Building Jordan Digital Cadastral Data Base (JDCDB) in the Department of Lands and Survey (DLS)

Zuhair ALOSTAH and Saad ALKHATIB, Jordan

Key words: Digital cadastral maps secure land tenure using in house customized standards & professional practice with relatively low cost technology.

SUMMARY

The Department of Lands and Survey (DLS) is almost the oldest official governmental organization in Jordan. It was established in 1927 and took over the cadastral and land registration tasks and documents from the Turkish administration.

Since DLS is in charge of establishing real-estate rights, safeguard them, keep the necessary documents concerning them, facilitate the use of these rights, and contribute on the building of GIS, DLS has thus initiated a programme aiming at improving land management and cadastral data in terms of quality, integrity, and completeness in the whole country.

In 1987 DLS started the process of Automating the Real Estate Register to serve all the activities related to land registration affairs. All of land ownership data are converted to digital form and stored in Ingress RDBMS migrated recently to Oracle. In 1995, DLS started a large scale project to convert (18.000) analogue cadastral sheets to digital format using optical scanners and home customized raster-to-vector software.

The high price of lands, the expectations of owners to get accurate and definitive results, and the conflicts between owners because of parcels boundaries; are all factors pushing in the direction of improving accuracy of the JDCDB and making it available in an easy and friendly form.

This paper will review the objectives, conclusion, and upgrade methodologies to keep JDCDB updated and accuracy enhanced. JDCDB now is available to all other institutions in Jordan.

لقد تم إنشاء دائرة الأراضي والمساحة في الأردن عام 1927، وهي الدائرة الحكومية الوحيدة المسؤولة عن حفظ الملكية العقارية وصيانتها (الخارطة، السجل العقاري). بدأت دائرة الأراضي والمساحة منذ عام 1995 الإعداد لمشروع تحويل الخرائط الورقية القديمة إلى خرائط رقمية، من خلال تجديد نماذج مختلفة من الخرائط. وتبذل الدائرة الآن جهوداً كثيفة لبناء نظام المعلومات الكادسترائي والذي يعتبر أساساً لنظام معلومات الأراضي على مستوى وطني.

استخدمت دائرة الأراضي والمساحة أجهزة المساحة الحديثة وأجهزة الرصد بواسطة الأقمار الصناعية لرفع درجة الدقة في الإحداثيات ولتلبية حاجات المستخدمين. في عام 1987 تم انتشار الحوسبة لتوفير خدمات جديدة، حيث تم حوسبة جميع الملكيات في قواعد البيانات العلائقية وفي عام 1995 بدأ مشروع تحويل (18.000) خارطة ورقية إلى صيغة رقمية بواسطة استخدام تقنيات المسح الضوئي وبرمجيات التحويل من الصيغة النقطية إلى الصيغة الرقمية.

هذه الورقة ستراجع الأهداف، الآليات، والنتائج لهذا المشروع وتصف آليات تحديث هذه الخارطة وتحسين دقتها.

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1. INTRODUCTION

Jordan's total area is around 89000$_{km2}$; its population is around 6 millions inhabitants. The country is divided into 12 administrative districts called governorates. The capital city is Amman with population of about 1.5 million inhabitants.

Since the 20s of the last century, DLS is working hardly to achieve its mission in a proper way. The maps were established over time by different methods and scales and have different qualities not to say imperfections.

This situation was satisfactory up to the moment where land became more and more scarce, and more expensive to acquire. When big parcels were subdivided and the average parcels area was reduced with time leading to a high demand on DLS to deliver accurate and reliable information regarding the positions of these parcels in the space and in Georeference system.

DLS-maps are based on a geodetic network, which has a low relative accuracy (non-homogenous geodetic network). This network is computed in Cassini-Soldner projection, and does not serve properly the needs of DLS. The total number of points inside this network is around 42000, and the total number of maps drawn using this network is around 18000, their scales range between 1/500 in some urban areas, down to 1/20000 in some remote regions, the accuracy of cadastral maps is not good because of the geodetic network limitations.

Fortunately, Jordan has since 1978 a highly accurate Doppler based geodetic network called Jordan Transverse Mercator (JTM). This national network has a density of one point per 25$_{km}^2$, and it has a relative accuracy not better than 1/100000.

JDCDB aim at improving the quality of the Cadastral Information System (CIS) and making it user friendly, DLS have embarked on a programme to ensure that: - Cadastral maps and land register are in digital form, matched, updated regularly, complete and available to the users in a proper and agreed on format.

1.1 Rational behind the project

1. Provide up-to-date Information for DLS needs, since it is expanding CIS to all 32 land registration directorates (LRDs) distributed in major cities and villages within the country. DLS now maintains 1.3 million of land parcels reflected in (18.000) digital cadastral maps, these parcels are associated with 3 million ownership records.
2. With such huge data, it is very difficult to manage such quantity in manual and conventional methods, meanwhile LRDs around the country should provide satisfactory services to the customers, and such an objective requires speeding up and increasing the accuracy of the operations. Also providing CIS facilities for 32 LRDs that allow transactions to be processed locally (decentralization), as well as providing faster, transparent, and more efficient services for the public in many domains such as land

valuation system, land sub-division, boundary fixing administration, and state owned land protection and managing.

3. Avoiding damaging the analogue sheets: - in 1995 DLS found out that many parcels had been vanished out of the sheets, this will affect the credibility of official records, and degrade the geometric properties of the existed parcels. Subsequently, possible loss in property markets.
4. Avoid manual renewal of analogue sheets: - before 1995, maps are copied by manual renewal way, this was done by fixing transparent tracing paper over the analogue sheet, copy the elements of the sheet, then copy again the transparent paper to a new sheet by hand, this process destroyed the geometric position of the origin sheet, sine a lot of errors were added and transferred to the new one.
5. Provide up-to-date digital information for external users, license surveying accredited by DLS, those surveyors operate all transactions; their results are considered as the basic input to build up and feed CIS. License surveyors play important role for building JDCDB.
6. JDCDB provide efficient and powerful tool for cost recovering of the cadastre, since digital cadastral maps are being sold for other institutions through mutual agreements that facilitate data flow between different institutions and DLS.
7. More constancy land ownership: - JDCDB promotes higher level ownership security and confidence by protecting ownerships against damage or forgery as will as smooth data updating and maintenance.

1.2 Benefits

– High accuracy for boundary fixing that protects ownership security. Parcel boundaries are represented by coordinates that are measured from the field and replaced the vectored ones, this coordinates will enhance the relative accuracy and will reduce land disputes which will provide high level ownership sustainability.
– JDCDB is the basic layer for land information system and is used by other local government agencies (such as municipalities, water authority …etc) for planning, zoning permits, open roads (expropriation), public works, and so on so forth. Appropriate land use could be failed because of unsuitable outdated CIS (insufficient protected land tenure system), ex: lands may be destroyed (forests) by uncontrolled exploitation.
– Decreasing LRDs transactions time, by providing surveying information more quickly (plans, cadastral maps, coordinates, cadastral sketches, etc…) to external users, LRDS are distributed around the country, linked to JDCDB by digital lease lines and frame relay (WAN).
– Real time support for decision making (Information is power):- providing essential up-to-date information to decision makers is a magic tool for efficient management and for sustainable development.
– Providing different services: - maps, charts and reports that have correct and proper Information in true time for different levels in local government agencies, municipalities, general directors, etc.

- Supporting land property valuation:- Building up database for land values is along term and tedious work but it can be managed easily using JDCDB. Now, the latest selling prices are introduced to tables which are associated with parcel number (DLS_KEY), prices are defined as a preliminary attributes for the base price for regions, which can be used as a reference price for the valuators.
- Protecting state owned lands.
- Enhancing spatial accuracy by applying the concept of partial renewal.
- Enabling E-services.

2. PROJECT PLANNING AND METHODOLOGY

2.1 Project planning

DLS cadastral maps are based on a geodetic network, which has a low relative accuracy. This network is computed in Cassini-Soldner projection, which is a non-conformal projection. The total number of points inside this network is around 45000.

The time frame for concluding the project was for five years (1995-2000) which had defined by the high management according to the initial plan which was prepared. Steering and technical committees supervised and controlled the whole process of the project to insure that the objectives were met. Computers, plotters, printers, scanners, software's, and interfaces had acquired for the project from the beginning.

<u>2.1.1 Requirements (user needs) in JDCDB</u>

- To be up to date.
- To be reliable.
- To be complete (cover the whole country).
- To cover all layers needed (vertical).
- To be modeled, easy retrievable, easy maintained and easy invoking queries.
- To be linked to other layers such as land use, zoning.
- To be secured (confidentiality, limited access).
- To be accurate enough.
- To be easy for data flow (ready for other users).
- To be systematic, classified.

<u>2.1.2 Aspects had been considered in the project</u>

- Vectorized maps must conform to technical standards.
- 3 different quality marks were given to the maps according to the source of source of production and type of measurements.
- Any digital map in JDCDB with low quality mark was definitely considered better than the original because all shrinkage and scale problems would be adjusted.
- Some identified problems have solved by brain storming during workshops.
- A formal project management (manager, group's leaders) mixed with informal team spirit would eventually overcome the resistance and solve problems easily.

– Vectorized map must be converted to the homogenous datum JTM by applying the produced measured zone parameters.
– Reflecting the original quality of the hard copy and enhancing the accuracy will be ultimately achieved by new daily direct survey measurement in the field.
– Upgrading of low quality maps will come later on through the new transactions which are performed according to DLS surveying technical specifications.

2.2 Project methodology

In house training for DLS employees had conducted in many subjects such as: scanning and vectorizing process, and how to ensuring the consistency, the structure, and modeling in the JDCDB. Cadastral maps were scanned with ANATECHN scanner, but the used drum scanner was not suitable in the following cases:

1) Many maps had an intermediate layer consisting of metal.
2) Many maps were in a miserable state: they had folds, tears and adhesive tapes (misused in the past).Obviously the state of the maps caused a slip while the map was running through the drum and therefore the accuracy of the scanned maps got worse.

2.2.1 Scanning process

Optical scanning were used to scan (18.000) analogue sheets, starting by preparation and inventorying all the sheets, recording all scanned sheets in a follow up system (RDBMS), sending all local maps to field surveying, preparing special form for daily work for each sheet, preparing all trig points needed (names, coordinates, gridlines), and Cleaning up the sheets from all dirties. All reference points were cleaned and pricked again, some grid lines intersections used in transformation after they had pricked by using sharp nail (diameter < 0.2 mm).

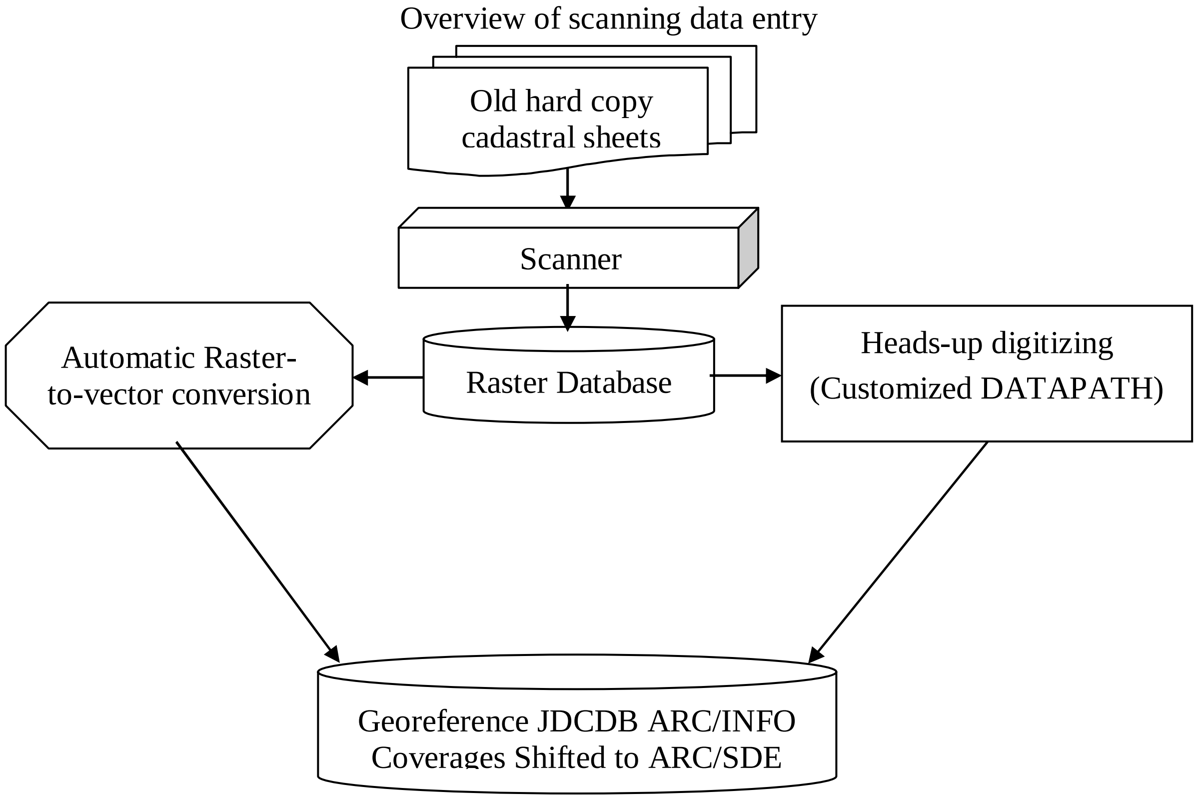
Optical resolution for the scanner should be greater than (254 dpi), this meant that points with diameter of 0.1mm have caught as one pixel in scanned image, but for better accuracy 300_{dpi} were used for all scanned sheets.

- Format used was tiffg3 (less size).
- All scanned sheets were oriented north to the top all the time.
- A lot of maps had an intermediate layer consisting of irregular surface, this lead to slip while the map is running through the drum of the scanner, those maps handled by adhesive tapes and their accuracy checked by measuring 6 comparison distances.
- Checking the distortion happened in an image pixels (figure 1, b, c).
- Checking the scanned image: - 6 distances were measured for each image, 3 in X direction, 3 in Y direction, checking that the distortion in (x,y) not exceed 0.04_{cm}, if the tolerance of (0.4_{mm}) was overstepped, the scanning process was repeated.

$$\Delta X_1 = X_1(real \quad on \quad sheet) - X_1(distance \quad on \quad image)$$
$$\Delta X_2 = X_2(real \quad on \quad sheet) - X_2(distance \quad on \quad image)$$
$$\Delta X_3 = X_1(real \quad on \quad sheet) - X_3(distance \quad on \quad image)$$

Shrinkage should be systematic

- In some cases, additional points in a regular order (grid plate) were drawn (pricked) in the sheet, after the scanning, those points were measured on the screen in order to execute an affine transformation. Gross mistakes of the scanning could be recognized by the residuals. This might be considered easier than measuring 6 distances. If the map couldn't be scanned because it had an intermediate layer consisting of metal, the production camera was used, or old films were used, and their distortions could sufficiently be removed by affine transformation.
- Scanning data entry software tools were used to edit raster data, but this process took longer time than vectorization process.
- Heads-up digitization process is cost reduction alternative for most expensive data automation process.
- Heads-up digitization is in general faster, and more accurate than table digitizing. Scanned and Vectorized data had more consistent coordinates than the digitizing one (random errors).
- Heads-up digitization methods could be easily learned.
- Heads-up digitization for poor quality analogue sheets was more effective, but it took more time for data editing, cleansing, and separate features in to different layers.
- Scanning data entry needed additional disk storage and more powerful CPU.
- Evaluating of scanning data entry was a key factor in ensuring success, the bi-tonal (B & W), line art map data source had least pre or post- processing with a single data layer, but a lot of clutters, presences of registration tics (georeference marks) and dirty, low-contrast media.



2.2.2 Transformation to the national datum

Choosing the reference points and the examination of the results of the transformations was executed using DATAPATH software. At least 5 points were selected as reference tics, which should be a mixture of grid points, trig points that cover > 90% of the sheet. Selected reference points on the edge are more important than reference points in the middle and should be close to the data in the sheet, therefore reference points out side the universal frame were eliminated in case of having reference points on the edges, and Distances between them were consistent. In some sheets, selection of some points from high quality marked neighborhood sheets with low residuals was very useful. Trig points had higher priority than grid points; trig points which are located at parcels boundaries were preferable, because it had privileges at further stages (edge matching-first interpolation).
Affine transformation had been used. Its results were saved for each map in soft copies as well as hard ones. Checking (RMSE), standard division(S), and residuals for all registration tics points was conducted. The residuals for any registration tic point was < 3S. It was important to know the results of the transformations for all neighboring maps, therefore it was necessary that all maps of one village are scanned and transformed together after vectorization. The local subdivisions which were drawn outside the sheet had been inserted to the correct georeference position using helmet transformation.

Graphical coordinates of all reference points were saved (kept) for any further adjustment, especially when the concept of the renewal of cadastre is to be applied. 40% of the map points measured in the field is enough for upgrade the map accuracy (this is has been doing in DLS for 2 years).

Extrapolation is not allowed, but in some exceptional cases when d <D/4 it was justified (figure 1, a).

Figure 1

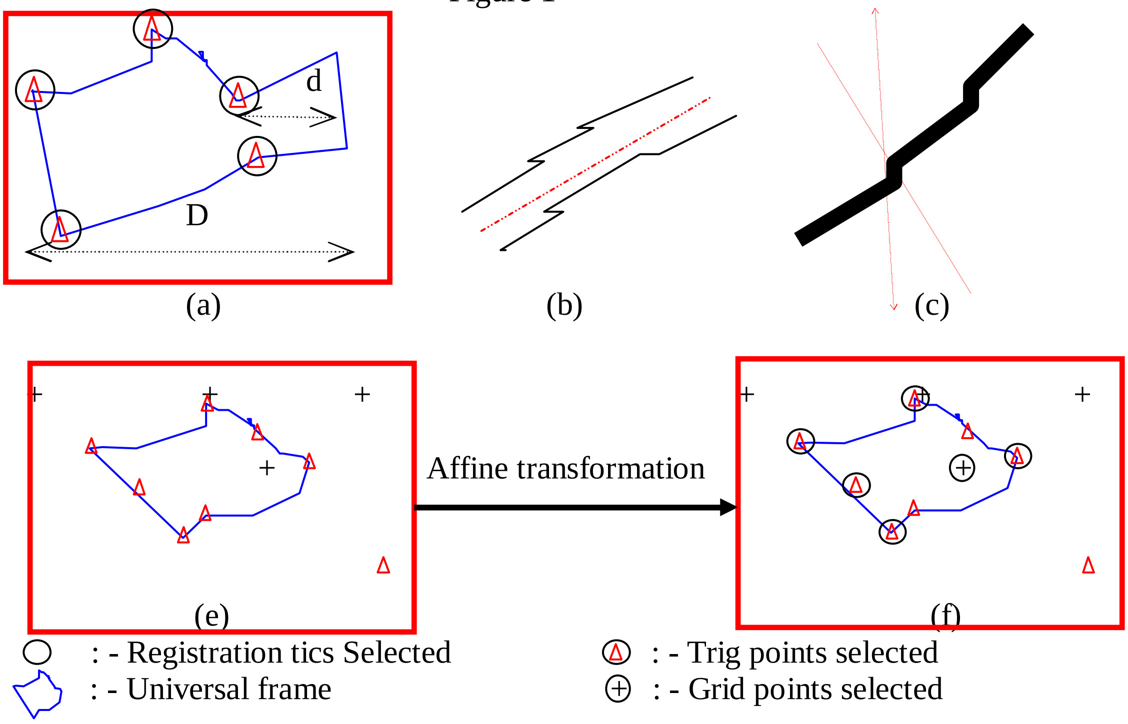


Table 1 / RMSE tolerances in Different Scales	
Scale	RMSE (in cm)
500	5.08 - - 10.16
1000	10.16 - - 20.32
1500	15.24 -- 30.48
2000	20.32 - - 40.64
2500	25.40 - - 50.80
5000	50.80 – 101.60
10000	101.60 - - 203.20
20000	203.20 - - 406.40

2.2.3 Checking of map elements

The initial control plots were done using the same scale of the original sheets on a transparent paper or foil. All sheets elements, header and logo were checked, all errors were marked. Symbols were designed for all elements and agreed upon between all project units.

Things should be checked for each map:-

a. All paper documents and transformation report (RMSE, residuals, standard deviation).
b. All electronic files generated from transformation process.
c. Codes, location, grid, scale, and completeness, etc...
d. Cadastral lines layer: - this layer had been checked by comparing the plotting of the transparent copy of the vectorized map with the original one. Checking overshot, undershot intersections, colors, and subtypes, etc.
e. Point's layer:-ensuring that all subtypes are correct.
f. Parcel (polygon layer) had been checked for parcel-ID, SOURCE, etc.

2.2.4 Checking of the final transformations

If big residuals were encountered in a necessary (can't be replaced) registration point, this residual was compared with the neighboring analogue sheet/sheets and treated according to the following rules:

1) If the residuals nearly had the same value and direction in all sheets, that meant sheets were homogeneous, trig coordinates were to be checked.
2) If coordinates were true: transformation was retained.
3) If coordinates were wrong: trig point/points were to be cancelled.
4) If RMSE was bigger than graphical accuracy (0.2mm*scale), the whole map was considered not homogeneous (or real coordinates are not homogeneous) or both possibilities.
5) If their were no reference points in a necessary area (i.e. edges):
    1. Transforming of both neighboring analogue sheets with extrapolation.
    2. Calculating the weighted mean value for involved edge point, using it as a real coordinate in the next transformation.
    3. Use identical points from neighboring analogue sheet.
6) All trig points which had real coordinates should be vectorized and have had transformed coordinates (model coordinates).

2.2.5 Data structure

Creation of vector data base from the original analogue sheet was not enough; all features were separated into layers, all similar elements were grouped together in one feature class and were symbolized, all user data were added to all elements. In order to keep the map up-to-date, all new transactions should be inserted in to the vector data base, The DLS carried out approximately (20.000) transactions each year.

Layers

Nodes	Lines	Labels	Groups
1 Settlement Nodes 2 Transaction Nodes 3 Other Nodes 4 Trig-txt	1 Settlement Lines 2 Transaction Lines 3 Other lines Registration lines	1 Settlement -Labels 2 Transaction - Labels 3 Other - Labels	Annotations in 10 levels included Registration distances

- Lines layer:- Lines were classified in to 3 main subtypes:-
  a. Settlement lines (black original first initial surveying lines).
  b. Transaction lines (red line were created by new subdivisions).
  c. Other lines (administrative boundaries, utilities, wadis, wells, canals … etc).
- Points layer: divided to 11 main subtypes, each subtype have had specific properties:-
  a. Settlement (black nodes connected settlement lines)
  b. Transaction (red nodes connected trans-point).
  c. Other (caves, trig point, traverse points, graphics-point).
  d. Ref- points (tied points for edge matching).
  e. Trig-txt (names of trig points)
  f. Wells springs.
- Parcel (polygon layer):- a layer contains the boundaries of land ownership parcels which are identified by a unique number.
- Registration distances layer: - a layer contains the legal distances which represent the distance in the index of change which was created through different transactions.
- Special annotation linked to parcels which had 10 levels of annotations (roads, distances…), 2 colors were used (black, red), and size for each text was registered according to origin map scale.

2.2.6 Creating a coverage model→JDCDB

- All geometric coordinate files that are associated with attribute files were converted automatically from DATAPATH to ARC/INFO by using customized macros. Coverages were generated automatically with an accuracy of double precision and full attributes. All COGO elements were added for all features, topology was built, to produce the final copy.
- All maps in digital form should be seamless, scaleless with high accuracy (high quality mark). JDCDB structure is composed of governorates, divided into villages (cities), divided into blocks, divided into sectors, divided into sheets, and up to smallest unit which is the parcel. The graphical accuracy of the original map should be less or equal 0.2mm/point, therefore the tolerance between the original map and the control plot could be a little bit larger than this value was accepted.

3. EDGEMATCHING (SEAMLESS JDCDB)

It was obvious and well-known, and expected to have none matched edges of the maps. The edges of the neighboring maps were not identical and the difference between those edges reached more than 4m for maps at scale of 1/2500 in urban areas. The dimension of such difference was bigger than expected, and was beyond the graphical accuracy.

Edge matching process started in 1997 and concluded in 2004; a mathematical model was elaborated and implemented.

The task had certain technical procedures with very important rule that insures conservation of the geometrics shape of the parcels in a sufficient matter without contradictions with legal aspects.

Shapes discrepancies (mistakes) between neighbored maps were verified in the field (partial resurveying). DLS has the right to clarify these discrepancies by getting a written agreement of the owners for the concerned parcels or by court verdict.

3.1 Reasons for discrepancies in map-edges

a. Non-homogeneous network (Cassine).
b. Each map has its own transformation parameters, distribution (first interpolation) of the residuals over all map elements minimize the discrepancies between map edges.
c. Different quality in original cadastral analogue sheets which have been vectorized (different material, different scales, and different accuracy).
d. Physical distortions (influence of temperature, humidity, shrinkage, tears, folded).
e. 10% of the original maps were local (not connected to geodetic reference network).

3.2 Working rules in Edge-matching

1) Formation of simple/weighted mean of an edge point in which two or more maps are connected (touch). Vectors linked between graphical (transformed) coordinates to mean edge point.
2) Sequence of treatment:-
   - Starting from the middles of an area was preferable (treatment unit).
   - Deleting all comparison lines.
   - Checking differences between maps

     $$diffferen\boldsymbol{e} \prec \left(3 \times \sqrt{2} \times 0.2_{mm} \times \sqrt{E1^2 + E2^2}\right) \qquad \text{Map scale} = 1/E$$

   - Having the same feature classes representation for each point in both maps.
3) First interpolation (distribution of residuals):- real coordinates replace the transformed ones for the pass points, the rest of the transferred coordinates were adjusted by interpolation. This procedure had been done by using the old saved transformation files. The first interpolation distribute the residuals on the reference points over all elements of the map, it had been done by a special procedure "adjust command" in ARC/INFO. To execute the adjust command residuals vectors must be defined on the screen, but it is important to fixed all points which have had real coordinates (constraint for real

coordinates). It could happen that straight lines are destroyed; this was cured by further shifts of points using second interpolation.

4) Determination of weights: - A weight for each map was calculated at the beginning, the weight (w) is dependent on the scale.

   $$w = cons\tan \times (scale)^2$$

   Scale = 1:5000 → w=1
   Scale = 1:2500 → w=4

5) When Weighted mean values on the edge are not formed?
   1. when its extremely big weights differ (scale1 = 1:10000 w=1 , scale2 = 1:2500 w=16)
      W for central map=1 W for neighboring map=16
   2. When the neighboring map has real coordinates.
   3. When the neighboring map is a transaction type.

   In all the above 3 cases, the edges of neighboring map are fixed and the edge points of the central map are shifted to the corresponding edge points of neighboring map.

3.3 Maps Transformation to JTM Datum

Jordan Transverse Mercator projection (JTM) is a geodetic datum uses the International Hayford as an Ellipsoid. This projection is with 6° zones, central meridian of 37° and scale factor in the central meridian of 0.9998. The National Geodetic Network and is highly accurate (Doppler based geodetic network).

The origin maps of JDCDB are in Cassini-Soldner projection which is some how a non-homogeneous datum. Therefore transforming all the (18000) maps to JTM fulfils the overall goal of establishing JDCDB. To reach this target an extensive fieldwork was carried out between 1998- 2000, 2200 DLS triangulation points (out of 45000) were re-observed in JTM using post process GPS surveying technique, relying on the National Geodetic Network JTM.

Once the transformation parameters were obtained, all 45000 DLS trig points had been transformed to JTM. Furthermore, densification of control points created using JTM datum directly.

4. DATA INTEGRATION

As it was mentioned earlier, one of the tools to achieve DLS mission, is to have cadastral maps in JTM based on the national geodetic network. This tool has different components:

- Edge matching digital maps
- Transforming digital maps into JTM coordinate system.
- Matching the electronic copy of the land register with the hardcopies (Land Register Matching).
- Matching the cadastral maps with the land registers (Cleansing JDCDB).
- Improving the cadastral data quality (Renewing of cadastre).

- Completing the cadastral information system by adding the missing layers e.g. the building, this could be done through orthophoto techniques.
- Creating DLS parcel data model.

4.1 Renewing of cadastre and quality control approach

The problem of low accuracy of the digital cadastral maps due to geodetic network limitations, the high price of lands, the expectations of owners to get reliable results, and the conflicts between owners because of contradiction between the physical reality on the ground and its reflection on the JDCDB, all these factors push in the direction of improving the cadastral information and making it available in an easy and friendly form. At different times during the 70s, 80s and 90s the whole resurveying concept was brought up as sole solution to this problem, but the tremendous work and costs needed to implement this solution made it unrealistic one.

The alternative that DLS come up with after consulting international experts on this issue (Mainly German experts through GTZ) was the concept of partial resurveying. The concept strategy is to renew the cadastral maps gradually by replacing the current coordinates of the boundary points by new accurately observed and computed coordinates using the JTM projection. The gradual replacement of old coordinates with new ones means that every time when a new subdivision of a parcel is under process, a boundary reestablishment must and should precede it. This boundary reestablishment will be carried out using a uniform, precise and homogeneous geodetic network in JTM; by this the result will be a set of new computed boundary points that will automatically replace the old one and by that updating the cadastral map gradually. For that to happen smoothly and without any duplication of work in the future, the cadastral maps must be converted into JTM projection first. Of course it's not necessary to wait for a new subdivision of a parcel in order to renew and update JDCDB; the same procedure can be executed for all areas with big discrepancies. The best way to put clear and exact priorities for areas to be resurveyed by taking into consideration the value, location, density, number of transaction, level of demand on accurate data, etc.

This strategy forms a big challenge to DLS and in order to see its successful implementation it needs to be accepted and explained very clearly to all concerned stakeholders and especially the public and licensed surveyors as main executors.

4.1.1 Partial Resurveying Concept

The partial resurveying concept focused on improving the quality of the cadastral data. This concept involves many actors, the Surveying Services Directorate at the HQ, 32 (LRDs) spread all over the country, and the licensed surveyors, these actors are working in the domains of boundary fixing and land sub-divisions.

The new procedures are concentrated mainly on the field work, which can be done by licensed surveyors as well as by surveying groups of DLS. There is no doubt, that the renewing concept will increase the field work but the benefit will not come directly, new surveying measurements of the geometrical parts of the real estate cadastre in boundary fixing and plot division measurements. The results of the field work must be delivered in the requested manner by the surveyors and the present instructions for the field work are more precise. The handling of the quality parameter (QP) for new calculated coordinates is the main backbone for the renewing by determined the standard deviation in location (SDL) as shown in Table 1.

(Table 1):

SDL	quality parameter QP	remarks to the accuracy
< 50 mm	30	Excellent
< 80 mm	31	very good
< 150 mm	32	Good
< 250 mm	33	Average
< 500 mm	34	Poor
< 1000 mm	35	Bad
≥ 1000 mm	36	very bad

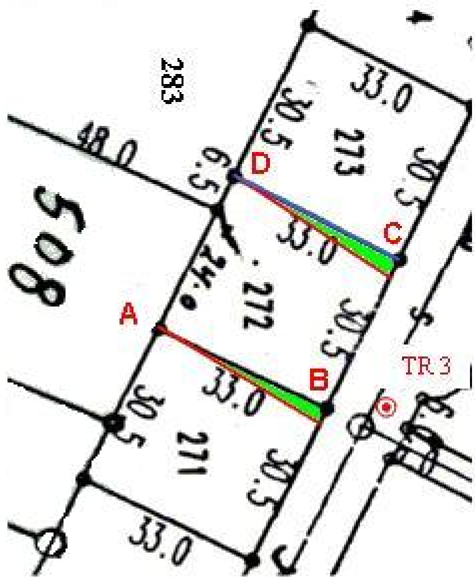
- QP = 30 for the trig. Points of the DLS, traverse points and witness points.
- QP ≤ 31 for boundary points in urban areas.
- QP ≤ 32 for boundary points in agriculture areas.

4.1.2 Improvement of the JDCDB by importing the new surveyed coordinates

The experience of the DLS in the past years showed that JDCDB has improved by importing of the new determined surveyed coordinates. Therefore surveyors add some measurements at the edge of the concerned block. If then the (legal) width of the streets is affected in not an acceptable dimensions, a common solution with the concerned municipality will be compromised. (It is also possible, that the private owners have exceeded the street boundary and have to shift it back, but this investigation has to be done during the boundary fixing work). In some difficult cases the improvement has to be extended to the next block on the other side of the concerned street.

For transaction measurements outside the settlement sheets, the coordinates of the vectorized boundary of the settlement (origin) parcels have been measured, and the origin parcel subdivided in to different new parcels, new parcels were replaced the origin one.

Figure 2



Since 1993 all transactions are done in digital form (AUTOCAD/SW shifting to Geograph/SW in 2004) in the same way. In transaction process some discrepancies between computed distances (derived from vectorized coordinates) and the legal/registered distances. These differences are checked in the field by measuring the real distances and resolving the mistake, and then the map was corrected by a special formal procedure. Only in special cases like the correction of areas, the director general (DG) has to interfere, but still all information is available centrally and no control is left out, every day daily transactions result from LRDs were sent via modem to HQ, 3 pilot LRDs for first phase of the project (Irbid, Mafraq, South Amman), together (1/3) of the workload.

The physical boundaries (red lines fences, figure 2) of the plot (272) were measured. With these elements the coordinates of the local points were calculated and compared with the presentation coordinates (black lines). But we noticed the following: On the basis of the boundary report the owner shifted the fence to plot 271 and the iron pegs were disappeared, green area is considered aggression area and should be corrected.

The procedure of boundary fixing is an administrative act and the removal of the mark of a boundary point is an offense. The institution (DLS, LRD or licensed surveyor) which is carrying out a boundary fixing have to invite not only the owner of (272) but also the adjacent neighbours, point **B** belongs to the owners of the plots 272, 271 and the owner of the street (municipality?). Point **C** belongs to 272, 273 and the street. The legal problem here only can be solved if an on-site re-established and measured boundary point is accepted by all affected owners or if they don't agree to this point, they have to litigate in the decision.

4.2 Land register matching

DLS has 3 different copies of the land register; the main one is a hard copy kept and updated within the Land Registration Directorates LRDs (regional offices), its commonly called the white sheet; the 2nd one is also a hard copy but kept and updated at DLS head quarter, its commonly called the red sheet, and the 3rd one is an electronic data base kept centrally at the head quarter but maintained either by the LRDs or by the HQ itself. This is a quite complicated situation, which creates inconsistency and discrepancy among the three copies. DLS started to remediate to this situation, but it lacks enough qualified personnel to achieve it in a reasonable time.

4.3 DLS parcel data model

Nowadays DLS started creating Semi-international parcel data model called DLS-PDM, especially with the object catalogues and with the structure of objects, attributes and associations using UML language. Relationship between different layers defines the way the objects are modelled. This model will manage economically an intelligent use of CIS, and protecting land tenure, and recovering the cost.

4.4 Cleansing JDCDB

In order to improve the quality of the cadastral information and make it user friendly, DLS have embarked on a programme to ensure that DLS cadastral maps and land register are in digital form, matched, updated regularly, covering the whole country and available to the users in a proper and agreed on format.

DLS mission is formulated to documenting the ownership rights, save guard them, facilitate the dealing of this rights, and sharing for building the GIS. That is why CIS must be complete, accurate, and easy to retrieve. So our quality policy started by implementing sub-project such as computerization for LRDs and data cleansing. This continuous process means that both map and register must be complete, homogenous and matched, consequently each parcel in JDCDB has record in the register (Oracle) through common key (DLS_KEY),and all question concerning to where, how much, who, and how should be answered in any time, amended by means of inspections reports to display

- All parcels in the JDCDB but not in the register.
- All records in the register but not in the JDCDB.

4.5 Accuracy of JDCDB

The accuracy of the vectorized coordinates is not known because of no surveying measurements was obtained, The JDCDB should be accurate and up-to-date, since the new field measurements have QP and will ultimately replace the vectorized data. The relative accuracy has been improving gradually since 2002. However the question of accuracy is a relative issue, but in the end an accuracy that will satisfy the needs of the users without creating any additional conflicts should be acceptable.

The QP for new determined coordinates is dependent on The QP of the coordinates of the used reference points; the quality parameter of the new determined points cannot be better than the quality parameter of the used reference points in principle. Therefore reference points with a good QP are to be chosen.

The quality of the observations (accuracy and geometrical configuration): such as the correct centring of the instruments above the marked station, the levelling of the theodolite, keep the reflector bar strict vertical above the target point. Another important part in this context is the reduction of the measured distances to the JTM-projection plane; there are 5 different corrections or reductions to regard:

1. Additional constant of the system total station – reflector, if unequal 0.
2. Meteorological corrections because of temperature and air pressure.
3. Reduction of the slope distance into the horizontal distance.

4. Reduction of the horizontal distance from the height of the survey region to the ellipsoid (which is approximately identical with mean sea level, MSL)

5. Reduction of the ellipsoidal distance into the plane of the JTM-projection.

Because the JTM is homogeneous and the scale deviation is smaller than 20 ppm it is permitted those polar points with distances up to 1 km can be determined directly with highest accuracy better than 5 cm.

The degree of the redundancy of the coordinate determination: The SDL for new calculated points can only be determined, if redundant observations are available (a sufficient number of measurements). The calculation has to deliver reliable results for the quality. Measurements without these characteristics are not suitable for cadastre purposes.

In most cases a minimum number of 3 well-distributed reference points is necessary for the free station-method and for traversing. For the resection method, when only directions are observed, a minimum of 4 reference points is necessary to get a rough control at least.

5. FINDINGS

1. It was necessary to have software capable of presenting all residuals as vectors (i.e. graphical error-ellipsis) on the screen, such software helps the operator to define the direction of the errors, its values, and the source of the errors (random, systematic).
2. Distortions of mechanical movement in scanning process affected the results in large magnitude, so serious care and attention was being considered during this process.
3. Very bad status of some cadastral analogue sheets took more time during scanning and vectorization (10 times more than usual), so the conversion project should had been rather started earlier before further damage had occurred to analogue sheets.

Having parcel data model would be much better if it preceded the conversion project.

4. Tangible results helps to change strong resistance happened at the beginning.

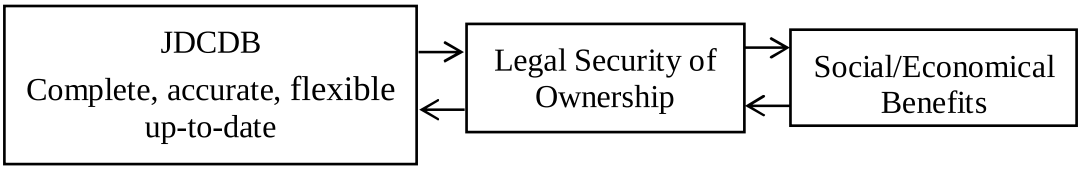
Tangible results

BEFOR JDCDB	AFTER JDCDB
Scattered island maps	Seamless database (national level spatial analysis)
Manual cadastre sketches or indexes	Automated cadastre sketches and indexes
No administration boundaries	Districts, villages, Blocks, sectors and sheets boundaries are available
Manual parcels inquiry (archives drawers).	Computer parcels inquiry (reports, statistics)
Manual transactions on hard copy sheets	Using JDCDB, computer and CAD systems in transactions (Arc/info, Geograf, AutoCAD)

5. Institution Future Vision Formulation: - “Land management is based upon complete and accurate geo-referenced information”, it is necessary to have statement that summarizes the future vision of the DLS. DLS wishes to be able to support and contribute to the process of land management effectively by providing all institutions dealing with land

management aspects and applications with complete, accurate and up-to-date cadastral data. It also DLS wishes to be able to improve the quality of its products and services and to make it available to all interested users.

6. Up-to-date JDCDB is an important pre-requisite for sustainable developments.



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CONTACTS

Zuhair Ostah
Department of Lands and Survey
P.O.Box 910815 Amman, 11191 Jordan
Phone: 00962 6 4632601/3015
00962 6 4632039
Fax: 00962 6 4601207
zuhair.o@dls.gov.jo
www.dls.gov.jo

Saad Khatib
Department of Lands and Survey
P.O.Box 910815 Amman, 11191 Jordan
Phone: 00962 6 4618285

Fax: 00962 6 4601207
saad.k@dls.gov.jo
www.dls.gov.jo