

MONITORING OF POTENTIALLY-DANGEROUS RAILWAY LINES BY DIFFERENTIAL INTERFEROMETRIC PROCESSING OF SATELLITE RADAR DATA

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Monitoring of condition and state of railway transport infrastructure objects is one of the basic ways to keep uninterrupted railroads' operation and to maintain the operational safety of transportation. Operative monitoring involves duly arrangement of activities on elimination of defects and deformations appearing as a result of negative influence of natural and artificial factors on the railway to prevent dangerous emergency events. Earth remote sensing (ERS) data acquired by optical and radar spaceborne imaging systems may be used as a source of operative, detailed and reliable geospatial information, providing in real time remote monitoring of railway infrastructure in addition to traditional periodic in-situ inspections.

Modern spaceborne high resolution optoelectronic scanning systems make it possible to evaluate the state of railroad tracks, embankments and objects of railway infrastructure by the acquired images. It is possible to analyze the situation in the railroad right-of-ways and fenced-off areas, and also over the neighboring territories with increased risk of natural or artificial dangerous processes. The capability of operative survey by onboard instruments from space in optical waveband is however limited mainly by the meteorological conditions. Synthetic aperture radar (SAR) systems allow to provide operative imaging of ground objects independent from time, illumination and weather conditions. Rapid development of spaceborne SAR systems of high spatial resolution, in particular, successful launch of TerraSar-X and Cosmo-SkyMed missions in 2007 and start of their operation have resulted in the fact, that spatial resolution of commercially available radar and optical data and, as a consequence, target detectability over the images became comparable. This makes it possible to use SAR data in a case of emergency events and to arrange on the basis of the image analysis rapid and sustainable preventive and response management activities aimed on minimization of damage.

Specific features of SAR image generation lead to additional benefits of such information in comparison with the optical ERS data. Interferometric processing of high resolution SAR data allows the direct evaluation of detailed and accurate digital terrain models. Differential interferometric processing of several SAR images (DifSAR), acquired at different time, allows the direct measurement of the observed surface displacements with the sub-centimeter accuracy, inaccessible by other techniques.

Railway infrastructure objects are often situated in the areas affected by geodynamic deformations, caused by karst events, mining or construction works, alternating insiccation, swelling, freezing and melting processes. Significant part of railway lines in Russia operates in permafrost environment under the influence of dangerous cryogen geologic processes of thermo-karst, thermo-erosion, solifluction etc. Detection of small terrain displacements and slumps by differential radar interferometry makes it possible the early detection of negative geodynamic influences on railroad tracks, embankments and other railway infrastructure objects and arrangement of duly precautions against emergency events.

Pilot project on monitoring of potentially dangerous railway lines with the use of remote sensed data is carried out over the Tuapse–Adler line of Northern Caucasian railway situated in extremely hard landscape, natural and climatic conditions. The line is affected by continuous intensive impact of negative geological processes and events (landslides, landslip,

mudflows, water erodes, sea abrasion). This causes various damages, defects and deformations and may lead to accidents.

Detection of sources of possible mudflows and landslides formation - places of loose conglomerate deposits' accumulation, damaged vegetation and soil cover areas, and also monitoring of state of wave-cut and protective constructions, drainage channels and collectors is performed on the base of high resolution satellite images (for instance QuickBird, perhaps Resurs-DK in future). Monitoring of potentially-dangerous landslide areas with the use of radar data provides preventive detection of ground surface displacements before landslide initiation.

Verification of the developed surface displacement monitoring techniques in landslide, rock-fall and karst areas is carried out by means of retrospective analysis of database with the recorded information on emergency events and negative natural influences on railway at the studied line collected at Northern-Caucasian railway, and also with the use of archive imagery, obtained by middle resolution SAR instruments onboard the ERS-1/2, EnviSat, ALOS s/c for the last 15 years. Techniques of detailed displacement analysis by means of differential interferometric processing of high resolution TerraSar-X and Cosmo-SkyMed SAR images are under development.

Developed monitoring techniques will insure the arrangement of rapid response actions to prevent dangerous events and the maintenance of railway infrastructure in fault-free condition.