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MONITORING THE FINAL ORBITAL DECAY AND THE RE-ENTRY OF TIANGONG-1 WITH THE  
ITALIAN SST GROUND SENSOR NETWORK

**Abstract**

The uncontrolled re-entry of spacecraft and upper stages is quite common, occurring nearly every week. Among them, intact objects having a mass greater than five metric tons re-enter, on average, 1-2 times per year. Therefore, the re-entry of the first Chinese Space Station, Tiangong-1, was far from unusual, but attracted anyway a great worldwide attention and some concerns. For these reasons, the Italian component of the European SST (Space Surveillance and Tracking) consortium took this opportunity for carrying out a national exercise.

According to Chinese official sources, the ground control of Tiangong-1 was lost in March 2016, precluding the planned de-orbiting in the South Pacific Ocean Unpopulated Area (SPOUA). However,

the autonomous on-board attitude control system remained operational, making this case very different from a typical uncontrolled orbital decay, driven exclusively by natural forces. Tiangong-1 consisted of a cylindrical section,  $10.5m$  in length and  $3.4m$  in (maximum) diameter, with two rectangular solar panels of  $3m \times 7m$ . The mass was estimated to be around  $7500kg$ .

The Italian network of sensors activated for the campaign included mono-static and bi-static radars, optical telescopes, a laser ranging station and a network of all-sky cameras, originally deployed for the observation of fireballs and bolides. In addition to providing complementary information, concerning the orbit, the attitude and the photometry of Tiangong-1, this quite heterogeneous collection of national assets provided also the occasion for testing, in an operational environment, the Italian sensor tasking preparedness and the data acquisition, exchange and processing capabilities within the European SST consortium.

In this respect, it is important to remember that in 2014 the European Commission, well aware of the topic criticality, took the commitment to implement a European network of sensors for surveillance and tracking of objects in Earth's orbit by starting a dedicated SST support framework program. Italy, France, Germany, Spain and UK joined it and constituted, together with SatCent, the front desk for SST services, the EUSST Consortium.

In this paper, a description of the Tiangong-1 monitoring activities and of the main observations results obtained by the Italian sensor network are reported. Attention is also devoted to the coordination aspects of several Italian entities (military, civil and research organizations) that worked together. Finally, a description of the re-entry prediction and alert procedure for the national civil protection authorities is presented.