Onshore Pipeline Engineering Course

Advanced Pipeline Routing & Information Management

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ibc Energy

Overview

Pipeline Routing Challenges

Using GIS for Pipeline Routing

Multi-Criteria Evaluation

Pipeline Information Management

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Challenges of Onshore Pipeline Routing

- Inaccessible and remote terrain
- Limited availability of mapping, and information
- Security restrictions
- Transportation and logistics
- Project schedule
- Dispersed project team

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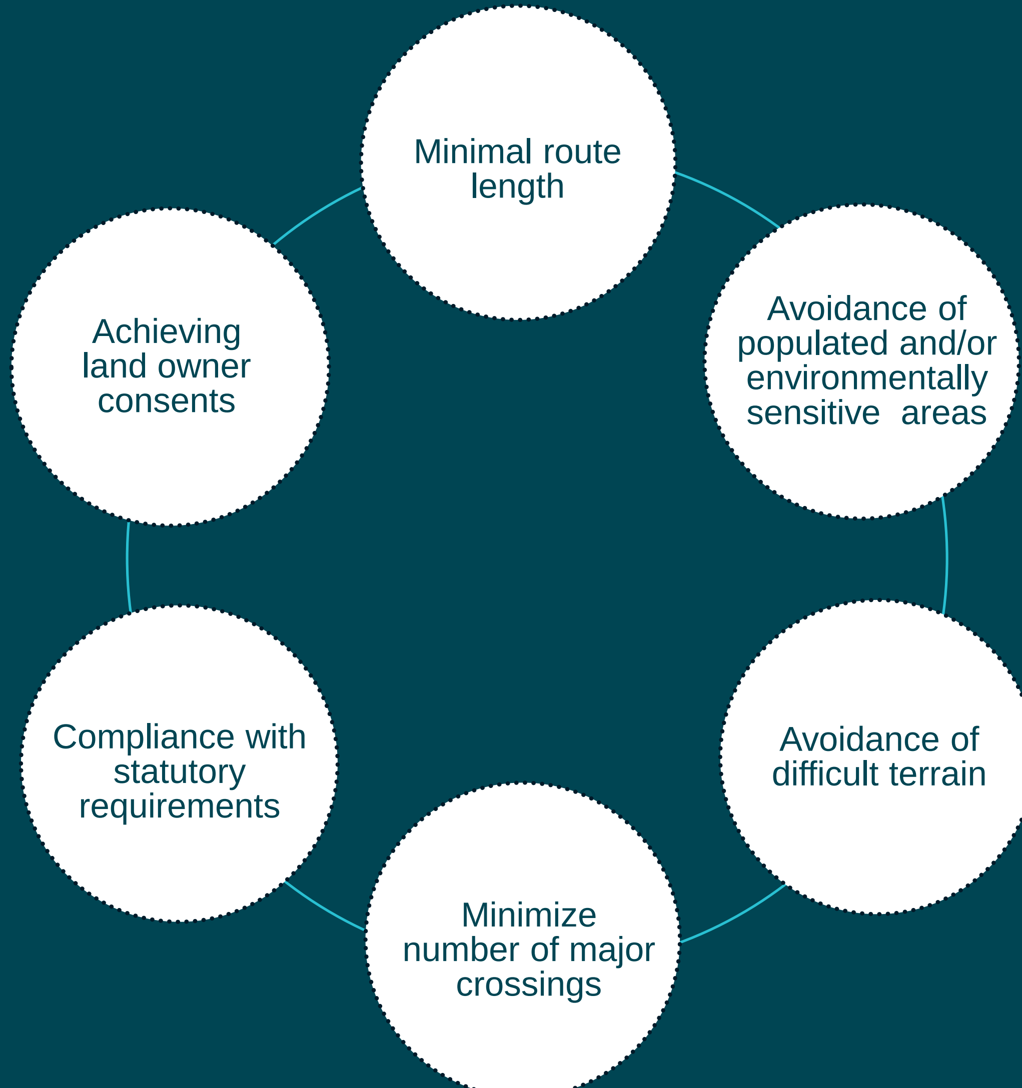
Objective of Pipeline Routing

The main objective is to achieve the most viable and optimum design solution using the best available information.

Pipeline routing is inevitably a compromise between the opposing factors of:



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Information Acquisition

- Remote sensing (Imagery, RADAR, LiDAR)
- Published data (Plans, Maps, Geological data)
- Local knowledge (negotiations with landowners)
- Statutory and non-statutory organisations
- Site surveys

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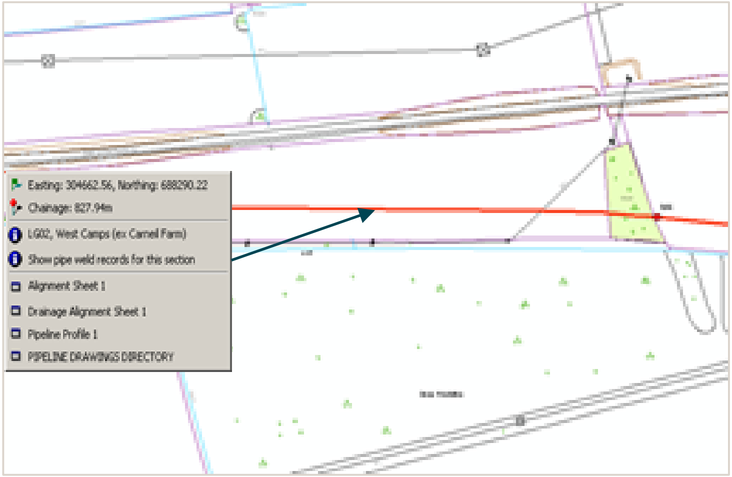
Technology Advancements

- GIS provides the platform to integrate spatial and tabular information in a variety of different formats, allowing for better decision making process by using all available information in a seamless format.
- Powerful visualisation and analytical tools help determine an optimum route taking into account all routing criteria and available constraints.
- Use of GIS enables evaluation of route alternatives and greatly assists in selecting the least costly route.
- GIS can be used for managing engineering and construction data and progress information.



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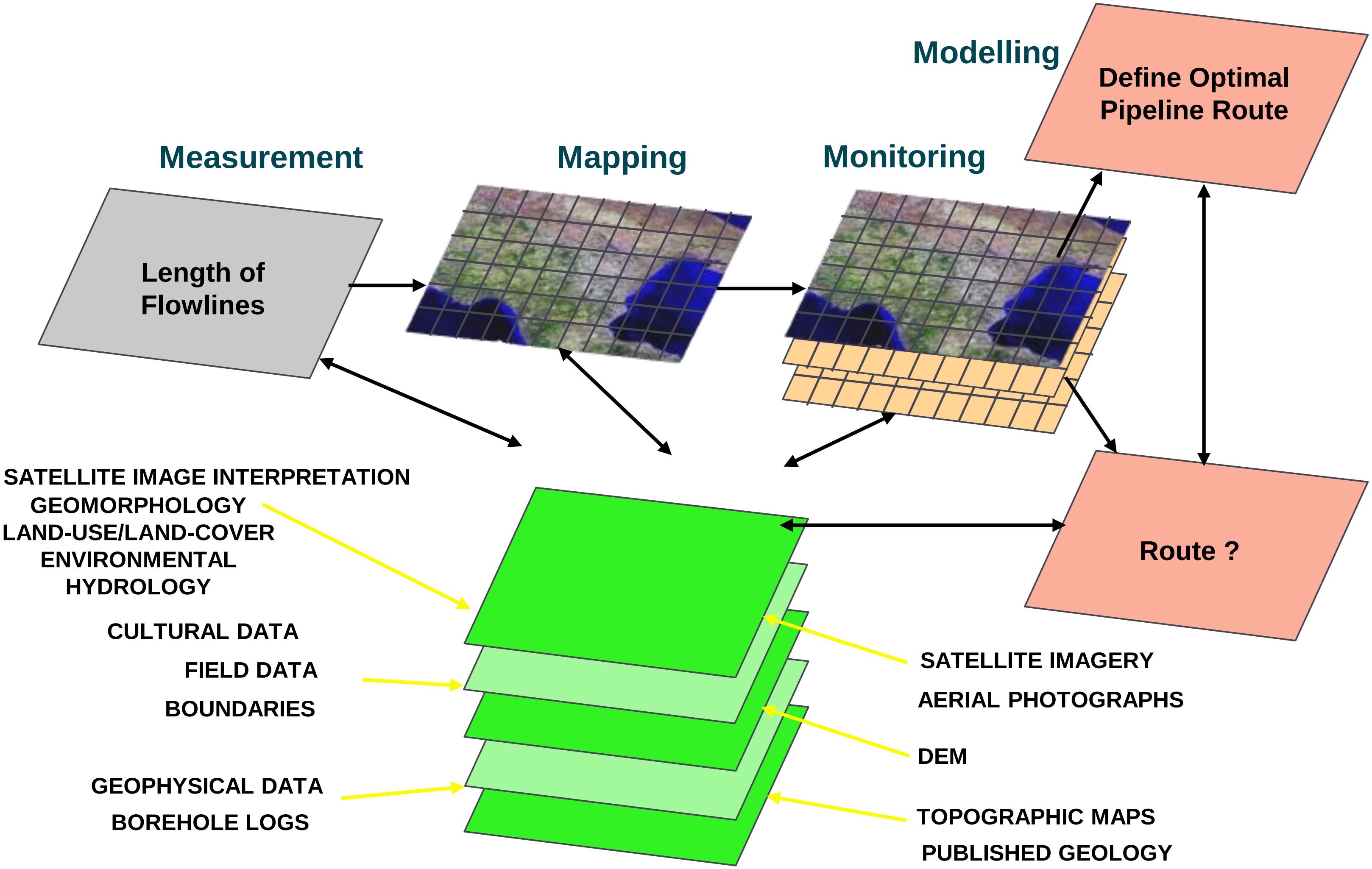
GIS and Data Integration



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Common Questions

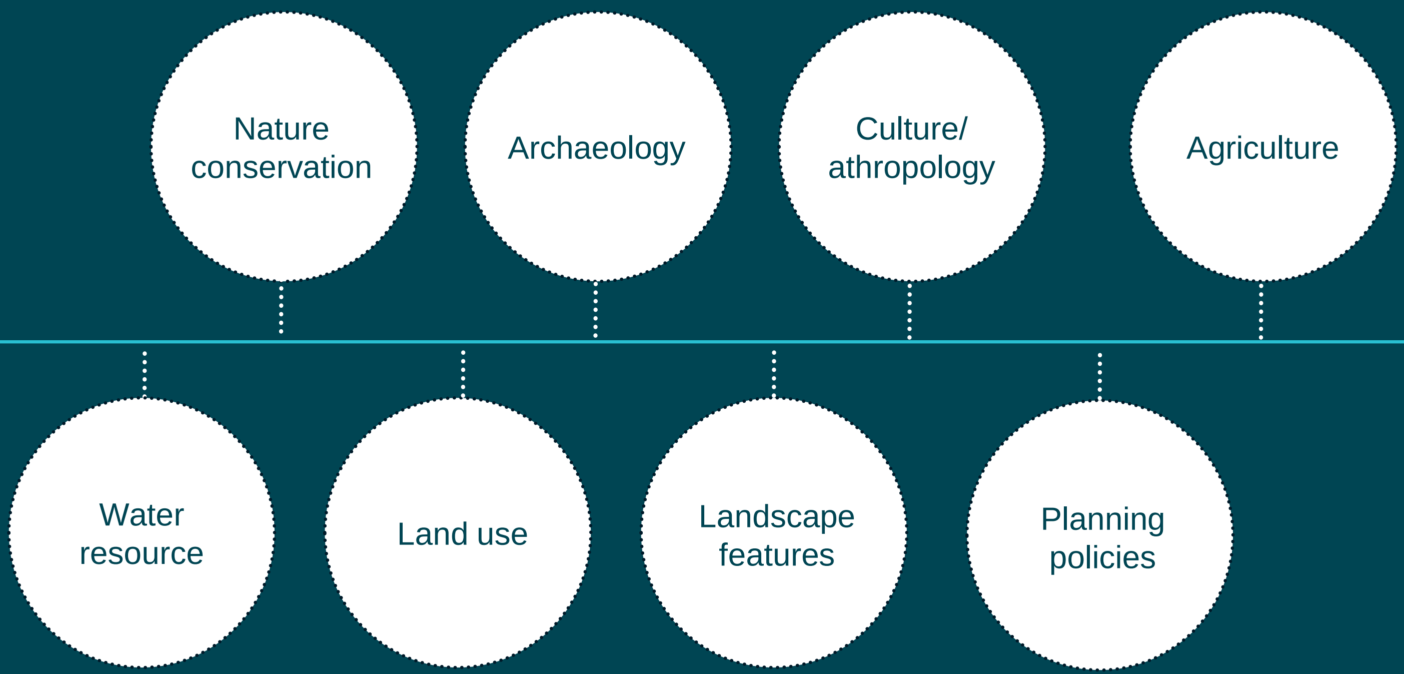
How does pipeline routing impact on the environment?

As with other linear developments (road, railways), the effect that pipeline construction has on the environment largely depends on it’s route.

The process of careful route selection is of primary importance to eliminate or minimise any adverse effects on the environment.

Common Questions

What are the types of environment constrains?



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Common Questions

How do the engineering codes govern onshore routing

- Design codes for pipelines employ a system of area classification to create an objective view for the design factor allocation and minimum proximity.
- Liquid hydrocarbon pipelines generally utilise a single design factor which does not vary by location or proximity.
- Area classification generally works on the premise that risk increases as a consequence of the concentration of population.

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Common Questions

How do you evaluate more than one possible route option?

- How do you evaluate more than one possible route option?
- Shortest Route?
- Capital cost?
- Least No. of crossings?
- impact on environment?
- impact on safety?
- Impact on operating costs?
- Supported by consent?

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Constraints and Factors

Available information are categorised to Constraints and Factors.

Constraints Map indicates restricted zones where pipeline will not be routed through.

Factors Map indicates suitability of land. Passing through more suitable area is less costly and more feasible.

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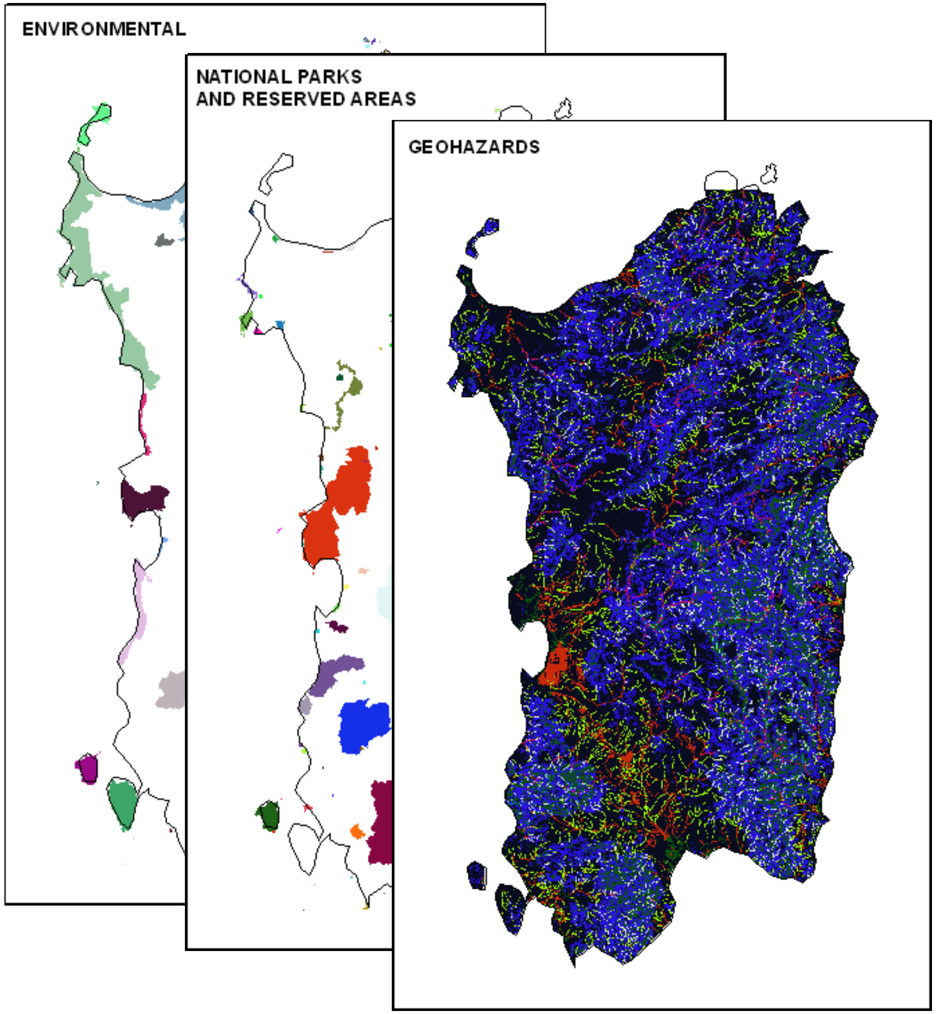
Constraints

- Start and end points
- Urban restrictions
- National parks and reserved areas
- Environmental restrictions
- Geo-hazards
- Constructability constraints



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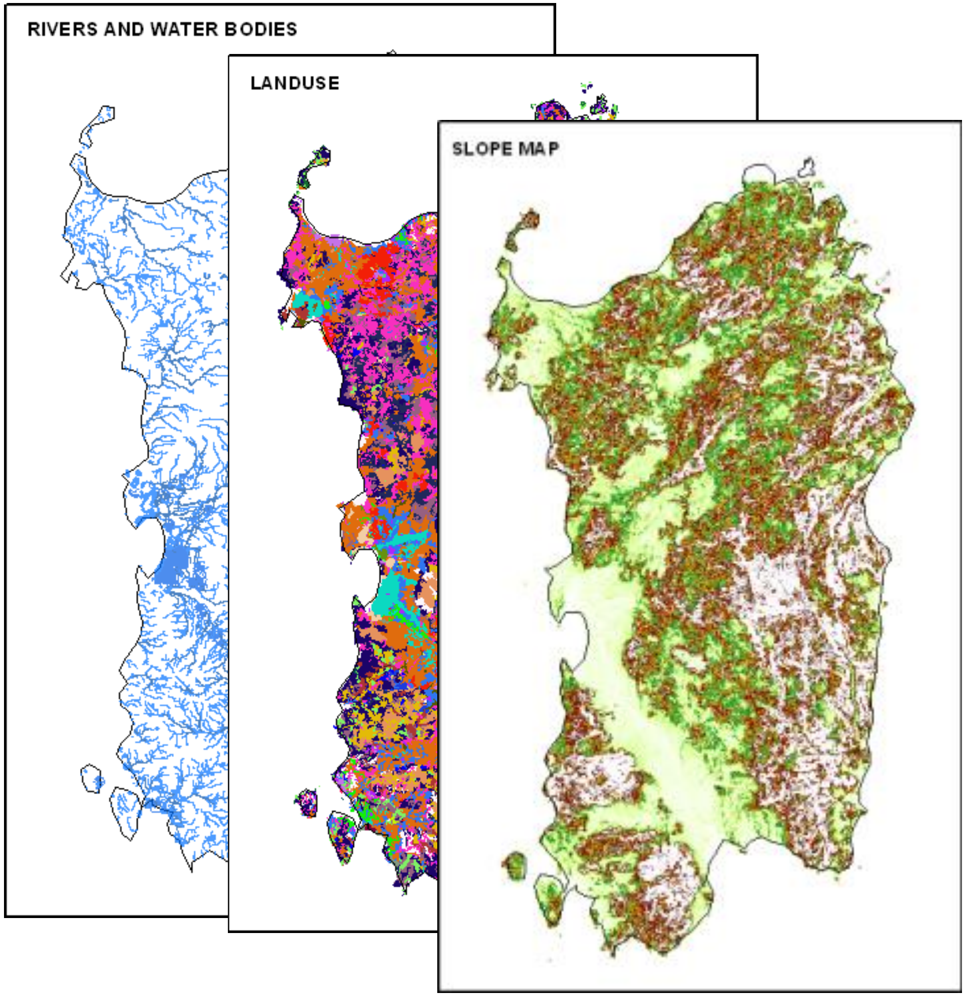
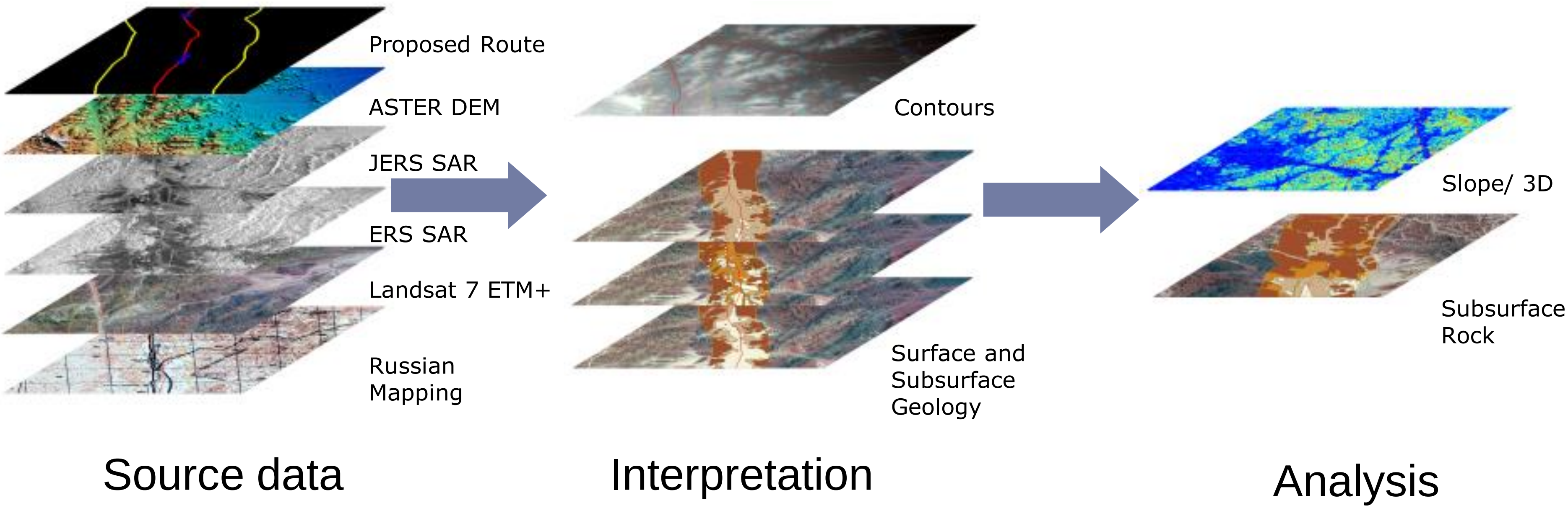
Factors

- Slope suitability
- Soil type
- Land use cost effectiveness
- Rivers and water bodies
- Hydrology data
- Roads and railway networks

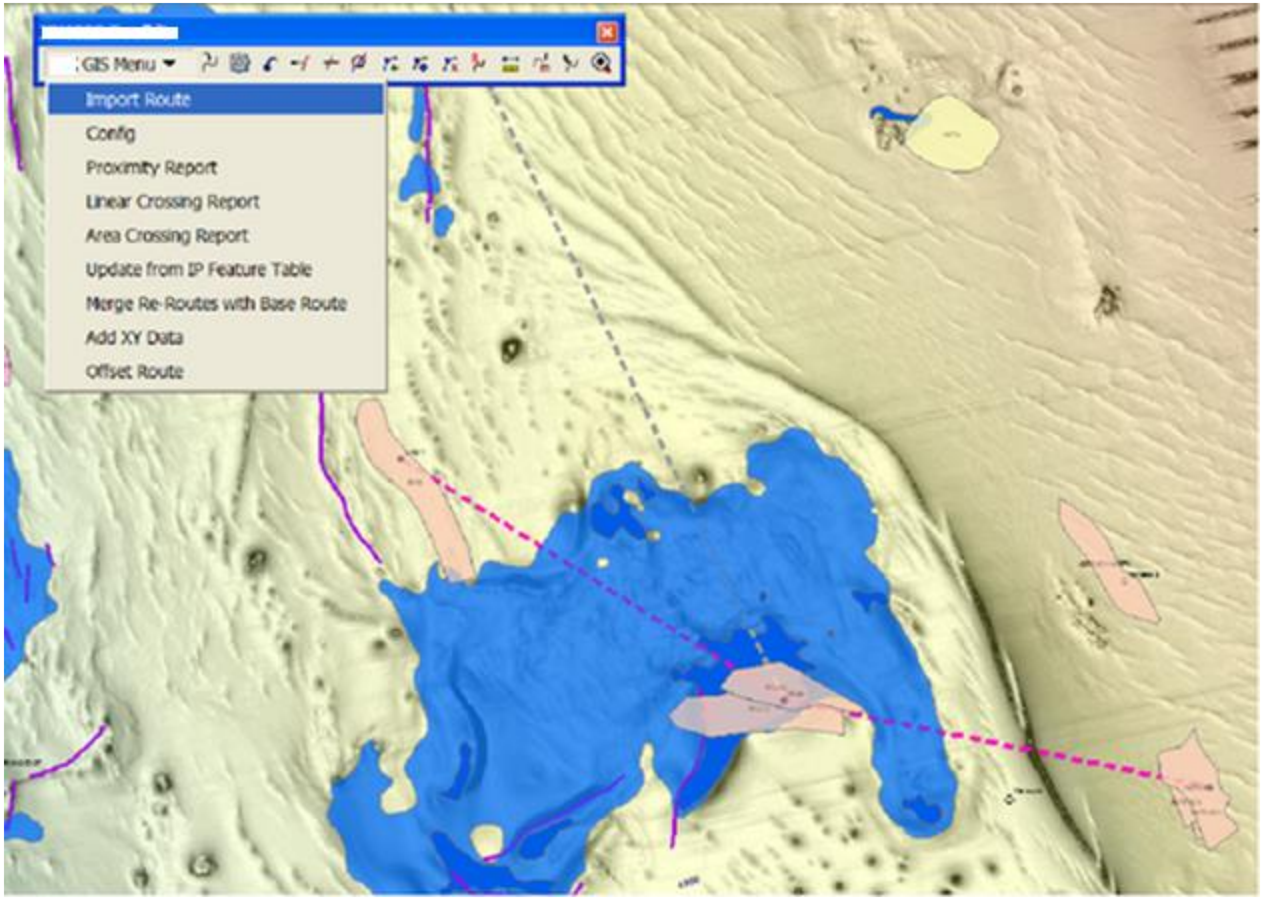


Remote sensing data

GIS data stack



Customised GIS Tools



GIS customised tools to

deliver faster

route definition and reports

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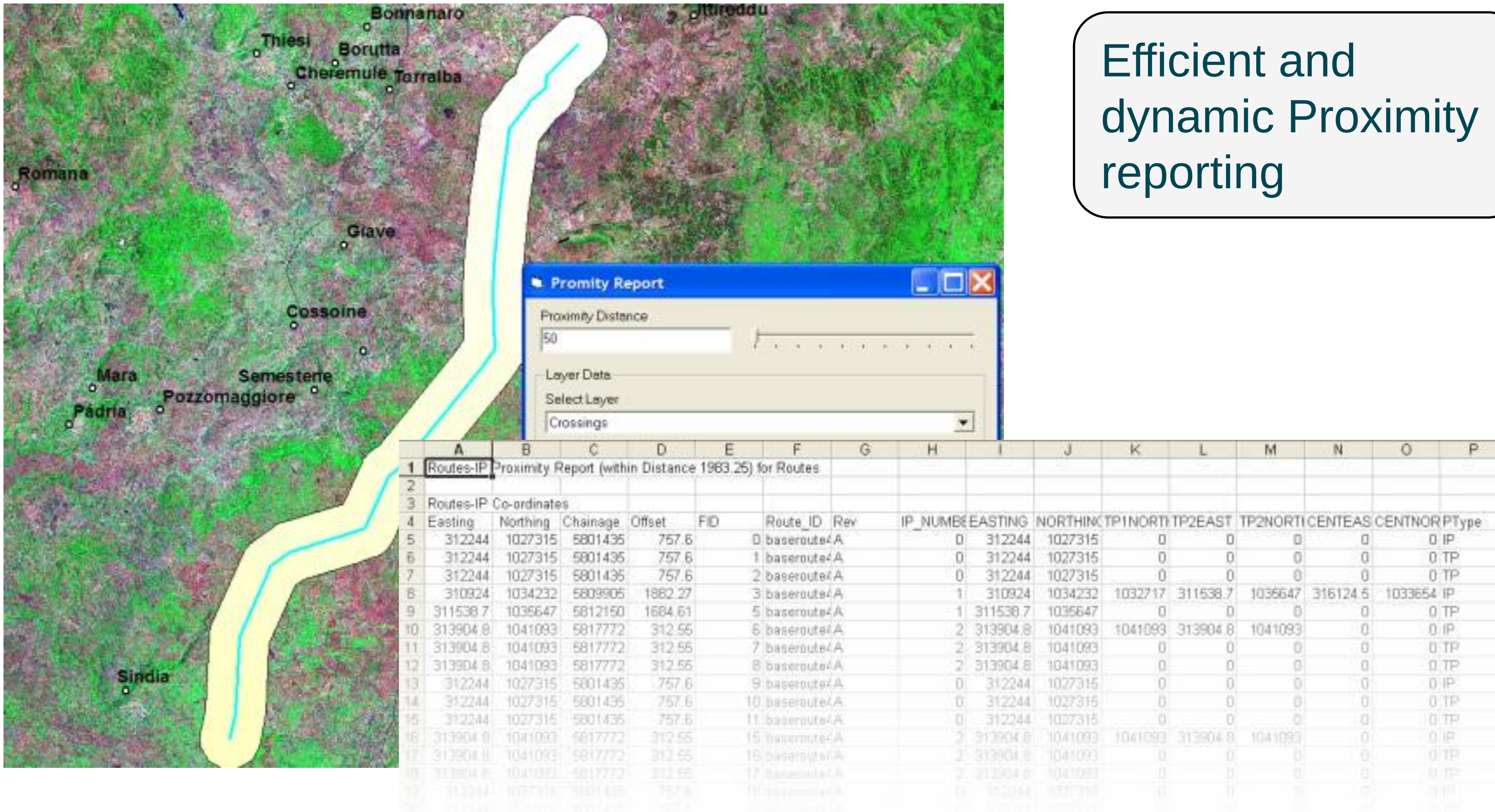
Customised GIS Tools

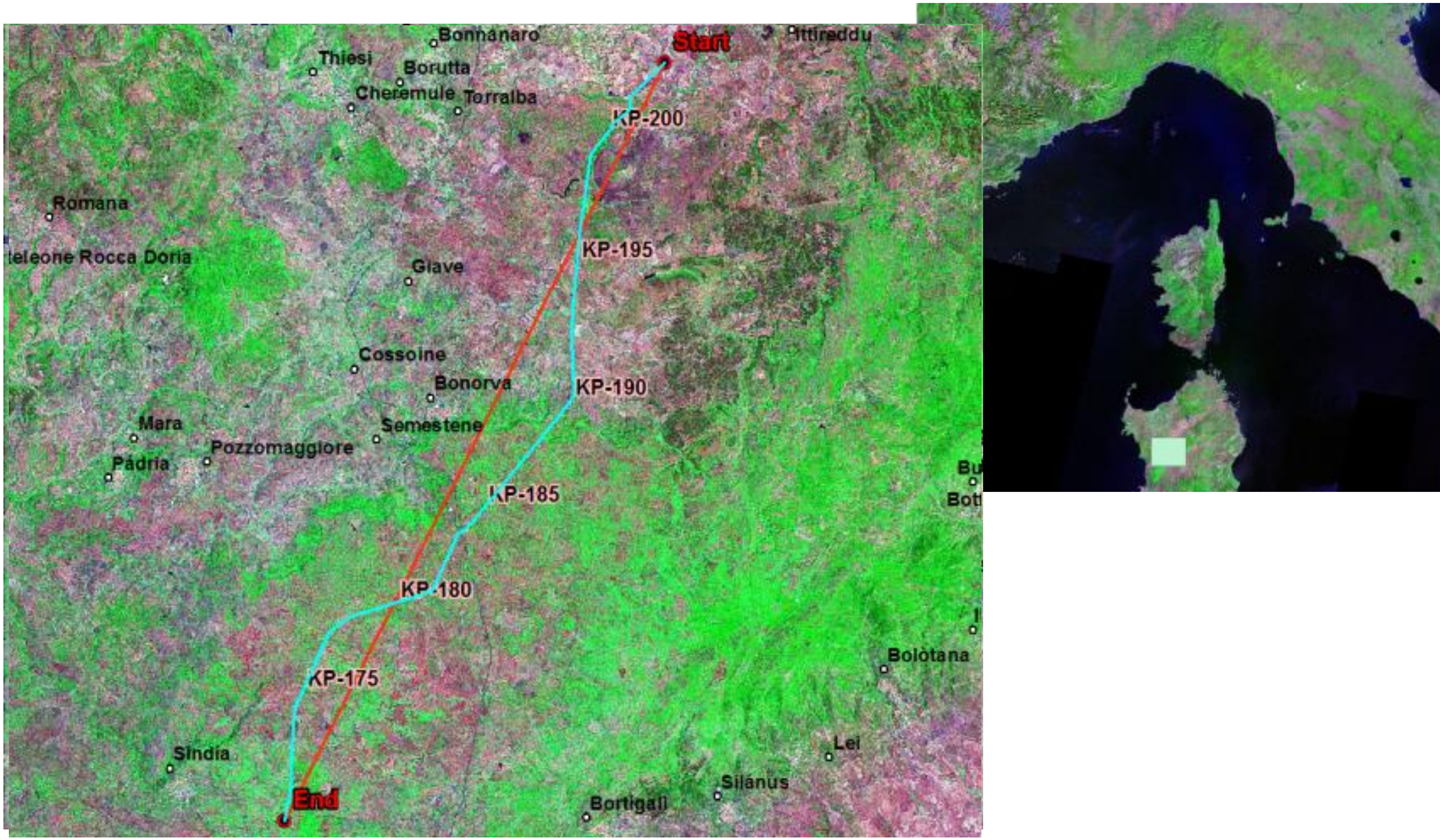
Proximity Report



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Routes-IP	Proximity Report (within Distance 1983.25) for Routes														
2																
3	Routes-IP Co-ordinates															
4	Easting	Northing	Chainage	Offset	FID	Route_ID	Rev	IP_NUMBE	EASTING	NORTHIN(	TP1NORTI	TP2EAST	TP2NORTI	CENTEAS	CENTNOR	PType
5	312244	1027315	5801435	757.6	0	baseroute4	A	0	312244	1027315	0	0	0	0	0	IP
6	312244	1027315	5801435	757.6	1	baseroute4	A	0	312244	1027315	0	0	0	0	0	TP
7	312244	1027315	5801435	757.6	2	baseroute4	A	0	312244	1027315	0	0	0	0	0	TP
8	310924	1034232	5809905	1882.27	3	baseroute4	A	1	310924	1034232	1032717	311538.7	1035647	316124.5	1033654	IP
9	311538.7	1035647	5812150	1684.61	5	baseroute4	A	1	311538.7	1035647	0	0	0	0	0	TP
10	313904.8	1041093	5817772	312.55	6	baseroute4	A	2	313904.8	1041093	1041093	313904.8	1041093	0	0	IP
11	313904.8	1041093	5817772	312.55	7	baseroute4	A	2	313904.8	1041093	0	0	0	0	0	TP
12	313904.8	1041093	5817772	312.55	8	baseroute4	A	2	313904.8	1041093	0	0	0	0	0	TP
13	312244	1027315	5801435	757.6	9	baseroute4	A	0	312244	1027315	0	0	0	0	0	IP
14	312244	1027315	5801435	757.6	10	baseroute4	A	0	312244	1027315	0	0	0	0	0	TP
15	312244	1027315	5801435	757.6	11	baseroute4	A	0	312244	1027315	0	0	0	0	0	TP
16	313904.8	1041093	5817772	312.55	15	baseroute4	A	2	313904.8	1041093	1041093	313904.8	1041093	0	0	IP
17	313904.8	1041093	5817772	312.55	16	baseroute4	A	2	313904.8	1041093	0	0	0	0	0	TP
18	313904.8	1041093	5817772	312.55	17	baseroute4	A	2	313904.8	1041093	0	0	0	0	0	TP

Efficient and dynamic Proximity reporting

Route Optimisation



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Route Optimisation

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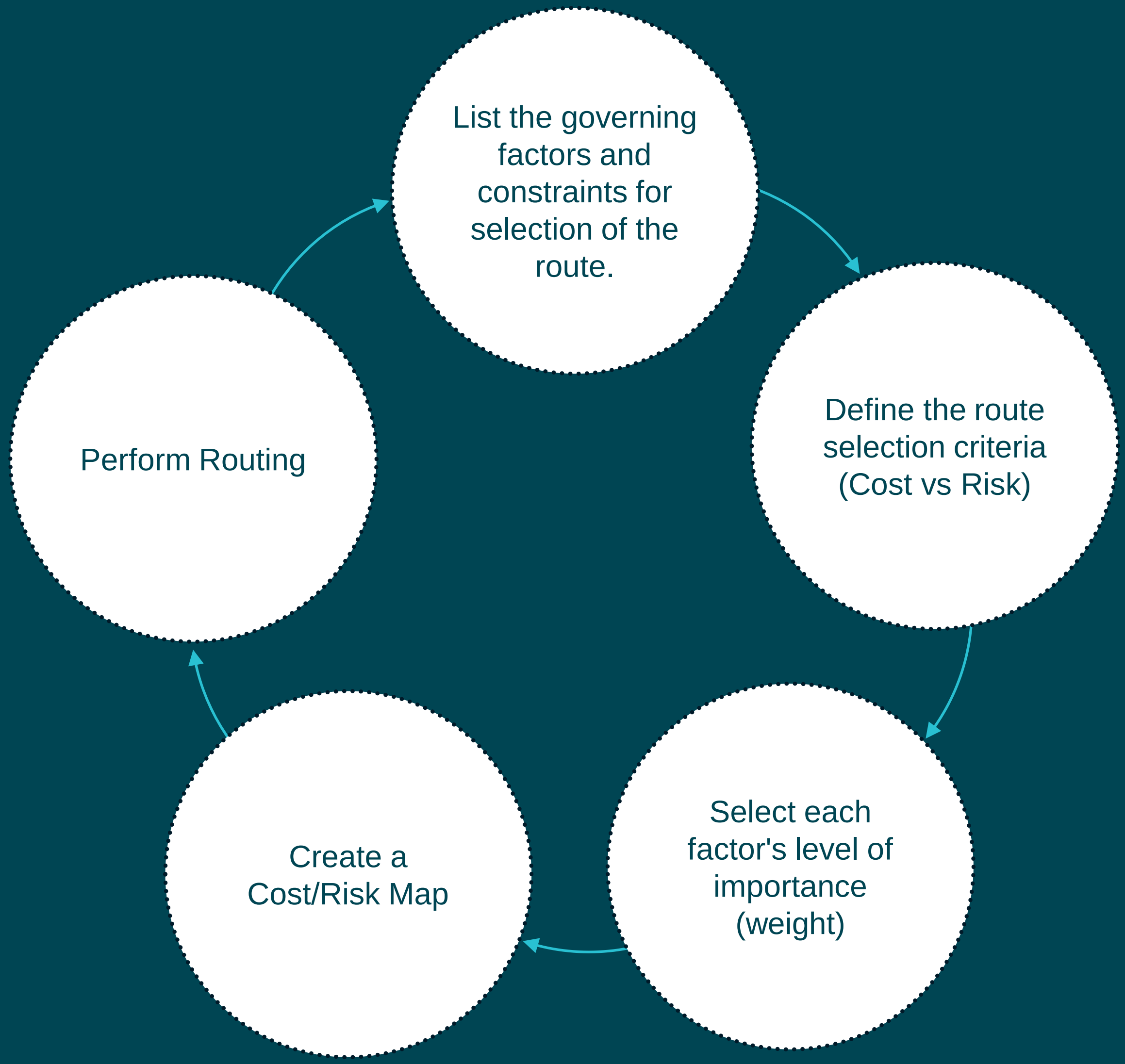
Multi-Criteria Evaluation (MCE)



Cost-Base vs Risk-Base

Cost-Base

- A primary weighting is introduced for the project elements, e.g. material cost, construction cost, land acquisition, etc.
- Secondary weighting is introduced for each factor is based on the cost implications of the variables of the factor, e.g. cost of trenching in rock compared to bare soil
- A map is produced by applying the given weightings
- The map colour code will be representative of the cost

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Cost-Base vs Risk-Base

Risk-Base

- Each factor is given a weight based on the risk implications of the variables of the factor, e.g. flood and scour risk in hard ground is lower than soft soil.
- A map is produced by applying the given weightings
- The map colour code will be representative of the risk

Cost-Base vs Risk-Base

Rule 1:

Never mix cost factors and risk factors in one MCE map

Rule 2:

Cost and risk factors are not always in opposite directions

Rule 3:

Acceptable level of risk and cost increase should be identified prior to final route selection

Example of Route Ranking

Assessment Spacing (km)	**12.4**	**24.8**	**37.2**	**49.6**	**62**	**8.4**	**20.8**	**33.2**	**45.6**	**58**	
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	
Topographical (slopes)	1	1	1	1	1	1	2	2	2	1	13
Access	1	1	1	1	1	1	2	1	2	1	12
Crossings	2	1	2	1	3	1	1	3	1	2	17
Geology	1	1	2	1	3	1	2	1	3	1	16
Land Use	1	1	1	1	1	1	2	1	1	1	11
Hydrology	1	1	1	1	0	1	1	1	1	1	9
Geological Hazard	0	1	0	1	1	0	0	1	1	0	5
SIC, ZPS ANPIL	0	0	0	0	0	0	1	1	1	0	3
Environmental	0	0	1	0	0	0	0	0	0	0	1
Parks	0	0	0	0	0	0	0	0	0	0	0
Urbanisation	0	0	0	0	0	0	0	0	0	1	1
Archaeological	0	0	0	0	0	1	0	0	0	0	1
Subtotal	7	7	9	7	10	7	11	11	12	8	
Total											**89**

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GIS on Site

Technologies

- Increased accuracy of hand held GPS
- GPS-Cameras
- GIS enabled PDA and Tablets

Benefits

- Shorter site visits
- Accurate data collection
- Increased flexibility and productivity

Pipeline Data Models

With fast growing volume of information/data produced and captured on projects, need for a standardised (or at-least compatible) framework for data capture and storage is more evident.

There has been several attempts in the past, and several models introduced. Despite this bespoke models are created every now and then.

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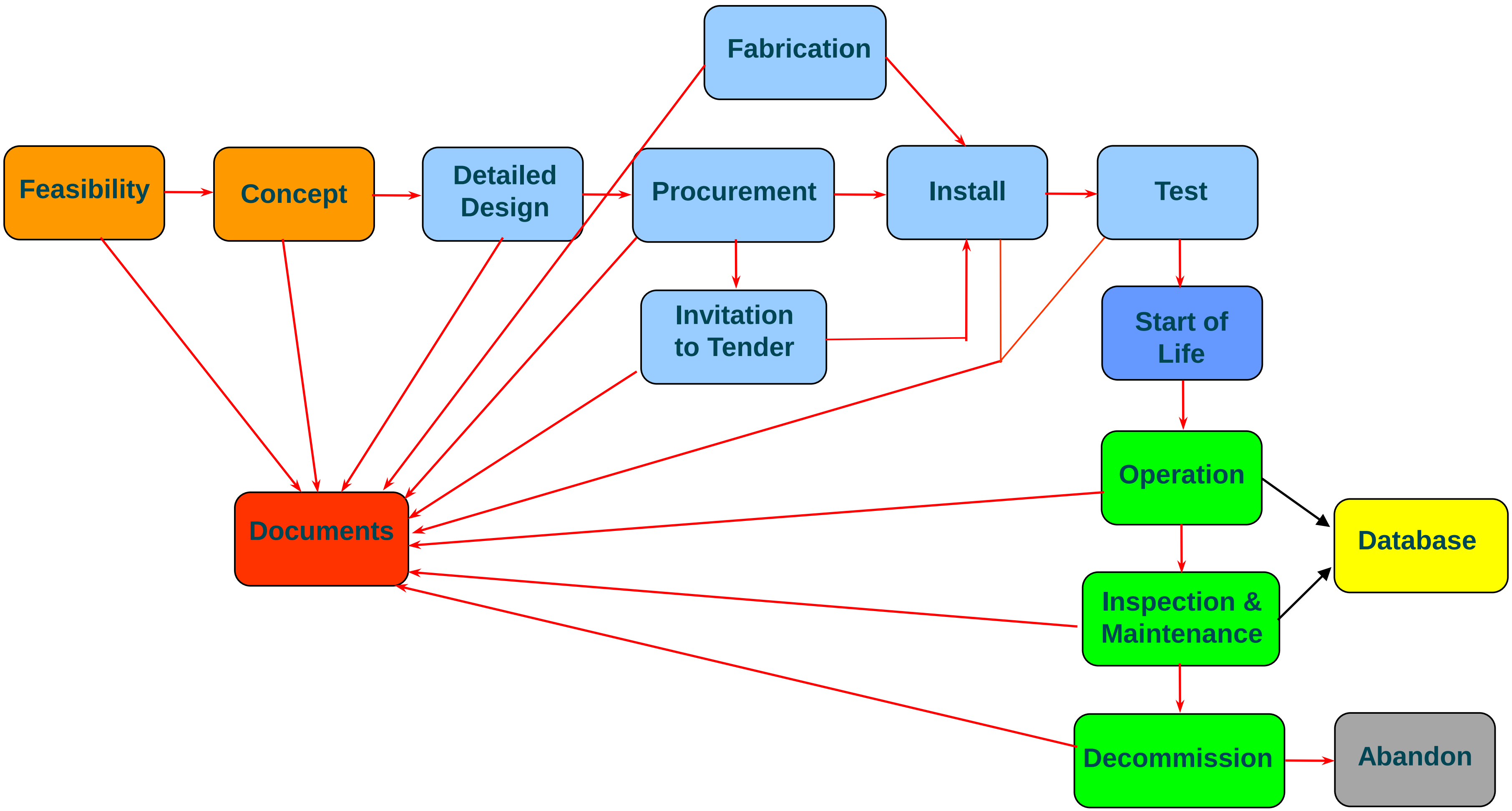
Pipeline Data Model - Definition

An industry standard relational database that provides the framework for holding data pertaining to pipelines and associated components and features.

The objective of an industry standard model such as PODS™ is to provide a common platform to create standard-based GIS database.

Traditional Approach



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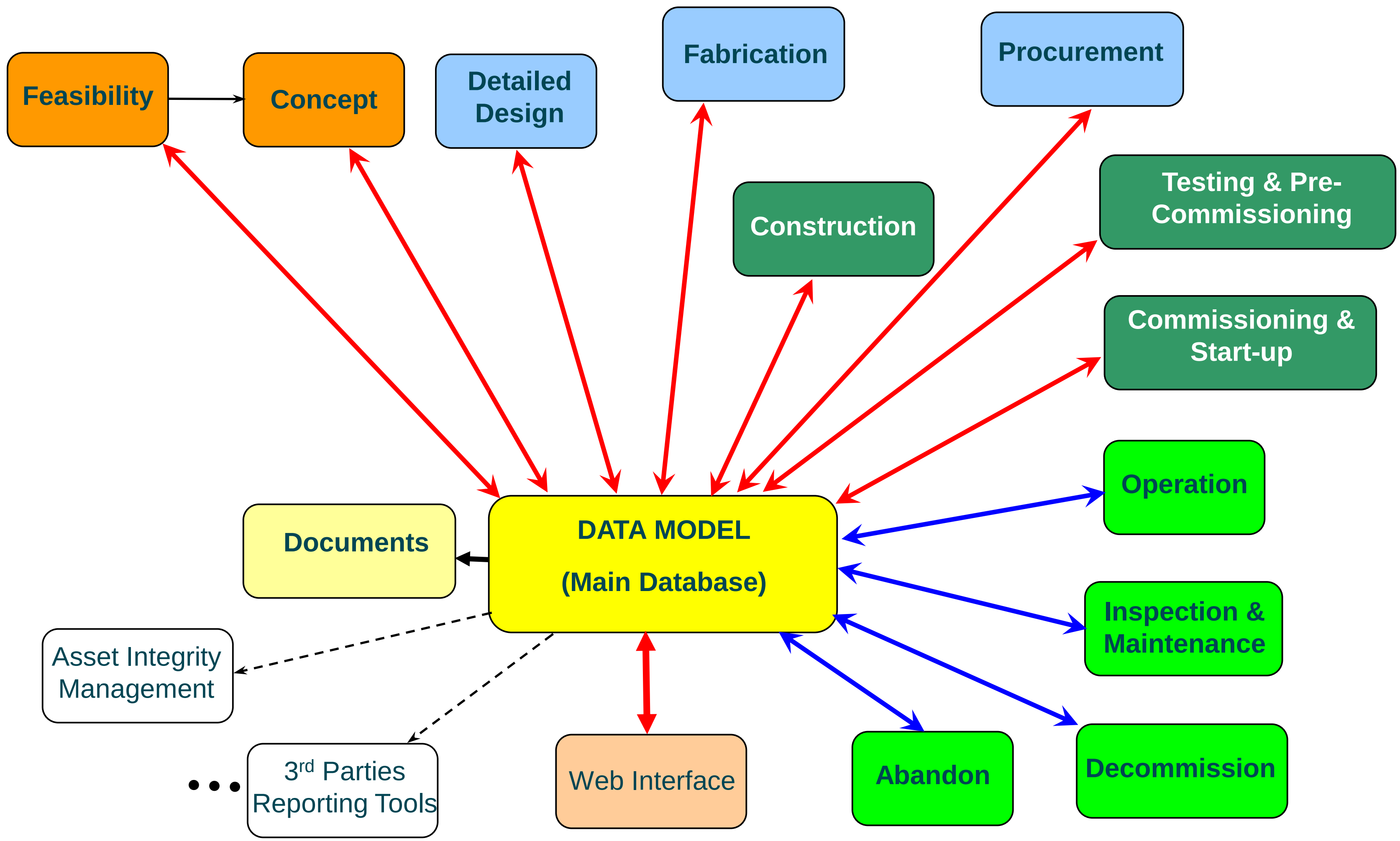
More Efficient Approach



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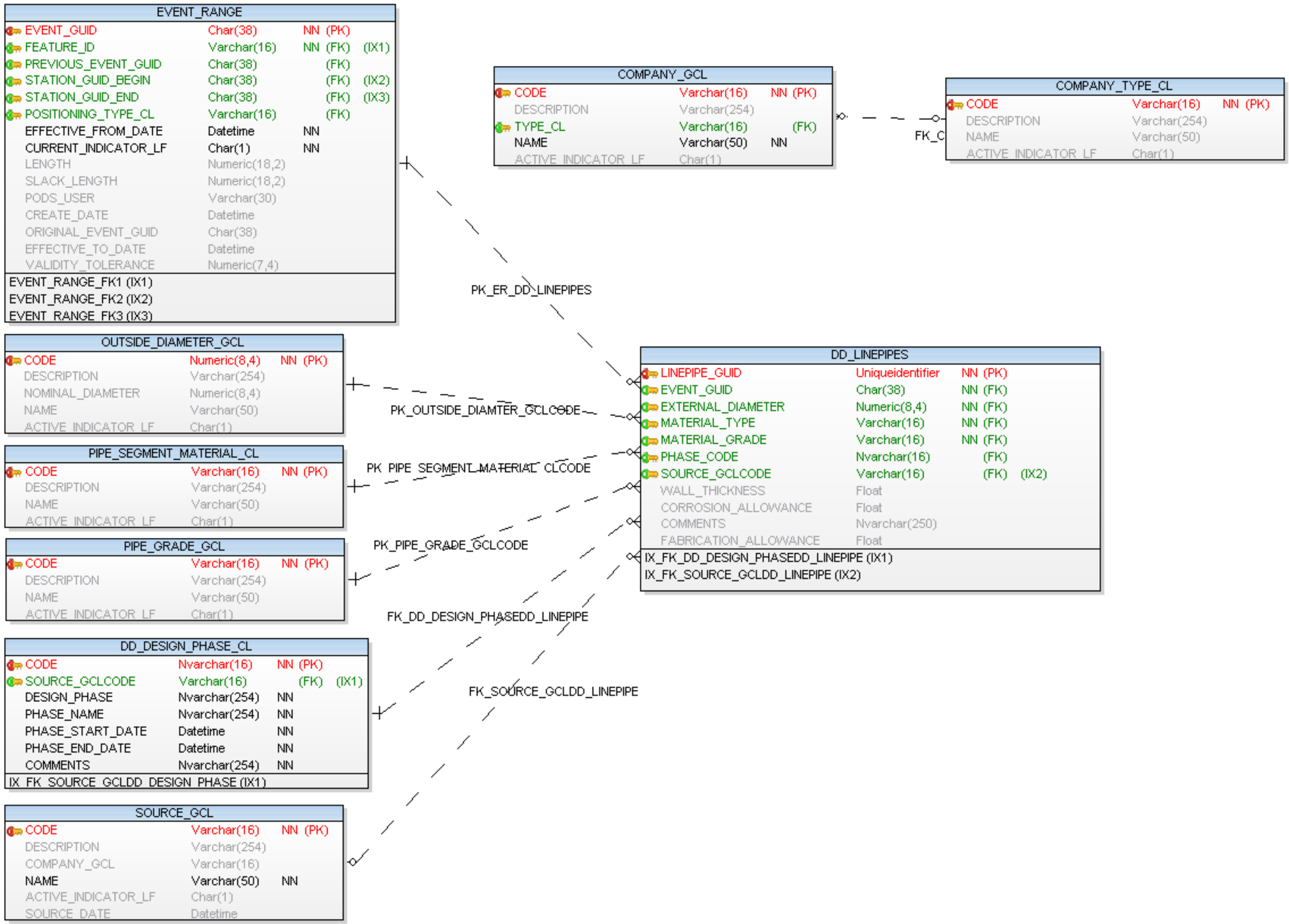
Current Pipeline Data Models

- PODS - Pipeline Open Database Standard
- APDM - ArcGIS Pipeline Data Model (now renamed to PODS ESRI Spatial)
- EPISTLE - European Process Industries STEP Technical Liaison Executive (ISO 15926)
- Operators' Customized Data Models

Data Model – Relational Tables



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Pipeline Data Model - Benefits

- Pipeline data will be easily accessible through the use of standard desktop applications and WEB technology.

- Integration of data from different sources will enable safety and integrity audits to be undertaken with a higher degree of confidence.

- Better decision making through the development of Asset Management tools such as Remnant Life Prediction, Repair/Replacement/Survey optimisation, Fitness for Purpose Assessments and Trend/Probabilistic Analysis.

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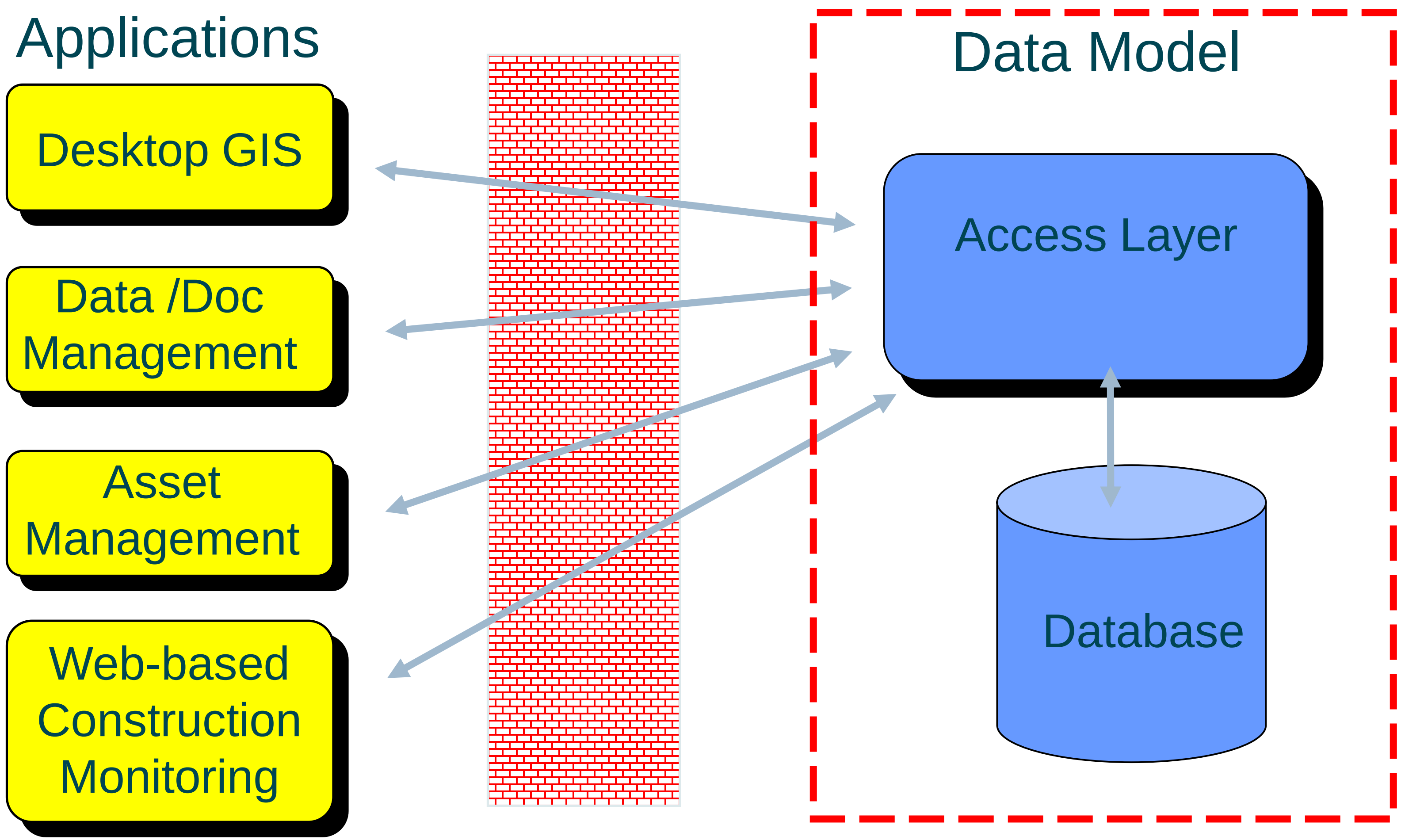
Applications



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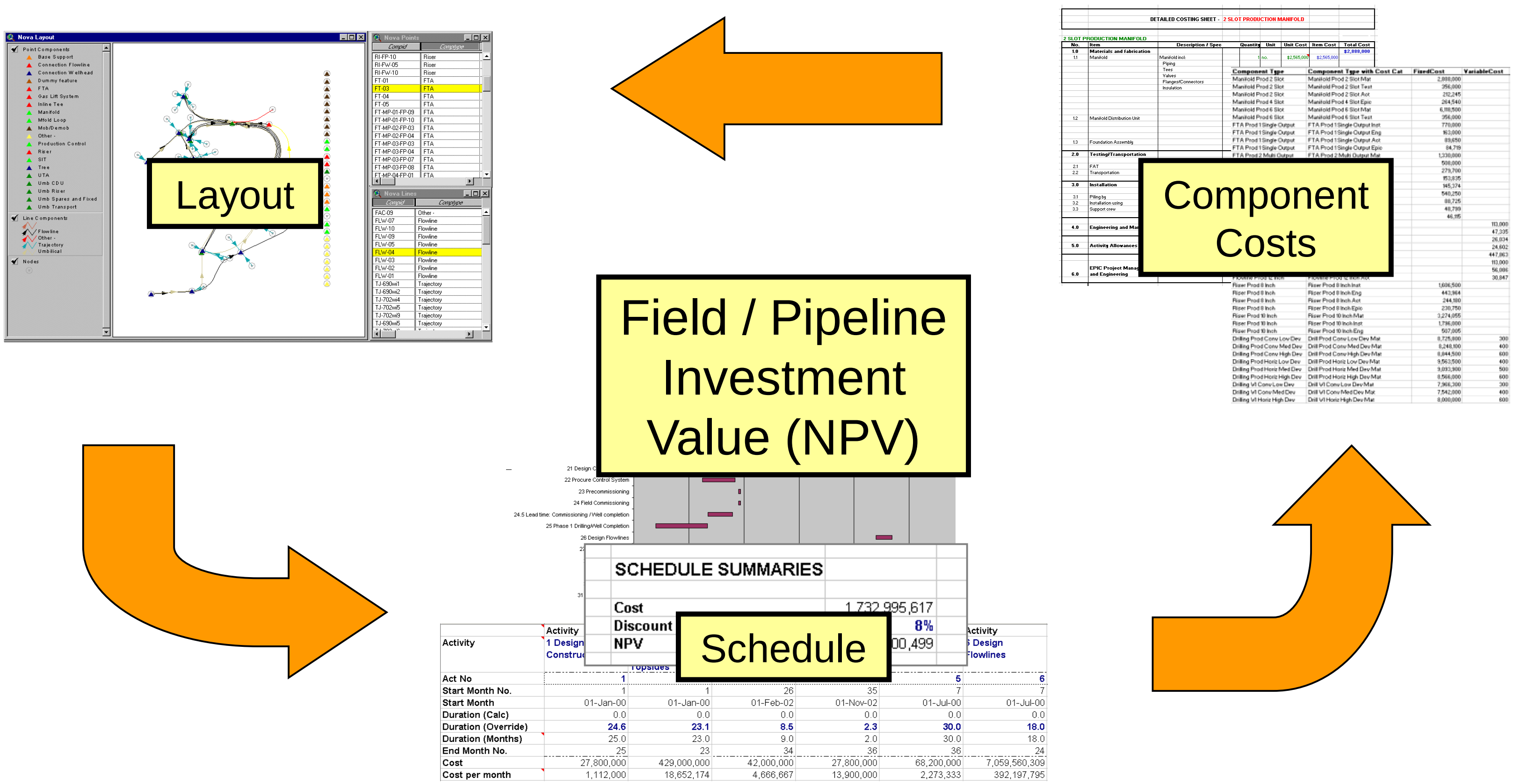
GIS and Cost Model Integration

- Specification and optimisation using GIS mapping environment, in terms of choice and location of components (directional wells, flowlines, manifolds, access roads, etc)
- Analysing the effect of field layout and development schedule on field economics (CAPEX, OPEX, production revenue and NPV)
- Reduced time to evaluate alternative field development scenarios
- Automated checking of layout and configuration against project specific rules

GIS and Advanced Cost Model

Time-phasing of CAPEX costs using a pseudo schedule allows calculation of present value, PV while integrating money value of time.



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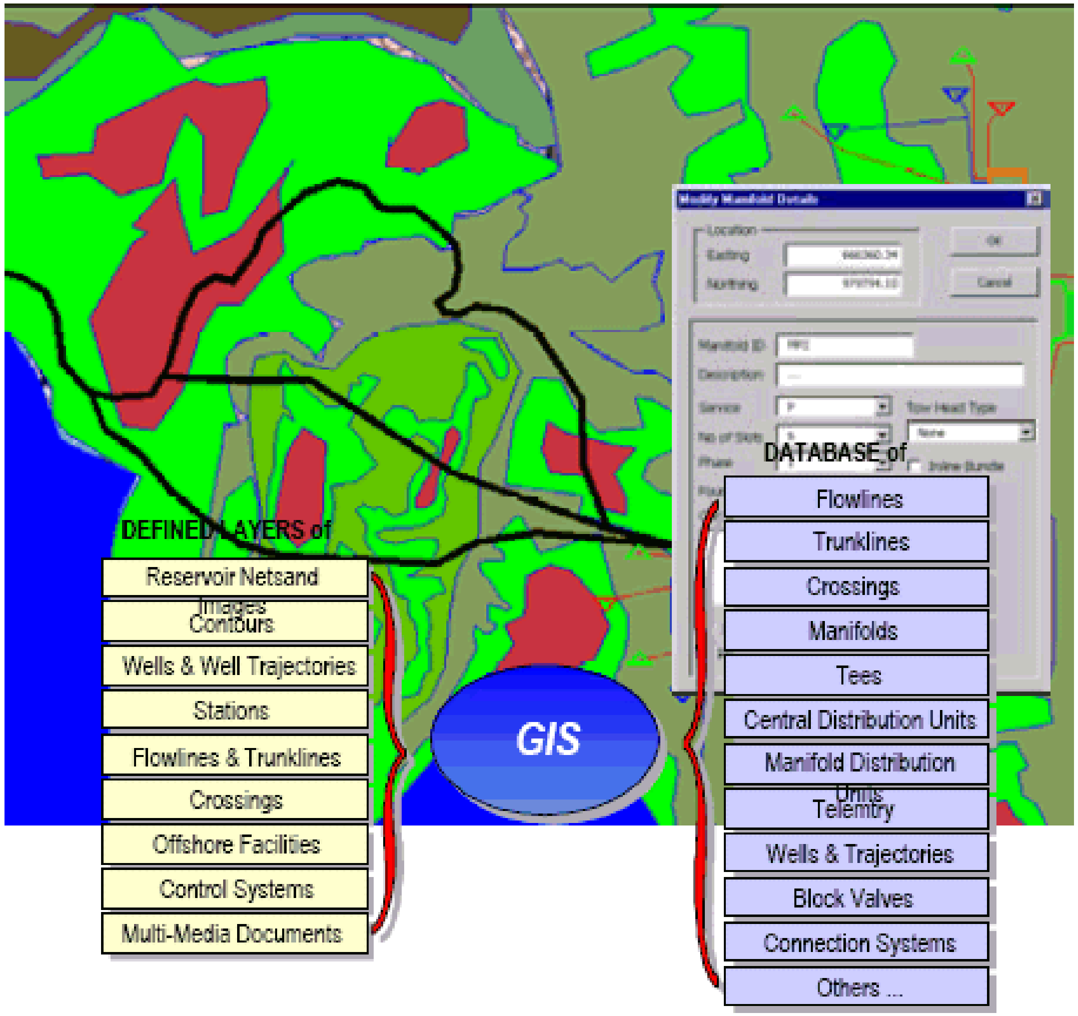
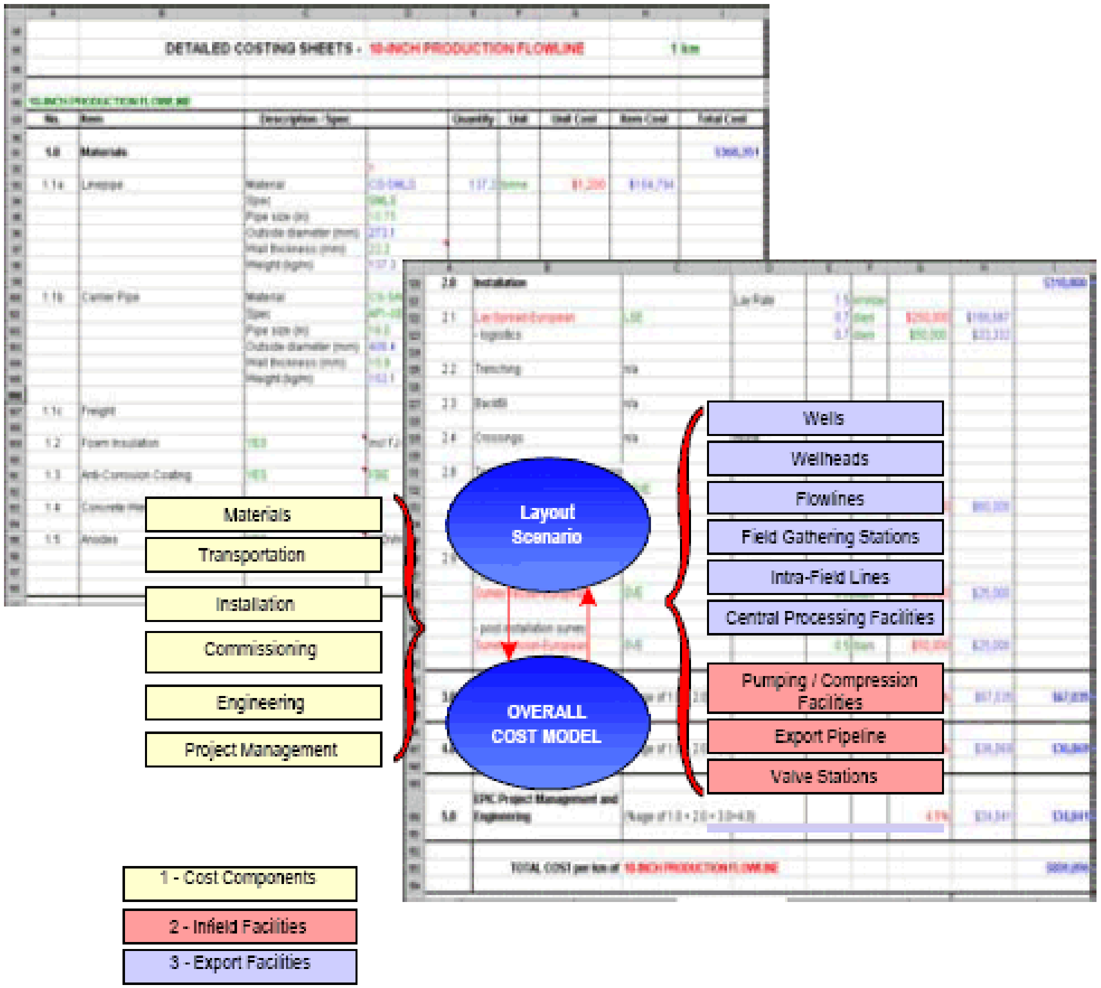
Building the GIS Model



Building the Cost Model



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Cost Model

DETAILED COSTING SHEET - GAS LIFT PHASE 1 | No of Production Risers (P1): 2

GAS LIFT PHASE 1

No.	Item
1.0	**Materials and equipment**
1.1	Integrated Gas Lift Risers
1.2	Foundation/tether System
	Connectors
	Handling Frame & Protective Covers
	Valves & Actuators
	Sensors, Connectors & Leads
	Ancilliary Items
2.0	**Testing**
2.1	FAT
3.0	**Services/Support**
3.1	Contract Services
3.2	Offshore Services Support Crew
3.3	Transportation
	Mob/Demob Of Services
4.0	**Installation**
4.1	Mob/Demob
4.2	Risers, Tether Bases & Foundations
	MSV-Local
4.3	
5.0	**Engineering and Management**
6.0	**Activity Allowances**
7.0	**EPIC Project Management and Engineering**

DETAILED COSTING SHEETS - PRODUCTION WELLHEAD CONNECTION 25 m

PRODUCTION WELLHEAD CONNECTION

No.	Item	Description / Spec	Quantity	Unit	Unit Cost	Item Cost	Total Cost
1.0	**Materials**						$347,000
1.1	1 No rigid spools - insulated						
1.2	Male hubs for collet connectors	NOTE: Costs included in struc					
1.3	Collet conectors						
1.4	Internal Cladding						
1.5	Control jumpers (from CDU to Tree)	1 No per tree					
1.6	**Transport**						
2.0	**Installation**						
2.1	Support vessel mob/demob	Shared					
2.2	Support vessel costs	MSV-European					
2.3	Connection tool mob/demob	Inc in Unit costs - one off					
2.4	Connection tool costs						
2.5	Connection team mob/demob	Inc in Unit costs - one off					
2.6	Connection team						
2.7	In-Field fit-up & field well of spools	Inc. in Subsea Scope					
2.8	ROV costs	incl in vessel costs					
3.0	**Engineering and Management**	(%age of 1.0 + 2.0)					
	Activity Allowances	(%age of 1.0 + 2.0 +3.0)					
	EPIC Project Management and Engineering	(%age of 1.0 + 2.0 +3.0+4.0)					

DETAILED COSTING SHEET - 2 SLOT PRODUCTION MANIFOLD

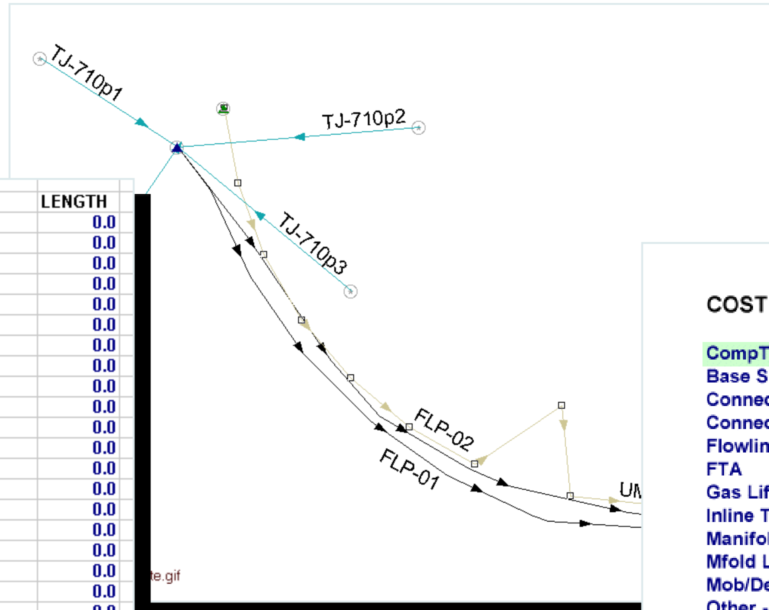
2 SLOT PRODUCTION MANIFOLD

No.	Item	Description / Spec		Quantity	Unit	Unit Cost	Item Cost	Total Cost
1.0	**Materials and fabrication**							$2,888,000
1.1	Manifold	Manifold incl: Piping, Tees, Valves, Flanges/Connectors, Insulation		1	no.	$2,565,000	$2,565,000	
1.2	Manifold Distribution Unit							
1.3	Foundation Assembly							
2.0	**Testing/Transportation**							$356,000
2.1	FAT			1	LS	$206,000	$206,000	
2.2	Transportation			1	LS	$150,000	$150,000	
3.0	**Installation**							$615,000
3.1	Piling by	MSV-European	MSVE	3	days	$120,000	$360,000	
3.2	Installation using	MSV-European	MSVE	2	days	$120,000	$240,000	
3.3	Support crew			10	mandays	$1,500	$15,000	
4.0	**Engineering and Managemen**	(%age of 1.0 + 2.0 + 3.0 +4.0)				10.00%	$385,900	$385,900
5.0	**Activity Allowances**	(%age of 1.0 + 2.0 + 3.0 + 4.0 + 5.0)				5.00%	$212,245	$212,245
6.0	**EPIC Project Management and Engineering**	(%age of 1.0 + 2.0 + 3.0+4.0+5.0+6.0)				4.50%	$200,572	$200,572

'Unitised' component costs

Costs classified according to timing of expenditure

GIS Data for Cost Model



GIS (if needed) to calculate lengths and quantities

COMPID	COMPSUBTYP	LENGTH
CD-04	Umb CDU Type 1	0.0
FC-MP-04-FP-01	Connection Flowline Prod	0.0
FC-MP-04-FP-02	Connection Flowline Prod	0.0
FAC-02	Other - FPSO Phase 1	0.0
RI-FP-01	Riser Prod 10 Inch	0.0
RI-FP-02	Riser Prod 10 Inch	0.0
RI-FP-05	Riser Prod 10 Inch	0.0
RI-FP-06	Riser Prod 10 Inch	0.0
RI-FP-07	Riser Prod 12 Inch	0.0
RI-FP-08	Riser Prod 12 Inch	0.0
RI-FP-09	Riser Prod 10 Inch	0.0
RI-FP-10	Riser Prod 10 Inch	0.0
RI-FW-05	Riser WI 12 Inch	0.0
RI-FW-10	Riser WI 12 Inch	0.0
FT-MP-04-FP-01	FTA Prod Type 1 Single Output	0.0
FT-MP-04-FP-02	FTA Prod Type 1 Single Output	0.0
MF-04	Manifold 4 Slot	0.0
ML-MP-04	Mfold Loop Pigging	0.0
TR-702p3	Tree Prod	0.0
TR-710p1	Tree Prod	0.0
TR-710p2	Tree Prod	0.0
TR-710p3	Tree Prod	0.0
UT-UMB09-CDU04	UTA Type 1	0.0
WC-702p3	Connection Wellhead Prod	0.0
WC-710p1	Connection Wellhead Prod	0.0
WC-710p2	Connection Wellhead Prod	0.0
WC-710p3	Connection Wellhead Prod	0.0
RU-07	Umb Riser Type 1 Dynam 2000m	0.0
RU-08	Umb Riser Type 1 Dynam 2000m	0.0
RU-09	Umb Riser Type 1 Dynam 2000m	0.0
RU-11	Umb Riser Type 1 Dynam 2000m	0.0
RU-16	Umb Riser Type 1 Dynam 2000m	0.0
FLP-01	Flowline Prod 10 I	
FLP-02	Flowline Prod 10 I	
UM-09	Umbilical Type 1 P	
TJ-710p1	Trajectory Prod Co	
TJ-710p3	Trajectory Prod Co	
TJ-710p2	Trajectory Prod Co	
TJ-702p3	Trajectory Prod Co	

Input : List of component quantities and lengths

COSTING SUMMARIES

CompType	Sum	Count
Base Support	18,000,000	3
Connection Flowline	11,257,413	13
Connection Wellhead	37,277,428	36
Flowline	54,848,288	20
FTA	31,591,364	16
Gas Lift System	7,198,399	2
Inline Tee	14,157,817	7
Manifold	30,716,005	5
Mfold Loop	3,053,647	5
Mob/Demob	68,240,000	9
Other -	745,800,000	9
Production Control	6,316,100	3
Riser	56,794,163	10
SIT	3,980,274	2
Trajectory	456,909,254	36
Tree	126,915,835	36
Umb CDU	5,108,522	6
Umb Riser	8,617,802	5
Umb Spare	-	-
Umb Fixed Items	4,465,808	1
Umb Transport	-	1
Umbilical	33,425,407	15
UTA	8,322,093	25
	1,732,995,617	265

Output: Summary of costs

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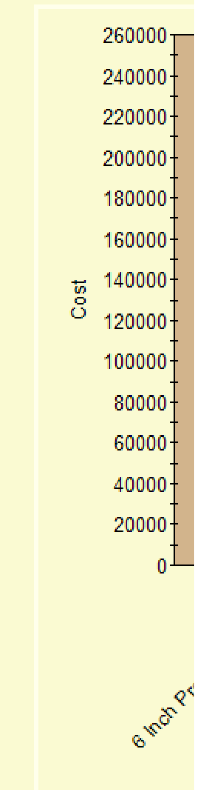
Cost Model - Analysis



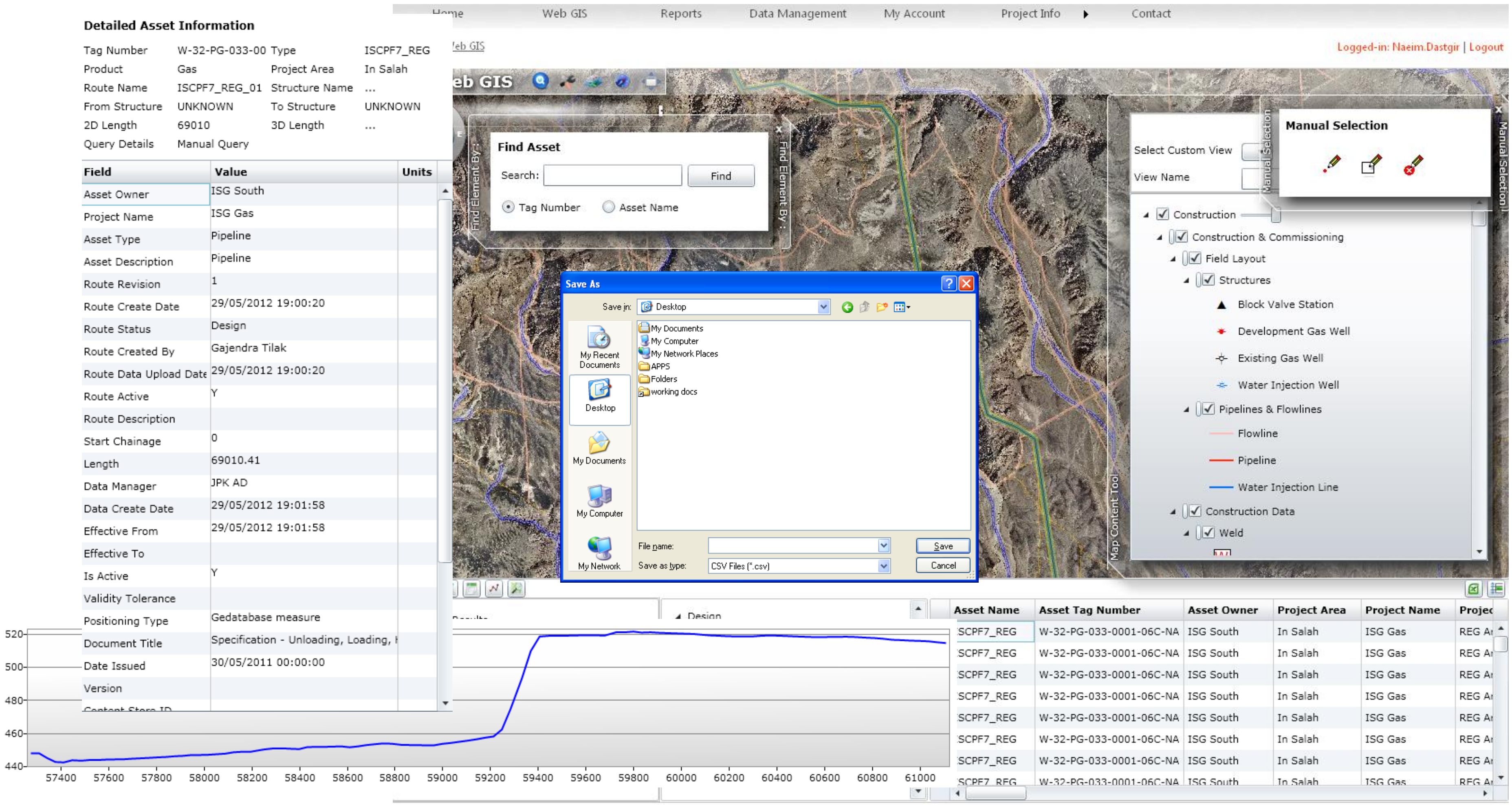
Item	Description	Unit Cost	Total Cost
		$MM	$MM
	CAPEX Costs		
	Infield Facilities	$208.81	
	Export Facilities	$395.19	
	CAPEX Subtotal		**$604.00**
	Total Contingency		**$56.80**
	CAPEX Total		**$660.80**
	CAPEX Present Value		**$543.16**
	OPEX Total		**$742.48**
	OPEX Present Value		**$263.40**
	Total Recoverable Reserves (MM barrels)		**459.65**
	Total Recoverable Reserves Present Value (MM barrels)		**149.23**
	Net Cost per Barrel		**$5.40**
	Total Value of Reserves		**$11,491.20**
	Present Value of Reserves		**$3,730.64**
	Project Total NPV		**$2,924.08**
	% Return on Investment (Project Total NPV/CAPEX Present Value * 100)		**538%**
	Based on an annual Discount Rate of	8.00%	
	and an oil price of	$25.00	per barrel
	Variable		

Web GIS

Most of us are currently using Web based GIS in the form of Google Earth, Google Maps, Bing Maps & MS Virtual Earth.

- Global coverage with no specialist software requirements.
- Flexible and easy to use, aimed at the non GIS specialist.
- Quick data turnaround.
- Can integrate into other databases.
- Can overlay own personalised data.
- Better collaboration across project disciplines regardless of location.
- All discipline information becomes integrated and the data is viewed in the context of a project as a whole rather than in isolation.
- Decision making is improved via better planning and money is saved or invested in a more efficient way.

GIS Web Application - Reporting



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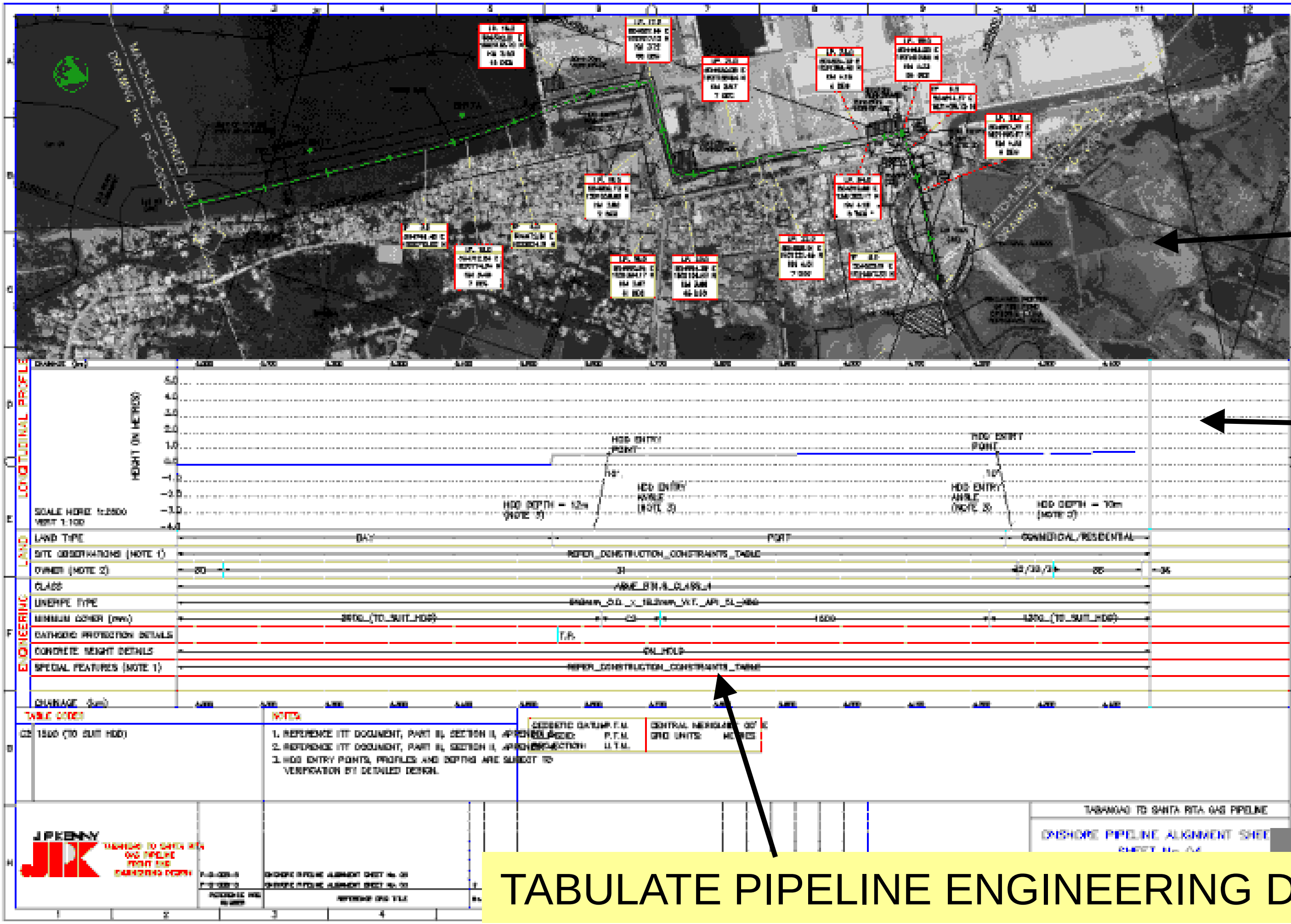
Alignment Sheets



PLAN DATA - Aerial imagery used for mapping detail

PROFILE

TABULATE PIPELINE ENGINEERING DETAILS

Any Questions?

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Thank you

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