Building a Major Oilfield Around Pipeline GIS in the Sahara Desert of Algeria

The El Merk Project

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Presentation Objectives

• Demonstrate the power of GIS from project concept definition through bidding, surveying, design, construction, and implementation.

• Convince “old dogs” that “new tricks” can improve efficiency and productivity with GIS applications.

• Prove to “dinosaurs” that acceptance of GIS technology can improve work flow with minimal paperwork- the usual gripe and excuse.
Anadarko Petroleum Corporation- The Woodlands, Texas entered a Production Sharing Contract with Sonatrach- The National Oil & Gas Enterprise of Algeria in the late 1980’s.

Extensive geological and geophysical seismic work was conducted in the Sahara Desert with exploratory drilling in the early 1990’s.

Anadarko made their first oil discovery in Block 404 of the Hassi Berkine Basin early in 1994.

The Sonatrach Anadarko Association (SAA) developed the HBNS Field Stage 1 (60,000 BPD) during 1995-1997.

Other fields followed HBNS with HBNS Stage 2 Development (330,000 BPD) in 1998-2000.

In 2002, SSA participated in the Ourhoud Development (220,000 BPD) about 60 km south of HBNS.

SAA Block 208 oil and gas condensate discoveries were a further 90 km south of Ourhoud in a rugged sand dune terrain very remote from any existing infrastructure. SAA and partners with neighboring reservoirs for production came together to form the El Merk Project (150,000 BPD).
Area map showing HBNS/OO
El Merk Infrastructure
El Merk Ownership

- Sonatrach
- Anadarko
- Conoco Phillips
- ENI
- Maersk

El Merk operating responsibility will be under the SAA “Groupement Berkine” organization.
El Merk Contractors

- Petrofac- UAE for the Central Processing Plant
- ASP- Consortium of ABB (Milan, Italy)/ SARPI (Algeria) / PetroJet (Egypt)- Offsites
- Bentini- Faenza, Italy- Living Camp and Industrial Base
- Bonatti- Parma, Italy- Export Pipelines and Terminals
- Kahrif- Algeria – Powerlines
- Siemens- Lyon, France- Substation
- El Merk GIS Management- ABB/Intergraph- Milan, Italy
El Merk Project Scope

- Full Field Development → Three fields: EKT, EME, EMN + One utilized field: EMK
- Production zones → TAGI Oil, RKF/Strunian Gas Condensate
- Central Process Plant → Separation, Stabilization, Gas compression, Treating for export, Storage, Pumping Systems, NGL extraction, Utilities and Services
- Industrial Base → Offices, Warehouses, Shops, Emergency Power, Fire and Security Systems, Telecoms
- Living Base → Housing, Catering, Medical, Mosque, Recreation, Administration
- Infrastructure → Air Strip, Military Camp, Central Waste Management Area, Roads & Highways
- Telecoms → VHF Radio, Fiber Optic systems, Satellite
- Powerlines → 220 KV systems (150 km), 30 KV systems (150 km), Substation for primary and back up power supply to CPF, Base de Vie, and Offsites
- Pipelines → Crude Oil/ LPG/ Condensate (total of 410 km), Offsite Systems
- Temporary Worker Camps (6000 man peak)
El Merk Offsite Systems

- Well hook-ups,
- Field Gathering Stations,
- Gas Distribution Manifolds,
- Water Systems for Injection,
- Flowlines for production, gas lift, dilution water, water source supply
- Trunklines for oil and gas condensate production, gas injection, and water injection
- Field distribution of FO cable for telecoms and power supply
El Merk Challenges

- Pioneer development- no previous area infrastructure
- Remote harsh desert environment
- Terrain includes dunes over 1000’ high
- Camp accommodation developed for 6000 peak manpower for project development
- Concurrent construction with developing reservoir drilling and testing
- Competing projects in Algeria for manpower and services
- Security concerns require military presence and escorts for expat personnel
- Logistics for civil materials, fuel, supplies, etc.
- Unique local geodetic conflicts require special survey considerations
- Compliance with government regulatory concerns impact importation, contract stipulations, bidding, inspection, and certifications
- Project Management includes multi-international locations, rotational staff, language barriers, cultural sensitivities, partner management structures.
- Management of change for maturing reservoir development plan
- Interface management between multiple contractors and operations
- Survey coordination between contractors and control networks.
El Merk GIS Development History
Front End Engineering Design

- In 2006, the paper mapping work failed to meet change management guidelines and GIS development specifications were adopted for the Project.
- The initial FEED contractor was expected to develop the total project under a full scale EPC contract but economics could not justify this approach.
- The initial FEED contractor insisted that over 700 alignment sheets would be required to bid the pipelines with international contractors.
- Major field development changes were identified in 2007 that required major engineering change to the Offsites with a complete re-design while international tenders were underway.
- AMEC Paragon was awarded an Engineering Assistance Contract to aid the El Merk project in developing a pipeline GIS for re-design, bid solicitation, and construction planning.
El Merk GIS Development History
Tender Requirements

- AMEC’s GIS Team used an ESRI Platform to import various Autocad files, available imagery, and infrastructure maps from Groupement Berkine and Ourhoud onto the LIDAR base map to establish the initial GIS model.
- Layouts of revised well layouts, were used to locate FGSs OP wells and GDMs to GI wells. Trunklines were then routed to/from the CPF.
- Data was extracted to develop profile information for pipeline hydraulics for various case studies.
- Pipe specifications were developed with the pipeline design data.
- The pipeline model was used to evaluate slugging studies and dynamic modelling for surge.
- Structural evaluations were performed to analyze loadings for flexibility and anchoring.
- The GIS model was used to develop infrastructure and pipeline routings for the pipelines to establish pipe quantities for purchase and construction.
- A Pipeline GIS with PODS was specified as a deliverable. Alignment sheets were not required as a deliverable but an alignment sheet generator was required.
- AMEC developed a GIS viewer that enabled the bidders to query a CD database of the pipeline system. Base maps were provided for record.
El Merk GIS Development History
Contract Strategy & Tendering

- The revised contract strategy identified Lots of the overall project that bidders would be allowed to tender for but bids could be presented for multiple Lots:
  - Lot 1: CPF and ICSS/Telecoms
  - Lot 2: Export Pipelines
  - Lot 3: Offsite Facilities Design and Material
  - Lot 4: Offsite Installations (Combined 3&4 for Contract)
  - Lot 5: Industrial Base
  - Lot 6: Base de Vie (Combined 5&6 for Contract)
  - Lot A: Site preparation
  - Lot B: Overhead Powerlines
  - Lot C: Substation

- While tenders were being prepared by worldwide EPC contractors, B212 facilities were deemed uneconomic and delted from scope- requiring revision to the RDP and major scope change for Offsites.

- Tenders were put on hold and changes to scope were revised with Lot 1 and Lot 3&4 bidders during 2008 for end of year revised tender packages.

- It became evident that the Lot 3&4 Contractor would be required to manage the El Merk GIS to coordinate all interface locations for all Contract Lots using the Pipeline GIS model.

- Bid openings in December 2008 assured no single EPC contract and multiple teams would be required for engineering to start early 2009
El Merk GIS Development History
GIS Capabilities & Contract Award

- During the tender evaluation process, each of three European bidders presented experience and capabilities for GIS management.

- One contractor uses GIS extensively in their projects and is now doing a neighboring development for an El Merk partner with similar export pipeline needs.

- ABB and the other contractor required special GIS planning assistance to demonstrate suitable capability. ABB brought their business partner Intergraph Italia to demonstrate their expertise.

- The ASP Consortium was the low bidder for the Lot 3&4 Offsites and started work on the project in April, 2010.
El Merk Project Management Assessment of GIS Importance

- GIS is the key to El Merk Project Success- “GIS Rules”

- Without the GIS tools developed by AMEC, El Merk would have been delayed at least a year (at 150,000 BPD)

- GIS enables El Merk and its contractors to manage change quickly and reliably

- GIS is being used to manage interfaces in infrastructure from drilling all the way to telecoms.
Intergraph GIS Architecture
Mr. Massimo Pagani

Intergraph technology and services to support GIS projects for the Oil & Gas Industry
Topics

- GIS Scope of Work
  - Technological architecture
  - Topographic Survey
  - Users Access
  - Web Data Dissemination
- PODS Standard
- Ongoing project improvements:
  - Field Data Acquisition
  - Sub-Contractors Management
- Project status
GIS Scope of Work

- Catalog information acquired from various sources and in a variety of formats
- Provide necessary tools to integrate and manage this data
- Provide a foundation for downstream operations and maintenance activities
- Datasets included in the model are incorporated in near real-time and continue throughout the life of the pipeline system operation
- Regular updates to the datasets
- Provide additional decision making tool
- Web data dissemination
- Provide to Sub-Contrators GIS tools to access project data in real time
- GPS survey acquisition and project cost control
- Project cost/time reduction
El Merk GIS Architecture Overview

The GIS system ingests data from different sources and provide functionalities for data sharing, Web dissemination and digital cartographic output.
Technological Architecture
(Client Side)

Internet User
Desktop User
Intranet User

Browser (Thin Client) -> GIS Desktop -> Smart Client

Direct to Oracle Geodatabase
Web Services GIS OGC for data sharing (WMS, WFS)

AAA: Windows Domain Authentication/Active Directory and Oracle

Client: Cache LAN: Cache

PNG JPG CGM GML
Topographic Survey

- Definition of roles data acquisition on the field and delivery
- Implementation of acquisition processes
- Data exchange and format definition
- Validation definition parameters for geographic data
- No constraints about GIS technology, but only 3 files format to be used:
  1. Shape
  2. ASCII formatted file
  3. DWG/DXF

- Typical information that must be included into geographic files:
  - Geographic coordinate system
  - Datum (geodesy)
  - Spheroid
  - Prime meridian
  - Map projection
  - Units used
  - Parameters necessary to use the map projection, for example:
    - Latitude of origin
    - Scale factor
    - Central meridian
    - Standard parallels
    - False easting
    - False northing
GIS Projects - User Levels

ADMINISTRATOR
- User Access Definition, Smart Client definition,
- New data entry validation,
- Data Uploading Rules to the central GIS System
This level is composed by ABB, Intergraph, C.A. offsite

POWER USER
- Proposing modifications, New data acquisition (to be validated)
- Data Process. Advanced query. Custom Interface for each organization.
- Updating, CAD Data Upload

BASIC USER
- Basic users: Data display, reading, querying, analyzing – Data Download
- according to an extended list of people authorized by all involved entities
  (C.A. offsite, C.A. HMS, ABB, Sarpi, Petroject, Other Lots Contractors)
Web Power User [Intranet]
• PODS™ (Pipeline Open Database Standard) is an independent database modeling initiative applicable to gas and liquid gathering, transmission and distribution pipeline systems.
• The objective of PODS™ is to provide a common platform that will enable pipeline companies to create a standards-based GIS database. The PODS™ data model represents the requirements of the industry as a whole—it provides the framework that will enable an organization to concentrate on the unique aspects of the company rather than the generic requirements of the pipeline industry.
• The PODS™ data model is implemented as a relational database in Oracle or Microsoft SQL Server. The model can also be spatially enabled providing tight integration with our GIS software platforms.
• The PODS data model is the most widely implemented and working pipeline data model in the industry. It has allowed many major oil and gas pipeline operators to quickly migrate from paper and legacy databases into a standards-based data model that has a strong organization behind it.
Field Data Acquisition
Workflow GPS Acquisition in RTK Mode

- Remote Data Stations
  - INTERNET
  - GPS
- GPS Interface
- GeoMedia Mobile
- Stage DB
  - Working database
GPS Data Acquisition

GeoMedia Mobile with integrated GPS navigation

Satellite constellation with PDOP planimetric indication accuracy

GeoMedia map pointer
GIS Site Coordination Activities

- Topographic survey workflow
- Data uploading from Field to Central DB
- Data validation procedures
- Survey validation using GPS technology
- Field feedback (construction crews) management
- Work in progress control:
  - a structured breakdown in fields and type of pipeline
  - each pipeline broken down into the main erection activities (laying, alignment, welding, X-rays, test),
  - each one with an assigned weight
  - simple algorithms defined to calculate the progress
- Project cost control in a real time
Progress Monitoring

1. Objective
   - To measure using a simple tool, GIS integrated, the progress of the construction direct
   - Activities for flowlines, trunklines, gas lift lines, water injection and water source lines

2. Structure
   - Excell file to be filled by simple information got at the cut-off date by a site survey and ingested by GIS that automatically calculate the progress, according to agreed weight for the various activities and agreed formulas.
   - Breakdown completely aligned with contract

3. Managing report
   - Easy visualization through GIS of the overall progress of pipelines network
   - Possibility to select and know, through GIS system, any single line construction progress
   - Possibility to input in a direct correct way the relevant invoice construction progress matrix.
## Construction Progress Monitoring

### PRICE BREAKDOWN EXAMPLE - GROUPS CONSTRUCTION

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>4100</td>
<td>BLOCK 208 FIELDS</td>
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<tr>
<td>4110</td>
<td>GATHERING NETWORK</td>
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<tr>
<td>4120</td>
<td>FGS</td>
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<tr>
<td>4130</td>
<td>WATER INJECTION NETWORK</td>
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<tr>
<td>4140</td>
<td>GAS INJECTION NETWORK</td>
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<tr>
<td>4150</td>
<td>SOURCE WATER NETWORK</td>
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<tr>
<td>4160</td>
<td>ACCESS ROADS</td>
</tr>
<tr>
<td>4170</td>
<td>POWER AND TELECOM NETWORK</td>
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<tr>
<td>4200</td>
<td>UNITIZED EMK FIELDS</td>
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<tr>
<td>4210</td>
<td>GATHERING NETWORK</td>
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<tr>
<td>4220</td>
<td>FGS</td>
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<tr>
<td>4230</td>
<td>WATER INJECTION NETWORK</td>
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<td>GAS INJECTION NETWORK</td>
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<td>4250</td>
<td>SOURCE WATER NETWORK</td>
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<tr>
<td>4260</td>
<td>ACCESS ROADS</td>
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<tr>
<td>4270</td>
<td>POWER AND TELECOM NETWORK</td>
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<tr>
<td>4400</td>
<td>MISCELLANEOUS WORKS</td>
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<tr>
<td>4500</td>
<td>MATERIAL SUPPLY (FUTURE)</td>
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</tbody>
</table>
Construction Progress Monitoring

4110 - Gathering network

4112 Flowlines

Oil production

Gas Cond. Prod.

EMN

EME

EKT

4113 Trunklines

Oil production

Gas Cond. Prod.

EMN

EME

EKT

4114 Gas lift

Oil production

EMN

EME

EKT

4115 Dil. water

Oil production

EMN

EME

EKT

See table A
Typical Field Schematic

- **CPF**
- **FGS\textsubscript{n+1}**
- **Water Source Well (Barreniam)**
- **Well Type 1**
- **Well Type 2**
- **Well Type 3**
- **GDM\textsubscript{n+1}**
- **Water Injection Well**

**Flowlines**
- Trunkline – Dialution Water
- Trunkline – Production Water
- Trunkline – Water Injection
- Trunkline – Gas line
- Trunkline – Gas Gathering Network
- Trunkline – Oil Production
- Flowline – Dialution Water
- Flowline – Source Water
- Flowline – Gas Condensate
- Flowline – Gas Lift
- Flowline – Gas Injector
- Flowline – Gas Injector
## Construction Progress Monitoring

<table>
<thead>
<tr>
<th>Civil w. ass. to pipelines</th>
<th>Pipelines</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>40% Excavation</td>
<td>10% Laying</td>
<td>100% Test done (site hydraulic test)</td>
</tr>
<tr>
<td>60% Backfilling</td>
<td>15% Alignment 50% Welding 25% X rays done</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Corrosion protection</th>
<th>Crossing</th>
<th>Fiber Optics</th>
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<tbody>
<tr>
<td>35% Pits + Anodes install. 45% Cable laying 20% Transf./rect. install.</td>
<td>100% Crossing work done</td>
<td>20% Excavation works 50% Cable laying 30% Backfilling</td>
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</table>
Progress Evaluation Sheet

Gathering network----> Trunklines---->Oil production-

T= trunk line ; O.P. =Oil Producer

<table>
<thead>
<tr>
<th>FIELD</th>
<th>LINE TYPE</th>
<th>LINE N°</th>
<th>FROM</th>
<th>TO</th>
<th>DIAMETER</th>
<th>TOT.LENGTH</th>
<th>UNIT WEIGHT</th>
<th>TOT. WEIGHT</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( &quot; )</td>
<td>( m )</td>
<td>( Kg/m )</td>
<td>( Kg )</td>
</tr>
<tr>
<td>EMN</td>
<td>T- O.P.</td>
<td>6&quot;</td>
<td></td>
<td>252</td>
<td>15</td>
<td>3780</td>
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<td></td>
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<tr>
<td>EMN</td>
<td>T- O.P.</td>
<td>8&quot;</td>
<td></td>
<td>1200</td>
<td>20</td>
<td>24000</td>
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</tr>
<tr>
<td>EMN</td>
<td>T.-O.P.</td>
<td>8&quot;</td>
<td></td>
<td>2424</td>
<td>18</td>
<td>43632</td>
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</table>

**PIPPINES**

<table>
<thead>
<tr>
<th>10%</th>
<th>15%</th>
<th>50%</th>
<th>25%</th>
<th>Progr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layed</td>
<td>Aligned</td>
<td>Welds executed</td>
<td>X rays done</td>
<td>%</td>
</tr>
<tr>
<td>ACT.</td>
<td>ACT.</td>
<td>N°</td>
<td>N°</td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>m</td>
<td>Tot. Welds</td>
<td>Actual.welds</td>
<td>Actual X rays</td>
</tr>
<tr>
<td>144</td>
<td>96</td>
<td>20</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>180</td>
<td>180</td>
<td>99</td>
<td>8</td>
<td>6</td>
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<td>1536</td>
<td>1440</td>
<td>320</td>
<td>117</td>
<td>61</td>
</tr>
</tbody>
</table>
Video demo
Conclusions

- “Old Dogs” at ABB have learned to appreciate these GIS tools as the detailed engineering has progressed on the Offsites.

- When the “Dinosaurs” who have been skeptical about GIS value to the project see what the tool can do to save their skin, we have new converts.

- There is still a lot of sand in the Sahara for “Ostriches” to keep their head buried with regard to the potential of this technology. We will get to them in due time…
Many thanks for your attention

- M. Doyle Sanders  
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