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How integrating 3D LiDAR data in the dike surveillance protocol: The French case

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The recent and dramatic floods of the last years in Europe (e.g. Rhône river major flood, December 2003, Windstorm Xynthia, February 2010, in France) and in the United-States (Hurricane Katrina, August 2005) showed the vulnerability of flood or coastal defence systems. The first key point for avoiding these dramatic damages and the high cost of a failure and its consequences lies in the appropriate conception and construction of the dikes, but above all in the relevance of the surveillance protocol.

Many factors introduce weaknesses in the fluvial or maritime dikes. Most of them are old embankment structures. For instance, some of the French Loire River dikes were built several centuries ago. They may have been rebuilt, modified, heightened several times, with some materials that do not necessarily match the original conception of the structure. In other respects, tree roots or animal burrows could modify the structure of the dike and reduce the watertightness or mechanical properties.

The French government has built a national database, "BarDigues", since 1999 to inventory and characterize dikes. Today, there are approx. 9000 km of dikes protecting 1.5 to 2 millions of people.
In the meantime, a GIS application, called « Dike SIRS » [Maurel P., 2004] , provides an operational and accurate tool to several great stakeholders in charge of managing more than 100 km of dikes.

Today, the dike surveillance and diagnosis protocol consists in identifying the weaknesses of the structure and providing the degree of safety by making a preliminary study (historical research, geological and morphodynamic study, topography), geophysical study (e.g. electromagnetic methods and electrical resistivity tomography) and at last geotechnical study (e.g. drillings and stability modelling) at the very local scale when necessary [Mériaux P. & Royet P, 2007] .

Considering the stretch of hundreds of kilometres, rapid, cost-effective and reliable techniques for surveying the dike must be carried out.
A LiDAR system is able to acquire data on a dike structure of up to 80 km per day, which makes the use of this technique also valuable in case of emergency situations.
It provides additional valuable products like precious information on dike slopes and crest or their near environment (river banks, etc.).
Moreover, in case of vegetation, LiDAR data makes possible to study hidden structures or defaults from images like the erosion of riverbanks under forestry vegetation.
The possibility of studying the vegetation is also of high importance: the development of woody vegetation near or onto the dike is a major risk factor.
Surface singularities are often signs of disorder or suspected disorder in the dike itself: for example a subsidence or a sinkhole on a ridge may result from internal erosion collapse.
Finally, high resolution topographic data contribute to build specific geomechanical model of the dike that, after incorporating data provided by geophysical and geotechnical surveys, are integrated in the calculations of the structure stability.

Integrating the regular use of LiDAR data in the dike surveillance protocol is not yet operational in France. However, the high number of French stakeholders at the national level (on average, there is one stakeholder for only 8-9km of dike !) and the real added value of LiDAR data makes a spatial data infrastructure valuable (webservices for processing the data, consulting and filling the database on the field when performing the local diagnosis)