

INTERNATIONAL BOUNDARY MAKING – THREE CASE STUDIES

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ABSTRACT

International boundary making starts with the intention of two or more countries of boundary delimitation and/or demarcation. These terms are ruled by their function like *separating*, *developing* or *connecting* the different countries. The initial intention is usually identified by a treaty or agreement. International boundary making with regard to natural, geometric or artificial boundaries can be accomplished in two ways:

- The countries (states) of concern implement their boundaries themselves by setting the requirements and specifications in a treaty negotiated between them; and they control the output (boundary documents and maps) and its later use.
- The countries call upon the Secretary General of the United Nations to make arrangements to demarcate the boundaries between them.

Mapping and satellite imagery often play an important role in international boundary making. This paper examines both ways as being realized by the borders between Indonesia and Timor, and Nigeria and Cameroon and compares them to a more comprehensive way of boundary making as being established by the border demarcation of The Kingdom of Saudi Arabia and The Republic of Yemen.

1. BACKGROUND

Obviously, stable and mutually agreed boundaries are a major pre-requisite for a peaceful cooperation between countries. Surveying and mapping in general and aerial and satellite imagery in particular, play a major role in establishing the borders physically which is an important fact in the recognition of borders. Before discussing boundary making, several terms which are commonly used in this area are shortly reviewed such as *treaty*, *delimitation*, *demarcation*, and *delineation*. They appear in many stages of establishing international boundaries, and their definitions are found e. g. in [1], [6] and [8].

The meaning of *treaty and international agreement* under Article 102 of the charter of the United Nations is defined as: "Treaty is a generic term embracing all instruments binding under international law, regardless of their formal designation, concluded between two or more international juridical persons". The Vienna Convention (1969) defines a treaty as "an international agreement concluded between States in written form and governed by international law, whether embodied in a single instrument or in two or more related instruments and whatever its particular designation"[3].

Treaties between two or more countries are political-juridical instruments enforcing delimitation and demarcation by an executor, taking into consideration the customary international law represented by the United Nations (UN) for accepting, binding and

maintaining sovereignty rights over the territory of the concerned countries. Boundary delimitation requires to have external specifications which define the scope of work, technical specifications for each part of work in terms of description, physical properties, time covering the cycle of boundary making (surveying, construction, mapping), allowing the internal specifications to define the true needs of boundary administration for operation.

Delimitation is the legal process by which two sovereign nations establish and describe in writing the location of their common boundary, mainly as the output of the decision making on the negotiation table.

Demarcation is a field operation. Its purpose is to mark the position of the boundary on the ground so it is visible to all, and this normally starts by surveying which is the initial stage of demarcation. The objective of demarcation is to place or adopt physical marks that accurately represent the location of a delimited boundary. Wherever possible, demarcation by artificial boundary marks should consist of monuments placed directly on the boundary line (see figure 1). A joint commission, composed of an equal number of members from each country, normally undertakes the physical demarcation.

Boundary demarcation is based on requirements with either static documentation (paper mapping and reports) as an output, which for securing knowledge or



Figure 1: Monumentations as a tool for boundary demarcation

information about their boundaries, are to be attached to the treaties archived in the UN; or they are based on dynamic output (like data for Geographic Information Systems, GIS) to be used by future boundary administrations.

Delineation is the graphical or mathematical representation of the boundary. Frequently, a joint commission undertakes both demarcation and delineation. The commission's published results consist of reports, photographs and other illustrations, maps, and tables showing geographic positions of boundary monuments and survey control stations used for the entire period of field work. In this way delineation is the comprehensive description of the entire demarcation and mapping activities that is able to document the boundary for future reference.

There are two types of boundaries: natural and geometric or artificial boundaries.

Natural boundaries are the hydrological boundaries, or watercourses, dry boundaries (wadis), mountain ranges and other natural landmarks. Artificial boundaries are boundaries marked by monuments.

Boundaries that are based upon natural characteristics quickly come to mind, e. g. the border between Spain and France or the one between France and Germany. But it is obvious that many boundaries in today's world do not depend on natural characteristics. Generally, flat areas are appropriate for border crossings and it is not easy to see such a boundary unless they are clearly defined. There are several border definitions generally referring to physical and/or ethnic characteristics. However, there are also boundaries that depend neither on physical nor ethnic characteristics. These types of boundaries can be classified as artificial boundaries. Unfortunately, this type of boundaries causes many disputes.

Boundary making can be accomplished in two ways.

- The countries of concern set requirements, specifications and implementation rules and

share the output and its future use by the boundary administration between them.

- Countries call upon the UN Secretary General to make arrangements to demarcate their common boundary. In this case the requirements and specifications are often different, because the cost of boundary making plays a major role and may affect the output. This type sometimes tends not to be fully state-of-the-art.

Boundary making can be influenced also by a wide range of historical, geographical, political, economic and cultural factors. As a consequence, "there is no single model of good practice in boundary demarcation and maintenance, but sharing experience from around the world can help generate new ideas" [2]. The examples discussed in this paper compare boundary making according to the two ways described above.

2. BOUNDARY MAKING

2.1 PROCESS STEPS

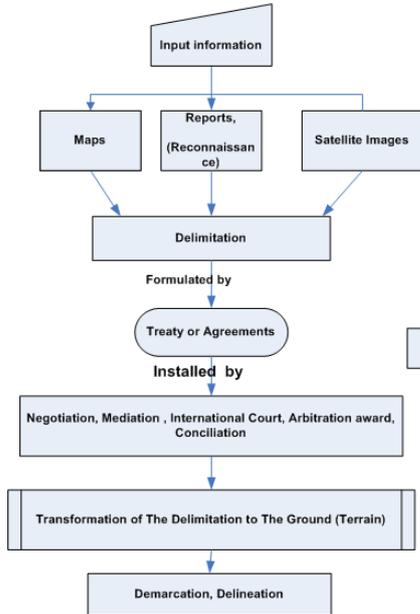
The process of boundary making (delimitation, demarcation and delineation) normally starts by establishing a joint committee which includes technical experts mainly in surveying, monumentation, and mapping, responsible for executing the treaty in its framework and for setting up the technical specifications. These steps should be seen in light of the ISO standards [5], the 9000 family (organizational specifications) and 19100 family (technical specifications), see also below.

There are three stages of the international boundary making process as mentioned in section 1, see also figure 2:

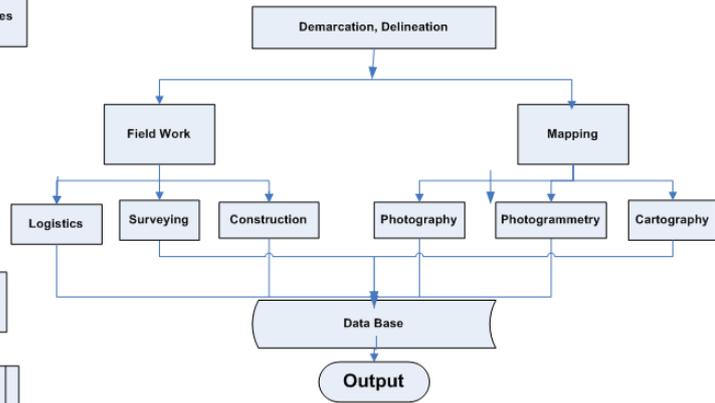
- 1- The preparation of boundary delimitation starts with drafting of border treaties or agreements. The boundary engineer serves as technical adviser to the negotiator by providing the input information for decision making as shown in stage (1).

2- The demarcation work includes all field activities, where delineation covers the mapping process, see stage (2).

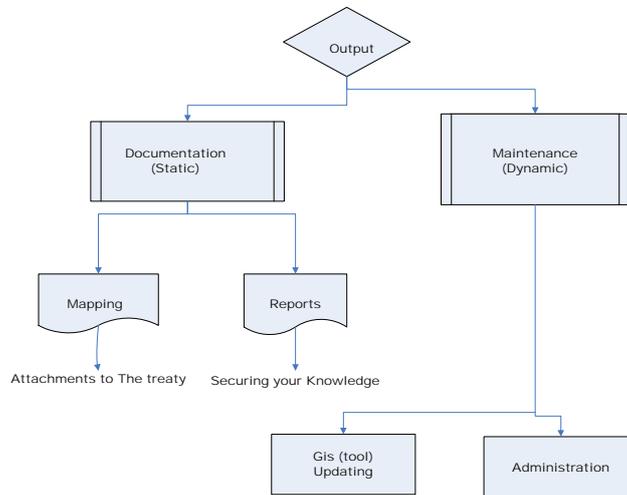
3- Stage (3) illustrates the output of the boundary making process: static documentation or dynamic purposes for future use.



Stage (1)



Stage (2)



Stage (3)

Figure 2: The three stages of the boundary making process

2.2 THE USE OF QUALITY STANDARDS FOR THE BOUNDARY DOCUMENTATION PROCESS

As mentioned, there are two types of ISO quality standards, organizational (ISO 9000 family) and technical (ISO 19100 family). The reason for implementing them in the boundary documentation and mapping production is to standardize the geographic information and identify needs and uses. User requirements are in general the most important issue to take into account when implementing quality standards.

The process of boundary documentation should be implemented based on the requirements of boundary administration using quality principles from ISO 19113, the ISO 19131 data product specification, the conformance of the data to the ISO 19114 quality evaluation, meta data according to ISO 19115, and data quality measures (ISO 19138) to ensure its international acceptance and reliability, taking into consideration the qualification of the producer who should be ISO certified for quality, showing that its quality management system meets the requirements of the ISO 9000 family (organizational), and providing confidence to the client in that particular organization.

The ISO 19100 family of standards (technical specifications) was set up to define, describe and manage geographic information. The focus of this family of standards is to define the basic semantics and the structure of geographic information for data management and data interchange purposes, and to define geographic information service components and their behavior for data processing purposes. Standardization efforts also facilitate interoperability of geographic information systems including interoperability in distributed computing environments. Interoperability is the ability of a system or system component to provide information sharing and inter-application co-operative process control [5]. In many cases these standards are applied in connection with the ISO 9000 family. Figure 3 shows this connection for boundary administration.

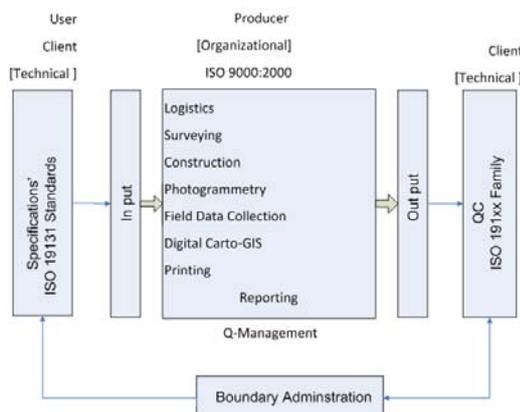


Figure 3: Connection between ISO 9000 organizational and ISO 19100 technical specifications

3. EXAMPLES OF BOUNDARY MAKING

3.1 BOUNDARY BETWEEN INDONESIA AND TIMOR

Referenced to the report published by the Center for Boundary Mapping of the National Agency for Surveys and Mapping of Indonesia [7], the activities for boundary making are summarized:

In 2003 The Republic of Indonesia and the Democratic Republic of Timor-Leste have agreed to delimit their boundary according to their 1914 treaty. The two countries conducted the joint delineation and demarcation surveys of the land boundary between them.

Coordinates were produced along the border lines based on an agreed geodetic reference system, and a common border geodetic datum reference frame (CBGDRF) was established. The ITRF2000 (International Terrestrial Reference System, solution 2000) was selected to map the CBGDRF into a known international reference frame and to prepare and produce a series of border maps along boundary lines for presentation of the land border.

After independent processing by the two countries, and subsequent joint analysis and correction, the final coordinates of the CBDRF network were agreed upon. They serve as a guarantee of the accurate delineation of the border line [7].

Border line delineation on maps and images was done independently by each country as a preliminary step which needed to meet the agreed accuracy standards and the technical specifications. The delineation processes were implemented on both agreed maps and images as well as through joint field surveys.

Field verification was done with respect to terrain features by a joint field team. The products of this boundary making were:

- A list of point coordinates
- 1 General Map sheet at 1:125,000 scale, 17 sheets of Border Maps at 1:25,000 scale, and 26 sheets of Image Maps at 1:10,000 scale.

3.2 BOUNDARY BETWEEN NIGERIA AND CAMEROON

In the absence of a treaty the boundary of Nigeria and Cameroon had been dictated by the 2002 ruling of the International Court of Justice (ICJ). Since then the two countries have made substantial progress in implementing the court ruling under the direction of the UN. A boundary commission established sub-commissions and joint technical teams including experts (mainly surveyors) from the UN, Cameroon and Nigeria responsible for processing the physical demarcation of the land boundary. The sub-commissions agreed on several activities of demarcation and mapping, many of which are being contracted out to the private sector. According to [4] the process can be summarized as follows:

Preliminary map sheets at scale of 1:50,000 were prepared using SPOT5 satellite imagery. This task was carried out by the UN cartography section in New York. The corridor covers 30 km on either side of the boundary. The images were ortho-rectified, the digital terrain model (DTM) was derived from the STRM (shuttle radar topographic mission) and had a 90m resolution. The accuracy of these maps was satisfactory for the field reconnaissance.

A field assessment of the land boundary was done to accurately identify the locations of the boundary pillars to be constructed. Coordinates were determined in UTM projection using GPS to sub-meter accuracy. An international boundary should be referenced to internationally recognized systems, and the WGS 84

system was chosen for this purpose. The geodetic network consists of 10 primary markers equally spaced along the boundary in either country along with 30 secondary markers located closer to the boundary. The accuracy of the network was recorded as 0.01m + 1.0ppm for the primary markers and 0.02m + 10.0ppm for secondary markers [4].

The primary pillars stand at some 2m in height and will be placed at 5km intervals, the smaller secondary pillars will be constructed in between at 500m and 100m intervals through towns and villages.

The end of the boundary making chain is the final mapping, whereby all the information from the final survey will be transferred to the fully rectified 131 maps at scale of 1:50,000. Archiving of the data will be done by the UN along with the transfer of the information to the two countries.

Mapping was performed based on aerial imagery using Bentley's Micro Station software package. The basic data model had primarily been designed to fit the needs of the digital photogrammetric-cartographic compilation process, keeping each mapped feature on a separate storage level. Furthermore, the basic data model contains some elements necessary for generalization, quality control, pre-press processing and other steps in the cartographic workflow. The basic data model was subsequently revised in some aspects, enabling a more convenient use of the data under ArcGIS.

The final mapping products for the Saudi-Yemeni international border were 192 conventional printed maps on paper in 7 different scales (1:10,000 to 1:1,000,000) and digital data sets were prepared to be used in a GIS for the future use of the border administration. Some of the maps were required as attachment to the treaty. After field and map production a final technical report was

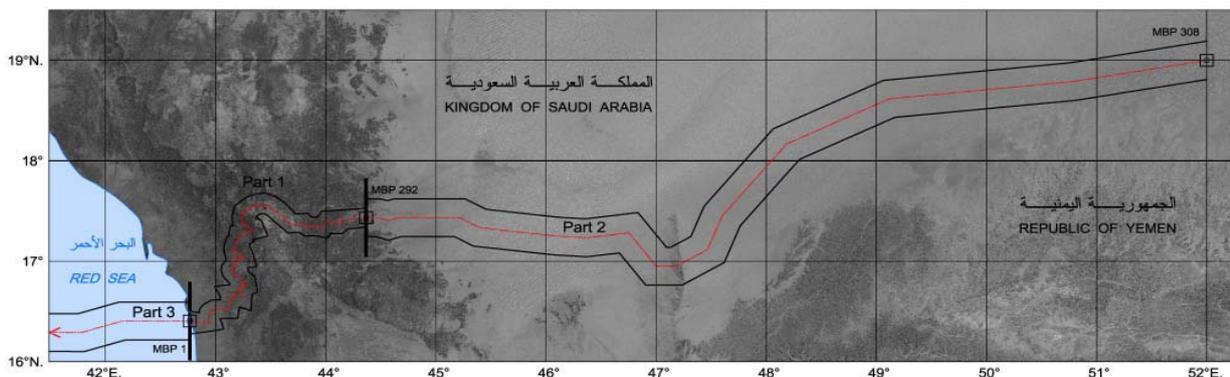


Figure 4: The indicated corridor zone of the Saudi-Yemeni border

3.3 SAUDI-YEMENI BOUNDARY MAKING PROCESS

On June, 12th, 2000, the Kingdom of Saudi Arabia and the Republic of Yemen, signed the International Boundary Treaty that was the culmination of negotiations which began in the 1930s. The preparation of the international treaty from the engineering point of view went through some technical input information processes such as maps, reports, satellite images, and office and field reconnaissance. At the negotiation of the treaty it was agreed to start with a common line map at the scale of 1:1,000,000 which was prepared using Landsat satellite images for the desert and open areas in the Empty Quarter. For inhabitant and mountainous areas French SPOT images and Russian satellite images (KVR 1000, TDK 350) were used to produce maps at scales 1:100,000 and 1:50,000.

The Saudi-Yemeni international border treaty extended in geodetic lines connecting boundary point (main boundary points) coordinates along the border lines based on an agreed geodetic reference system, to establish a CBGDRF. The ITRF2000 was selected, identified by coordinates in the World Geodetic System 1984 (WGS 84) with a total length of the land boundary of 1326.6 km with 667 boundary markers (see figure 1). The maritime boundary extends from the land terminus into the Red Sea along latitude and geodetic lines connecting two further points defined by coordinates. From the last point the line continues parallel to the latitude until the end of the boundary between the two countries (see figure 4).

prepared. The report covers all the activities done in the field and during map production for the purpose of documentation of the border information.

4. DISCUSSION OF THE EXAMPLES

The discussion of these examples starts with a comparison of the three described cases:

Republic of Indonesia and the Democratic Republic of Timor-Leste

For the boundary between The Republic of Indonesia and the Democratic Republic of Timor-Leste no clear requirements about the further use of the data were set. Thus, it was not clear whether the results were just for static use e.g. border line documentation, or whether they were also to be used for boundary administration following the initial boundary making process.

Also the boundary marker design was not mentioned. This is a disadvantage especially for the artificial marks, because boundary signs should be place for everyone to see and recognize. The quality and reliability of the results are unknown except for some metrics of data quality indicating the map scales and the surveying work which was stated in the technical specifications. We therefore conclude that the purpose of the output of the boundary making is probably for static use only. Cost and time spent was not clear since each country did their side of the border area, and no related reports were released.

The boundary of Nigeria and Cameroon

For the boundary of Cameroon and Nigeria the requirements are clearly to solve confrontation and boundary disputes between the two countries. Requirements for documentation and mapping were set by the UN for the execution of the ICJ ruling, for archiving of the data in the UN and transfer to the two countries. Also in this case the purpose of boundary making is for static use only. The cost was carried by contributions from some countries under the direction of the UN. Since cost thus played a major role, the boundary output was minimal and based on static output. The time spent was not clearly mentioned in the available reference.

The Saudi-Yemeni border

Both countries agreed in the international treaty that boundary making would be carried out jointly, so all the requirements and the cost for mapping were agreed and the specifications of the data were done to meet the static output required for the archiving in the UN. Design and documentation of the boundary making strategies were carried out jointly, and dynamic output for future use of the data for development of the border area after finishing boundary making was done, keeping in mind the functions of boundary making, namely *separating*, *developing* and *connecting*. Survey and mapping were done according to collective international specifications and agreements available at that time. The cost was agreed between the two countries and the time spent was less than 5 years.

5. CONCLUSIONS

The design and documentation of the boundary making strategies should be such that countries can carry out jointly the surveying and mapping according to international specifications and agreements. Standardization of boundary making can be served best by a set of international standards that integrates a detailed description of the concepts of geographic information and technology for future use such as those from ISO. This is also a good start for developing peace.

Effective border management requires technical skills relating to positioning and mapping and the ability to exchange spatial data, and to have inspections within regular interval to avoid disputes and degeneration of the boundary and its data, in order to protect the demarcation investment and build confidence between government authorities.

The execution of the boundary making of the first two examples are based on static documentation (mapping and reports) for securing knowledge or information about the boundaries to be attached to the treaties or agreements of the UN. The cost was at the minimum requirements of boundary documentation, but good enough for that purpose. The concept which was used for the demarcation and delineation of the Saudi-Yemeni border and the quality control procedures used in the execution of the border project have resulted in highest levels of permanence and quality.

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