

# The Komplast Experiment: Space Environmental Effects after 12 Years in LEO (and Counting)

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The Komplast materials experiment was designed by the Khrunichev State Research and Production Space Center, together with other Russian scientific institutes, and has been carried out by Mission Control Moscow since 1998. Komplast panels fitted with material samples and sensors were located on the International Space Station (ISS) Functional Cargo Block (FGB) module exterior surface. Within the framework of this experiment, the purpose was to study the effect of the low earth orbit (LEO) environment on exposed samples of various materials. The panels were sent into orbit with the FGB when it launched on November 20, 1998. Panels #2 and #10 were retrieved during Russian extravehicular activity in February 2011 and sealed within cases to temporarily protect the samples from exposure to air until they could be studied on the ground. Panel #2 contained an experiment to detect micrometeoroid and orbital debris (MMOD) impacts, radiation and UV sensors, several pieces of electrical cable, and samples made from elastomeric and fluoroplastic materials. Panel #10 contained a temperature sensor, and both carbon composite and adhesive-bonded samples. Figure 1.A shows the location of panels #2 and #10 on the FGB module aft endcone. The panels were subsequently returned to Earth by Space Shuttle Discovery on the STS-133/ULF-5 mission after 12 years of LEO exposure and opened in an argon chamber at the Institute of Nuclear Physics at Moscow State University in July 2011 (see figure 1.B.)

Based on the results of analyzing the readings from sensors located on Komplast panels and in studying material samples from the panels, the comprehensive effect of spaceflight factors on the FGB (at the locations of Panels #2 and #10) was evaluated. Total solar exposure was determined to be  $960 \pm 200$  kJ/cm<sup>2</sup> or 21,000 equivalent solar hours. Because of location of these two panels and the ISS flight attitude, atomic oxygen (AO) fluence was relatively low for such a long duration exposure, approximately  $1.5 \times 10^{21}$  O atoms/cm<sup>2</sup>. Most of the AO fluence occurred during the early phase of ISS assembly. Temperatures ranged from a maximum of 107°C to a minimum of -80°C.

The MMOD environment was determined [1], as is shown in figure 2. Interestingly, the distribution of craters and low-velocity impact particles observed in the 5-50  $\mu$ m size range was ~2-3 orders of magnitude higher than that predicted by the ORDEM2000 model of natural and artificial origin microparticles in the ISS orbit.

Contamination observations were also made, through the evaluation of optical properties on thermal control coatings and by the examination of visible deposits located near several samples on the panels, primarily from elastomeric samples. These elastomer samples were extensively investigated for their physical property changes and sealing capability. In addition, 16 samples of adhesive-bonded joints using three types of epoxy adhesive were evaluated studying fracture toughness, failure surface, and adhesive volume properties. Both rubber and adhesive-bonded specimens also underwent additional (post-flight) ground-based exposures to simulate a total 30 years in LEO prior to their evaluation.

Overall, results indicate that space environmental effects will not adversely impact the service life of the FGB through 2028. Our investigation is complete and a summary of the results obtained from this uniquely long-duration exposure experiment will be presented [2].

## References

- [1] S.K. Shaevich, et al., A Study of Microcraters in Material Samples After Long Duration Exposure on the ISS Komplast Panels”, ISMSE-12, Noordwijk, September 2012.
- [2] The authors acknowledge the International Space Station program and FGB Service Life Extension Team for their support (all Boeing activity is under the NAS15-10000 contract).

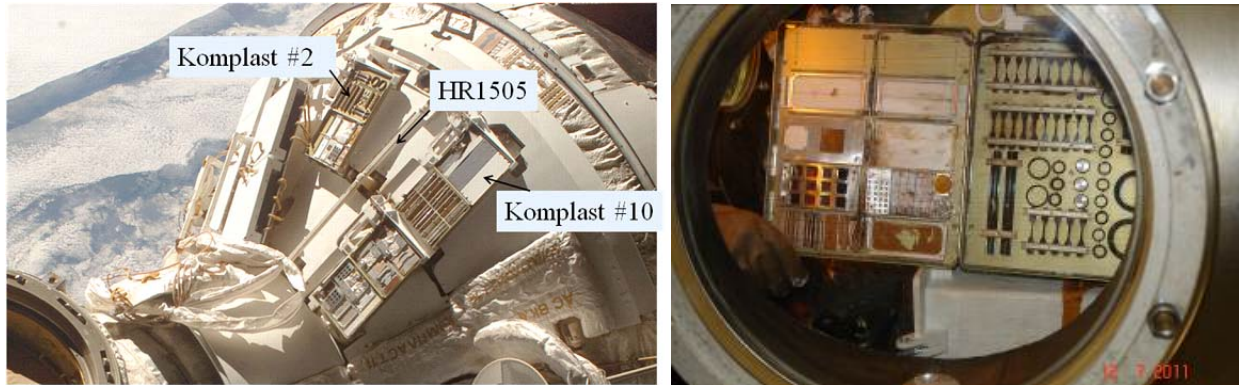
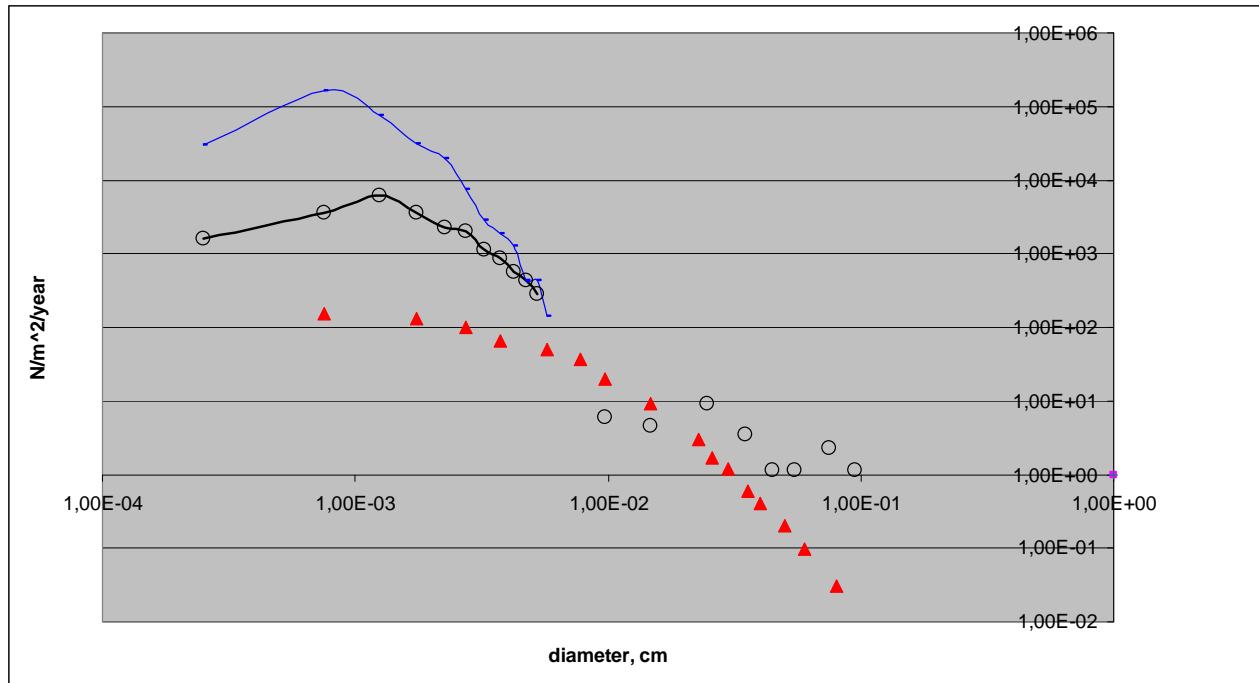


FIG. 1.A) Komplast Panels #2 and #10, located either side of handrail 1505 on the aft endcone of the FGB module, prior to retrieval; and FIG. 1.B) Komplast #2 just opened in the environmental control chamber at Moscow State University, after removal from its transportation canister.



- ▲ ORDEM2000 predictions
- ⊙ Craters on aluminum and copper surfaces and Panel 2
- Total number of craters and particles on aluminum and copper surfaces

FIG. 2. Distribution of crater diameters obtained from Komplast in comparison with ORDEM2000.