SK EU2016

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UPDATE OF THE METHODOLOGY FOR RASTER DATA INTERPRETATION (REMOTE SENSING) FOR DETECTING CLUES OF CONTAMINATION WITHIN THE CONTAMINATED SITES INVENTORY PROJECT

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Main Topics

- Raster platform for NIKM project and its updates
- Data mapping services used in the NIKM I project
- Experience from the NIKM I project
- Current and near future status of the geographic support
- New layers
- The advantage of the use of laser altimetry
- An update of methodology through a systematic use of attributes for objects contained in geographic maps
- Vision
- Conclusions

Raster platform for NIKM project and its updates

- The methodology for remote sensing use within the National Inventory of Contaminated Sites project (NIKM) project was published in 2011
  (Doubrava et al., 2011: Methods for remote sensing of the National inventory of contaminated sites (in Czech). CENIA, Czech Environmental Information Agency, ISBN: 978-80-85087-91-8, Prague, pp. 1-94).

- For the second phase of the NIKM project (under preparation for the Operational Programme of the Environment - OPE 2014-2020) **the methodology was updated**:
  - added the stage of **reinterpretation / revision of the clues** identified by the first interpreter through the revision of a supervisor;

  - used of the information contained in the **Hill Shaded Digital Terrain Model** of the Czech Republic of the 4th and 5th generation (DMR 4G, DMR5G), provided by the Czech Office for Surveying, Mapping and Cadastre (ČÚZK) in the form of web services (ČÚZK, 2016a, 2016b). Already this basis alone allows us to find the artificial formations which may indicate (and sometimes clearly indicate) the existence of contaminated sites as they are understood in the context of the NIKM project;

  - the systematic **use of attributes for objects** contained in geographic maps.

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The set of data mapping services used in the NIKM I project

- A photomap from the 1930's
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- A photomap from the 1950's
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- Current aerial photomap ČÚZK - the current status of the Czech Republic

- Comparative image layers (binary rasters with contours, generated by filtration of the original orthophotomap)
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- Landsat ETM - multispectral images from NASA satellite - used to colour highlighting the aerial photomap
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- RETM (Raster Equivalent of Geographic Maps) - a set of military maps in the latest available version, shown in raster format and available from web services

The success rate (a share of clues resulting in the records of potentially contaminated sites) varies between 5 % and15 % of the original number of gathered clues, according to the character of the area and the state of the content of the database.

Experience from the NIKM I project

Evaluation of raster background data using the methods of remote sensing (RS) was performed in 2009-2013 on 9.4 % of the Czech Republic's area (7397 km^2). 284 clues were identified, from which, after examination, 78 were registered as a contaminated site - see Table 1 (data source: Suchánek et al., 2013).

Features of sites (objects of interest) sets	Number of sites	%	%
Total number of objects of interest gathered from Remote Sensing (historical and current photomaps) and from existing databases - input data set for inventory	8 637	100	
thereof sites, entered into evidence and earmarked for further evaluation	284	3.3	100
thereof sites detected using remote sensing	78	-	25.5

Table: Overview of pilot inventory outputs performed in the NIKM project first stage

Experience from the NIKM I project

Positive experience and results:

Basic overview of the project objects of interest before the start of field works

Creation of a working background documentation

Developed a planning basis for the management of inventory works

Background information for discussion with local authorities etc.

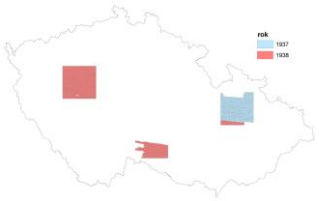
Streamlining of the field work and planning (transport, accommodation).

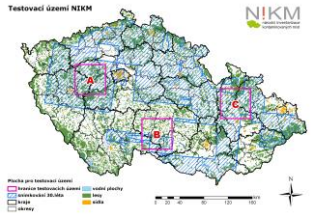
Negative experience:

High complexity in the preparation of certain documents.

Historical photomap of the 1930's does not have nationwide coverage and a number of clues displayed on them is considerably low, and almost exactly overlap with clues and findings on the photomap made from images dated from the 1950's.

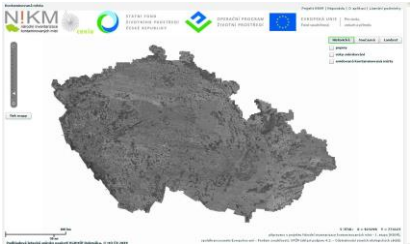
Current and near future status of the geographic support of the project activities





Items in play:

- The photomap of the 1930's will not be included.
- The photomap of the 1950's **will be utilized in full**.
- Current aerial photomap (ČÚZK) **will be used in full**.



- Comparative image layer will not be created, instead of that, the transparent maps or other comparative analyses **will be used** to comparative use.
- Landsat data will not be included in the standard portfolio of documents, but for a more sophisticated ad hoc analyse, newer Landsat 8 data **will be considered**.
- Texts (attributes, abbreviations) identifying objects and contained in topographic works **will be utilized**.
- A type shape catalogue of objects of interest **will be created**.

New layers

- **Sentinel 1** - showing radar data (Synthetic Aperture Radar - SAR) to identify the elements of infrastructure and water areas.

- **Sentinel 2** - a new multispectral instrument, comparable to Landsat but having a greater spectral resolution.

- **DMR4G and DMR5G** - newly acquired altimetric data from ČÚZK, taken by laser altimetry methodology

New layers

Sentinel satellites data are available for eventual use, as well as Landsat data.

The altimetric data that are available as WMS shaded relief represent a fundamental improvement. Thanks to the highly detailed measurements of the altitudes, "shadowed" formations that reveal surface human activity stand up from the relief model showing these formations in a form of detailed "3rd dimension".

The use of laser altimetry for the inventory of contaminated sites.
Distinguished types of objects :

- Landfills, waste dumps or mine tailings
- Buried terrain depression
- Buried water streams
- Discharge hoppers
- Rock quarries, sand quarries, clay quarries, brickyards, small local quarries
- Underground mines (surface objects and traces of mining activities on the ground, e.g. mouth of a gallery or depressions)

New layers

An example of a clue, of a contaminated sites interpretation, using "classical" **interpretation of ortophotomaps** compared with the image of these objects in a shaded model **DMR5G**.

The investigated object is situated on the southern edge of an already registered contaminated site - former military base of the Soviet Army **in Stráž pod Ralskem** (ID56466001 database SEKM). South of the site of former garages of the tank regiment we have **identified a rectangular area** with dimensions of 60x90 m with coordinates of the centre of the area of 50° 41'46.45 "N, 14° 49'50.27" E.

This area is nowadays **covered with grown forest** and is not mentioned in the current description of the registered site.

One interpretation could be that this is an area of **a former fuel station** of unknown localization noticed in the record of the site. Another possibility is that it is **an illegal landfill partially remediated or another „historical“ object** (before 1950's).

Based on our clue identification we can proceed to field investigation within the framework of a national inventory of contaminated sites.

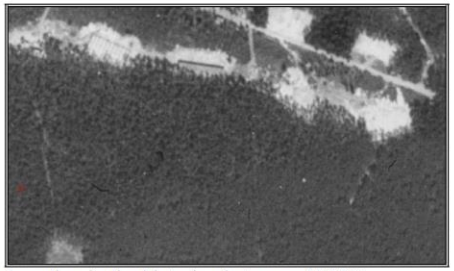
New layers

New layers

Visualizations of a clue - a new potentially contaminated site close to the site ID 56466001 (Stráž pod Ralskem)

Location in current photomap (2010)

Shaded DMR5G of the location (status quo). Buildings and forest are digitally removed from the model.



Location in the historic photomap (1953)

Shaded DMR5G of the location (status quo) on the background of images from 1953

Shaded model of the location above the photomap from 2010

Shaded model of the location on the background of a topographic map

New layers

Visualizations of a clue - a new potentially contaminated site close to the site ID 56466001 (Stráž pod Ralskem)

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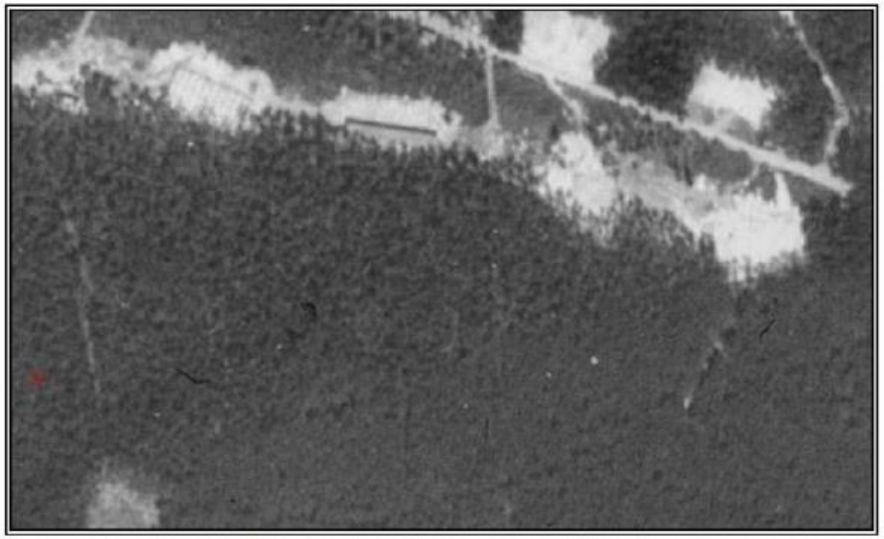

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New layers

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Visualizations of a clue - a new potentially contaminated site close to the site ID 56466001 (Stráž pod Ralskem)

Shaded model of the location above the photomap from 2010

Shaded model of the location on the background of a topographic map

- **An example of a clue -** Landfill, SEKM registered site, Slezské Pavlovice
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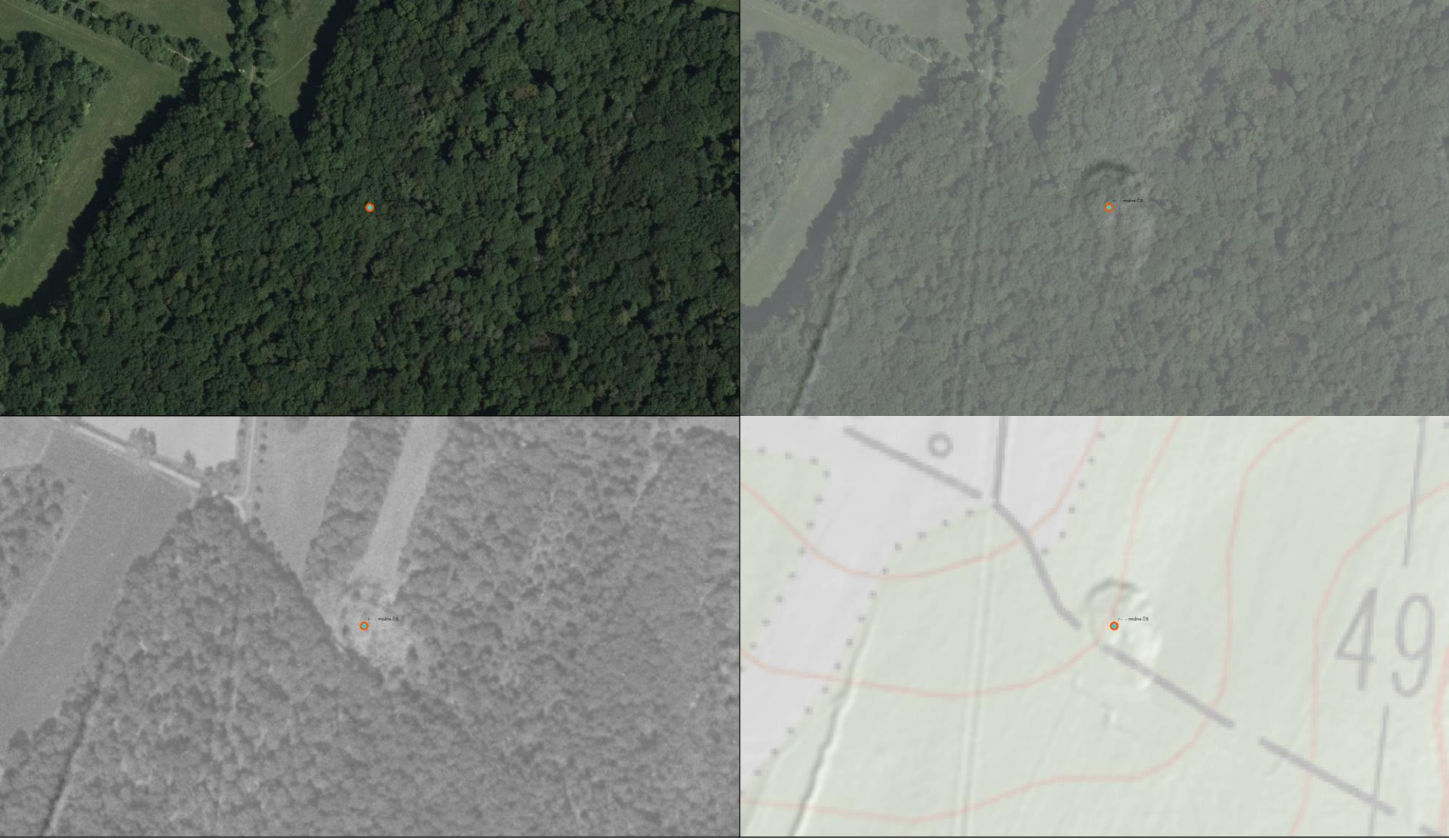
- **An example of a clue** - an industrial waste dump covered with wood, Hrochův Týnec, remediated area of historic suger mill



- **An example of a clue -a** small local quarry covered with the forest, Heřmanův Městec

The advantage of the use of laser altimetry

- All objects detectable as "strange shapes" on the natural terrain relief are of NIKM 2 interest.
- They can be found even under vegetation or in other places where from the photomap even from the current map cannot read the actual shape of the terrain.
- The use of the direct interpretation of the terrain morphology significantly increases the efficiency of interpretation and through it thus supports fieldworks.
- Omitting this preparation many objects can escape attention when working in the field. Many units can be overlooked due to vegetation cover.
- An increase in the number of clues by a third is expected (from about 300 to 400 primary indications).
- In comparison with the first stage of the NIKM project, the number of confirmed clues entering in the form of records into the database is expected to increase by 20%.

The advantage of the use of laser altimetry

From the experimentally evaluated territory of five districts, it was found that performing a careful inspection of historical and current photomaps on average **about 400 clues could be found in one average district**.

In the revision step around **150** of the primary clues **could be eliminated**.

Therefore around **250 clues remain** as a result from a classic photo-interpretation.

In the photomap revision step, the DMR5G is also used as a support to the revision, as well as a tool for finding terrain anomalies that suggest the presence of other clues which cannot be found in the photomap. In this way, approximately **100 of the additional clues are found in the area of one district**.

In total, out of **350 clues found within Remote Sensing** works, roughly 70 % of the clues are detected with photo-interpretation, and **30% with visual analysis of shaded terrain relief**.

Utilization of DMR5G seems to be a very important and prospective element in the preparation of field investigation.

The advantage of the use of laser altimetry

The success rate of DMR5G utilization for clue searching is demonstrable in an example of the district Chrudim

Clues of the contaminated sites surveyed in two step interpretation and broken down by method (orthophoto vs. DMR5G)		Number of clues	%	%
The number of clues in the district of Chrudim gathered in the first step of interpretation incl. DMR5G		427	100	-
The number of clues discarded with revision (the second step of interpretation)		157	33.4	-
The number of clues in the district of Chrudim after revision		270	-	100
	thereof the number of detected clues gathered within interpretation of orthophotomaps	169	-	62.6
	thereof the number of clues detected using DMR5G	101	-	37.4

The situation in four other districts experimentally assessed is similar. The total number of clues varies depending on e.g. character of the district (the rate of industrialization, the rate of land use, population), but the share of clues identified using DMR5G is very similar and stable.

An update of methodology through a systematic use of attributes for objects contained in geographic maps

These attributes (textual data - abbreviated names - of the type of building, plant, installation etc.) bring us relatively useful supporting information, which can lead to exclusion or inclusion of clues of contaminated sites from or to the list of clues for further investigation.

To interpret the clues, the contents of the old raster maps, for example, old maps ZM10 (Base map 1:10 000, Land Survey Office), mine maps, military maps, etc., will also be systematically exploited, namely from the perspective of identification of areas with potential for contamination of soil and groundwater.

These include maps showing location e.g. of industrial buildings, farms, mining areas, queries, sand pits etc.

Vision

Currently in the Czech Republic we do not have available to us, sophisticated software tools that would allow us **to automatically detect clues** of contaminated or potentially contaminated sites.

We can address particularly the following promising directions:

Advanced terrain analysis (morphology, comparison of slope gradient, edges, heights, different lighting, ...) based on a mathematical analysis of terrain surface formations has not yet been tested.

However, in principle it is possible to create algorithms that on the original, so called hydrologically correct shape of the terrain can detect artificially created elevations or depressions.

Compared with other background information it is then possible to unambiguously identify the places where it is necessary to carry out another survey of contamination on the surface or just below the surface, and underground (e.g. dumping contaminants in the old mining object), etc.

Vision

Hyperspectral image data analysis requires a special sophisticated sensing device which displays Earth's surfaces in a number of very narrow spectral bands simultaneously.

Where such data are available, it is possible to purposefully seek certain types of potentially contaminated sites, for which have typical certain specific spectral manifestations of some contaminants or their accompanying components.

Such components we call "markants" (characteristic features) and methodology of work with a detailed spectral image can be very precisely focused on their detection of the Earth's surface.

This procedure has already been tested in the first stage of the NIKM project. Unfortunately, a widespread use of this procedure is hampered by insufficient spatial resolution (must achieve at least 5x5m or better) and by a total lack of such data.

Vision

Comparing older and newer high-quality elevation models is currently the most promising analytical procedure, since at present we already have a relatively good quality of altimetry ZABAGED, which can be compared with DMR4G or DMR5G through map algebra. If technically possible, the NIKM project team provides such a comparison even before the field phase of NIKM II.
Based on the comparison, all formations that arose between the period of creation of accurate contour lines and performance of laser altimetry should secede.

Filtering out as much of the unnecessarily displayed formations (areas of settlements, new roads, etc.) then will remain for the further processing of the limited amount of detected anomalies that are already appropriate for a detailed interpretation.

Conclusions

The project methodology was completed with

- the stage of clues reinterpretation,
- with the use of the information contained in the Hill Shaded Digital Terrain Model, and
- with the exploitation of attributes for objects contained in topographic works.

We will focus on **the use of procedures for the routine detection of shapes**.

The solution would be **a synthesis of several partial analyses** (terrain morphology, data from GIS, supervised classification of multispectral data, object-oriented classification of hyperspectral images, etc.).

The common intersection of these analyses layers will be made and **a final clues layer serving for further inventory work** - methodical verification of identified contaminated sites – **will be elaborated**.

cenia

NIKM
národní inventarizace
kontaminovaných míst

Acknowledgement

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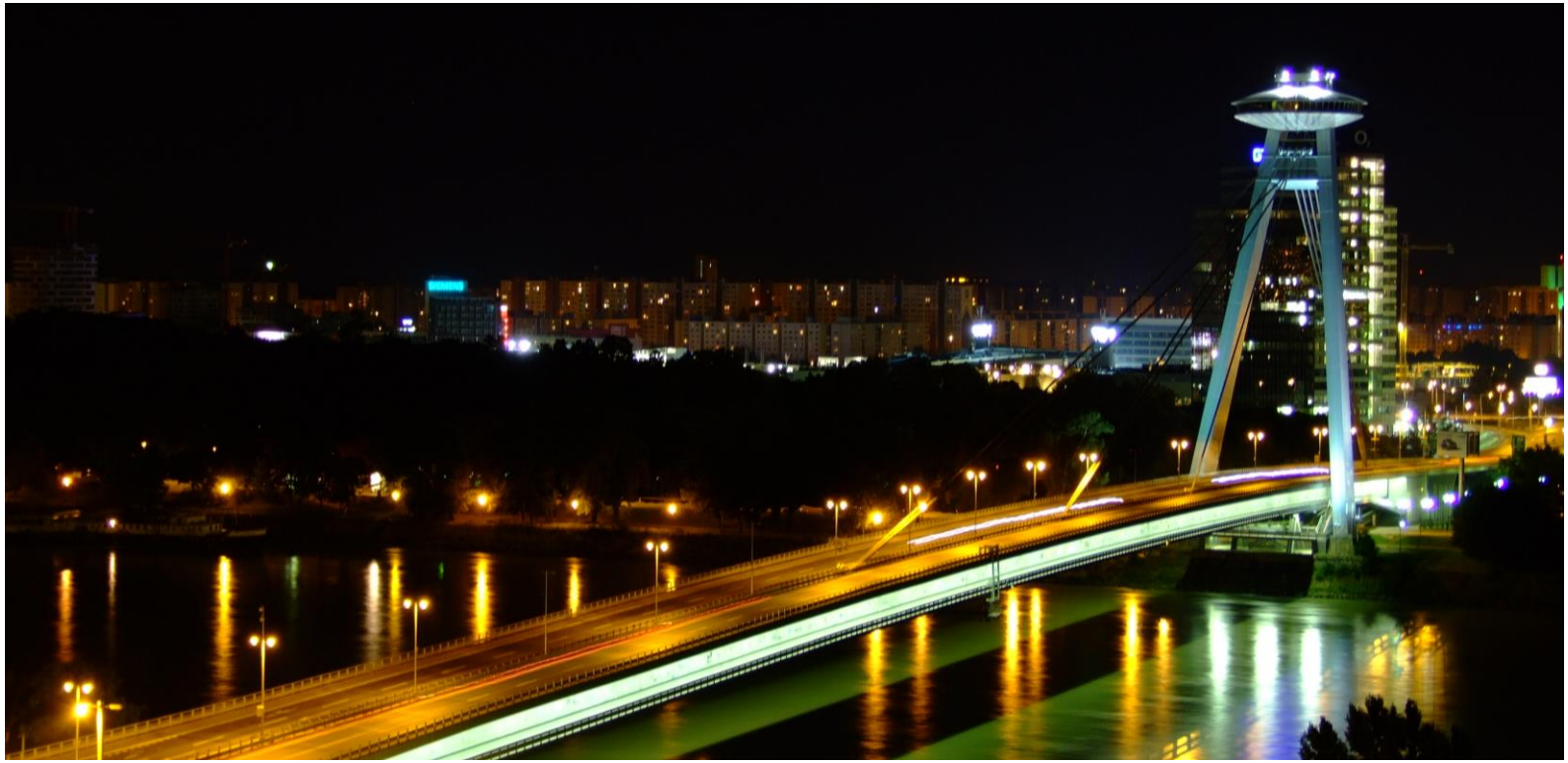

Thank you for your kind attention!

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