# Demarcation of Right of Way (ROW) and Re-Installation of Damaged Markers of Transmission Pipeline in Balochistan, Pakistan through Geomatics Technologies: A Case Study of Zarghun to Quetta High Pressure Natural Gas Supply

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**Abstract:** The alignment of gas pipelines in a rugged terrain has always been a serious challenge around the globe but they can be perfectly aligned with the help of Geo-Spatial technologies. When South Zarghun gas fields were discovered in Pakistan, gas transmission pipeline laying process between gas fields and Quetta city was as challenging task for the Government of Pakistan. Very rough terrain and extreme weather conditions especially in winter season were the two major constraints for the alignment of pipeline. Geomatics survey was essential before transmission pipeline construction work, done twice by private consultant in Pakistan's local geographic coordinate system. SSGC took decision in 2006 for the construction of pipeline but unfortunately it could not be executed due to law & order situation in Pakistan especially in Balochistan province and later all bench marks of pipeline alignment route were vanished by the locals. In 2012, SSGC again started pipeline construction work on war steps. Previous pipeline alignment survey was converted into existing SSGC's GIS coordinate system i.e. UTM Zone 42 WGS84 using ESRI ArcGIS software. Identification & re-installation of all bench marks and re-routing of pipeline were done by SSGC GIS survey team with the help of global positioning system (GPS) and satellite data. Finally, right of way (ROW) of transmission pipeline from Zarghun gas fields to Quetta city was designed and produced in the form of GIS map for pipeline construction activities.

**Keywords:** Geomatics Technologies, Realignment, Land Markers, GPS, ROW, Gas Transmission.

## 1. INTRODUCTION

Natural gas is considered inevitable source of energy for the world. It is being used in multiple sectors especially in energy producing sector, industrial, domestic or household and fueling the public vehicles etc. [1]. Iran has the 1st rank and Russia has the 2nd whereas Pakistan is on 28th rank of the total Natural Gas reservoirs throughout the world [2]. Natural gas in Pakistan was discovered during 1952 at Sui located in Dera Bhugti district, Balochistan which is 650 Kilometers away from Pakistan's most populous city Karachi. This gas field is considered major gas production facility [3]. The need of energy in Pakistan is increasing day by day and new sources are important to discover. Fortunately, Mari Gas Company discovered a gas field in 1998 at Zarghun (Zarghun South 1-2 gas fields) located 64 Km away from Quetta city in the Balochistan Province of Pakistan (Figure **1**) but it was abandoned due to poor economic conditions and lack of governance [4-6].

Global Navigation systems (GNSS) is used for wide ranged Geo-positioning with high precision around the world. Global Positioning System is most popular and widely used GNSS in the world [7]. There are various aims of the current research but the most important are to relocate GPS based natural gas pipeline network in the Zarghun, Balochistan which previously had wrong projection system and datum so the correction of the previous surveys and relocating the pipeline once again was the primary goal. The other main purpose of this study is to play a little part to bring the Geomatics technologies into common practice so that all companies and respected experts could widely use them without any hesitation knowing their wide scale of task handling capabilities.

## 2. STUDY AREA

The largest province of Pakistan by area is Balochistan covering 347190 km² which is 44% part of the country. The Geographic Information System (GIS) based Global Positioning System (GPS) coordinates of the Province are 60° 52' east longitude to 24° 54' north latitude and 70° 17' east longitude to 32° 06' north

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**Figure 1:** Shows two main gas fields discovered at Zarghun named South-1-2.

latitude [8]. The study area extends to two districts of Balochistan starting from district Mastung and ended in district Quetta. The GPS coordinates of Zarghun Gas field are 66° 25' 07'' east and 30° 06' 01'' north; this is the first point where the pipeline corridor is originated and these are the premises of Mari gas field [9]. The end point of the Zarghun pipeline network corridor is Town Boarder Station (TBS) Quetta which is SSGC's property, its coordinates are 66° 55' 42'' east and 30° 15' 13''north [10]. This area (Figures **3** and **4**) is considered one of the colder areas of Balochistan, where ground (topographic) conditions are very difficult to execute conventional surveys. Figure **2** illustrates the location of the study area.

Figure **3** illustrates the temperature conditions of the study area which are relatively harsh; annual average minimum temperature of Zarghun to Quetta was 15.16 to 17.35 (C°) respectively and as map reflected that neighboring areas had even more minimum temperatures. Figure **4** reflected the high elevation of the study area which is considered hard for doing such projects.

## 3. OBJECTIVES

After the discovery of Zarghun Gas field, the alignment of gas transmission line was totally executed through indigenous methods. Although the GIS based GPS survey for pipeline laid out was very important. For this purpose, survey had been done two times by a private company in the years of 2004 and 2009 but due to worst law and order situation of the Balochistan Province, security agencies did not allow pipeline laid out process. As a result of delay and insecurity, Landmark cemented Markers installed previously by surveyors damaged and pipeline laid out faced crises. The SSGC'S Kilometer Post (KMP-POST) markers and cemented turning and crossing points were totally damaged due to delayed snowfall, torrential rainfall, subsequent floods and insurgency. After establishing check posts along with the corridor, Pakistan Army and Frontier Corps (FC) gave the SSGC a green signal to start "Zarghun-Quetta Transmission Pipeline GPS Survey for demarcation of ROW and Re-installation of damaged markers" using in-house team of surveyors and experts in order to have effectiveness in survey and pipeline laid out. This transmission pipeline laid out was initiated after approval of SSGC'S 2006 Board of directors meeting [11]. The primary aim of meeting was the gas shortfall faced by the occupants of the largest city of Balochistan province Quetta and adjoining areas. It is also decided by higher management of the company that this project would be in housed based. Technologically, Geomatics is used for alignment of utility network like natural gas pipeline *via* its powerful location based tools which have specialized capabilities to deal with these sort of tasks using their spatial integrity and accuracy. Conventional alignment methods relatively poor in accuracy as well as

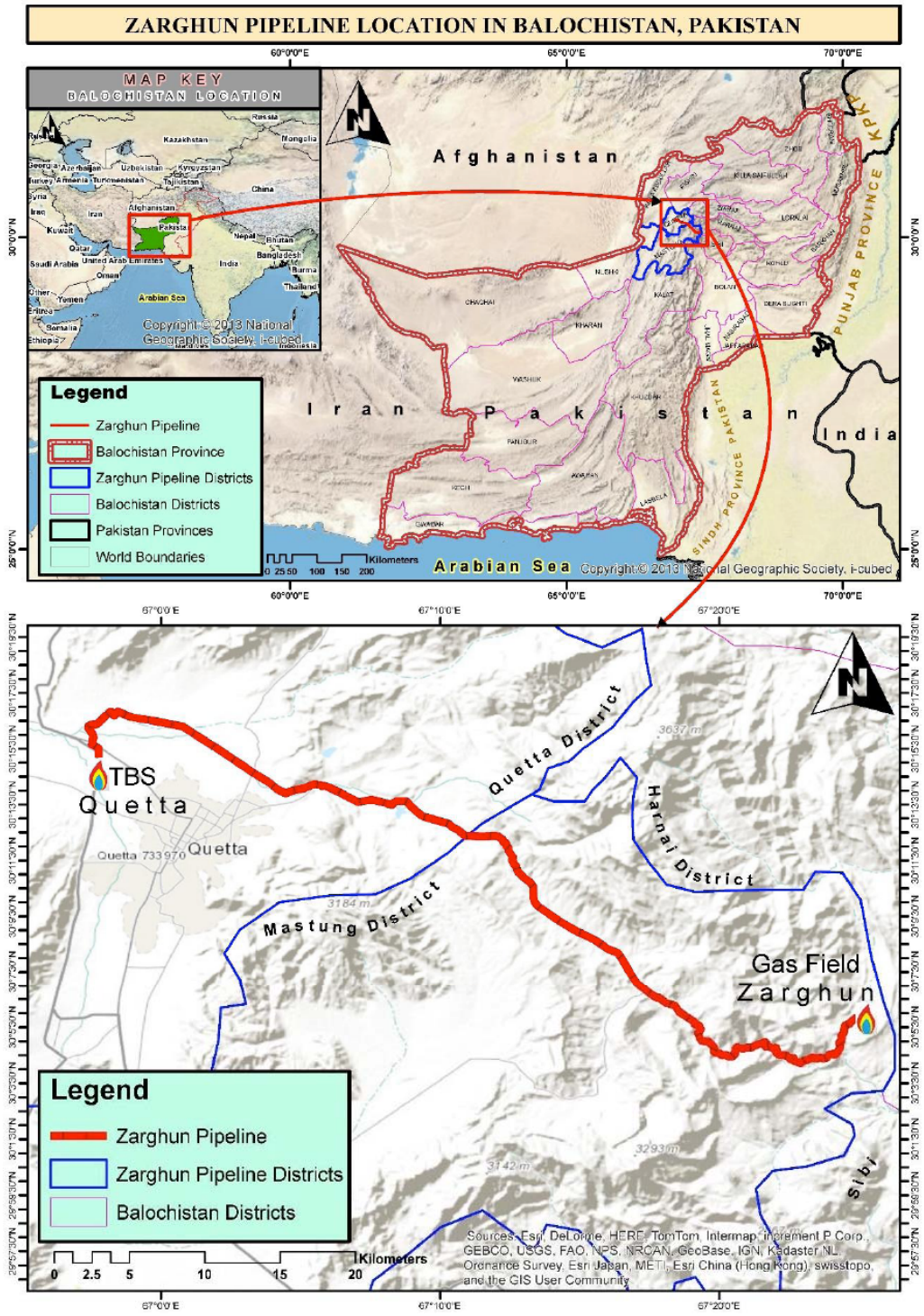


**Figure 2:** Zarghun Pipeline Location (Study area map).

operational management because when pipeline demarcation survey is conducted many physical and cultural features are taken as reference e.g. River edge, road, wall, tree, railway line and building etc. but these are all changeable so that alignment and operational needs are at risk of cost in effectiveness. On the other hand, GPS based survey needs no such reference its data is stored in safe devices easily to use and manipulate. Furthermore, this research shows the effectiveness and better result orientation of GPS in comparison to old techniques used by other companies previously. GPS helps in minimizing all sort of costs and it ensures the absolute location of pipeline in digital format which cannot be removed on ground which can be removed in conventional methods. Then it tracks changes and damaged locations of infrastructure for

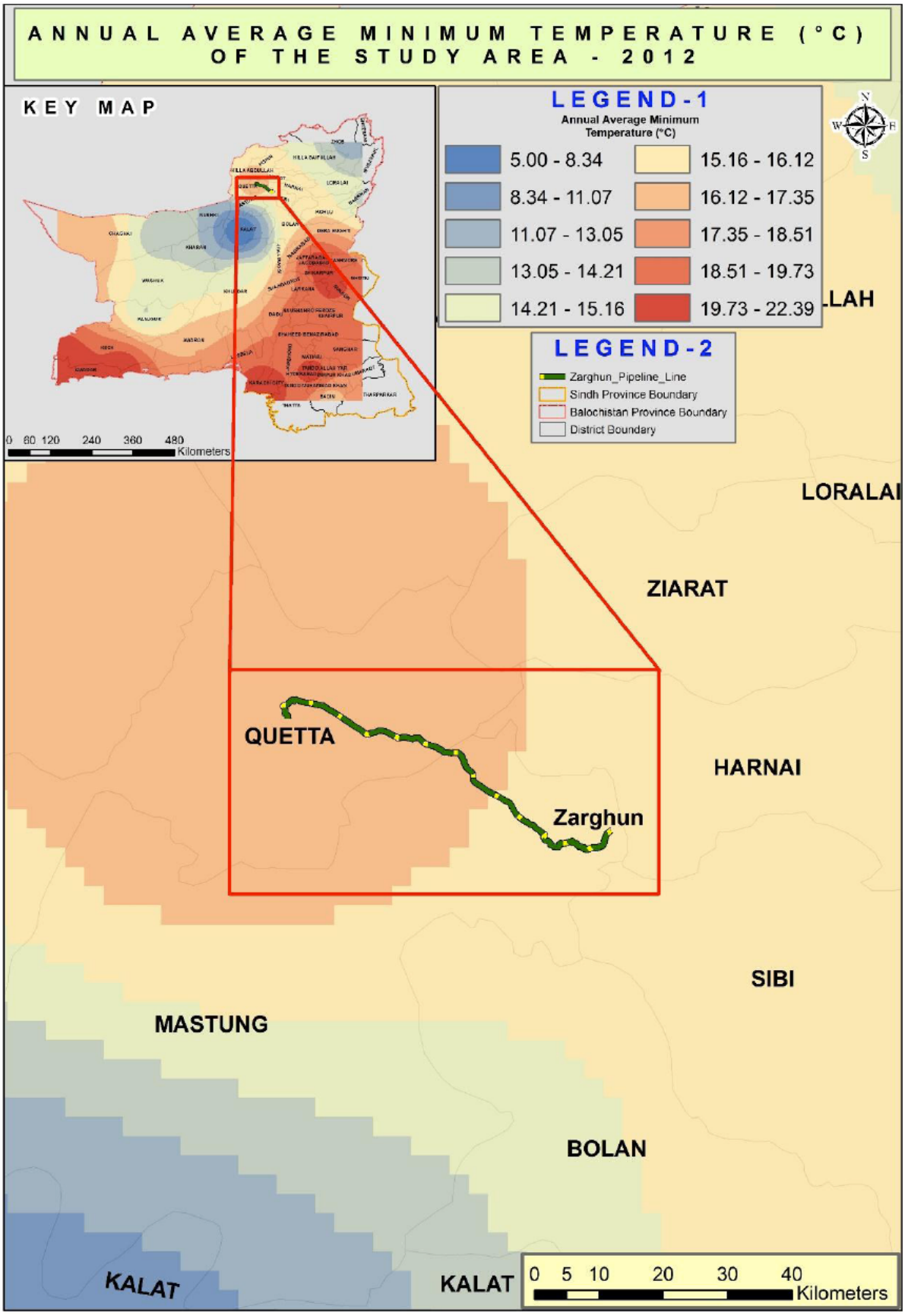


**Figure 3:** Zarghun Pipeline Temperature conditions.

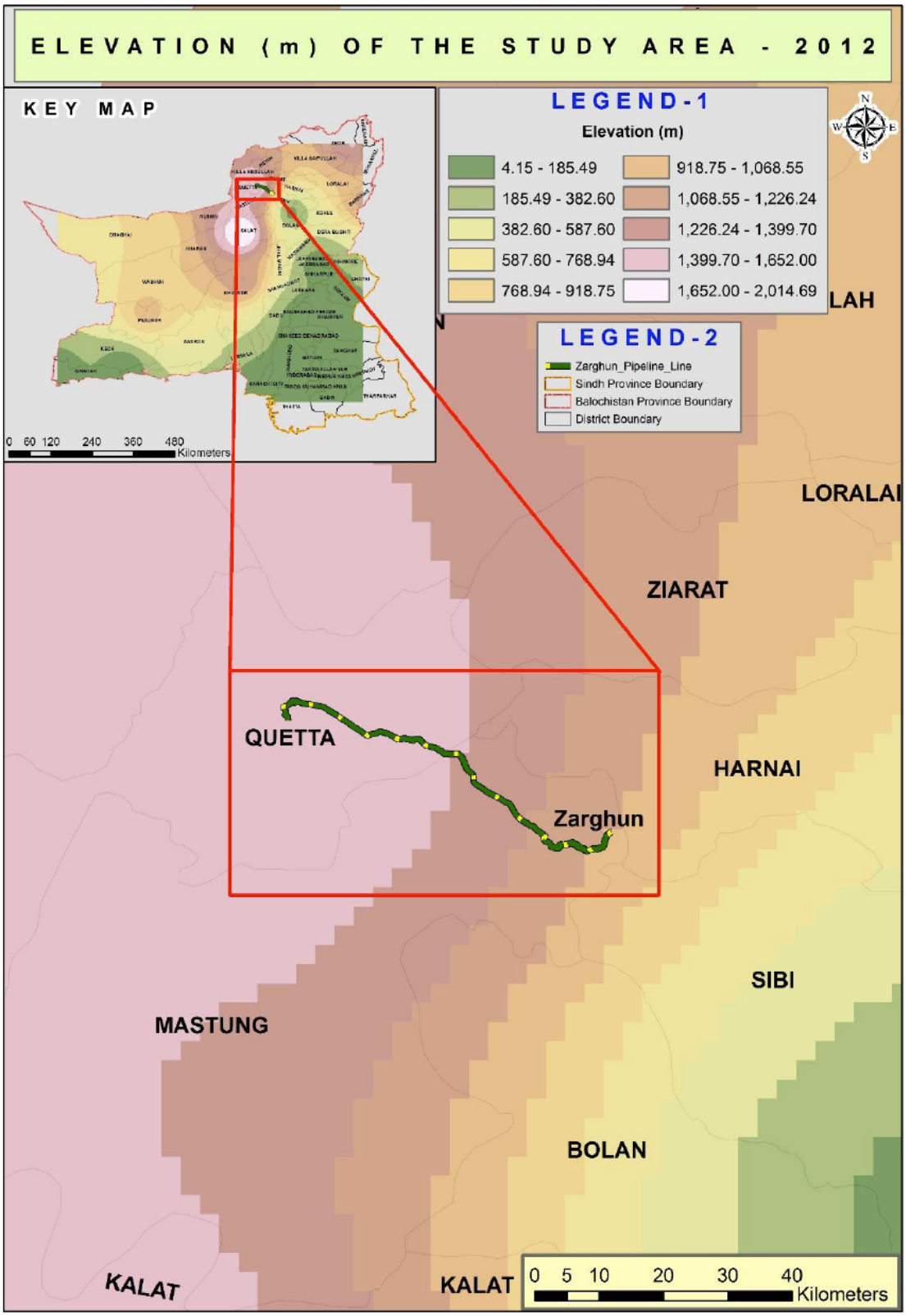


**Figure 4:** Study area elevation.

problem solution. So as a result, GPS is for better option proved worthy for operational solutions spatially routing and re-route utilities networks especially of pipeline. Considering these advantages of Geomatics technologies, GPS was chosen in this project for re-route damaged markers of the pipeline network. In a nutshell, authors with the team of SSGC did not only successfully conducted this modern technology based

survey in order to define new rout for natural gas transmission laid out but also got post surveying and mapping benefits for future utilities especially regarding Zarghun-Quetta gas field.

## 4. DATA AND MATHODS

### 4.1. Data

Temperature and elevation data (used in Figures **3** and **4**) was provided by Pakistan Metrological Department (PMD) and other data was the property of Survey of Pakistan and SSGC including 3rd party (consultant) GIS based GPS coordinates which were not compatible with standard operating procedure (SOP).

### 4.2. Methods

Geomatics technologies are currently essential for many utility organizations especially for natural gas companies. The Geomatics Technologies include tools, technique, methods and system used in Remote Sensing (RS), GIS, GPS, Differential Global Positioning System (DGPS), Satellite Differential GPS (SDGPS), Global Navigation Satellite System (GNSS), Global Navigation Satellite System (GLONASS), Cartography, Photogrammetry, Land Surveying and related forms of digital global mapping which are emerging swiftly and becoming profitable for many organizations specially regarding utilities throughout the world. In Pakistan, Geomatics technologies are also emerging at a rapid pace and becoming profitable for many utility organizations. As a result of pragmatic discussion, (as mentioned before) it was decided that Geomatics technologies would serve the best for the construction of Zarghun-Quetta Gas Pipeline network Corridor because of precision and cost effectiveness. Following that decision, work started with finding and studying of suitable models and literature that could aid the concept of pipeline networking. After this wide range of analytical and logical research, it was unanimously decided that it was possible for in house local team of national experts to execute pipeline corridor building because fortunately Geomatics experts had the potential of excellence and company entrusted this task to them. Then for achieving the tough goal, experts contemplated and successfully combined the conventional and modern knowledge workflow in form of a graphical chart. This chart was designed after reviewing of many old-new drawings, sketches, sheets, books, and reports etc... Carrying that chart relocation of damaged KMP-post marker and installation points was performed with the help of Geomatics Technology.

For achieving this complicated task, five Sui professional departments performed their obligatory duties with sincerity and loyalty. Those departments were Information Technology (IT), Planning and Construction (P & C), Planning and Development (P & D), Transmission and Security. Balochistan province had been facing insurgency sort of situation in which security was the very first priority that's why security department did the tremendous job and provided satisfactory circumstances to the team. Other most important thing was the courageousness of the whole team despite extreme climatic and security situations which were the main hindrances in execution of the plan because team had to face freezing cold, devastating rainfall with insecurity of Balochistan Province where many local and foreign terrorist organizations were actively doing their evil and despicable jobs. It's very important to remember that Terrorism in Pakistan have its roots in global conspiracy which is very strong as it became difficult for the bravest persons to work on this sort of national patriotic projects. Only working fellows would tell the difficulties and pain of terror couldn't be measured and explained in words, Survey remained continuous despite of the situation because Pak Army with FC participated in giving of strategic security. Transmission department did arrange well-furnished rooms for residence where team rested to vanish their tiredness in order to get prepared for next day's tiresome routine. In this resting scenarios we did not rest very much for the task importance; we processed GIS based GPS data on the daily basis then transfer it to the Laptop, USB and safe servers with backup plan.

### 4.3. Major Steps of the Study

A. The first major step before project execution was acquisition of Survey of Pakistan projected GPS coordinates from Third party consultant. Then transformation of coordinate system was performed and coordinates were shifted to UTM Zone 42N (WGS-84); for compatibility with our GIS based geodatabase.

B. Second key contribution was the scanning and Geo-referencing of Drawings, Sketches and other documentations provided by SOP and P & D department. Subsequently, we had one satellite imagery and map of estimated coordinate points with landmark locations. In short, we prepared an A4 sized map field book for our guideline and side by side in the data directory to make the data safer in our field

device. We finished every task and processed data on daily bases in order to avoid extra work load.

C. For data loading and processing in field devices, used three software are the most important; these software include “Trimble® TerraSync™ software”, “The Trimble® GPS Pathfinder® Office software” and “Trimble® ActiveSync® software” (Both field devices & desktop systems). At the parallel, if any software or hardware component is missing or not connected properly it would delay the survey process. Consequently, these essentials were handled carefully for project successfulness.

D. Forth but important step was about GPS field processing. Data dictionary was developed in order to save coordinates data in Geodatabase. It must be remembered that Data dictionary is made by focusing on project nature and requirements distinctively for every project. Transmission pipeline network information including pipeline intersection or cutting edges, rural utilities and other upper ground and underground information was saved in Geodatabase. GPS was then fully initialized with correct datum, projection and coordinates system (UTM,WGS-84, 42N).

E. GPS real-time data rectification and reprocessing was done by connecting with OmniSTAR multinational company and they helped us in connectivity settings because they usually change their settings for their system up gradation. We contacted them in their UAE and USA based offices in order to deal with these sort of connectivity settings complications.

F. Then data saved in Microsoft Data dictionary was converted into ArcGIS® format and made it usable in ArcGIS® environment; data was imported into ArcGIS® and exported into SHAPEFILES. Moreover, editing and quality check of all land information, pipeline installation information and other related information was performed with the help of digital, note book and pictures of the field.

G. After processing, conversion and manipulation of the data, accurate digitization was performed by experts in order to make effective Pipeline transmission hard and soft copy maps.

### 4.4. GIS Based GPS Survey Techniques

GIS based GPS survey for re-routs demarcation of Right of way (ROW) and re-installation of damaged markers in Balochistan with help of IT, P&D and P&C

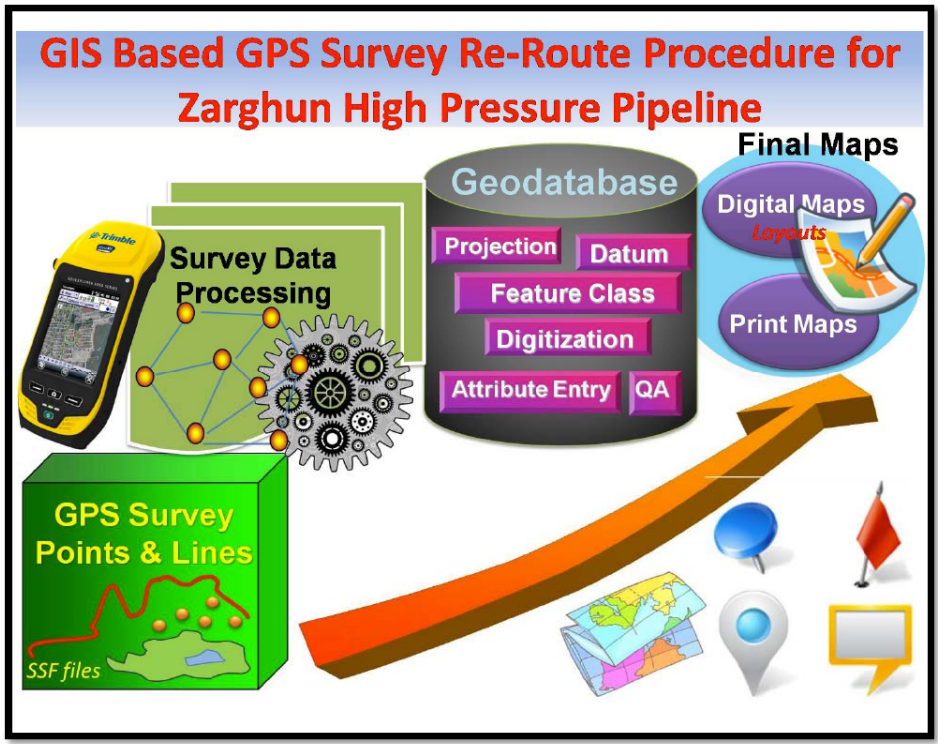


**Figure 5:** Concise GPS Survey process of Re-Routing the Zarghun Pipeline Project.

departments for Transmission Pipeline Networking from Zarghun field to Quetta TBS 64 kilometer was done jointly. This was totally in-house GIS based GPS reroute survey with the help of Geomatics Technology. Author marked temporary Symbols, KMP post marker and turning points regarding requirements of the pipeline Network project [10, 12].

With the grace of ALLAH and prays of family, teachers, friends and all well-wishers Authors with team completed another dangerous survey within the time.

### 4.5. GeoXT™ GPS CE Field Device

We used GPS of GeoXT™ field device from the Trimble® International Company's GeoExplorer® series is the essential tool for building digital Map after field survey. A high performance around the meter GPS receiver combined with a rugged handheld computer, the GeoXT handheld is optimized to provide reliable, high-accuracy location data, when and where you need it. It's ideal for use by utility companies, local government organizations, federal agencies or anyone managing assets or mapping critical infrastructure who needs accurate, up-to-date data to do the job. The handheld GPS GeoXT™ delivers consistent good accuracy with real-time processing [13, 14]. This device was used in this surveying.

## 5. RESULTS AND DISCUSSION

After applying methods and techniques, a map has been generated and overlaid on a high resolution satellite imagery (Figure **6**). That map was showing absolute new (re-routed) location of whole Zarghun-Quetta Pipeline. Map fulfilled two main purposes simultaneously; it gave absolute re-routed location for ground experts so that pipeline laid out process became very easy and secondly, it could facilitate future missions on this pipeline.

This project is having its special magnificence regarding the use of latest Geomatics technologies. This paper reflected the Geomatics techniques which are capable of handling old Datasets like SOP incorrect coordinates systems were corrected and then used for further re-routing of pipeline. The successful use of Geomatics techniques proved vital for other organizations which are looking forward to do such tasks.

Nowadays, GPS of USA is very widely used around the world even some countries like European Union,

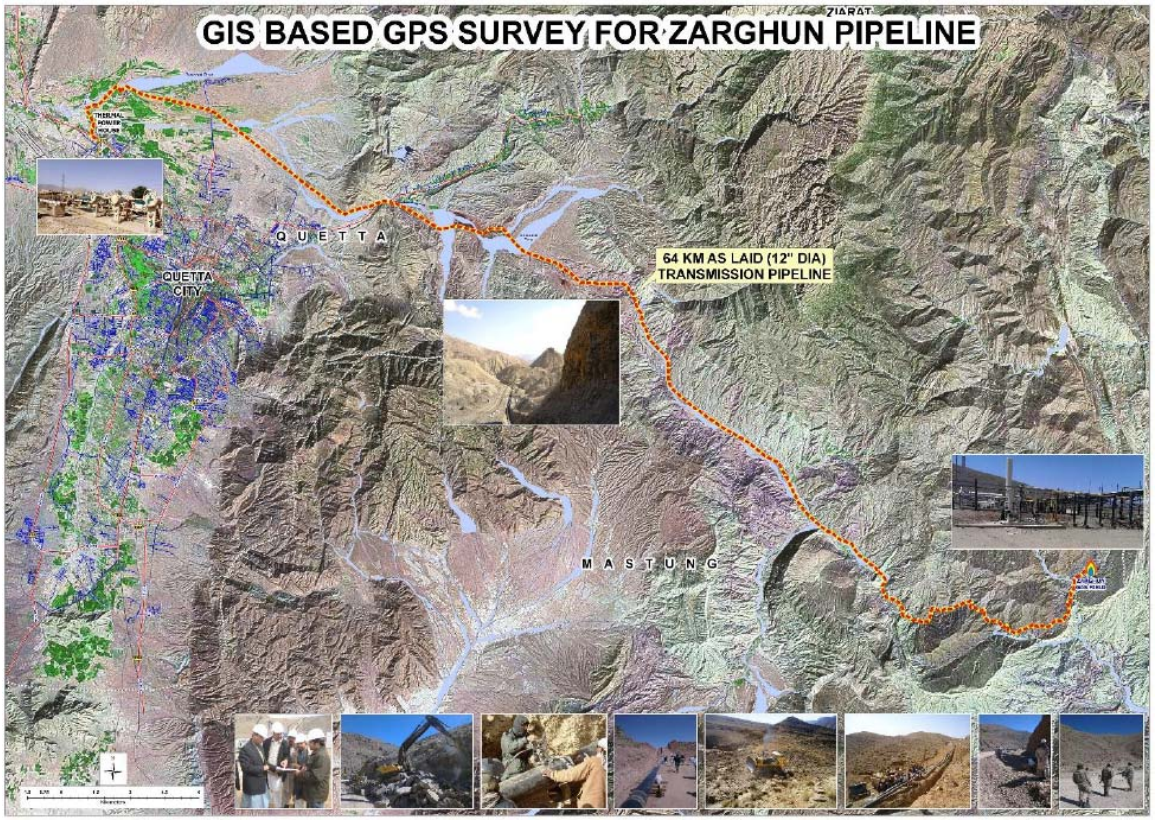


**Figure 6:** Final map showing Re-routed location of Zarghun-Quetta pipeline.

China, India and Japan are planning their own GPS systems [7] but painfully, Government (Govt.) of Pakistan is not doing satisfactory efforts regarding these sort of higher and modern developments. It is humbly suggested that Pakistan should also give some more weight to these latest Geo-technologies so that our country could stand with other powerful nations and move towards better future. In the conclusive way after applying Geomatics technologies in this study for a national project, there are various other suggestions risen but most important is about bringing these technologies in Pakistan at all levels which is still very much missing and still conventional systems are considered more reliable. It is humbly suggested that Govt. of Pakistan should take some revolutionary steps for making these technologies available at all levels making them so common that everyone could get its rewards.

## 6. CONCLUSION

GPS (e.g. GeoXT™ GPS CE Field Device) with its extraordinary benefits cannot be neglected e.g. it provides distance between points very easily which is very difficult in conventional techniques moreover good GPS device has many additional facilities like high resolution satellite imagery, land use or land cover information, street view, vegetation scenarios, water bodies, transportation networks, utility infrastructure vectors and topographic mapping etc. which is altogether a blessing for any project and study. So it can handle multiple tasks single handedly with precision and cost effectiveness which promotes its worth and demands among all utility and other organizations.

In this study, we used GPS because our company thought it would serve the best for this survey and fulfill the demands and needs efficiently using in house based team. Previously after Zarghun gas field's discovery, latest technological surveys were conducted by private consultants in 2004 and 2009 but due to the worst law and order situation pipeline laid out process was not initialized. Those private companies produced data in SOP coordinates system which was totally different regarding SSGS's base map standards so we converted all the pipeline corridor data into the UTM, WGS 84 and zone 42N. After this grand GPS survey conducted which did authenticate the coordinates and fixed the damaged places like KMP, TP, CX and land mark etc. This study has defined a new path for surveyors of the world who are still using conventional techniques and taught them what GPS could do by doing an impressive survey in which it did not only help in fixing data errors caused by previous survey companies but also re-routed the pipeline very effectively. On the other hand, it did not only present paper maps of new route for pipeline but also produced very precious digital data which could facilitate future analysis and management. This digital data of coordinates could open in any Geomatics software like ArcView®, ArcGIS® and MapInfo® in which mapping could make this data more and more effective. After the re-routing GIS based GPS survey pipeline successfully laid out with the help of comprehensive map.

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