Mapping basics

1. Definition of a map

The general definition of a map is the projection and scaling of objects or features on or near the Earth's surface onto a plane.

2. Reasons for using map projections

As the Earth's surface can only be considered planar in a small area, when we make distance and angular measurements on a larger scale, they cannot simply be used in calculations as if they were on the plane. In such a case, we have to use a projection, which is an established mathematical method, to transform our measurements (coordinates, distances, angles) from the approximated surface of the Earth (ellipsoid) to a planar surface or a surface that can be unwrapped to a plane.

We may use a simple plane as our projection's target surface, however that only works for a small area. For larger areas (e.g. countries, regions or the whole world) we use other surfaces, so called developable surfaces, that can be flattened into a plane without any sort of distortion. Developable surfaces used in projections are usually cylinders and cones (apart from planes of course).

3. The development of mapping and its instruments

1. At first, the Earth was supposed to be planar, maps were simply drawn from length and angle measurements. For small areas, planar mapping is still used.
2. After the discovery that the Earth is not planar, projections had to be used to map larger areas, because the distortions of using plane approximation were too high.
3. With the rise of the demand for worldwide positioning and geometrical information (navigation, web maps etc.), worldwide reference surfaces, such as the World Geodetic System 1984 (WGS83, the reference system used in GPS positioning) and projections had to be used, such as the Universal Transverse Mercator (UTM) or the Web Mercator (used by Google Maps).

Plane table: one of the earliest type of instruments used in mapping. Consists of a table that can be levelled using a bubble tube, a ruler with a telescopic sight and a drawing sheet. A staff was used in conjunction with the telescope to measure the distance from the table to the staff and using the ruler, the staff's position could be drawn instantly on the drawing sheet with a specific scale.

The more advanced surveying instruments were used later on, such as the theodolite (an instrument for measuring horizontal and vertical angles) and the tachymeter (basically a theodolite with distance measuring capability).

During the first world war, aerial photogrammetry was developed and extensively used to create maps from photos on a larger scale. In photogrammetry, images are taken (usually from aircrafts in case of large scale surface mapping) with significant overlap between the subsequent images. If an object is rendered on at least two images, its position relative to the aircraft can be determined. If we can also determine the position of the aircraft directly (using satellite positioning) or indirectly (using ground control points), the absolute position (the position in a specific reference system) can also be determined.

Nowadays, aerial photogrammetry is still commonly used (although, the camera carriers tend to shift from aircrafts to UAV or drones) besides satellite positioning using the various GNSS (Global Navigational Satellite Systems), such as the GPS, the GLONASS (Russian satellite based navigation) and the Galileo (EU founded navigation system). Modern

surveying instruments, like total stations (angle and distance measuring instruments) and laser scanners are also widespread.

4. Classification of maps

The scale of a map: the ratio between the lengths on the map and on the projection surface. The scale is usually defined by 1:M, where 1 is the size of a length on the map in some units and M is the size of the corresponding length on the projection surface in the same units.

Classification by scale:

- 1:100 000 – : small scale maps (geographical maps, world atlases/world maps)
- 1:10 000 – 1:100 000: medium scale maps (topographical maps)

} cartographers topographers

- 1:500 – 1:5000: large scale maps (base maps in surveying)
- 1:50 – 1:500: very large scale maps (construction plot plan)

} surveyors civil engineers

Classification by the content of the map:

- Thematic maps (ie. temperature map, average life expectancy, historical maps etc.)
- Cadastral map (very often used and created by surveyors, only contains data regarding the land registry)
- Public utility maps (sewers, electricity, water/gas pipes, created and maintained by companies who own the network)
- Road maps

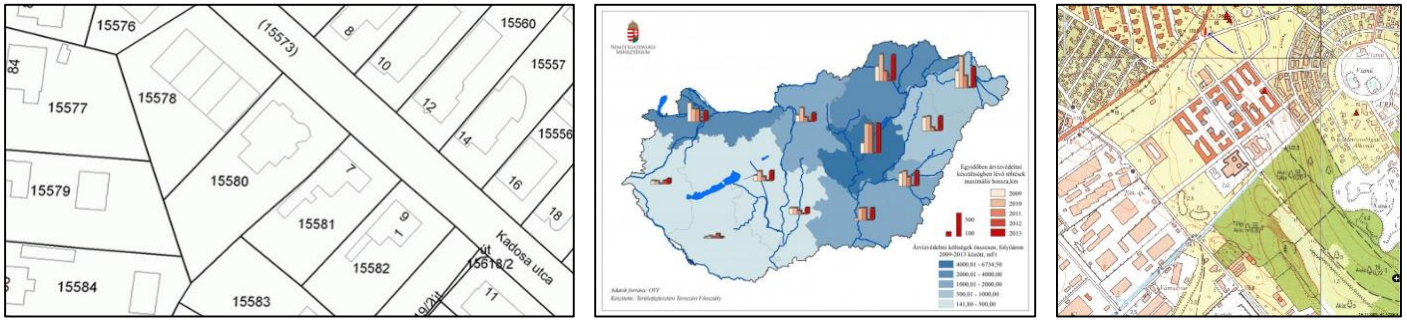

Figure 2. Examples for a cadastral (land registry information), a thematic (costs of flood protection per county) and a topographic map with a scale of 1:10.000.

Classification by projection type:

Different model and reference surfaces can be used. The model surface is the "final" surface of the projection that is unwrapped to a plane and reference surface is what is used to approximate the surface of the Earth inside the mapped area. Typical reference surfaces are the sphere and the ellipsoid, while typical model surfaces are the plane, the cylinder and the cone.

- Azimuthal projection: the model surface is a plane (stereographic, ortographic)
- Conic projection
- Cylindrical projection (they are also called Mercator projections): UTM (secant), Gauss-Krüger (tangential)

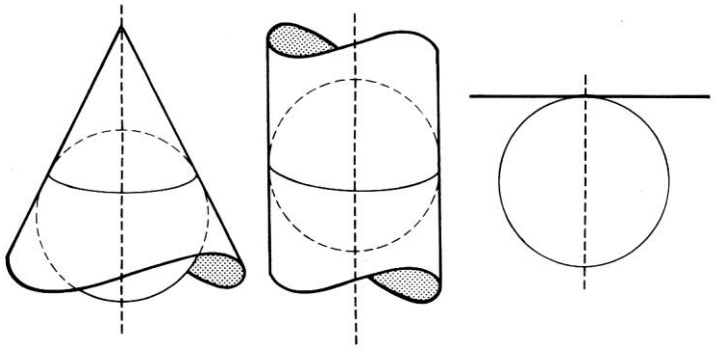

Figure 1. The developable projection surfaces of the conic (left), the cylindrical (center) and the azimuthal (right) projections.

5. Information contained in a map

The parts of a map can differ according to the type of information depicted on it, but typically, we can find two distinguished elements on most maps:

- the base map located inside the frame
- the additional information outside the frame

The base map contains the “actual” drawn area of the map and all the visual data contained in it, such as:

- labels for cities, countries, features
- point heights
- topographic information (color coded), contours
- symbols for certain features
- graticule (coordinate network) or grid system
- control marks
- inset maps
- north arrow or compass rose

The outside of the frame contains additional information regarding the usage of the map:

- scale
- legend or map key
- may include a compass rose
- the name and type of the projection
- title of the map
- author and creation date