EGeo Services SAS
Geoscience consulting solution
eric.gillot@egeoservices.fr

Land feasibility for 2D and 3D seismic projects

A wealth of experience with EGeo Services SAS

A feasibility study performed ahead of seismic work leads to better results. It provides all useful information the operating company and its partners need to estimate the most suitable technical parameters that will optimize the level of information the seismic survey can provide. This is an optimization process; it aims to add the maximum value for the allocated seismic budget.

The level of analysis requested for such a study is discussed with the client. It goes from pure theoretical designs, taking advantage of all previous work done over the permit area to the full preplanning after a detailed scouting of the area. All relevant geophysical methods with the potential of adding value to the overall project are considered. A feasibility study is a prerequisite to any seismic activity. To perform such work accurately is a must have that can provide considerable savings.

Seismic survey design should be driven by the seismic reservoir characterization objectives. Key parameters driving the data quality for seismic reservoir interpretation are the trace density and azimuth diversity, with the current acquisition equipment the source strength plays a lower role.

Acquisition teams have now to integrate surface condition, HSE and subsurface objectives to ensure the delivery of a seismic product fit for purpose.

Through its over 30 years of experience as geologist and geophysicist I will continue to develop in cooperation with Geolinks all needed software tools and know how to address seismic feasibility studies.

Phase 1 – Defining the best Seismic design for your project

How to choose the best set of acquisition parameters and ensure quality?

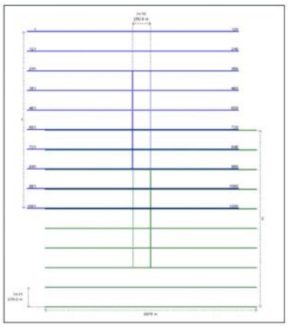
Theoretical desktop analysis

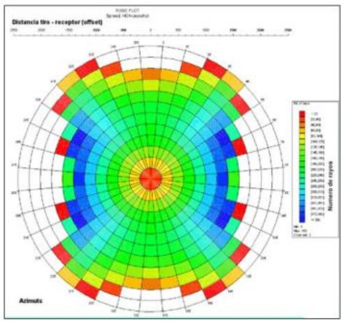
$$F_{max} = V_{int} / (4\ b\ tg\ \alpha)$$

$$b = V_{int} / (N\ .\ F_{dom})$$

At first stage, a desktop study is performed through theoretical formulae to assess bin size (through target size, maximum un-aliased frequencies; spatial resolution needed…), offsets, fold and azimuth requirements.

Based on the target depth, velocities and dip angles in all directions, the adequate acquisition template will be designed. Starting from the core area of interest (*i.e.* the area where you need the most accurate information), source and receiver statistics will be provided.





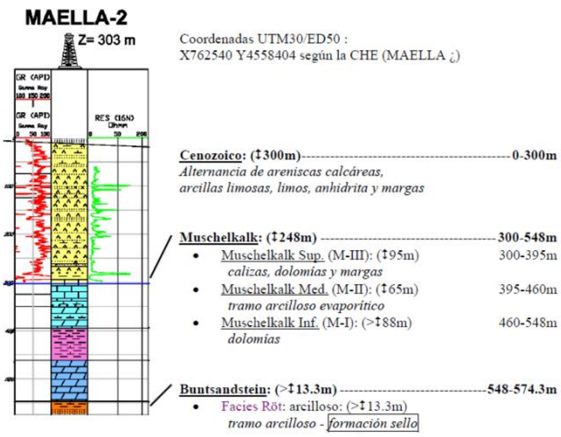
Seismic acquisition remains dependent on the specificities of the area of concern. An approach based on formulae is purely theoretical; when it comes to geoscience, we can expect uncertainties.

Consequently, it is important to push the investigation and consider the particularities of your area of concern by analyzing other sources of information.

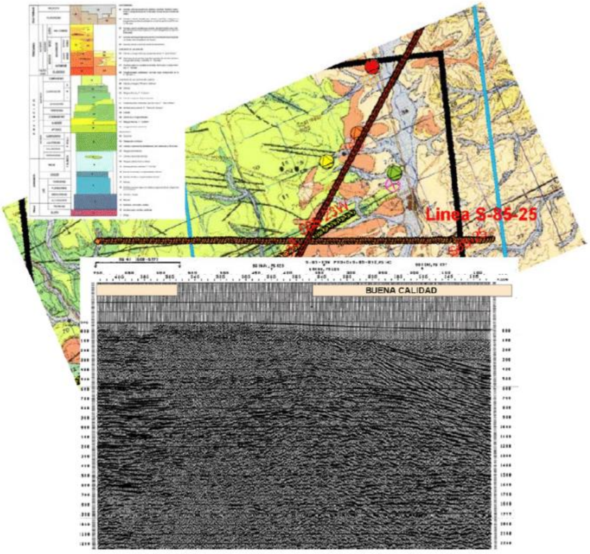
Collect of available geological and geophysical information

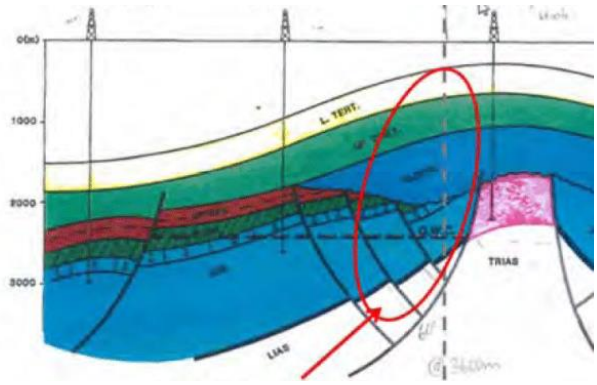
When Client has access to an extensive library of its own acquisition and processing reports. Using this valuable information (geology, boreholes, old seismic) will assist to select the optimum basic set of parameters whether for 2D or 3D surveys.

An initial geological analysis is performed keeping in mind that the final product behind the seismic volume is reservoir engineering. It can be done through visual analysis of data or using Geovation® processing software in case of numerical data is available, either in shot gather or any kind of stacked sections.

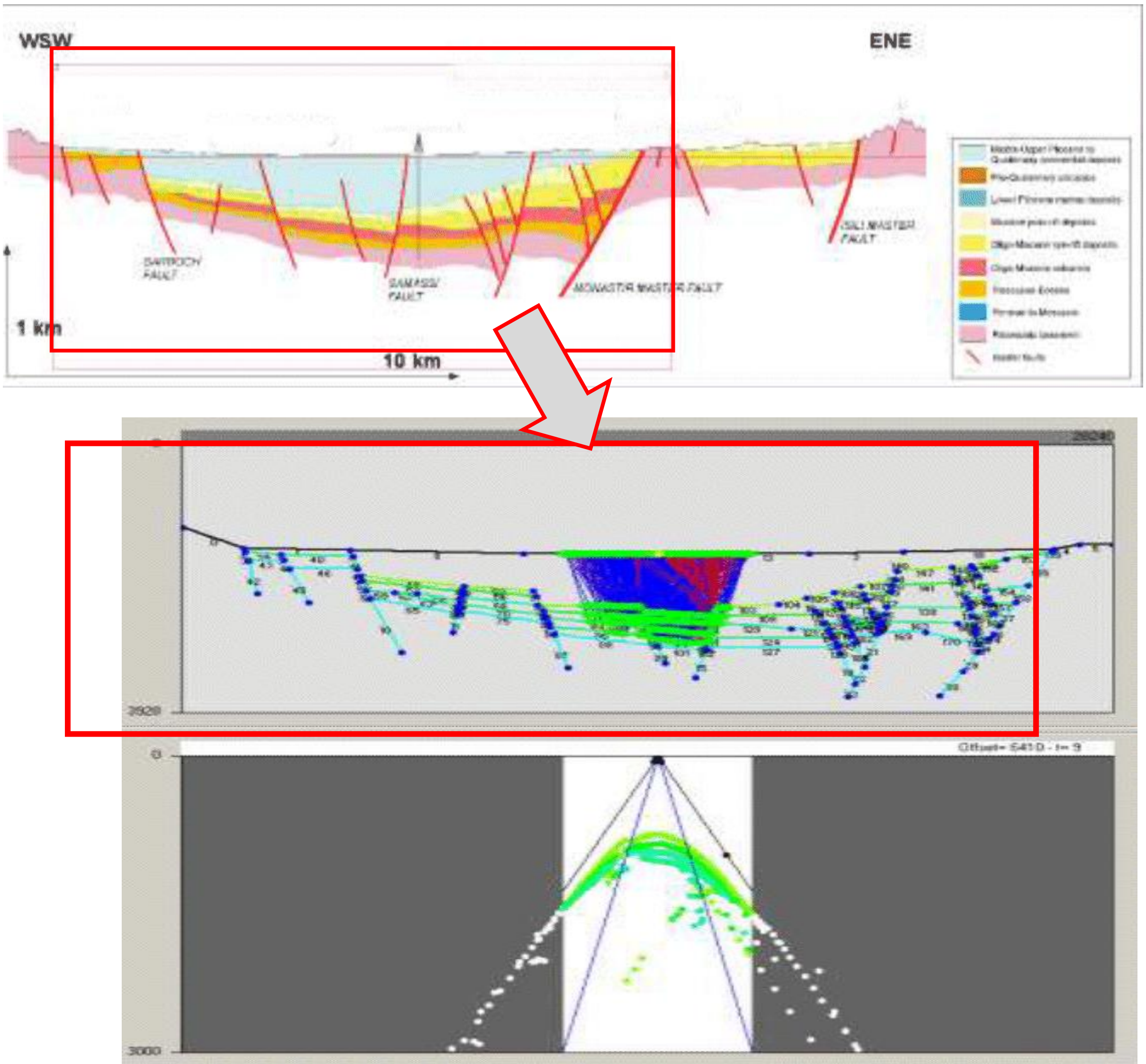


When borehole information is available the relevant values are extracted (especially if logging available). When there is no seismic data available, the reflectivity is assessed by analyzing whether the impedance contrasts (density times acoustic velocity) are sufficient to reflect acoustic In addition, if impedance log data are available; wavelets are tested to choose the useful frequencies that can be expected and/or needed. is the waves. various

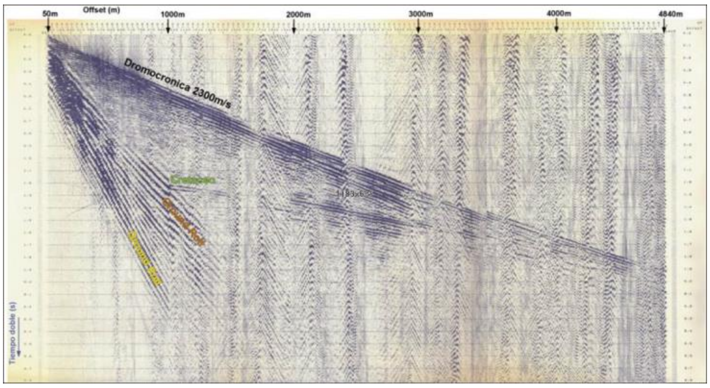


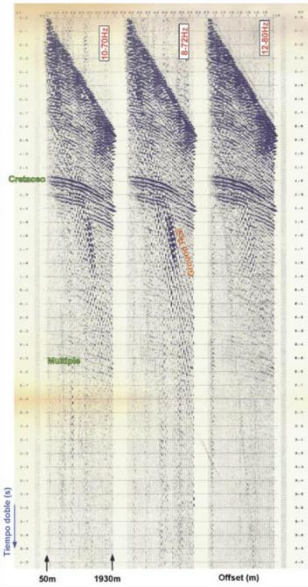


Old seismic sections are visually analysed and quality cross checked, for example with geological terrain conditions. Ray tracing on known 2D geological model is sometimes used to validate the offset choices.

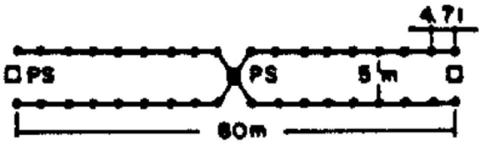


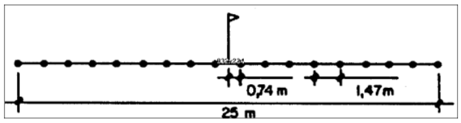
When individual records and noise tests are available, a quality assessment is performed and Ground Roll wavelengths are analyzed to define the best spatial sampling. A good sampling enhances the filtering of such noise at processing stage. Less noise means more signals to analyze.

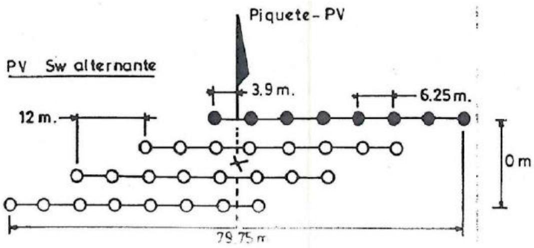




In the past, seismic recording systems combined low channel count capacity and consequently long receiver and source intervals to catch the far offsets. It was therefore impossible for the processing algorithms to achieve coherent noise elimination due the large spatial sampling. With such constraints, the only way to attenuate the Ground Roll noise was with complex geophone and vibrator patterns.



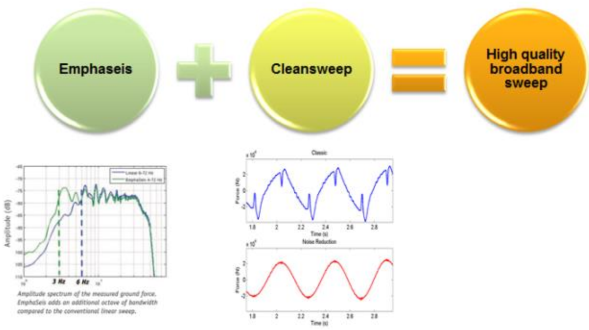




We often see vibrated Points (VP) comprising large numbers of vibrators and multiple sweeps with small move up.

Recent seismic recording systems and high productivity techniques manage high channel count with shorter sources and receivers' intervals. With modern seismic acquisition heavy patterns can be avoided through the use and high source density over large spreads within economic constraints

Frequency content analyses of the old seismic data indicate the highest frequency we expect to retrieve at the processing stage. Based on that, according to target depth and geology, we select the lowest start frequency to optimize the number of octaves on the signal. Nowadays, broadband sweep encoding benefit of a better resolution and interpretation.



For the receivers, the sensitivity of the pattern will be addressed and recommendation for digital or 10Hz, 5Hz analogue geophones would be provided.

Phase 2 – Evaluate the project feasibility and pre-planning

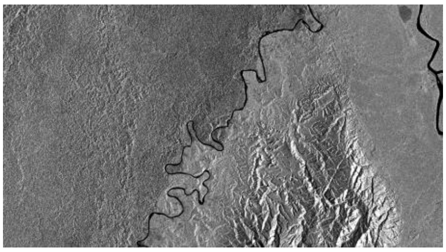
What can we anticipate when we deploy such design on your prospect? ……adapt the appropriate method, fit your budget and control your risks.

Data collect & Preplanning

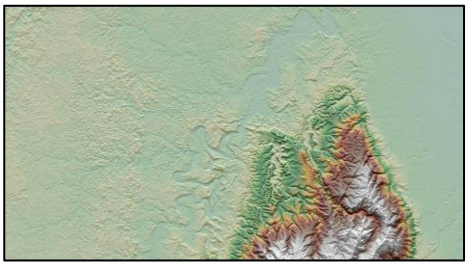
Different providers such as NPA Satellite mapping or among others can provide detailed satellite imagery and DEM from a wide range of optical and radar satellite imaging systems. Satellite imagery processing, coupled with Ordnance Survey maps can enable extremely detailed study of the proposed work zone prior to any field access. This enables the pre-planning of potential line locations to avoid areas of significant risk and to optimize quality and productivity.

NPA's TerrainExplorer service provides an improved understanding of the characteristics of a project area. Much of NPA's regional interpretation is performed using Landsat TM data. However, in the tropics, much of the terrain is cloud cover prone, even at 9:30am in the morning, when all Landsat images are captured. In that case radar images will be used. Radar data (ERS data in this case below) provides 30m down to 3m resolution. The advantages over optical (e.g. Landsat or SPOT data) are:

- "Sees" through clouds, night and day.
- Images "texture", or roughness, not color.
- Black tones – flat – no return.
- White tones – rough – lots of "backscatter".

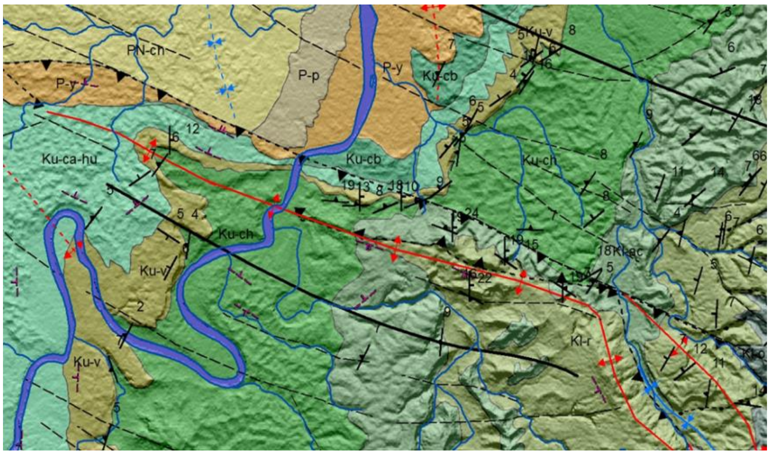


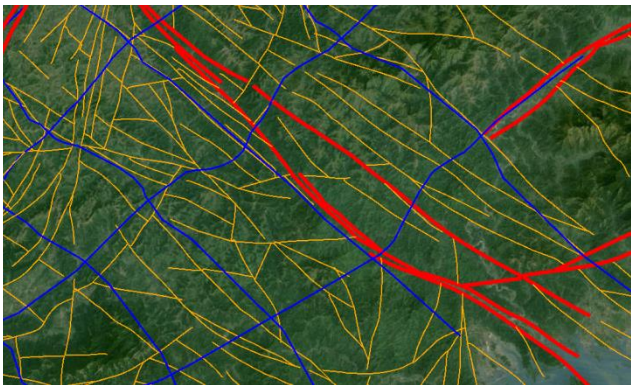
The Radar data is routinely merged with Shuttle Radar Topography Mission (SRTM) DEM data. In this image below, the color refers to elevation and the texture to the signal recorded from the Radar sensor, giving an image that illustrates terrain more dynamically. Faults and different terrain types are more easily discriminated in this way.



SRTM DEM data is now available with 30 m resolution but other more detailed options are available, although many involve airborne platforms – X- and P-band radar for instance, or the more recently available LiDAR, which provides the clearest images of the tropical forest/jungle floor as it penetrates the foliage to get a return from the forest floor. Landsat data and SRTM DEM data are free to acquire, but there are small costs associated with processing and formatting.

Structural and geological Interpretation details obtained from the previous images, clearly showing dip values and structural complexity… >>>



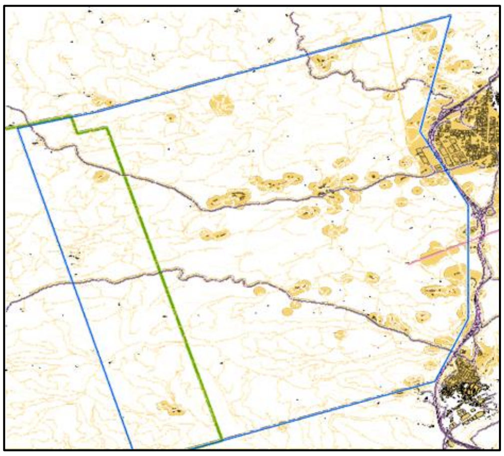


<<< Example showing the use of structural analyses conducted by NPA using public DEM in order to plan the best route for regional 2D seismic lines avoiding major faults (red and orange). Once the 2D line route (blue) is selected according to structural information, statistics were made between dynamite and vibroseis sources.

Once this input data preparation is made, a desktop feasibility with dedicated software possibly followed by full-field scouting will complete the feasibility and propose an accurate planning to address the scope of work before any tender process.

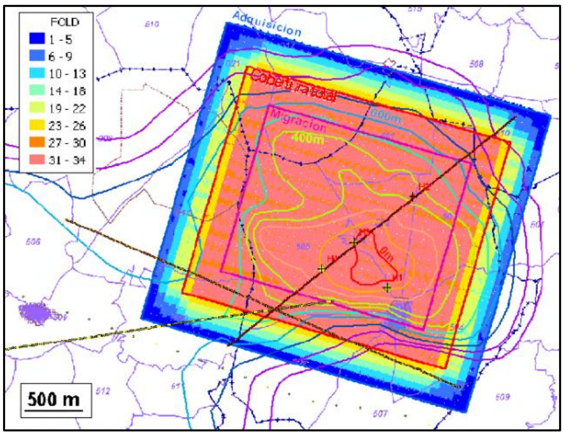
Desktop feasibility

Following a detailed mapping of the work zone or only importation of free satellites images and maps, the first step is a desktop study to move the theoretical positions of sources and receivers according to the observed features as cliffs, rivers, lakes, towns, railways,… Security distances are also applied to roads, buildings; visible electric lines…

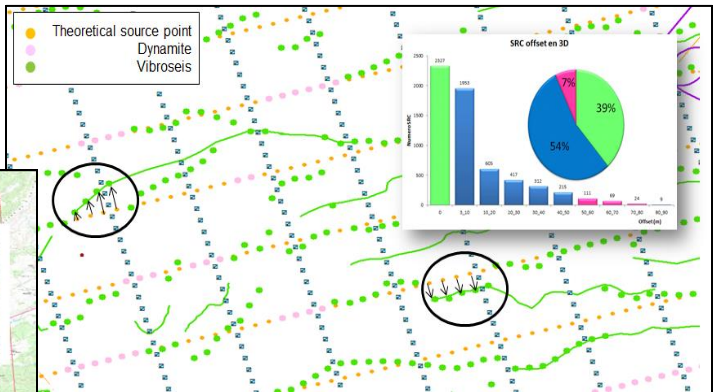


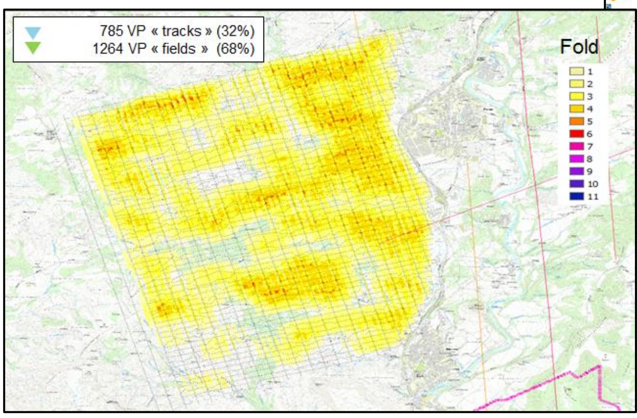
EGeo Services SAS perform design studies utilizing the Geoland® or the OMNIS planning systems. Theoretical receiver and source points can be entered and where necessary offsetting can be performed in response to access restrictions. Additional receivers can be inserted in the pre-planning to recover some of the data missing due to skipped or offseted source points.

If the pre-planning feasibility is carried out prior to the release of tender a fully detailed scope of work can be included in the tender documents which specifies with a high level of accuracy the percentages of terrain (forestry, lakes, agriculture and urban) and the source type associated with each area. In this way a much clearer tender process is possible allowing a true comparison between potential contractors.



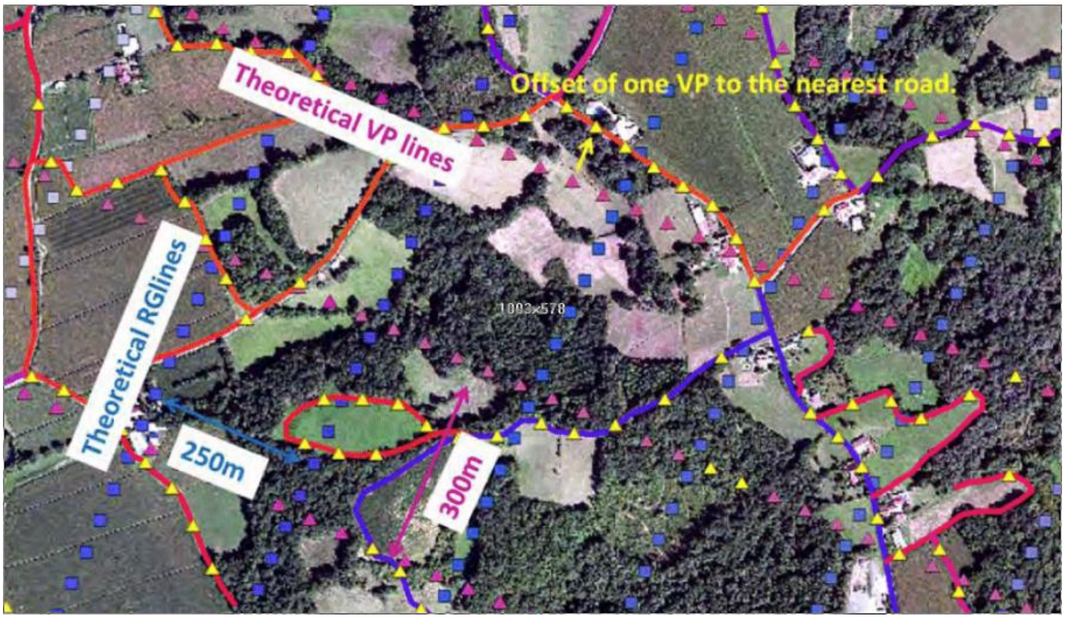
Displacement of sources and receiver are made according to rules defined for the survey together with the client. Statistics of offsets are provided. >>>



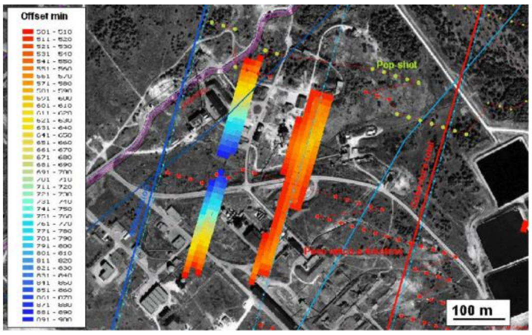


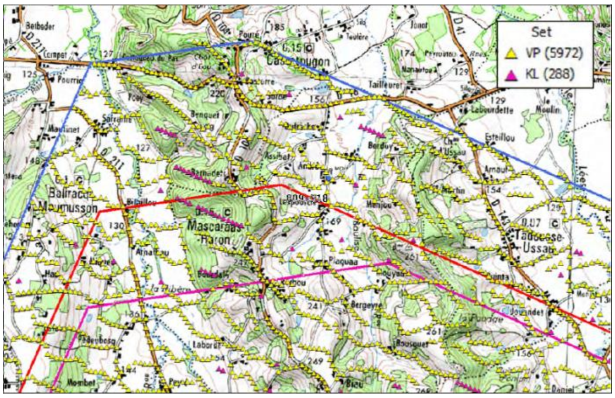
<<< Validation of preplanning is done regularly through coverage maps at different offset ranges.

Detailed desktop preplanning is accurate at 70%.



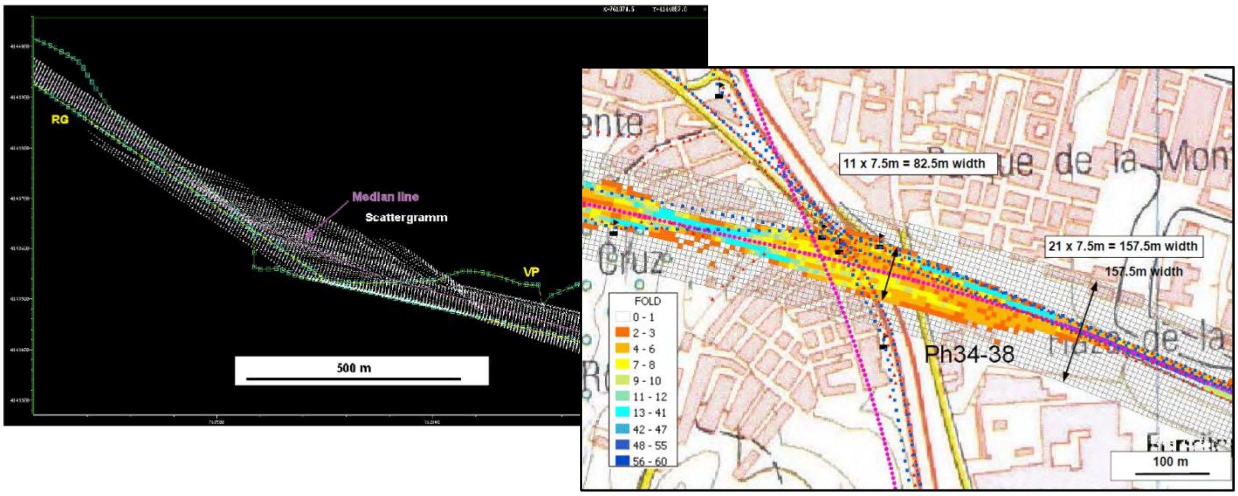
Fine tuning is made in case of holes in coverage. >>>

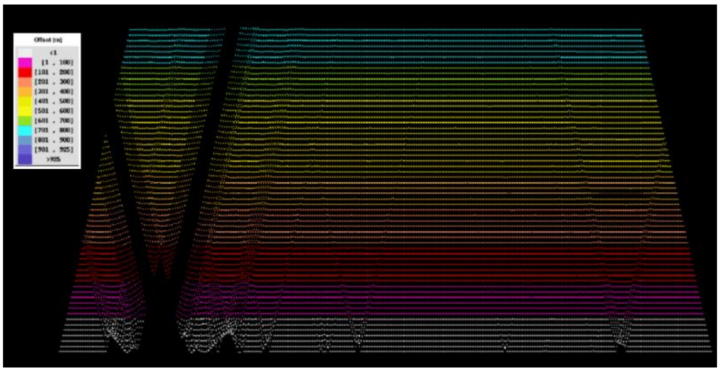


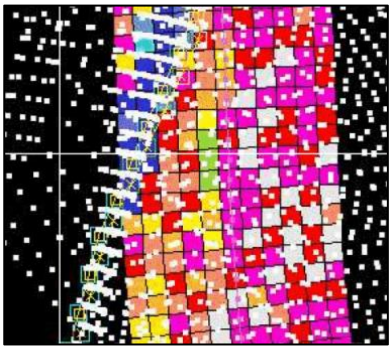


<<<Statistics of cancelled points are provided.

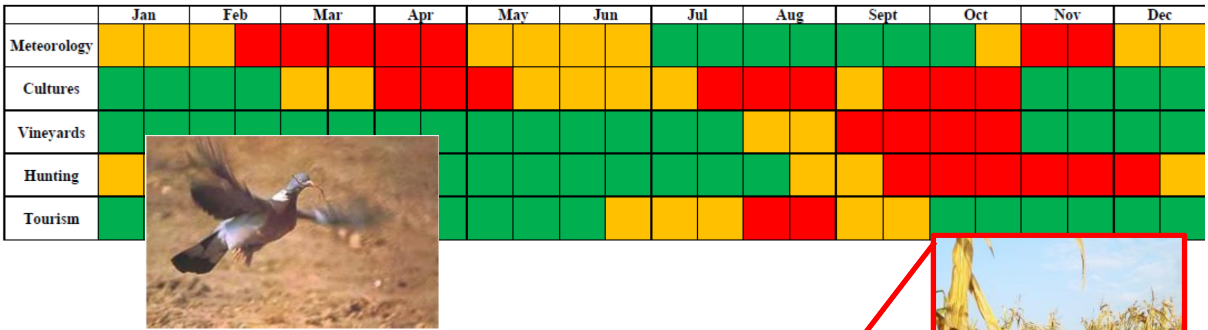
For 2D surveys, scattergrams, median lines and fold are checked all along the lines.

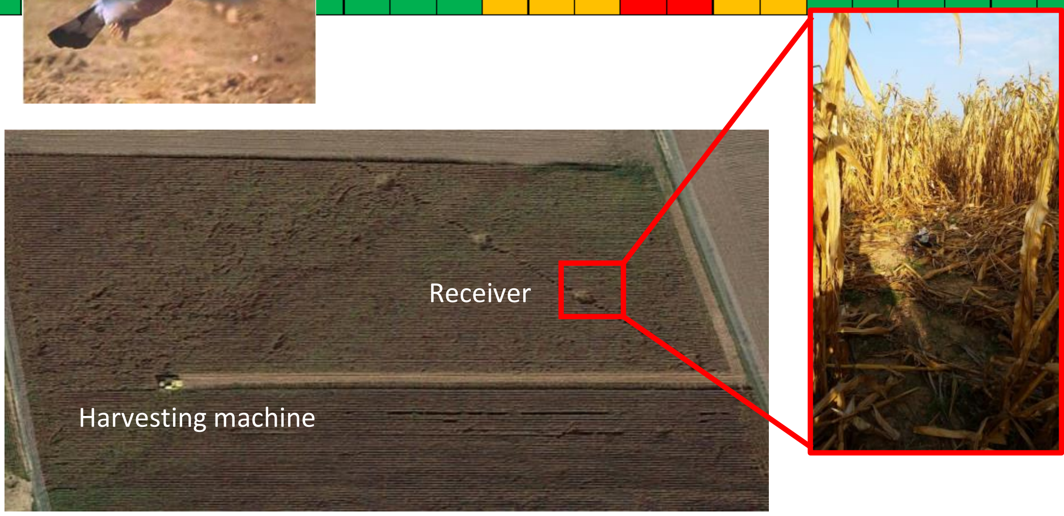






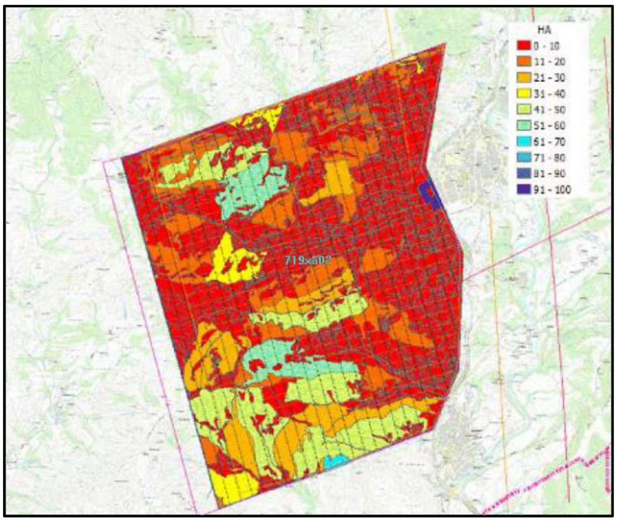
Together with permitman specialists, an assessment of the best period of the year for acquisition is done. A classification is made taking into account the meteorology, land crop uses, vineyards, hunting, tourism…



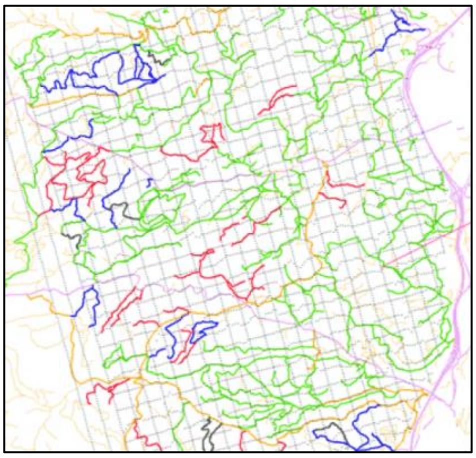


Field scouting trip and Full field feasibility

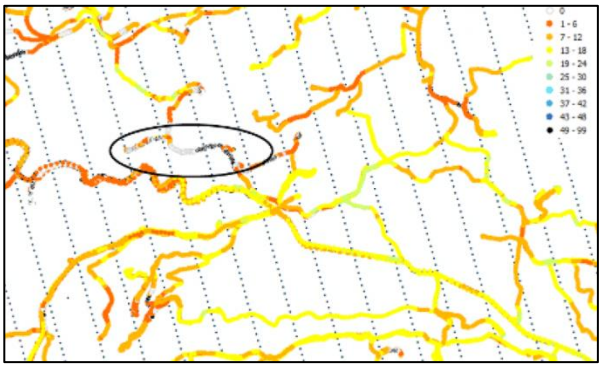
The next step is to carry out infield reconnaissance to validate the assumptions made from the imagery plus desktop study and to provide greater detail in the planning of potential work in the area. Using a combination of background mapping and GPS technology an initial study can be made of all public access roads. If allowed by client at this stage, initial enquiries could be made with the local authorities to ensure that the seismic survey does not clash with ongoing work programs and other events.



<<< A first assessment of properties would be made and initial contacts with local land agents used to provide information on large land occupiers that in case of a refusal could potentially jeopardize the whole exploration project.

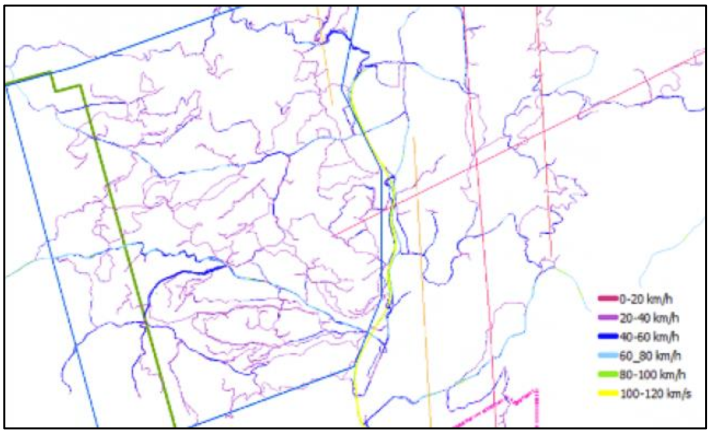


Track viability is also addressed and mapped during scouting. >>>



<<< GSM network is also mapped for HSE reasons (MEDEVAC), to indicate fall out coverage areas for topographic surveying when differential signal is received through GSM (in order to plan the need for relays) and also when QC attributes are sent to observer by GSM in case of autonomous shooting.

The car speed is also logged during scouting for geofencing in the VMS system that will be put in place during acquisition.
>>>



Risk Analysis

The Risk Analysis should be initiated as soon as all elements are known. The Risk and mitigation analysis is performed according to two risk analysis areas:

- Operations R&M.

Risk Category	Risk Title	General Description	Identified risk on this project	Initial Risk
Administrative / Business Environment	Air Custom	from No need to wait for license delivery to Mandatory to wait for custom license delivery before shipping		Low
	Marine Customs	Easiness of marine customs, need to wait for delivery of custom license before shipping		Low
	Custom Bond	Client warranty to CGG bank custom bond to submit. Low amount or high amount		Low
	New Vehicle only	from Possibility to import any used vehicle to Impossibility to import used vehicle (ie: used recording truck)		Low
	Classified Goods	No prohibition to import certain good to restriction to import certain good without proper certificate of origin		Low
	Radio or Satellite Communicat. devices	impossible to import without radio or sat license obtained to possible to import without any radio or sat license in place at time of importation		Low
	Temporary License Duration	from 6 month not renewable to 12 months or more renewable several time		Low
	Temporary License Transfer	not possible to transfer from one contract to another to possible to transfer from one contract to another		Low
	Past Litigation still pending	none to several known and pending		Low
	Known Custom Agent in country	no to yes and used in the last 12 months		Low
	Custom Agent represents an internationa agent	does the short listed custom agent represent a significant international company		Low
	Visas	Immigration rules, Status of expatriates, Working visa, potential delays		Moderate
	Explosive	Responsibility, Permit, Licence, Importation, etc.		N/A
	Radio licence	Difficulty to obtain sufficient frequencies, delays		Low
	Insurance	Local insurance coverage difficult		Low
	Labor	Constraints or insufficient knowledge about local workers		Low
	Environmental permits	Delays or outcome of EIA, Forestry permits, opening accesses, etc.		High
	Contravention of local laws	Local laws not clearly defined, leaving room to interpretation		Low
	Seizure of assets / Expropriation	Nationalization, Non-respect of importation rules		Low
	Competition in the country	Strong position of competitor in the country, able to interfere in admin processes		High

- HSE R&M.

Risks / Hazards	Risk Description	Initial Risk	Controls	Residual Risk	Comments
Population		N/A		N/A	> 400 per km² = H
Obstacles	Deep forest environment	Very High	Full control on the Helicopter in case of ERP Awereness program. Avoid rush (control of daily production)	Moderate	Hidden obstacles: World War II ERW contamination, no mines = H Clearance done by local army and no supervision ammowed = VH Hidden obstacles: Recent conflict ERW contamination or mines = VH
Pollution	On water, flora, and communities	High	Awareness program. Heliportable logistic	Low	Suspected radiocative or chimical weapons contamination = H Radiocative or chimical weapons contamination = VH
Workforce		High	Good knowledge of the country and people working for us	Moderate	< 20% Skilled, educated, experienced & fit = H
Acquisition period	Working during rainy season	Very High	Heliportable crew will avoid transport on slippery conditions	Moderate	Acquisition during Ramadan and Ramadan in summer = H
Medical response (local infrastructure)		Very High	Doctor on site, control on the helicopter in case of amergency	Moderate	No adequate medical infrastructure at less than 4 h by road = H No adequate medical infrastructure at less than 8 h by road = VH Helicopter medevac relying on local army = VH
Infectious / Contagious diseases (ex: Malaria, Dengi Fever, etc...)	Include food contamination	Very High	Procedure to keep in place	Moderate	More than one but less than three diseases in area, prophylaxis required = H
Products	Combustible and flammable	Very High	Explosive storage (procedure)	Low	Sub-standard critical products (detonators, explosives, CMR ...) = VH
Very high activities	Explosive source used	Very High	Procedure to put in place	Moderate	Land seismic helicopter support, Chain saw tree felling, Diving, Mountainning/abseil/rappel, Erecting scaffolding or Masts >5m = VH

Qualitative risk assessment:

RISK ASSESSMENT MATRIX						
		Likelihood of occurrence				
		Very Unlikely	Unlikely	Possible	Likely	Very Likely
Impact		A	B	C	D	E
Severity: Minor	1	Low	Low	Low	Low	Moderate
Moderate	2	Low	Low	Moderate	Moderate	High
Significant	3	Low	Moderate	Moderate	High	Very High
Major	4	Low	Moderate	High	Very High	Very High
Extensive	5	Moderate	High	Very High	Very High	Very High

Low
Moderate
High
Very High

Each risk must be individually assessed qualitatively according to (see above matrix).

Potential occurence (class A to E) x potential impact severity (class 1 to 5)

N/A If the risk does not apply to the project.

Unknown If the risk cannot be evaluated during feasibility phase, provide comments in this case.

Risk response: mitigations:

Each risk initially assessed as High or Very High should have a mitigation and the residual risk after mitigations adjusted accordingly. By default: Residual risk = Initial risk.

Initial Risk	Mitigation	Residual Risk
High	*Risk Response ==>*	Moderate

Dashboard:

Provides an overview of the risk analysis status & results. Each category bear the highest level of all risk assessments in this category. The risk displayed is the initial risk evaluation before & after any mitigations.

RISK ANALYSIS DASHBOARD

Country: Gabon | Project: Project

Client: Client

				RISK ASSESSMENT (before MITIGATIONS)						INITIAL	RESIDUAL
	Domain	Risk Category	Not Assess	N/A	Unknown	Low	Moderate	High	Very High	Overall Risk	Overall Risk
28	HSE	HSE / Security						1		High	Moderate
29	HSE	HSE / Natural Environment (terrain, climate…)					1	3	2	Very High	Moderate
30	HSE	HSE / Visible Obstacles (roads, etc.)		1			1			Moderate	Low
31	HSE	HSE / Hidden Hazards (Mine, Chemicals…)						1	1	Very High	Moderate
32	HSE	HSE / Land Transport (Vehicles, Drivers, Env.)					1	1	1	Very High	Moderate
33	HSE	HSE / Air Transport (hélicopters, planes)				1			1	Very High	Moderate
34	HSE	HSE / People						1	1	Very High	Moderate
35	HSE	HSE / Medical (diseases, medevac)							2	Very High	Moderate
36	HSE	HSE / Products							1	Very High	Low
37	HSE	HSE / Hazardous Activities						1	1	Very High	Moderate
38	HSE	HSE / Responsibility & Control		1					1	Very High	Moderate
39	HSE	HSE / Standards & Regulations				1	2			Moderate	Moderate

Report

Once the above steps have been taken, a full feasibility report is written that provide recommendations for the survey design based upon the geophysical requirements for reservoir characterization and all the information collected in the field such as environmentally sensitive areas, restricted access and no-permit zones. Numerical files can also be provided in various formats as shapefiles to be added in tender documentation as guideline for contractors.