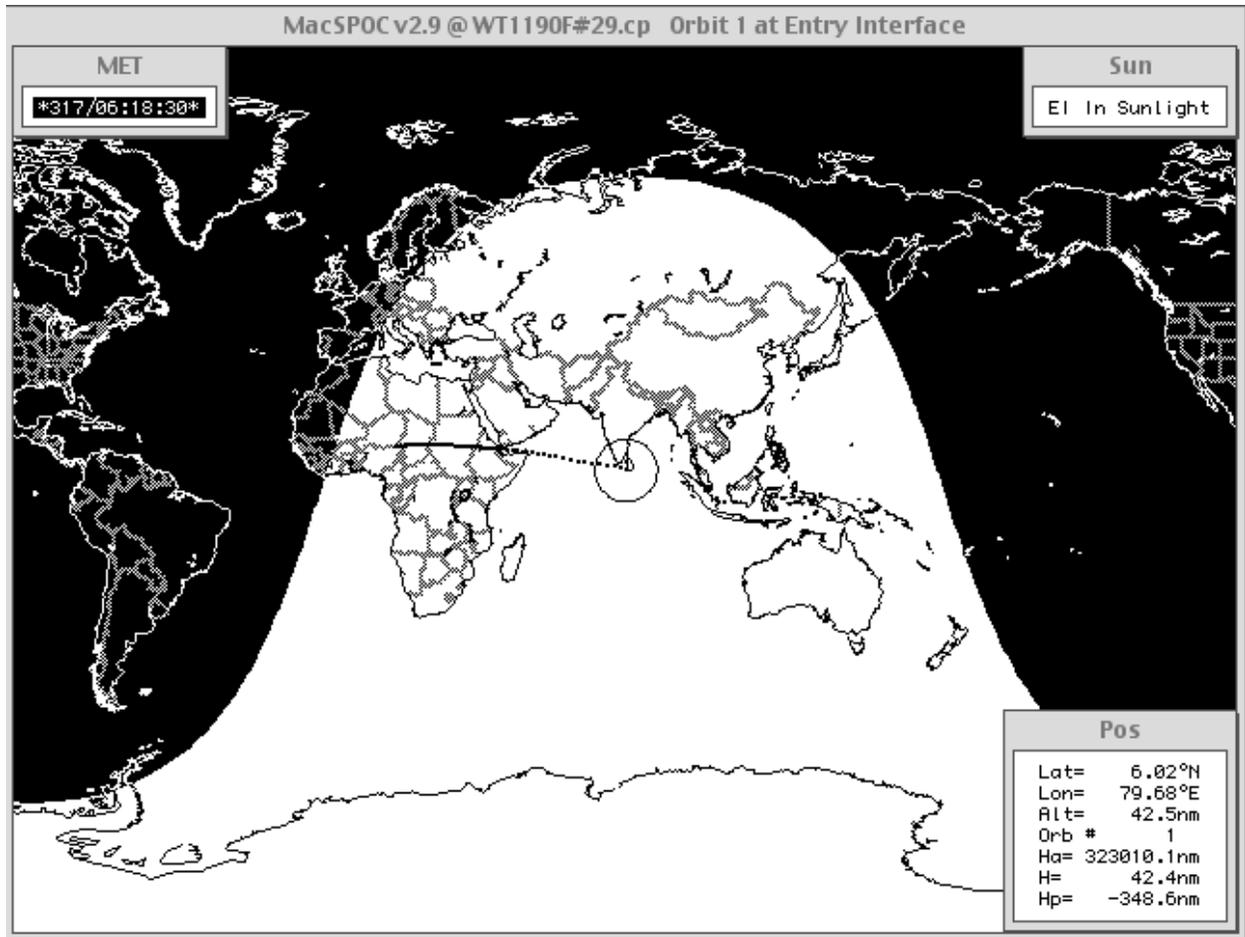
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The 31.0 October 2015 UT geocentric state vector from WT1190F's *Horizons* ephemeris serves as initial conditions with which to coast this object's Solution #29 trajectory into November 2015. Gravity accelerations from Earth, Sun, and Moon as point masses are modeled during the coast, together with Earth's first zonal gravity harmonic  $J_{20}$ . Figure 2 plots this coasted trajectory in the geocentric ecliptic plane, together with that for the Moon. The WT1190F coast reaches Earth atmospheric entry at a geodetic altitude of +121.92 km on Friday, 13 November 2015 at 06:18:18 UT. The last few hours of coasted Earth ground track leading to entry are plotted in Figure 3, confirming impact is indeed predicted near Sri Lanka near local noon solar time.



**Figure 2. Geocentric motion from coasted extrapolation of *Horizons*' Solution #29 ephemeris for WT1190F (blue) is plotted with that of the Moon (red) during November 2015.**

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**Figure 3. Terminal motion of WT1190F above Earth's surface is plotted as a series of black square markers at 30-s intervals leading to impact near Sri Lanka. The final ground track marker is circumscribed by a black circular locus of horizon points at the +42.4 nm (+78.5 km) height appearing in the Pos window. Earth's nightside is shaded black with white coastlines/political boundaries, and UT at the final ground track point is displayed in the MET window with DOY/HH:MM:SS format.**

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As of 28 October 2015, Solution #32 became the latest trajectory data available on *Horizons* for WT1190F. Solution #29 had then been configured to span *Horizons* ephemeris epochs from 19.0 September to 23.625 October 2015 UT. Subsequent epochs up to 13 November 2015 at 06:21 UT are covered by Solution #32. A coast initiated with Solution #32 epoch 13 November 2015 at 05:59 UT has been conducted to atmospheric entry. Table 2 compares entry circumstances from this coast with corresponding data from the more protracted coast initialized from Solution #29 at 31.0 October 2015 UT.

**Table 2. Earth atmospheric entry circumstances for two WT1190F coasts are compared. The UT column is 13 November 2015's epoch at which geodetic altitude reaches +121.92 km,  $\phi$  is geodetic latitude,  $\lambda$  is longitude,  $\gamma$  is inertial flight path angle,  $v_R$  is velocity magnitude with respect to an Earth-fixed coordinate system, and  $H_P$  is perigee height.**

Solution	UT	$\phi$	$\lambda$	$\gamma$	$v_R$ (km/s)	$H_P$ (km)
#29	06:18:18.431	+6.236°	+78.677°	-19.989°	10.586589	-644.7
#32	06:20:00.206	+6.286°	+78.072°	-20.081°	10.586883	-651.5