Surveyors Role in Delineation and Demarcation of International Land Boundaries

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ABSTRACT

This paper discusses the surveyors' role in processes leading to the delineation of International Land Boundaries, as a technical advisor to the boundary makers, who are statesmen, politicians, diplomats, lawyers, atc., whose background is very seldom in geodetic science or geomatics. It is the task of the surveyors to "bring the terrain" to the negotiating room and to provide the negotiators with maximum geographical information. It is also the task of the surveyor to assist the formulation of the delineation document in order to avoid ambiguities in interpretation during demarcation operations and later, in boundary management.

The demarcation, or the transfer of the delineation document to the terrain, is almost purely a technical operation, carried out jointly by the surveyors, acting as boundary engineers, of both parties. The result is a record of great importance in avoiding future disputes.

Two prominent examples are discussed, namely the delineation and demarcation of the Iraq-Kuwait boundary by the United Nations, with the aid of Swedish and New Zeeland experts, and of the Israel-Jordan boundary by the parties involved.

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1. INTRODUCTION

Two distinct groups of experts participate in the process of boundary making and boundary management. Boundary architects: statesman, politicians, diplomats, lawyers whose background is in international relations, law, history, political science and economics. Boundary engineers – surveyors and mappers, whose background is in geography, geodesy, cartography and computer science. They provide the architects with comprehensive and reliable information needed for negotiations and the expertise in transferring the agreement to the terrain.

There are three political consequences of the delineation of a boundary:

- Peace. The limiting treaties concluded between neighboring states are in most cases peace treaties or boundary agreements stressing the peaceful permanence of the delimitation as apposed to the provisional character of armistice lines.
- The reaffirmation of the independence of the state.
- Security created by a line which is quasi-sacred, quite apart from political guarantees or military arrangements.

In the preparation stage the boundary engineer should serve as technical expert/ adviser to the treaty negotiators by "bringing the terrain" to the negotiating table.

Let us first consider the perfect delimitation, based on the data and information collected before and during the negotiations, including good quality maps at 1:50,000 or 1:25,000 scales, aerial photographic coverage, a field reconnaissance during which prominent features were checked and named, a preliminary survey made, and even preliminary demarcation executed.

In such a case only replacement of temporary marks by permanent ones would be in order, followed by a final survey, with the results expressed in a well defined coordinate system.

There are, however, no perfect delimitations and the delimitation becomes a directive for demarcation of the boundary, except for those sections where the boundary follows a well defined natural feature. Thus the extent of work delegated to the Boundary Demarcation Commission is a function of the degree of quality of the delimitation and the geographical reliability of the definition. The appointment of a bilateral Boundary Demarcation Commission should be made within the framework of the agreement and its terms of reference stated.

In some of the professional literature and in a number of treaties, the demarcation is considered to be part of delimitation, although there is a clear difference between the two. The principal task of the demarcation is to set out on the ground, as exactly as possible, the *line* of the boundary as defined in the delimitation document. It is however inappropriate and dangerous to dismiss the demarcation as a purely technical operation of minor importance.

The wording of a treaty or an agreement should include anticipation of the demarcation stage and therefore boundary engineers should be represented amongst the treaty negotiators. Any deviation from the concluded treaty or agreement during the subsequent demarcation stage carries with it a potential for future disputes, minor or major but always in danger of eruption depending on the political climate (Adler, 2001).

2. INFORMATION ON THE BOUNDARY

The long process of the creation of a boundary begins with the stage of negotiations by boundary architects, continues, through the formulation of delineation and conclusion of a treaty or agreement, the demarcation and recording of the boundary position, and culminates with the transition to the peaceful management and coexistence on both sides of the line.

This is the culmination of a lengthy international political process and the beginning of cooperation in protection, maintenance and administration of the created boundary, with the emphasis on its permanency and stability.

Throughout this process, both sides need a smooth flow of information, at the beginning each side separately to its negotiators, together to and from the demarcators, recording the infrastructure of the boundary for posterity, and to and from the bilateral authority which constantly evaluates all matters pertaining to the measures necessary to achieve a smooth administration of the frontier.

The information is one our most important resources, not the least of them being the easy availability of the relevant information to the public directly or through the media.

This cannot be realised without assembling all the relevant data from which information about the boundary can be easily retrieved as required. The concept of a database is eminently applicable in this context. The following kinds of data should be included in the envisaged database.

- The text of the treaty, agreement, judgement, or award, with all the relevant protocols, on which the location of the boundary is based.

- The principles on which the boundary line over land is based, for example, that it runs in straight lines between marks, except where the line follows a terrain feature such as local watershed, or where it follows watercourses.

- The principles on which the boundary line following watercourses is based, namely, the middle line of a watercourse, or a bank of a watercourse, or a

thalweg, including clear definitions of these terms.

- The principles applicable in cases of natural changes in boundary watercourse bed.

- Description of the marks and monuments used to mark the course of the boundary and the principles governing their placement, relative to the boundary line.

- The numbering of the marks.

- Any special provisions or arrangements along the boundary line, such as clearing a strip of defined width on both sides of the line, or prohibition of construction of installations within a prescribed strip along the boundary.

- Principles governing inspection and maintenance of the boundary including restoration of markers where necessary. A specification for records of these operations.

- Measures appropriate to protection of boundary markers.

- The bilaterally agreed upon coordinates of the boundary markers, referred to a stated datum and expressed within a well defined coordinate system.

- The principles governing the recording of boundary incidents, such as illegal crossings, fires and damage to boundary fixtures.

- Principles governing the dissemination of information about the boundary.

Database is the beart of a computerised Boundary Information System, which can respond to queries and retrieve or disseminate information. The database in mainly digital in character.

3. MODERN DEMARCATION AND RECORDING SURVEYS

In the past decade, two demarcation and recording surveys, can serve as examples of the application of modern technologies to boundary making.

The examples have a lot in common, although they were not connected with each other in any way.

The first example is the demarcation of the international boundary between Iraq and Kuwait (ILM, 1993).

The second example is the demarcation and recording survey of the international boundary between Israel and Jordan, delimited in the Treaty of Peace (ILM, 1995).

It is worthy of note that both above mentioned demarcations were preceded by previous inadequate delimitations some seventy, eighty years ago and never fully demarcated.

3.1 Iraq - Kuwait Boundary

3.1.1 The Background

The background of the Iraq Kuwait boundary problems is ably presented in Schofield, (1993).

The Security Council resolution 687 (1991) called upon the Secretary General of the United Nations "to lend his assistance to make arrangements with Iraq and Kuwait to demarcate the boundary between them, drawing on appropriate material..." After consultations with the Governments of Iraq and Kuwait, the Secretary General established the United Nations Iraq-Kuwait Boundary Demarcation Commission, composed of three independent experts, one of whom whould serve as chairman and one representative of each Iraq and Kuwait to demarcate the boundary between the two countries.

The terms of reference provided that the international boundary should be demarcated in geographical coordinates of latitude and logitude, as well as by a physical representation (on the ground).

The delimitation formula was the 1932 Exchange of letters between the Prime Minister of Iraq and the Ruler of Kuwait as follows:

"From the intersection of the Wadi-el-Audja with the Batin and thence northwards along the Batin to a point just south of the latitude of Safwan; thence eastwards passing south of Safwan Wells, Jebel Sanam and Um Qasr, leaving them to Iraq and so on to the junction of the Khor Zobeir with the Khor Abdulla. The islands of Warbah, Bubiyan, Maskan (or Mashjan), Failakah, Auhah, Kubbar, Qaru and Umm-el-Maradim appertain to Kuwait."

Pursuant to paragraph 3 of resolution 687 (1991), the Secretary-General appointed Mr. Mochtar Kusuma-Atmadja, former Minister for Foreign Affairs of Indonesia as Chairman; Mr. Ian Brook, then Technical Director, Swedsurvey, National Land Survey of Sweden; and Mr. William Robertson, Surveyor General/Director General of the Department of Survey and Land Information of New Zealand, as independent experts. Iraq was represented by Ambassador Riyadh Al-Qaysi and Kuwait was represented by Ambassador Tarek A. Razzouki. Mr. Miklos Pinter, Chief Cartographer of the United Nations Secretariat, was appointed Secretary to the Commission.

With effect from 20 November 1992, Mr. Kusuma-Atmadja resigned as Chairman of the Commission for personal reasons. Consequent upon the resignation of Mr. Kusuma-Atmadja, the Secretary-General appointed as his successor Mr. Nicolas Valticos,former Assistant Director of the International Labour Office, and member of the Institute of International Law, who assumed his functions on the same date.

In addition to the previously mentioned terms of reference, the Secretary General transmitted to the commission a set of 10 topographic maps at the scale of 1:50,000 by the British Military Survey, on which the boundary is shown as “undemarcated”. For a historical summary on the boundary, the reader is referred to ILM (1993) pp. 1434-1437.

One can divide the boundary into three parts:

a. The section in Wadi-el-Batin.
b. The section between Batin and the khowrs.
c. The section in the Khowrs.

The Commission held a general discussion on the three sections of the boundary as a whole on the basis of the discussion paper presented by the indepedent experts.

Considerable time was devoted on the investigation and discussion of the definition of the point south of Safwan, the general course of the boundary in the Batin, the position of the boundary south of Umm Qasr and the possible position of the boundary at the junction of Khowr Zhobeir and Khowr Abd Allah in the epoch of 1932. The principles to be applied in the demarcation of the boundary beyond the junction of the Khowrs were also considered at length. The language of the delimitation formula was debated extensively. Of particular concern were whether it was technically possible to demarcate the boundary without a turning-point at Safwan, whether the thalweg or the median line concept should be applied in the northern part of the Batin to divide the grazing areas equitably and whether there had been a shift in the junction of the Khowrs over the past decades. With regard to the Khowr Abd Allah section, the principle of the median line, tempered by equity, was considered.

In the technical sections of the discussion paper, the independent experts proposed methods for new mapping of the border area to provide a proper basis for demarcation. The maps and the related spatial data were, in the opinion of the experts, a necessary supplement to the existing maps and documents and would be required before demarcation on the ground could be carried out, as there were no adequate maps of the boundary area for the purpose of demarcation.

To assist the Commission in its deliberations and to enable it to achieve a precise demarcation, the independent experts therefore proposed a new survey and mapping of the entire border area. The proposal included the establishment of a geodetic control network and ground control points for mapping, using satellite-based (Global Positioning System (GPS) and Doppler) methods, combined with conventional survey techniques, aerial photography and the production of a set of large-scale orthophoto maps at the scale of 1:25,000. Included also were special maps to enable the Commission to study specific areas such as the Batin and the border areas at Safwan and Umm Qasr.

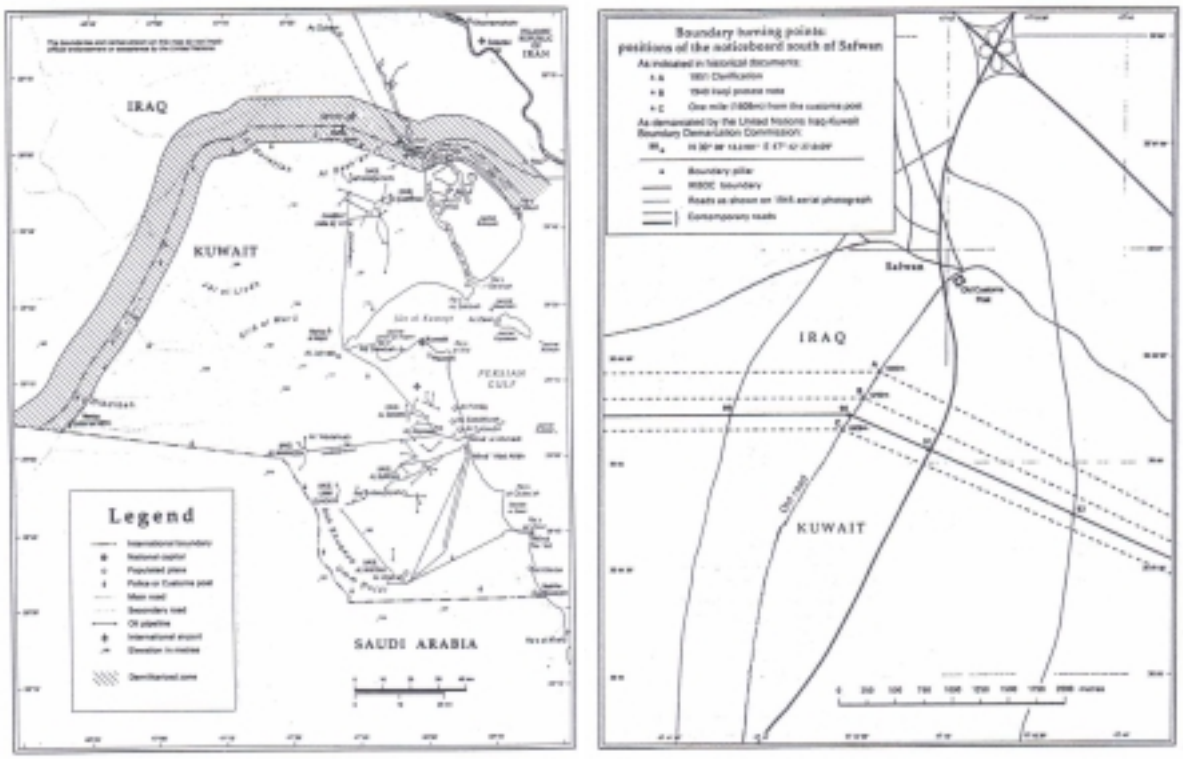

Figure 1: ***Orientation map of the Iraq-Kuwait Boundary***

During the first stage of the field work, the commission established its own geodetic datum called “IKBD-92” (Iraq Kuwait Boundary Datum, 1992), based on the WGS ‘84 ellipsoid and established geodetic network control for the purpose of demarcation of the boundary. It should be noted that the establishment of boundary datum and geodetic control network does not require their connection neither to the Iraqi geodetic control, nor to the Kuwaiti geodetic control.

Four datum stations, 25 geodetic control stations and 137 photogrammetric control points were established towards the end of 1991, by GPS and Doppler survey methods.

Initially, a series of 31 orthophoto maps (in English and Arabic) was produced at a scale of 1:25,000. In addition, separate orthophoto maps were produced at the scale of 1:7,500 for the Safwan and Umm Qasr areas.

For the Batin, 1,420 transverse photogrammetric height profiles were produced. From these the lowest-point line in the Wadi was determined by examining the elevation contours, by measuring along the profiles and by generating three-dimensional digital terrain models.

At a later stage, the aerial photography was extended eastwards to the outer reaches of the Khowr Abd Allah, from which additional orthophoto maps were produced at the scale of 1:25,000. In order to reduce the final number of map sheets and to provide better coverage of the boundary, the size of the sheets was changed. The boundary from the trijunction (initial

southwestern point) to the eastern end of the Khowr Abd Allah is thus covered by 18 map sheets.

The commission dealt with the maritime sections of the boundary from Umm Qasr (boundary pillar 106 - the last land boundary point) eastwards, but this is outside the scope of this briefing. The wadi Al Batin section was demarcated along the line of the lowest points, by a series of straight lines of approximately 2 kilometers in length, balancing the areal departures from the lowest points line, between the two countries. This was done with the aid of terrain models and transverse elevation profiles.

The commission decided that the western section of the boundary will terminate at the intersection of the line of the lowest points in the Wadi Al Batin with the line of the latitude of the boundary point south of Safwan.

The northern section of the boundary required the shore point south of Umm Qasr.

On the old road south of Safwan there was a noticeboard marking the boundary, the position of which was apparently not measured, and two different versions regarding its location existed, namely 1609 meters (1 mile) and 1250 meters of the south west extremity of the customs post. A third version claimed that the position was 1000 meters from the customs post. The commission decided to estbalish the boundary half way between the two versions, which it considered most probable, at a mean distance of 1430 meters from the south west extremity of the old customs post and along the old road. This was done with the aid of several air photographs (from 1945 to 1992) and astronomical observations in 1942.

The location was determined by GPS obvervations and subsequent computation of coordinates producing a latitude of 30°06’13”.3181 and thus fixing the parallel of latitude for the boundary between the end of boundary in Wadi-Al-Batin and the point south of Safwan (boundary pillar No. 72) Looking at the coordinate of the parrallel, one notices that the estimate of the GPS location accuracy must have been in the order of single centimeters as compared with the hundreds of meters in estimating the location of the noticeboard (!).
These however are the realities of boundary making, that the purely technological data of the present day are, as a rule much more accurate than any estimates relating to past positions.

The commission determined the junction of Khor Zobeir with Khor Abdullah and used it to determine the intersection of the boundary with the shoreline at Umm Qasr, aided by the British 1:50,000 map and leaving Umm Qasr port and village as stated in the delimitation document (boundary pillar No. 106).

The section of the boundary between the turning point South of Safwan (boundary pillar no. 90) and the final land point (boundary pillar No. 106) is defined by the commission as being “along the geodesic”. This perhaps is the first instance of using the term “geodesic” in boundary making, geodesic being the shortest line between two points on the surface of the ellipsoid of reference, only experts in geodetic science or geodetic engineering being capable of setting out such a line on the ground or defining it by geographical coordinates.

3.1.2 Physical Demarcation of the Land Boundary

The coordinates for the land boundary are physically demarcated by 106 monuments, approximately 2 kilometers apart, and 28 intermediate markers. The first monument is the existing pillar marking the trijunction point of Iraq, Kuwait and Saudi Arabia. Each boundary monument site consists of a steel-reinforced, silica-mica aggregate concrete boundary pillar, painted yellow and black, 3 meters in height and measuring 45 cm^2 at the top and 90 cm^2 at the base. The pillars are sunk into the ground to an approximate depth of 1.5 meters. A $2m^2$ concrete collar is positioned over them flush with the ground. At each location one witness mark on the Iraqi side and one witness mark on the Kuwaiti side are buried in the ground to facilitate repositioning of the pillar should it become necessary. Small pointer pillars on either side provide a direction towards the site of the next pillar.

Before and after the pillars were emplaced, their positions were inspected and checked at each site. During this exercise it was found that intervisibility between pillars was not possible at every location, either because of the terrain or because of structures along the sight-lines. Where the terrain interfered with intervisibility, intermediate pillars were emplaced during the final field session, in April 1993.

The final output of the United Nations Iraq-Kuwait boundary commission is the list of geographic coordinates (latitude and longitude) of the 106 boundary pillars, 28 intermediate boundary markers and the 56 points defining the position of the low-water line and the median line at sea.

3.2 Israel - Jordan Boundary

The original delimitation of the boundary between mandatory Palestine and Transjordan was laconic and inadequate: "... line drawn from a point two miles east of the town of Akabh up the centre of Wady Arabah, the Dead Sea and the River Jordan to the junction of the latter with the River Yarmuk, thence up the centre of the River Yarmuk to the Syrian Frontier." One sentence in the order of the high commissioner, dated 1 September 1922, for a boundary almost 400 kilometers long, even if half the length is along natural features, such as rivers and the Dead Sea, where the demarcation is not strictly necessary. The section of the boundary between the Gulf of Aqaba and the Dead Sea, running "up the centre of Wady Arabah" was considered by the British too expensive to demarcate, considering the very difficult logistics in the area at that time, as well at the complicated problem of interpreting what was the "centre of the wadi", which is a flat bed, several kilometers wide. Only in 1945-1947, the Survey of Palestine, under the British mandate demarcated a short stretch of the boundary of less than 4 kilometers at the sourthern end of the boundary. The saving of expenditure for demarcation, became a source of friction between Israel and Jordan during the period of armistice and cease fire between 1949 and 1994.

The treaty of Peace between Israel and Jordan was signed on 26th October 1994, with the Joint team of Experts (JTE) acting in an advisory capacity during the negotiations concerning the delimitation of the boundary.

The delimitation was unique in character, using an album of orthophotos, showing the boundary line, as Annex I, Appendixes I-VI, to the Peace Treaty. The boundary line as shown on orthophotos is the best possible way of expressing its intended location within the delimitation and a clear directive for demarcation, avoiding problems connected with the interpretion of maps.

Figure 2: ***An example of an orthophoto attached to the Peace Treaty.***

The demarcation was carried out by the joint Team of Experts who worked together in all the professional activities, connected with establishing principles, reference frame, observations, computations, monumentation and the final set of coordinates.

The survey task of the demarcators is then very clearly specified. It is stated that:

> "The boundary pillars shall be defined in a list of geographic and UTM coordinates based on the joint boundary datum (IJBD 94) to be agreed by the Joint Team of Experts appointed by the Parties using Global Positioning System measurements... This list of coordinates... shall be binding and shall take

precedence over the maps as to the location of the boundary line of this sector."

This approach is undoubtedly the way ahead for boundary delimitation and demarcation.

Phase I of the demarcation was carried out by three Jordan/Israel field teams working in parallel. Every point was located on the ground, using the orthophoto maps for identification, and marked termporarily, with witness marks and ground measurements describing the location.

In phase II, the monumentation took place, pillars replacing the temporary markers, 124 in all.

The Israel Jordan Boundary Datum (IJBD '94) was established using the WGS '84 ellipsoid and 12 boundary datum points, 6 in Israel and 6 in Jordan. The location of the 12 datum points was decided upon after a two day reconnaisance and the points were observed with 12 dual frequency GPS receivers, in 2 sessions of 4 hours each, so that each point was observed for 8 hours (static observations) on the same day.

The 12 datum points established the connection to the reference ellipsoid and one of them - IJ 09 was chosen for the boundary datum, using computed average value calculated by each side using broadcast ephemeris. Both sides agreed to use ellipsoidal heights.

IJ 09 Latitude 31°45'04". 37449 Longtitude 35°36'13".70799 Height - 272.150 m

Using the UTM projection (Uviersal Transverse Meractor), grid coordinates were computed, using the appropriate mapping equations. Holding the datum frame coordinates fixed, the boundary pillar coordinates were computed for the 124 pillars between the Red Sea and the Dead sea.

A uniform accuracy estimated at sub-decimetre level was achieved by each side separately and in view of this an average value was accepted for the final coordinates of each pillar.

3.3 Conclusions Drawn from the Examples

- Demarcation is purely a surveyors' task, in a sharp difference to delimitation, where the principal players are statesmen, diplomats, international lawyers, political advisers etc., and the surveying and mapping experts act in an advisory capacity. Yet it is the demarcation which provides a permanent record of the boundary and an important component of the database, which serves as an infrastructure for managing, maintaining and preserving a boundary line. Let us remember that a borderless community of nations exists only in theory, or is limited at best to the European Community.

- The professional cooperation between the experts of the countries involved is of utmost importance. As (Rushworth, 1993) quite correctly says: "Delimitation by diktat of the winner of a war, such as the recent UN decision

on the Iraq-Kuwait boundary, tend not to stand the test of time. Agreed settlement of frontiers only occurs when relations between the states concerned are reasonably good and usually lags a considerable time behind any conflict.."

- All disputes, big and small can be solved by patient negotiation and by peaceful means.

- Orthophoto maps are an excellent aid to delimitation and are almost indispensable in avoiding disputes, which arise world wide due to faulty delimitations.

- A boundary datum not only avoids problems of connecting boundary points to national datum, but provides an important infrastructure for geographic information system, which is of primary importance in managing and maintaing of boundary.

- GPS observations, joint and simultaneous are the best way to define the location of boundary points within a very acceptable accuracy and a reasonable time. One can see that a GPS demarcated boundary line expressed in coordinates can always be restored by GPS means, without any other aids.

4. SUMMARY AND CONCLUSIONS

Practically every existing boundary has its own specific background, which includes technical aspects, often dating back several centuries. It is very difficult and perhaps unnecessary to modernise such boundaries by introducing modern technology, even though a computerised database system is desirable in every single case.

It is however imperative to implement the boundary making technologies outlined in this paper in all cases of newly emerging boundaries or the reestablishment of old ones. The following aspects should be stressed:

- Technical experts should participate in the negotiating teams in order to provide the negotiators with the most reliable information available, in other words, to bring the terrain to the negotiating room.

- The boundary treaties and agreements should rely less on maps and more on recently acquired digital data. Great care should be taken in order not to misuse significant figures. All maps used should be evaluated by experts and the results of the evaluation recorded.

- Each boundary should have a geodetic boundary datum, which would provide a well defined reference system, independent of national datums and completely unclassified.

- All location surveys should be executed by GPS methods with each location given its estimated accuracy. Demarcation records should be meticulously prepared and digitally stored, permitting restoration of marks at all times.

- A computerised boundary information system outlined in this briefing should be established for the purpose of efficient and peaceful administration of the boundary. Selected parts of the specific boundary database should be included in a world wide database.

- Every effort should be made to bridge the gap between the boundary architects and boundary engineers.

It is hoped that the model of technological services to boundary creation and its administration will, through its implementation, become a contribution to preserving the international peace.

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BIOGRAPHICAL NOTES

Ron Adler received a Master of Science degree from Ohio State University in 1963 and a Doctor of Science degree from the Technion, Israel Institute of Technology in 1970. He is a registered professional engineer and licensed surveyor and has held a number of posts at the Center for Mapping – Survey of Israel, including 21 years as Director General.

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