Satellite surveying reduces costs for oil exploration projects

Calgary Global Exploration Forum

PhotoSat - Over 600 global stereo satellite topographic mapping projects

www.photosat.ca

Basic proposition

- ***Uncertainty in topographic surveying causes delays at many phases of oil and gas projects. A study of a typical onshore project shows that higher accuracy surveying earlier in the project greatly reduces delays.***

- ***Satellite surveying has improved to a level where it may be used as an alternative to ground surveying or airborne LiDAR.***

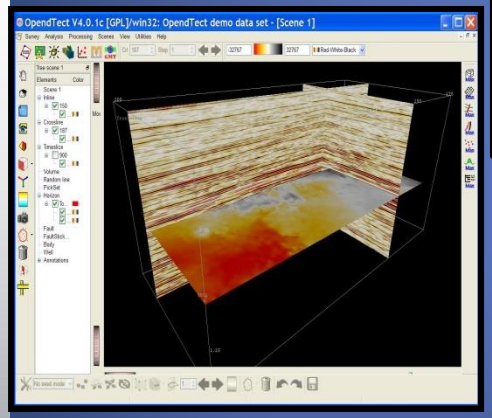
- Background on Satellite surveying
- Estimating the value of accurate surveying in an Oil and Gas project.
- Real world examples

Satellite surveying technology background

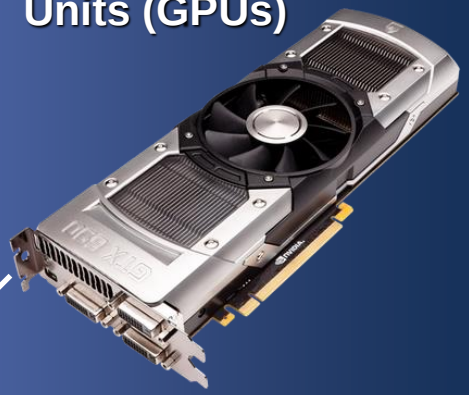
Four key technical components enabling elevation mapping from space

High resolution stereo satellite photos

Adaptation of seismic processing systems



Graphics Processing Units (GPUs)



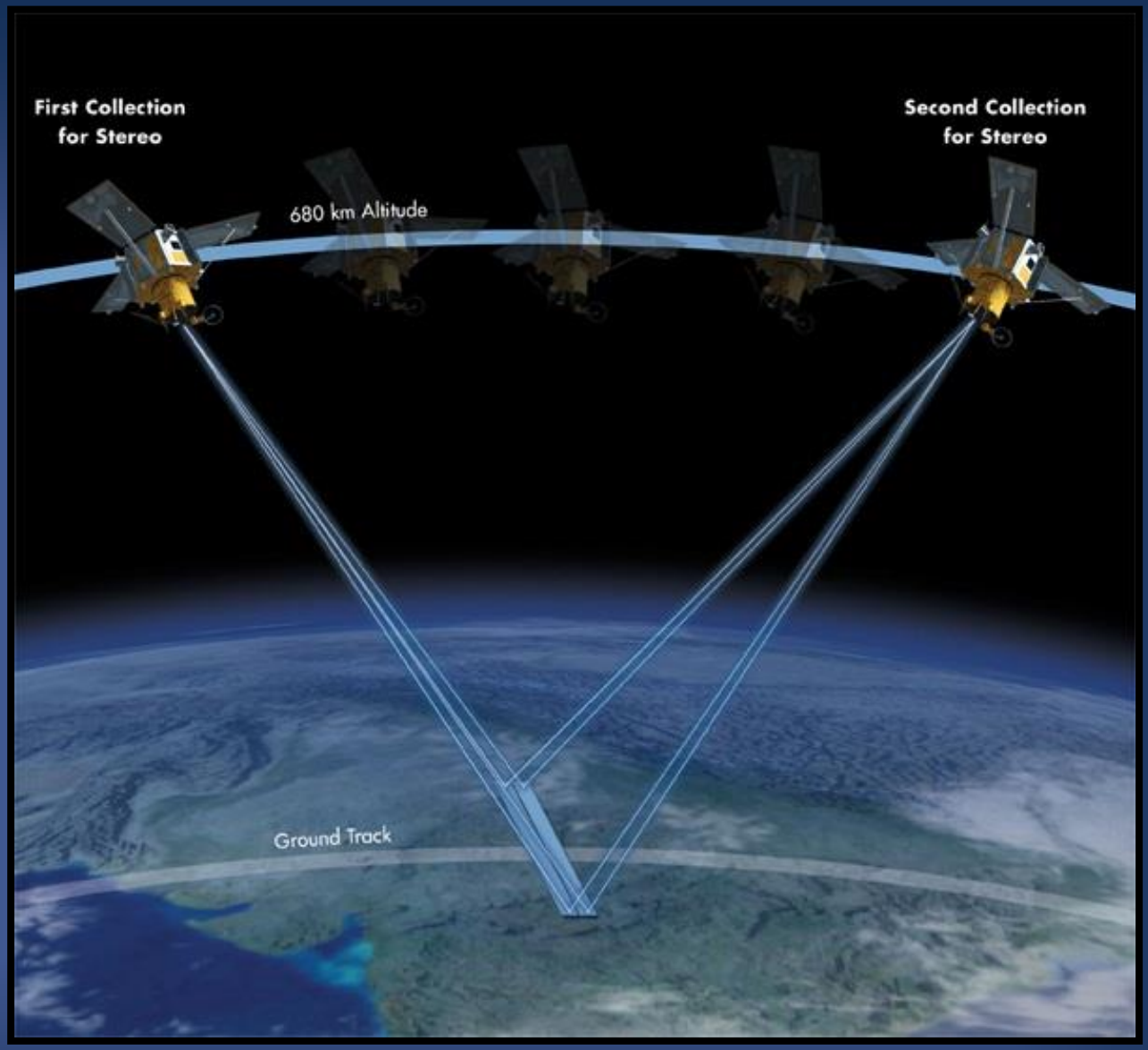
Oil Sands surveying

Characterize the satellites and optimize the process

www.photosat.ca

PhotoSat Algorithms

- **Based on Seismic algorithms**
  - Achieve 4x better accuracy when compared to conventional photogrammetric algorithms
- **No image warping**
  - Can assess accuracy compared to ground control
- **Consistent throughout the area**
- **“Experience database” can be incorporated**
  - Ft McMurray and other projects have allowed us to identify systematic errors.
- **Ideal for GPU processing**
  - 20x better throughput
  - Allows iteration during QC



Stereo satellite photos used to map topography

Really ?

30 cm accuracy from space ?

- Standards – USGS
- Accuracy studies – PhotoSat website
- Over 600 projects worldwide

Quantifying survey costs and delays

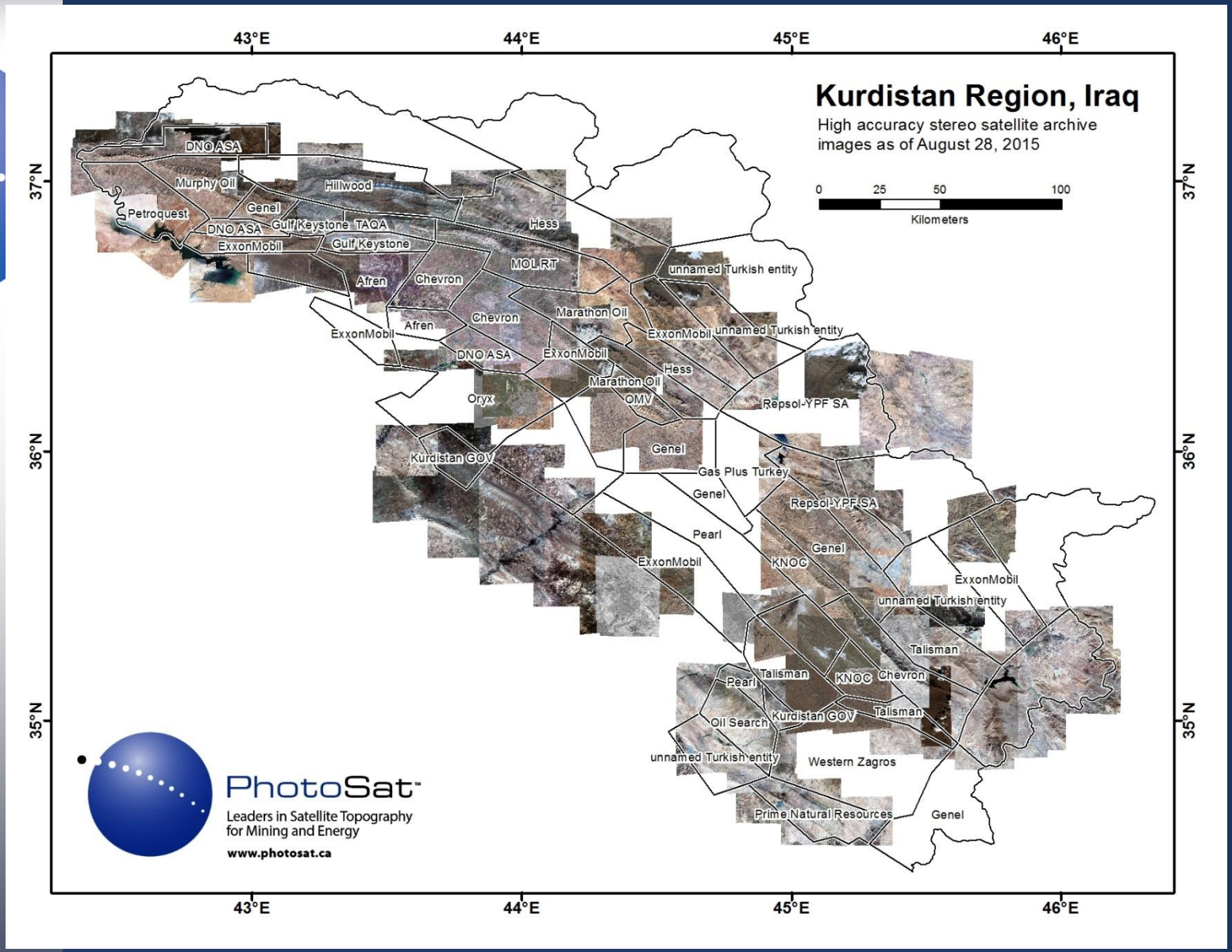
Client Anecdotes

- *"… reduced scouting costs by 80%"*
- *"… eliminated the need to wait for drill site surveying"*
- *"… saved 100's of thousands of $ on dynamite..*
- *"… reduced contractor costs for road construction."*
- *"… eliminated delays and costs for Seismic planning"*

Assessing the cost savings and impact of Surveying delays

PhotoSat commissioned a critical path model of a typical Oil and Gas project with the objective of quantifying costs and delays caused by the “multiple survey” approach.

Calibrated using actual client data for projects in Kurdistan.


Kurdistan Region, Iraq
High accuracy stereo satellite archive images as of August 28, 2015
0 25 50 100
Kilometers
43°E
44°E
45°E
46°E
37°N
36°N
35°N
DNO ASA
Murphy Oil
Hillwood
Petroquest
Genel
DNO ASA
Gulf Keystone
TAQA
Hess
ExxonMobil
Gulf Keystone
MOL RT
unnamed Turkish entity
Afren
Chevron
Marathon Oil
Chevron
Afren
ExxonMobil
ExxonMobil
unnamed Turkish entity
DNO ASA
ExxonMobil
Hess
Marathon Oil
Oryx
OMV
Repsol-YPF SA
Genel
Kurdistan GOV
Gas Plus Turkey
Genel
Repsol-YPF SA
Pearl
Genel
ExxonMobil
KNOC
ExxonMobil
unnamed Turkish entity
Talisman
Talisman
KNOC
Chevron
Pearl
Kurdistan GOV
Talisman
Oil Search
unnamed Turkish entity
Western Zagros
Prime Natural Resources
Genel
PhotoSat™
Leaders in Satellite Topography for Mining and Energy
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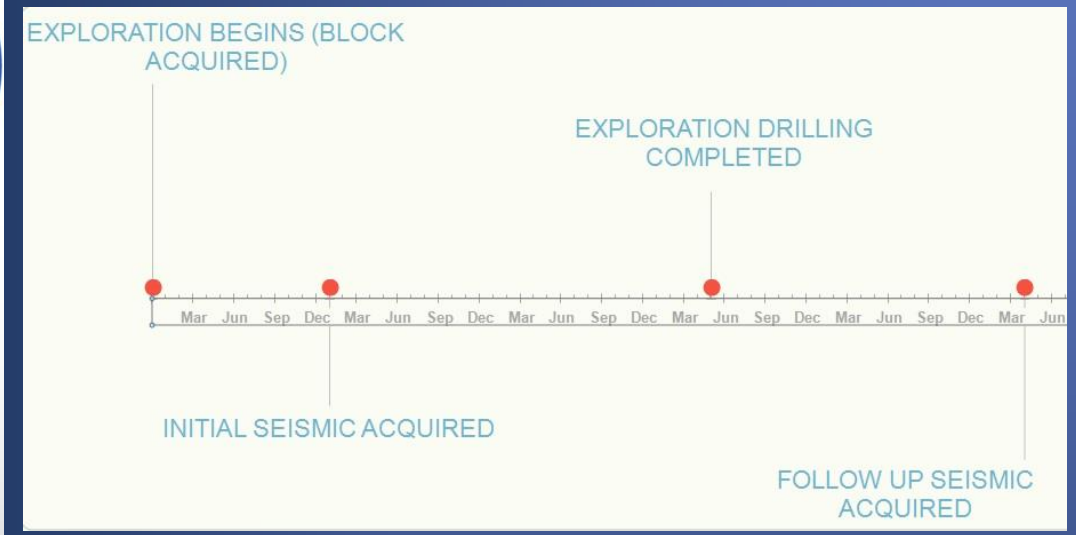
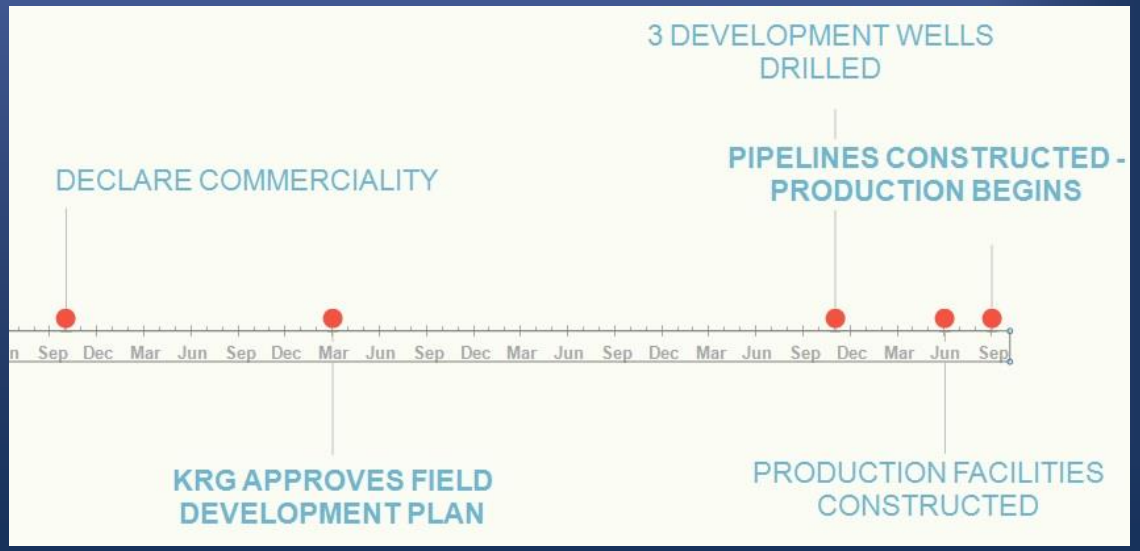
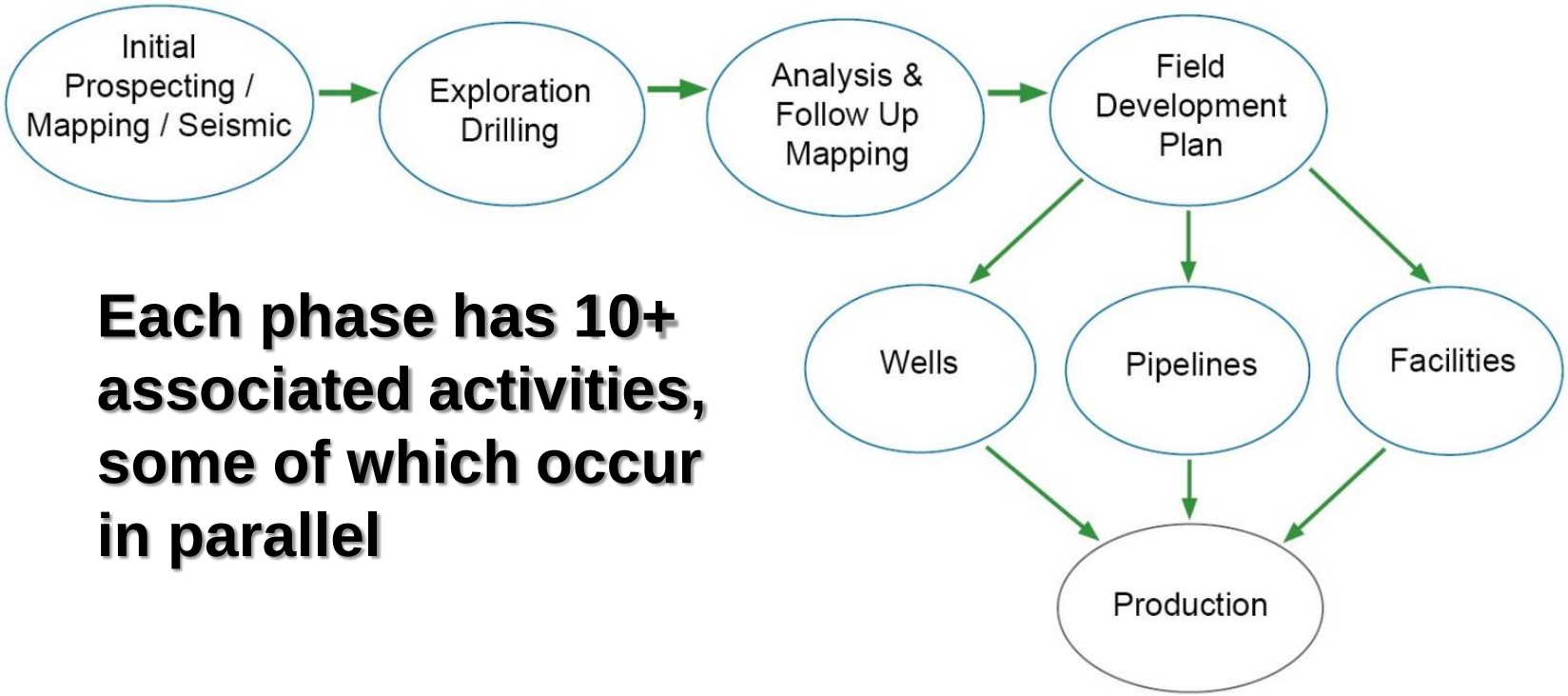
Timeline for Kurdistan onshore Oil and Gas project



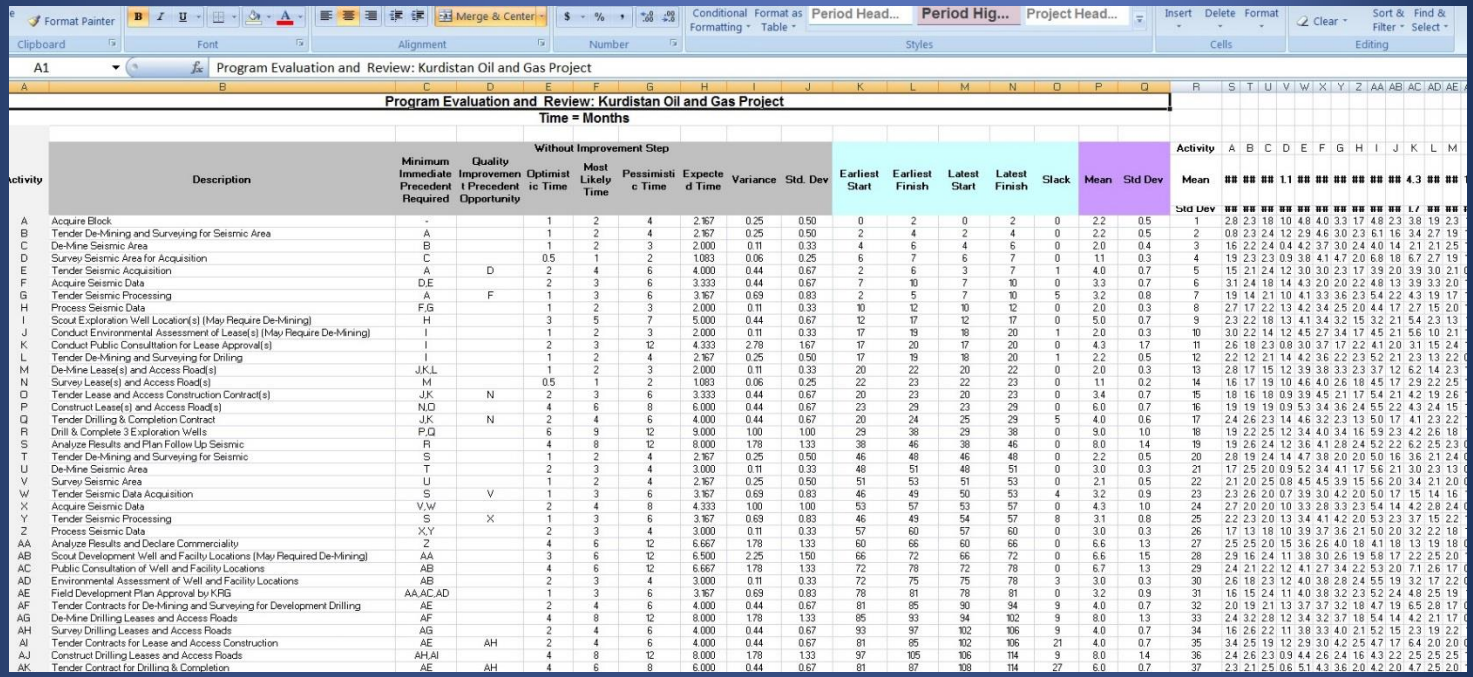


Phases of an onshore Oil and Gas project



Each phase has 10+ associated activities, some of which occur in parallel

Detailed model



Program Evaluation and Review: Kurdistan Oil and Gas Project

Time = Months

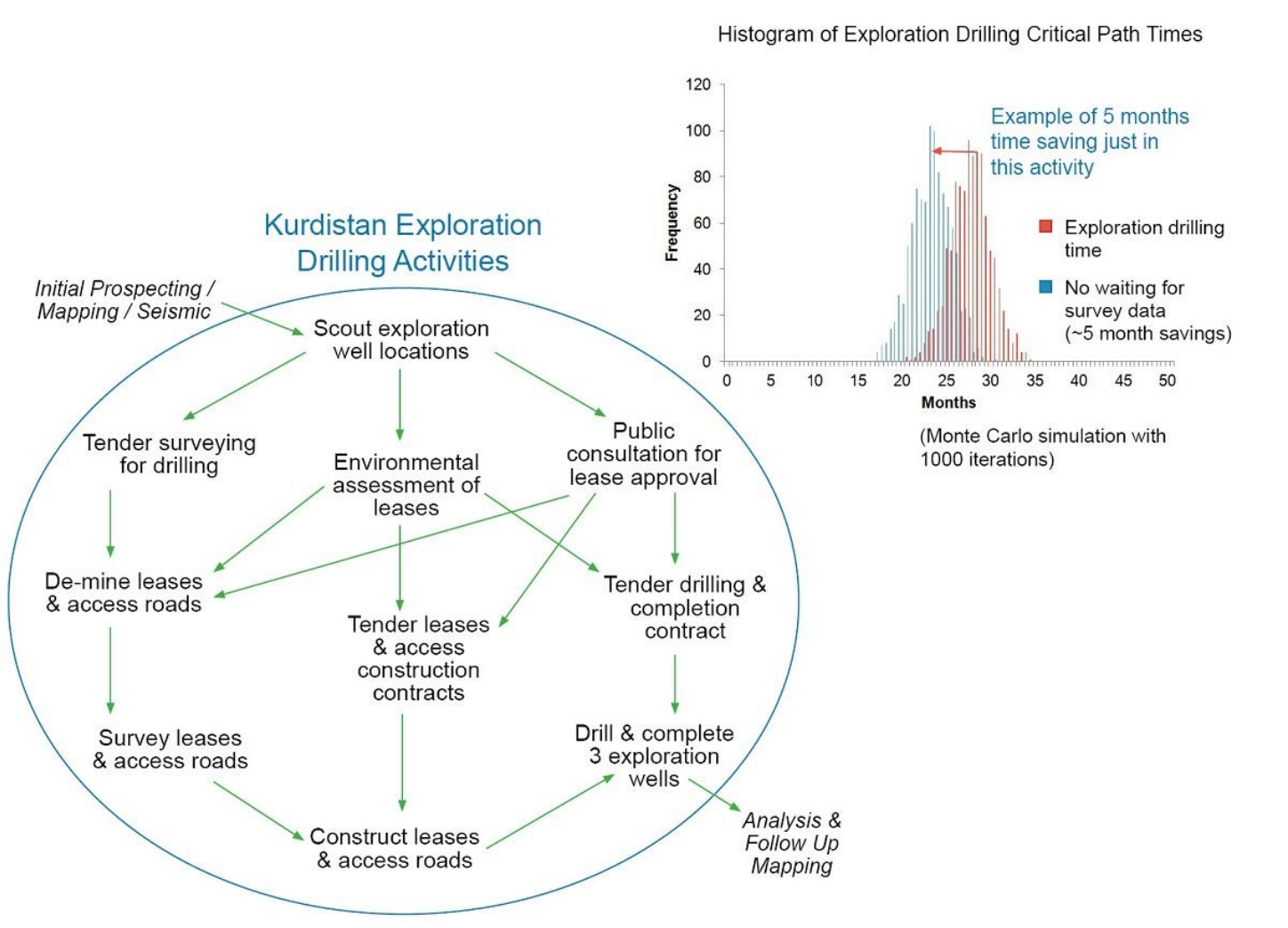
Activity	Description	Minimum Immediate Precedent Required	Quality Improvement Precedent Opportunity	Optimistic Time	Most Likely Time	Pessimistic Time	Expected Time	Variance	Std. Dev	Earliest Start	Earliest Finish	Latest Start	Latest Finish	Slack	Mean	Std Dev
				Without Improvement Step												
A	Acquire Block	-		1	2	4	2.167	0.25	0.50	0	2	0	2	0	2.2	0.5
B	Tender De-Mining and Surveying for Seismic Area	A		1	2	4	2.167	0.25	0.50	2	4	2	4	0	2.2	0.5
C	De-Mine Seismic Area	B		1	2	3	2.000	0.11	0.33	4	6	4	6	0	2.0	0.4
D	Survey Seismic Area for Acquisition	C		0.5	1	2	1.083	0.06	0.25	6	7	6	7	0	1.1	0.3
E	Tender Seismic Acquisition	A	D	2	4	6	4.000	0.44	0.67	2	6	3	7	1	4.0	0.7
F	Acquire Seismic Data	D,E		2	3	6	3.333	0.44	0.67	7	10	7	10	0	3.3	0.7
G	Tender Seismic Processing	A	F	1	3	6	3.167	0.69	0.83	2	5	7	10	5	3.2	0.8
H	Process Seismic Data	F,G		1	2	3	2.000	0.11	0.33	10	12	10	12	0	2.0	0.3
I	Scout Exploration Well Location(s) (May Require De-Mining)	H		3	5	7	5.000	0.44	0.67	12	17	12	17	0	5.0	0.7
J	Conduct Environmental Assessment of Lease(s) (May Require De-Mining)	I		1	2	3	2.000	0.11	0.33	17	19	18	20	1	2.0	0.3
K	Conduct Public Consultation for Lease Approval(s)	I		2	3	12	4.333	2.78	1.67	17	20	17	20	0	4.3	1.7
L	Tender De-Mining and Surveying for Drilling	I		1	2	4	2.167	0.25	0.50	17	19	18	20	1	2.2	0.5
M	De-Mine Lease(s) and Access Road(s)	J,K,L		1	2	3	2.000	0.11	0.33	20	22	20	22	0	2.0	0.3
N	Survey Lease(s) and Access Road(s)	M		0.5	1	2	1.083	0.06	0.25	22	23	22	23	0	1.1	0.2
O	Tender Lease and Access Construction Contract(s)	J,K	N	2	3	6	3.333	0.44	0.67	20	23	20	23	0	3.4	0.7
P	Construct Lease(s) and Access Road(s)	N,O		4	6	8	6.000	0.44	0.67	23	29	23	29	0	6.0	0.7
Q	Tender Drilling & Completion Contract	J,K	N	2	4	6	4.000	0.44	0.67	20	24	25	29	5	4.0	0.6
R	Drill & Complete 3 Exploration Wells	P,Q		6	9	12	9.000	1.00	1.00	29	38	29	38	0	9.0	1.0
S	Analyze Results and Plan Follow Up Seismic	R		4	8	12	8.000	1.78	1.33	38	46	38	46	0	8.0	1.4
T	Tender De-Mining and Surveying for Seismic	S		1	2	4	2.167	0.25	0.50	46	48	46	48	0	2.2	0.5
U	De-Mine Seismic Area	T		2	3	4	3.000	0.11	0.33	48	51	48	51	0	3.0	0.3
V	Survey Seismic Area	U		1	2	4	2.167	0.25	0.50	51	53	51	53	0	2.1	0.5
W	Tender Seismic Data Acquisition	S	V	1	3	6	3.167	0.69	0.83	46	49	50	53	4	3.2	0.9
X	Acquire Seismic Data	V,W		2	4	8	4.333	1.00	1.00	53	57	53	57	0	4.3	1.0
Y	Tender Seismic Processing	S	X	1	3	6	3.167	0.69	0.83	46	49	54	57	8	3.1	0.8
Z	Process Seismic Data	X,Y		2	3	4	3.000	0.11	0.33	57	60	57	60	0	3.0	0.3
AA	Analyze Results and Declare Commerciality	Z		4	6	12	6.667	1.78	1.33	60	66	60	66	0	6.6	1.3
AB	Scout Development Well and Facilty Locations (May Required De-Mining)	AA		3	6	12	6.500	2.25	1.50	66	72	66	72	0	6.6	1.5
AC	Public Consultation of Well and Facility Locations	AB		4	6	12	6.667	1.78	1.33	72	78	72	78	0	6.7	1.3
AD	Environmental Assessment of Well and Facility Locations	AB		2	3	4	3.000	0.11	0.33	72	75	75	78	3	3.0	0.3
AE	Field Development Plan Approval by KRG	AA,AC,AD		1	3	6	3.167	0.69	0.83	78	81	78	81	0	3.2	0.9
AF	Tender Contracts for De-Mining and Surveying for Development Drilling	AE		2	4	6	4.000	0.44	0.67	81	85	90	94	9	4.0	0.7
AG	De-Mine Drilling Leases and Access Roads	AF		4	8	12	8.000	1.78	1.33	85	93	94	102	9	8.0	1.3
AH	Survey Drilling Leases and Access Roads	AG		2	4	6	4.000	0.44	0.67	93	97	102	106	9	4.0	0.7
AI	Tender Contracts for Lease and Access Construction	AE	AH	2	4	6	4.000	0.44	0.67	81	85	102	106	21	4.0	0.7
AJ	Construct Drilling Leases and Access Roads	AH,AI		4	8	12	8.000	1.78	1.33	97	105	106	114	9	8.0	1.4
AK	Tender Contract for Drilling & Completion	AE	AH	4	6	8	6.000	0.44	0.67	81	87	108	114	27	6.0	0.7

50+ activities identified, calibrated using projects in Kurdistan

1000 iteration Monte Carlo analysis to include effect of random errors. Does not include "catastrophic delays" caused by errors in survey data.

Calculates delays – does not quantify these into $

Exploration drilling critical path



Examples of real world projects

- **Well location auditing**

  Pilot program using SADG Oil well heads

  Main project to locate 700+ wells in USA

- **Reconciling multiple surveys**
  - **Oil major – Kurdistan**
- **Drill collar mapping - Mexico**

Case study – SAGD well site in Alberta

Pilot program for
Producing SAGD well sites
In Alberta Canada

Project started Jan 30th 2015

Satellite images acquired
February 4th 2015

Processing complete
February 6th 2015

Pilot program deliverables

- X, Y, Z location of 70 well heads (excel + vectors)
- 1m elevation grid over well pad areas
- 50 cm contours
- 100 sq km of satellite image data + orthophoto.
- Colour elevation image
- $12k USD ($170 per well)

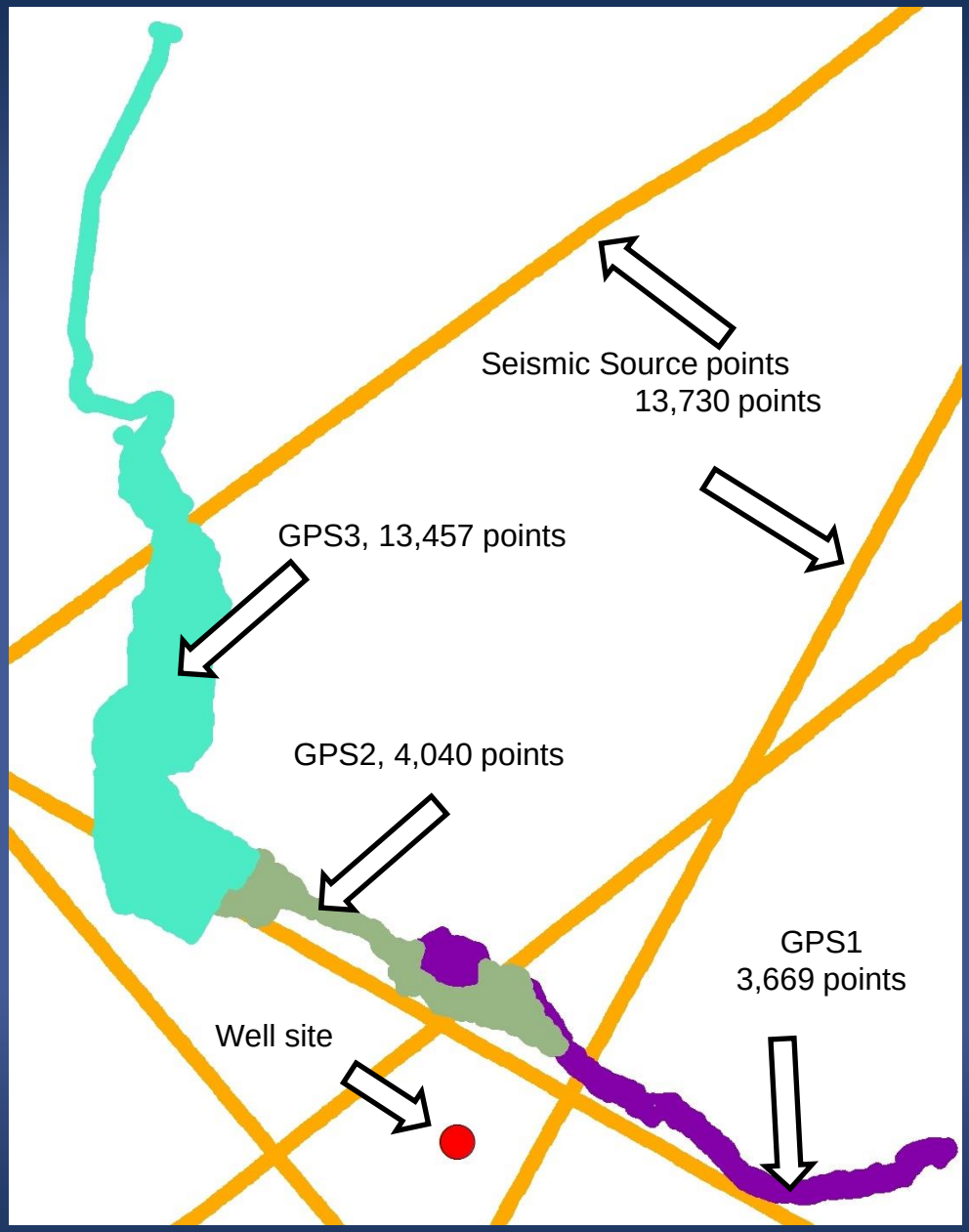
Well head locations were compared to Government of Alberta certified RTK surveying – RMSE <11cm.

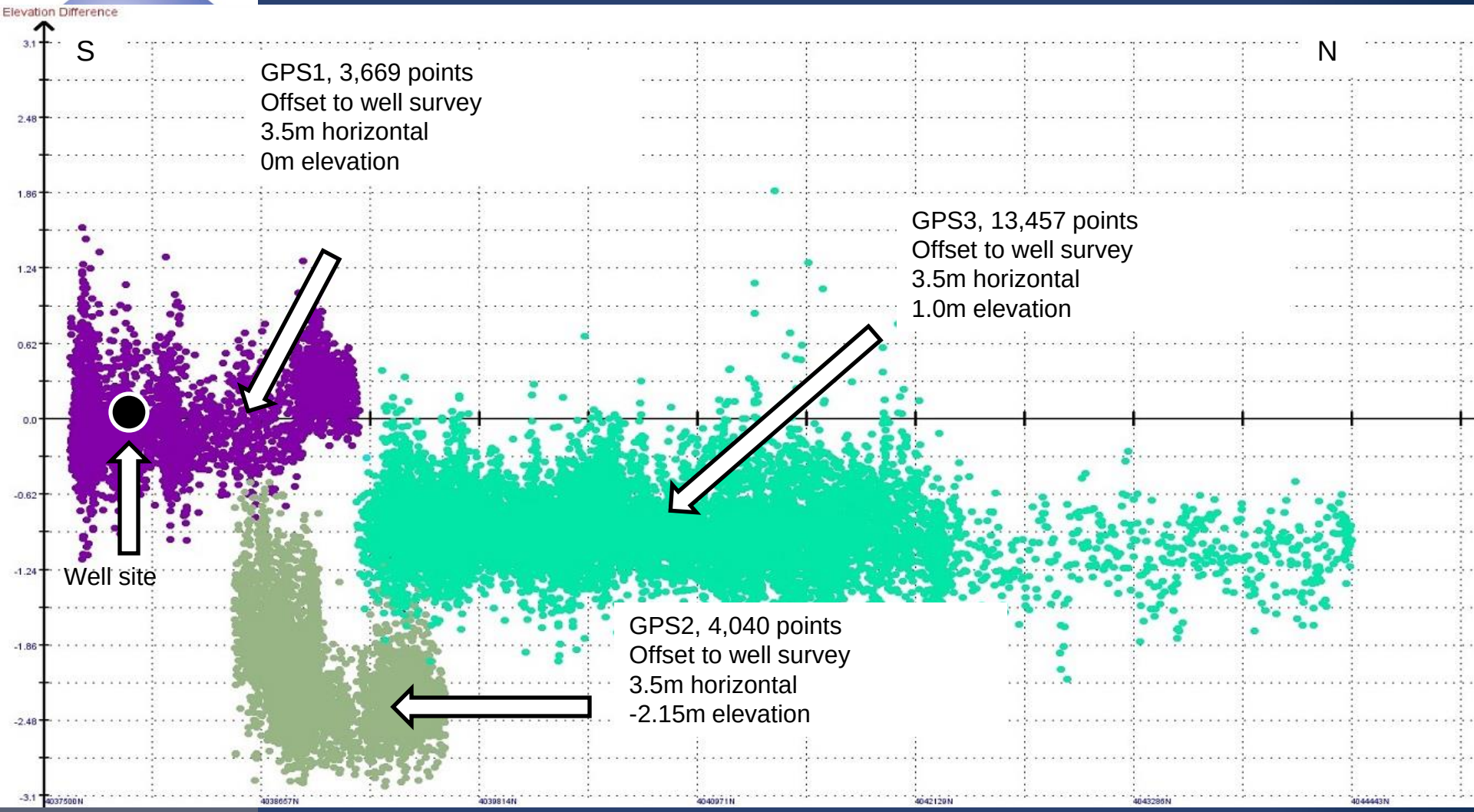
Future program to compare this to low cost GPS surveying instrument.

Continential USA project

- 760 well sites in continental USA.
- Survey dates ranging from 1940's through to 2015.
- Spread over a large area.
- Less than $70 per well.
- Approx 1 month.

Reconciling multiple data sets


Seismic Source points
13,730 points
GPS3, 13,457 points
GPS2, 4,040 points
GPS1
3,669 points
Well site


Elevation Difference
S
N
GPS1, 3,669 points
Offset to well survey
3.5m horizontal
0m elevation
GPS3, 13,457 points
Offset to well survey
3.5m horizontal
1.0m elevation
Well site
GPS2, 4,040 points
Offset to well survey
3.5m horizontal
-2.15m elevation
3.1
2.48
1.86
1.24
0.62
0.0
-0.62
-1.24
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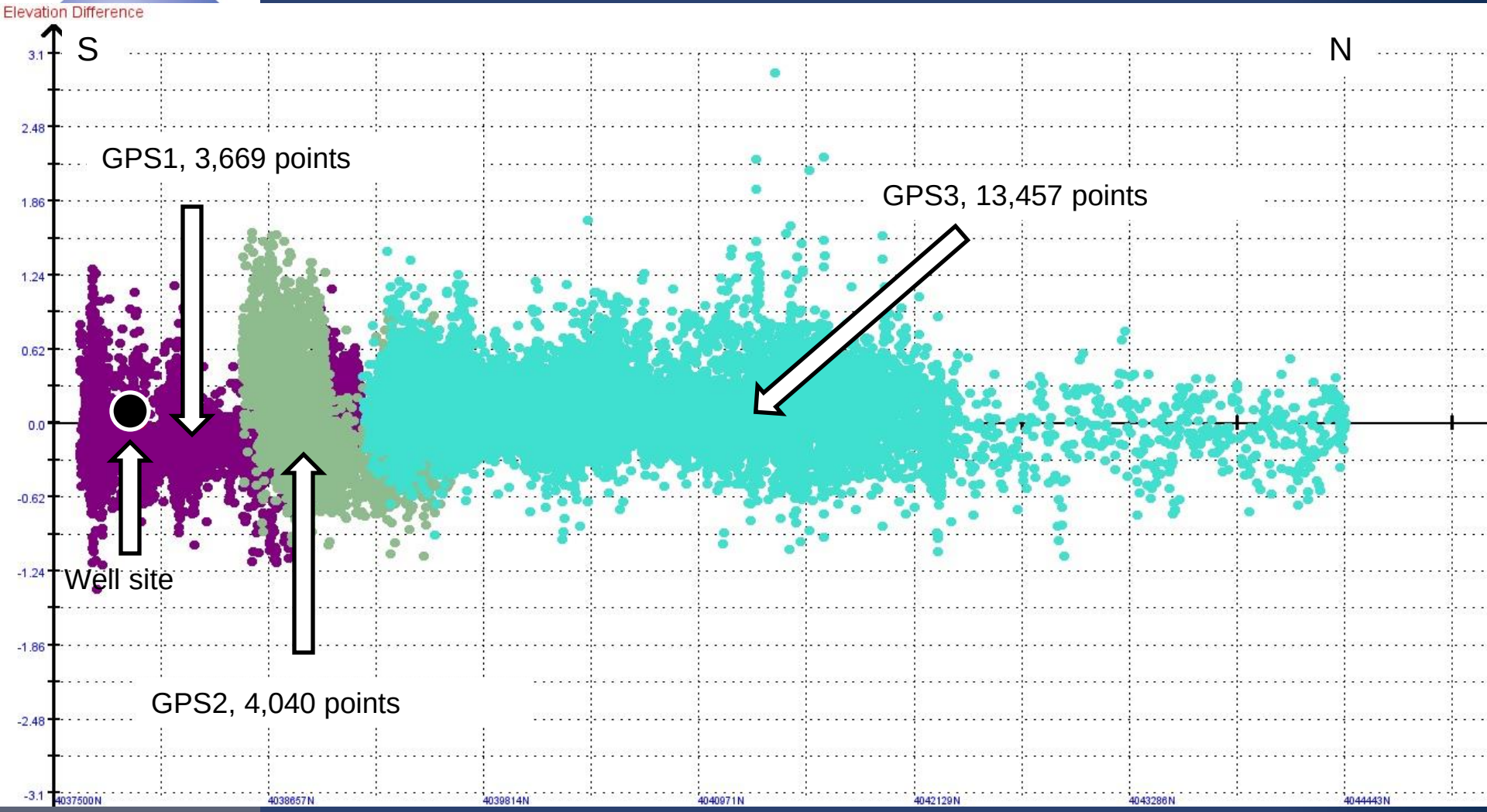
4037500N
4038657N
4039814N
4040971N
4042129N
4043286N
4044443N


Elevation Difference
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N
3.1
2.48
1.86
1.24
0.62
0.0
-0.62
-1.24
-1.86
-2.48
-3.1
GPS1, 3,669 points
GPS3, 13,457 points
Well site
GPS2, 4,040 points
4037500N
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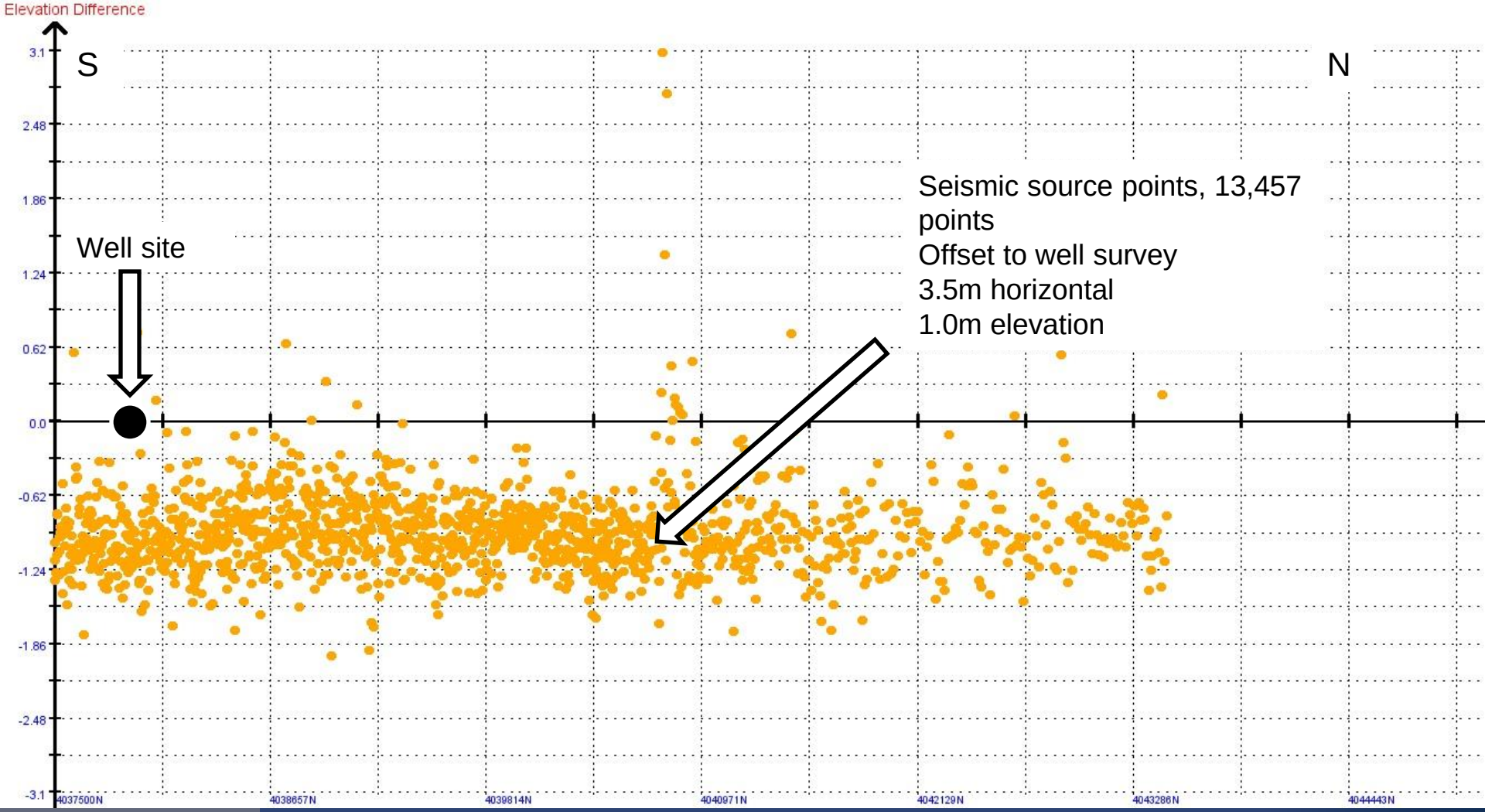
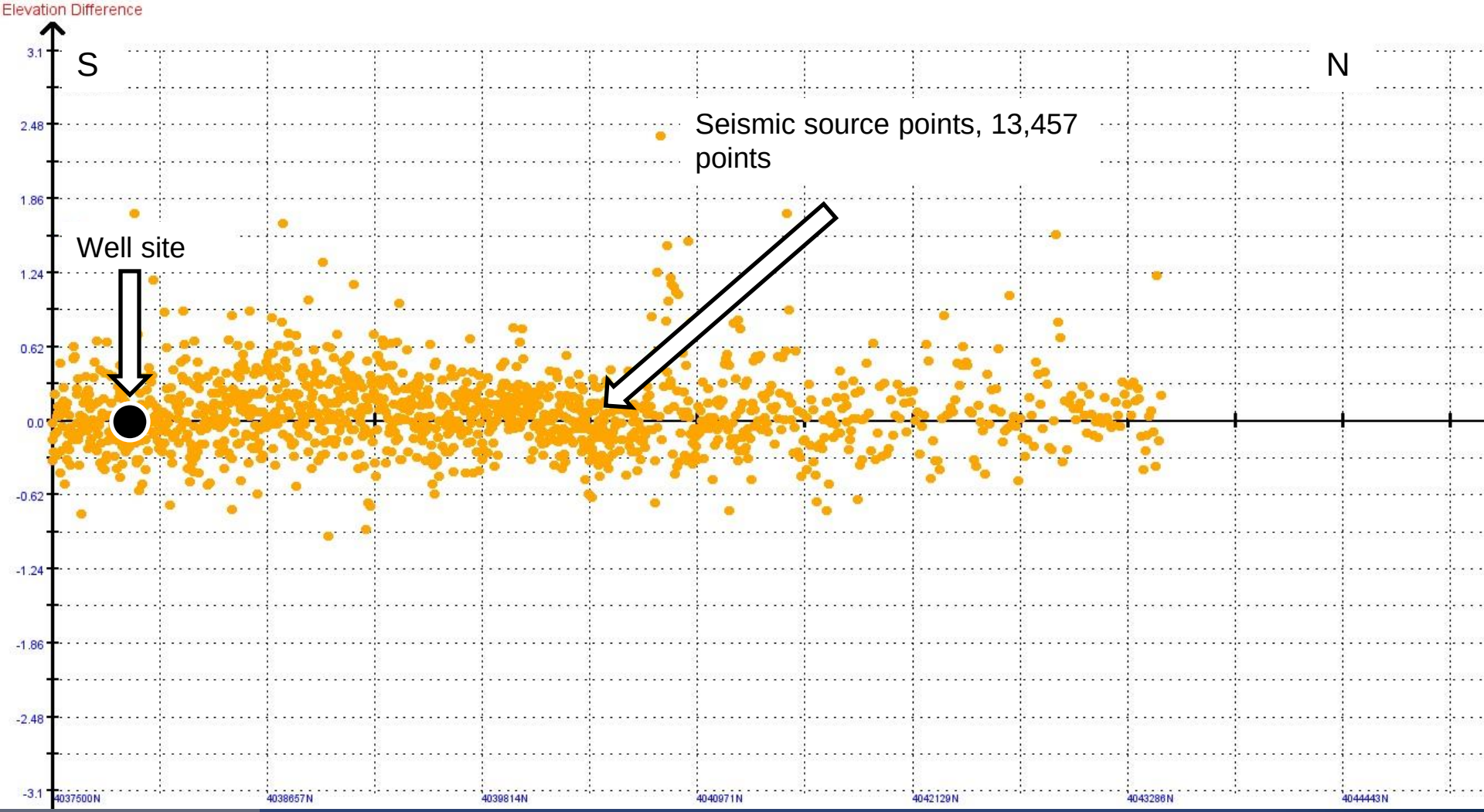
4039814N
4040971N
4042129N
4043286N
4044443N


Elevation Difference
S
N
Well site
Seismic source points, 13,457 points
Offset to well survey
3.5m horizontal
1.0m elevation
3.1
2.48
1.86
1.24
0.62
0.0
-0.62
-1.24
-1.86
-2.48
-3.1
4037500N
4038657N
4039814N
4040971N
4042129N
4043286N
4044443N


Elevation Difference
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Seismic source points, 13,457 points
Well site
3.1
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4037500N
4038657N
4039814N
4040971N
4042129N
4043286N
4044443N

Drill collar location examples from Mining applications

Drill hole collar coordinate mapping

750 Drill holes surveyed by three different survey contractors

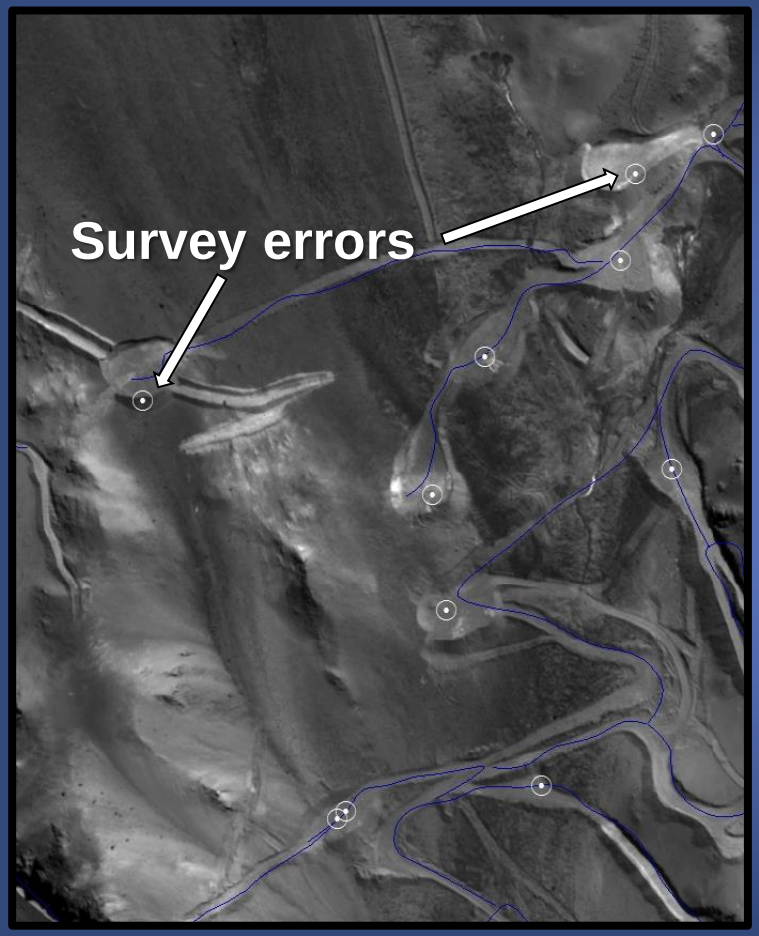
Drill hole collar locations determined directly from stereo satellite mapping

Drill hole collar

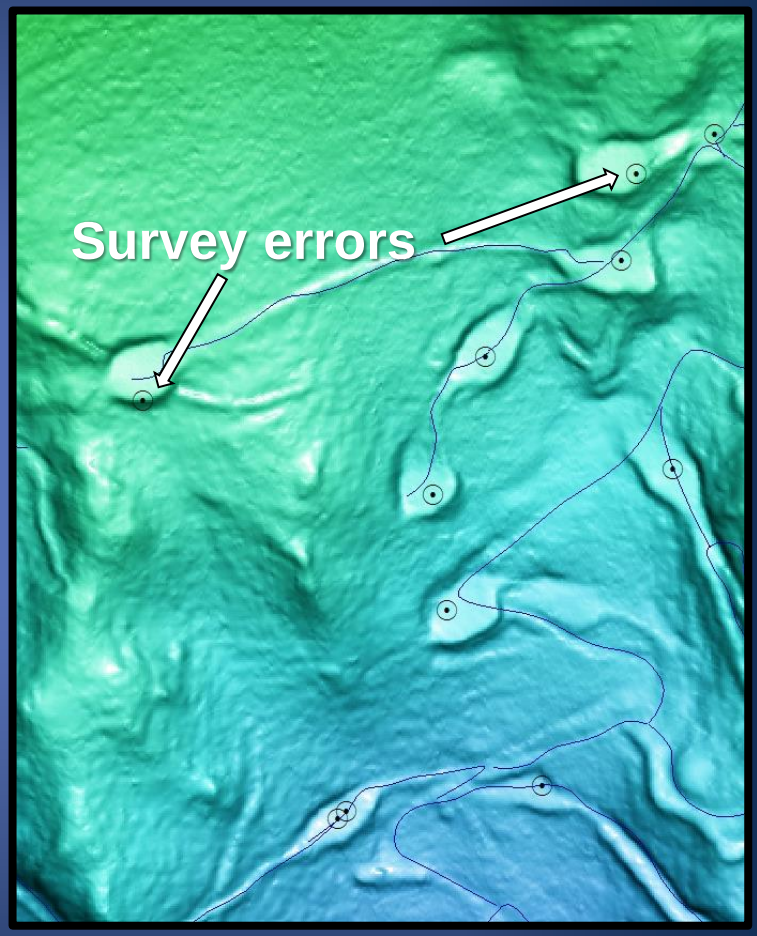
40cm x 40cm white concrete block

White drill hole collar blocks on WV precision ortho

Drill hole collar location errors identified with satellite mapping

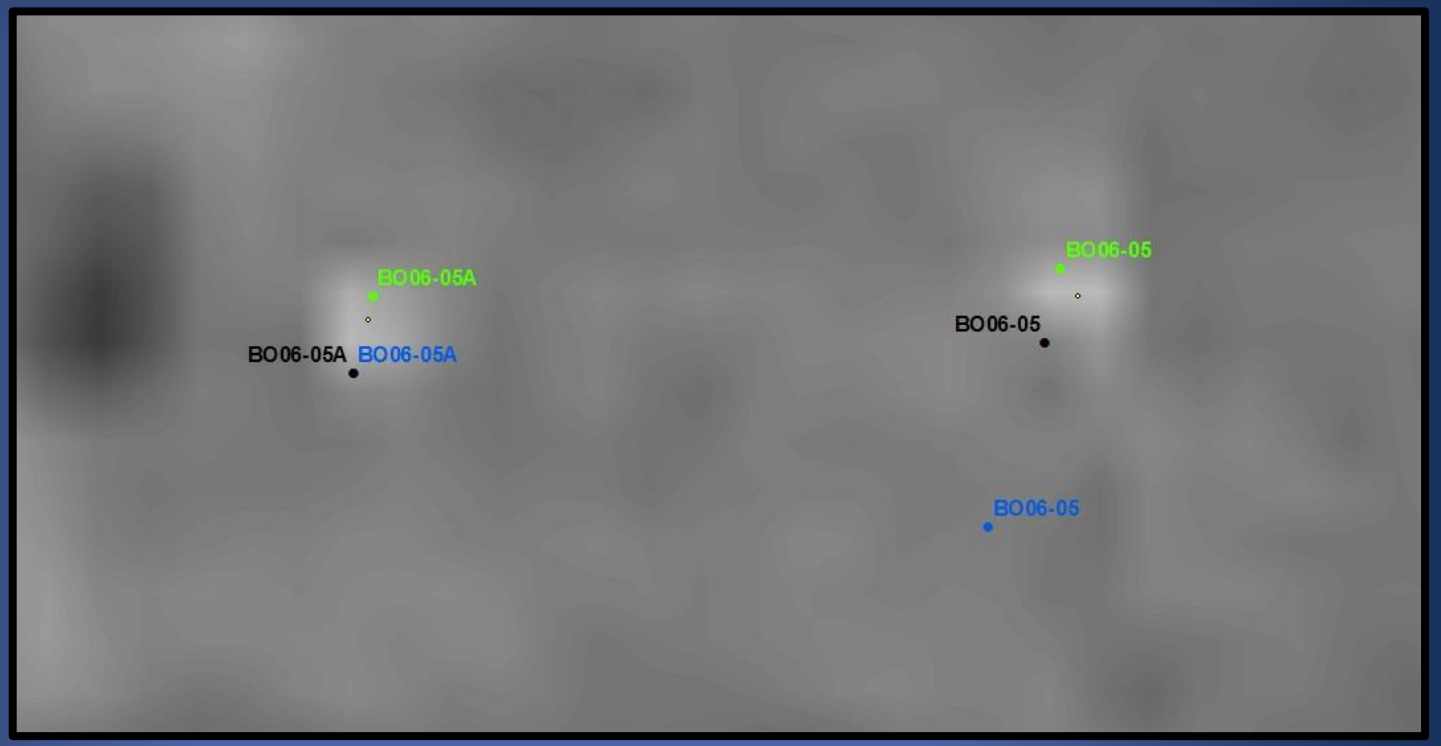


Drill holes on WV1 photo



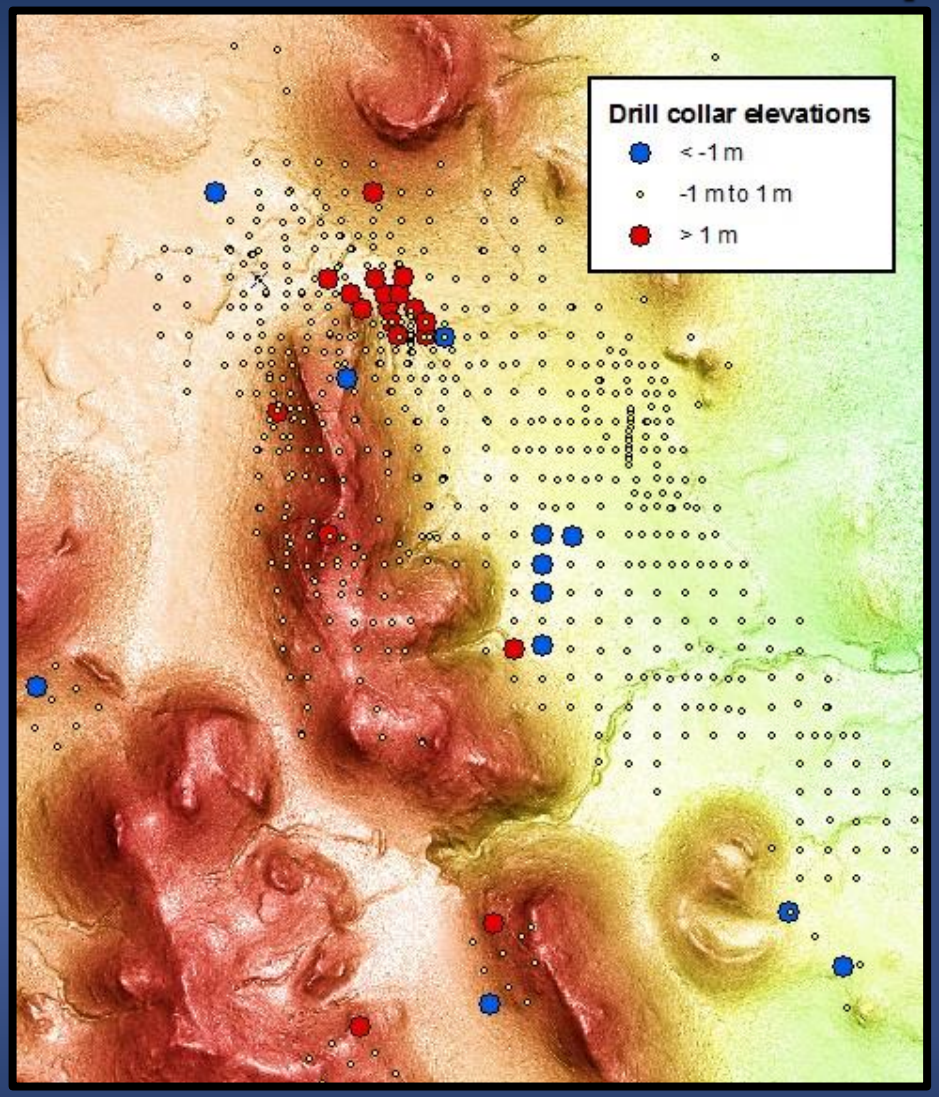
Drill holes on WV2 DEM

Drill hole collar coordinate mapping



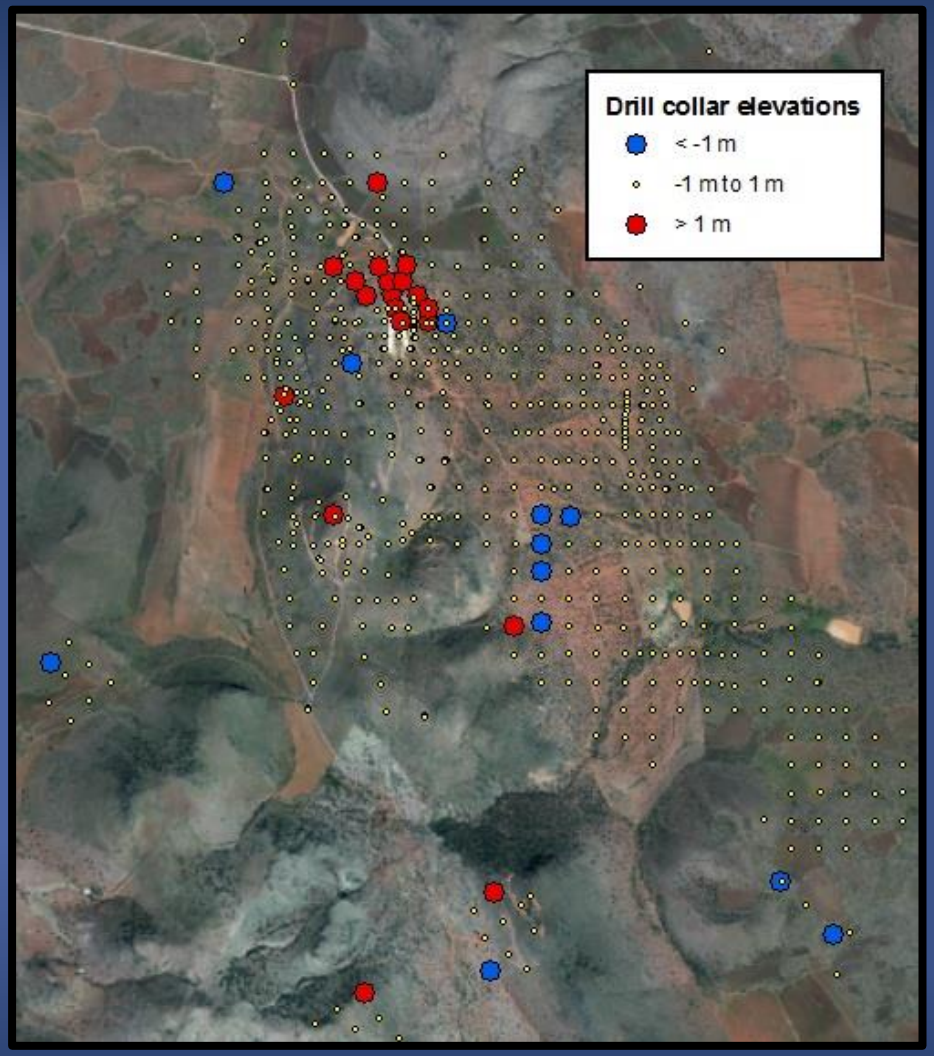
40cm x 40cm white concrete blocks on satellite photo and the coordinates from the three GPS surveys.

Drill hole collar coordinate mapping



Drill hole collar elevation differences between the GPS survey and the stereo satellite mapping

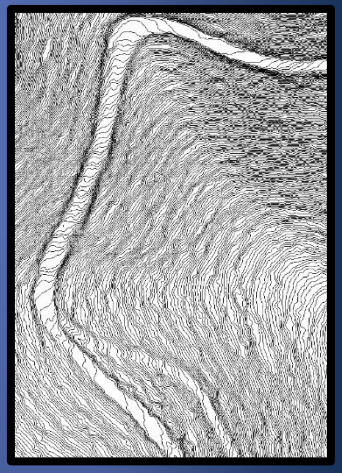
Drill hole collar coordinate mapping

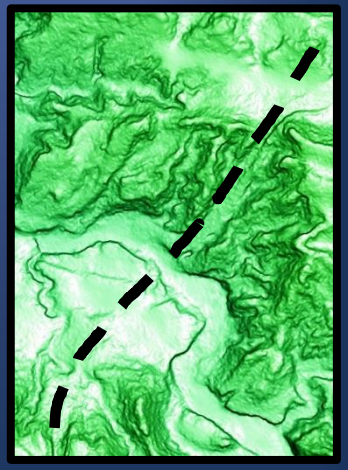


Drill hole collar elevation differences between the GPS survey and the stereo satellite mapping

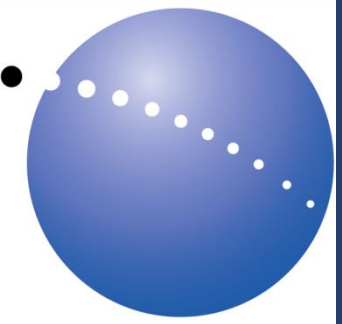
Other uses for Satellite surveying

- Pipeline route surveying
- Access roads and facilities
- Geological targeting
- Seismic safety





Conclusions



- ***Satellite surveying has improved to a level where it may be used as an alternative to ground surveying or airborne LiDAR for onshore oil and gas projects.***
- ***Satellite surveying is useful for detecting and correcting gross survey errors.***
- ***Uncertainty in surveying causes delays in many phases of oil and gas projects. A study of a typical onshore project shows that higher accuracy surveying earlier in the project greatly reduces delays.***