Modern level of digital aerial survey technologies using photogrammetric data processing reveals vast opportunities for effective and fast creating and updating large-scale topographic maps. This is especially important in mapping rapidly growing and changing industrial areas in developing countries. “KazGeoCosmos” JSC being specialized in the area of mapping various industrial objects in Kazakhstan has developed, integrated and operates a rigid production methodology. With help of airborne survey equipment owned by the Company specialists acquire high quality data for creation of digital topographic maps.

Wide format digital aerial sensor Vexcel UltraCamX camera mounted on a King Air C90A is used to conduct airborne data acquisition.

Preparation and aerial survey are conducted according to technical specifications requirements and within agreed standards and instructions in RoK.

All stages of photogrammetric processing are executed on acquired field data after initial pre-processing including creation of Digital Terrain Model and orthophotoimages in Photomod digital photogrammetric suite.

Topographic plans creation is initiated while DTM production is still taking place.

Operators draw Break lines over landmarks of artificial (roads, technological embankments, banks, heaps etc.) and natural origin (lines of watersheds, thalwegs and etc.) using PLANAR monitors in stereo mode (Fig. 1).

Such technology allows producing differing by origin outputs. For example, accurate DTM can be built that takes into account all artificial break lines and landmarks. This output is used for engineering purposes. By switching off the layer and leaving only natural and assumed natural landscape the topographical maps that satisfy cartography rules accepted in RoK. The natural landscape is indicated with topographic contours at requested or required by scale step.

Fig. 1. Pickets and break lines in PHOTOMOD.
Final stages of large-scale digital topographic maps creation are performed within ArcGIS environment with orthophotoimagery as background for handling graphic objects.

Field reconnaissance is the other stage of mapping process that takes place while data pre-processing and DTM creation is in progress of being compiled. Acquired earlier aerial imagery is used in-situ by field cartographers. During this phase, objects present on airborne images are identified and charted on the imagery with the set of required for charting parameters. Their qualitative and quantitative characteristics, graphical notes (i.e. topographical symbols), as well as their digital and textual views are used at later stage during topographical map compilation in the office (Fig. 2).

Depending on customer requirements and landscape condition, overall or partial areas of contracted zone is covered during field reconnaissance mission. Maps used for reconnaissance are either in the scale of the targeted end product or larger depending on the conditions.

Vectorization of both airborne data and field reconnaissance results is performed in ArcGIS environment. Group of Charters digitize and vectorize data on corresponding scale map sheets with use of specifically developed geodatabase and map document Standard and customary client driven geodatabase file is initiated for creation of objects with set of parameters that are initially defined with domains and other data proofing tools allowing for quality control during the vectorisation process.

Snapping rules are applied to linear and polygon objects on sheet borders during the vectorization. *LoadObject* method was used to merge data from each operating independently cartographer after vectorization process.

According to the typical geodatabase architecture vector cartographic data contains the following layers:

- buildings,
- civil points,
- earthworks,
- elevation,
- fences,
- geodetic Control Points,
- hydrography lines,
- hydrography points,
- hydrography polygons,
- industrial points,
- industrial lines,
- industrial polygons,
- landcover lines,
- landcover points,
- landcover polygons,
- road surfaces,
- topographic contour,
- transportation lines,
- transportation points.

Depending on the requirements of each project, the geodatabase structure can be changed and supplemented. This customary data is typically handled in a separate layer.

With the specific customer requirements and characteristics of industrial facilities attribute domains codes are adapted and completed
containing all types of topographic maps objects located in the area of interest.

Industrial facilities are treated with specific attention. For example, individual domain numbers are assigned to and subtypes are set for various pipelines, industrial buildings, etc. Because of the large numbers of hatchways, poles, power lines, etc., they are separated into unique layers dedicated to one specific parameter.

As natural and artificial stereomode digitized break lines can be exported only in shape file format, the next step is the line transformation into required geometry types (e.g., polygons) and conversion to layers of the geodatabase with corresponding domain codes.

Topographic contours based on digital elevation model with needed interval are prepared with Photomod tools and are also loaded into the geodatabase divided into sub-types.

In order to properly display and make landscape easy-to-read and according to standard symbology for topographic maps, algorithm was developed and is used for map enhancement that calculates position and orientation of slope incline indicators on closed topographic contours, reproducing the characteristic features of the terrain, such as peaks and hollows. The algorithm is based on the use of tools of spatial analysis, allocation and joining attribute tables of ArcGIS ArcToolbox package.

Once the geodatabase of landmarks and landscape models are finalised, Quality Check is performed:

- Checking the conformity, completeness and adequacy of digital data to initial raster orthophoto with all the errors recorded into a file of comments.
- Checking the conformity of semantic data in attributive tables to the field reconnaissance data.
- Loading together the map sheets on borders. Checking the conformity of the objects for southern and eastern part of the map sheets.
- Checking for presence of objects with missing classification codes.
- Checking inconsistency and typing errors in the attributive data.
- Checking the correctness of geometric topology by standard topology fixing tools for revealing various irrational errors.

In the progress of quality checking all separate lines of the same character that were created in different sectors of the map by varying cartographers are merged into one object according to attribute domains code.

In case of bilingual outputs the copy of geodatabase structure is made with codes of attributes saved and corresponding to each code language description substituted. Having two geodatabases in different languages enables to create Map documents (*.mxd) in which the names of layers, types of objects are presented in corresponding language.

Each object type is represented by symbols for maps according to RoK standard Symbols for 1:5000, 1:2000, 1:1000, 1:500 topographic maps (Fig. 3).

Depending on requirements from the client ArcGIS vector data that was produced and quality assured the dataset can be converted into MapInfo or AutoCAD environment files. Topographical maps can be exported into raster of JPG or PDF format.

Maps of mining area in Karaganda region, uranium ore deposit area in South Kazakhstan and oil deposit territory near Caspian Sea are presented below as examples of the end product created with use of KAZGEOCOSMOS methodology and experience (Fig. 4)
Fig. 4. Example of ortophotoimages and corresponding topographic maps.