Efficiencies in 3D Design - Implementation and Operations

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ABSTRACT

Design of 3D seismic models has received much attention over the years, and yet relatively little has been presented regarding the optimization of these models for implementation by modern acquisition crews.

Our primary goal is to provide designs of sufficient technical merit to image the intended targets. However, along this path we are presented with many choices that give approximately equal imaging characteristics but bear great influence on the ultimate cost of the project.

Using the concept of cost densities, we offer some guidelines to project optimization.

The cost of acquisition of a 3D project can be greatly influenced by the arrangement of lines. We present demonstrations of optimizing layout to attain the most efficient patch rolling while minimizing utilization of recording equipment. We show how these considerations may be sensitive to survey shape and source type.

Today we are seeing the implementation of much larger 3D programs than ever before. We are often forced to “Zipper” our programs in order to record them with a practical amount of field equipment. We discuss several methods and considerations required to optimize this planning.

These aspects of project planning can result in cost variations from tens of thousands of dollars in smaller projects to millions of dollars in very large 3D’s.

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Efficiencies in 3D Design - Implementation and Operations

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- ✓ Equipment Demands
- ✓ Patch Movement
- ✓ "Zippered" Surveys
- ✓ Half-Patch Recording
- ✓ Variable Grids
- ✓ False Efficiencies

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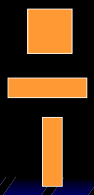
Line Spacing

$$SL \times RL = \frac{\pi \times \text{Offset}_{\text{Max}}^{2}}{4 \times \text{Desired Fold}}$$

Avoid: SL / RL = 1.0
SL / RL > 2.0
SL / RL < 0.5



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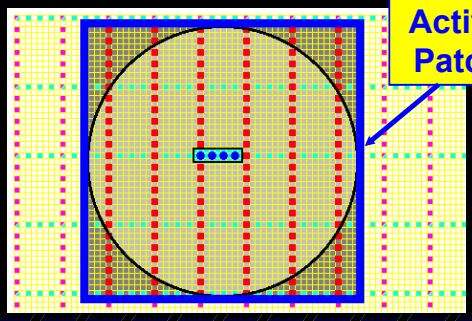
The Fold Equation Assumes a Large Patch …



. . . Sufficient to record all useable offsets

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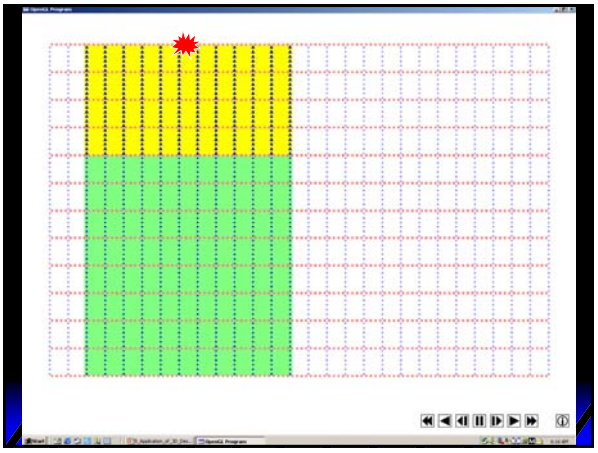
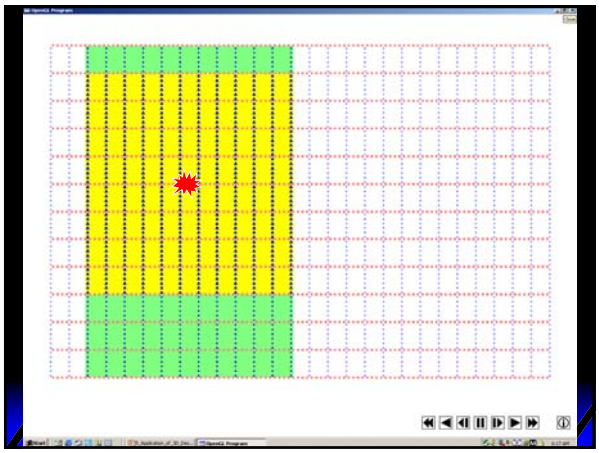
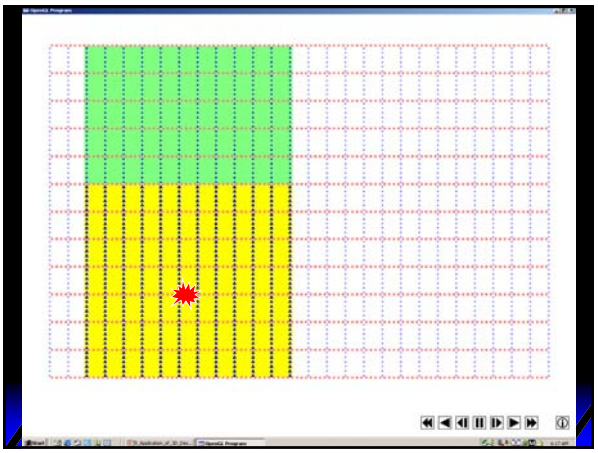
Rolling the Patch

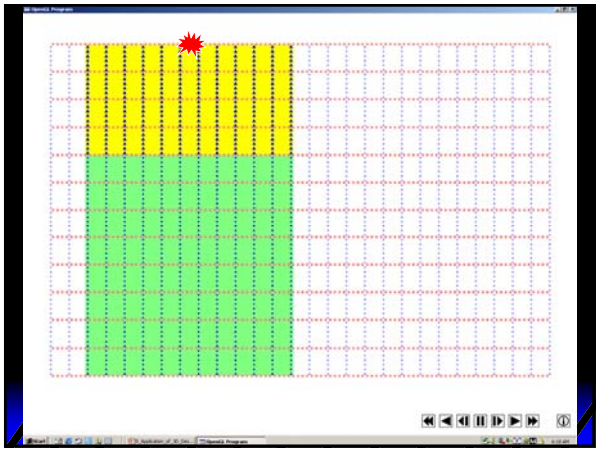
- "Normal" roll

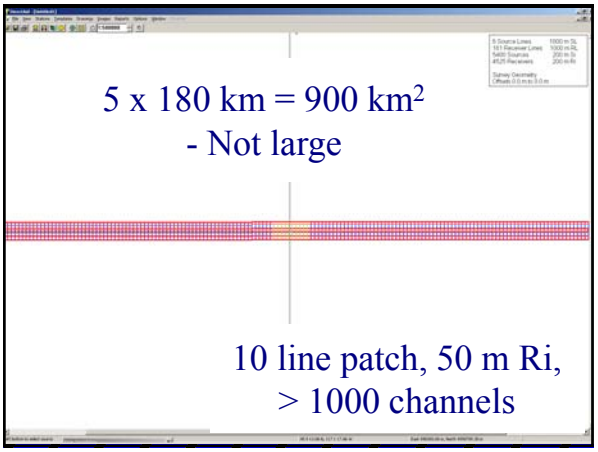
.\Demonstrations\RollDemo.exe

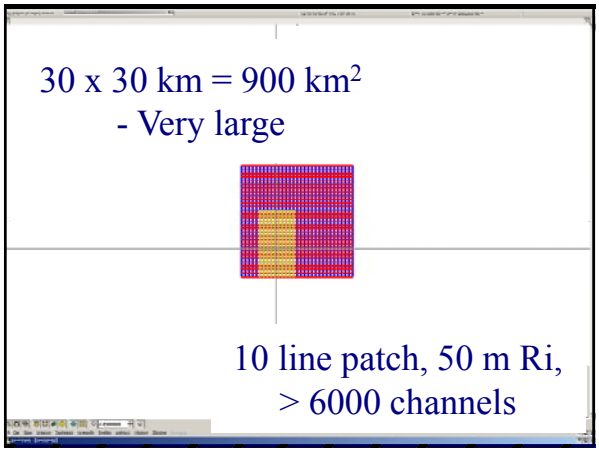


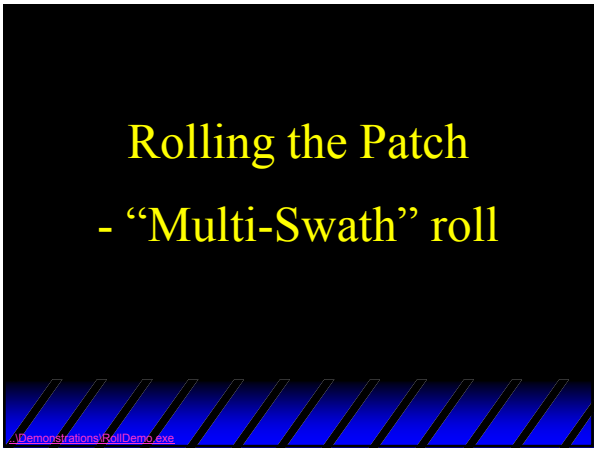







5 x 180 km = 900 km2
- Not large
10 line patch, 50 m Ri,
> 1000 channels


30 x 30 km = 900 km2
- Very large
10 line patch, 50 m Ri,
> 6000 channels


Rolling the Patch
- "Multi-Swath" roll
..\Demonstrations\RollDemo.exe

Rolling the Patch

- "Vibroseis" roll

.\Demonstrations\RollDemo.exe

Rolling the Patch

"Vibroseis" roll

- Better

.\Demonstrations\RollDemo.exe

Patch Analysis

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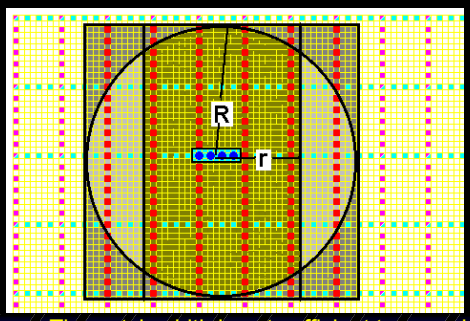
Sometimes, we are forced to use
Narrow Aperture Patches



. . . The patch width is not sufficient to record all useable traces

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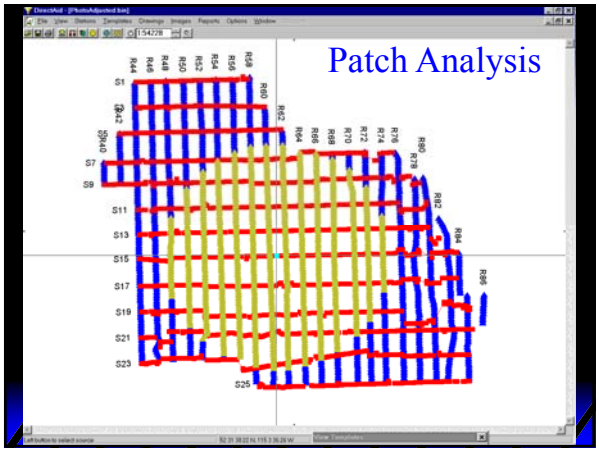

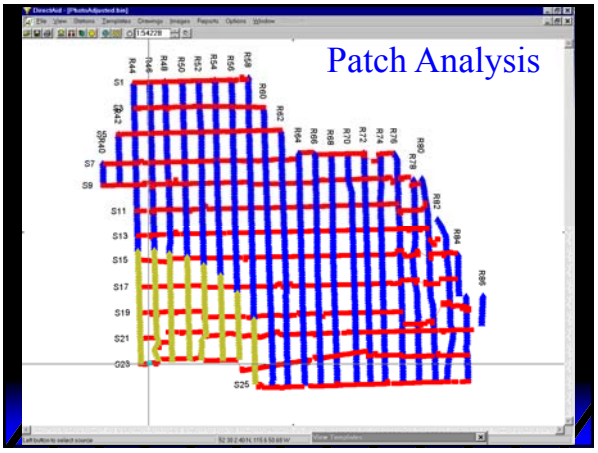

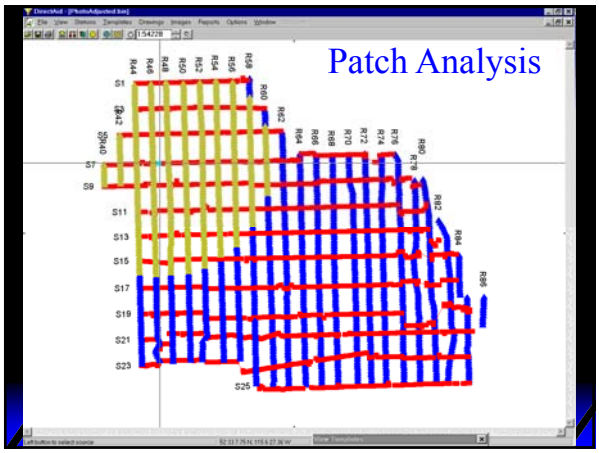

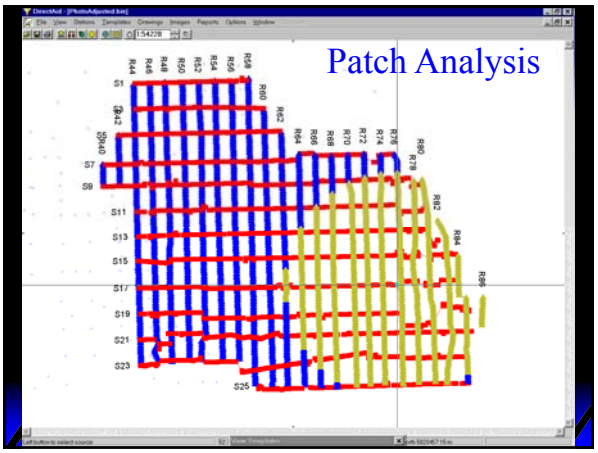

Patch Analysis

Percentage Of Receivers Included
Within Desired Maximum Offset
For Patches Using 'N' Lines

N	Rcvrs	Rcvrs %	Total %
1	112587	10.64%	10.64%
2	110755	10.47%	21.11%
3	108925	10.29%	31.40%
4	106103	10.03%	41.43%
5	102481	9.69%	51.12%
6	97982	9.26%	60.38%
7	91718	8.67%	69.04%
8	83501	7.89%	76.94%
9	71692	6.78%	83.71%
10	59252	5.60%	89.31%
11	46605	4.40%	93.72%
12	34668	3.28%	96.99%
13	22852	2.16%	99.15%
14	8852	0.84%	99.99%
15	118	0.01%	100.00%

R-line	Start	End	Stations	Length km	Existing km	Newcut km	Water km
40	40136	40145	10	0.659	0.659	0.000	0.000
42	42123	42144	22	1.454	1.454	0.000	0.000
44	44102	44222	121	7.982	7.982	0.000	0.000
46	46102	46221	120	7.975	7.975		
48	48101	48221	121	7.982	7.982		
50	50102	50221	120	7.918	7.918		
52	52102	52221	120	7.972	7.972		
54	54101	54221	121	7.983	7.983		
56	56102	56221	120	7.916	7.916		
58	58101	58232	132	8.709	8.709		
60	60114	60233	120	7.925	7.925		
62	62124	62234	111	7.322	7.322		
64	64135	64234	100	6.597	6.597		
66	66134	66233	100	6.600	6.600		
68	68135	68234	100	6.596	6.596		
70	70135	70234	100	6.598	6.598	0.000	0.000
72	72134	72233	100	6.594	6.594	0.000	0.000
74	74135	74233	99	6.533	6.533	0.000	0.000
76	76135	76234	100	6.601	6.601	0.000	0.000
78	78146	78233	88	5.813	5.813	0.000	0.000
80	80146	80233	88	5.806	5.806	0.000	0.000
82	82163	82234	72	4.752	4.752	0.000	0.000
84	84179	84233	55	3.780	3.780	0.000	0.000
86	86196	86208	13	0.858	0.858	0.000	0.000
		Total	2253	148.922	148.922	0.000	0.000
		Min	10	0.659	0.659	0.000	0.000
		Max	132	8.709	8.709	0.000	0.000
		Avg	93.875	6.205	6.205	0.000	0.000

Line Summary - receivers

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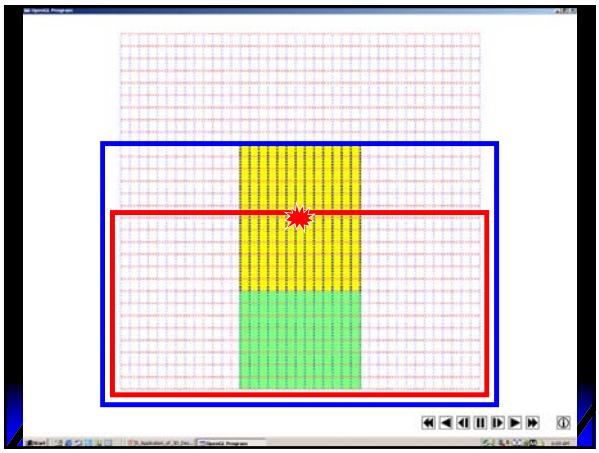
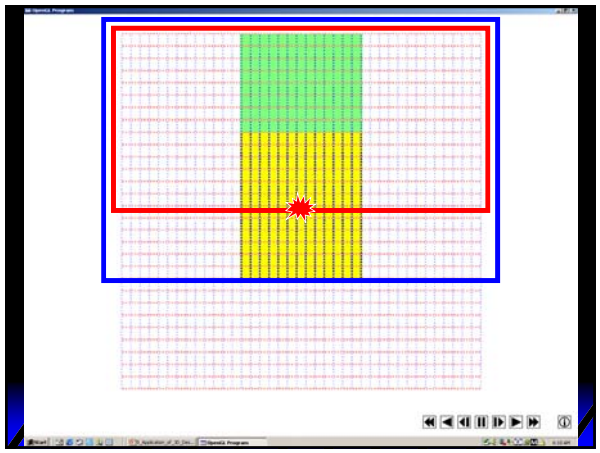
	17 lines	16 lines	15 lines	14 lines	13 lines	12 lines	11 lines	10 lines	9 lines	8 lines	7 lines
	875	755	755	634	634	514	514	394	394	273	273
	1007	875	875	755	755	634	634	514	514	394	394
	1127	1007	1007	875	875	755	755	634	634	514	514
	1238	1127	1127	1007	1007	875	875	755	755	634	634
	1338	1238	1238	1127	1127	1007	1007	875	875	755	745
	1438	1338	1338	1238	1238	1127	1127	1007			
	1538	1438	1438	1338	1338	1238	1228	1117			
	1638	1538	1538	1438	1428	[illegible]	1306	1206			
	1738	1638	1628	1528	1506	1406	1285	1185			
	1827	1728	1706	1606	1485	[illegible]	1265	1165			
	1905	1805	1684	1585	1465	1365	1244	1144			
	1872	1784	1664	1564	1443	1344	1224	1124			
	1840	1752	1631	1543	1423	1323	1203	1104			
	1791	1719	1599	1511	1391	1303	1182	1082			
	1726	1671	1551	1479	1358	1270	1150	1062			
	1619	1606	1485	1430	1310	1238	1106	1018			
	1498	1498	1378	1365	1233	1178	1058	986	875	787	687
	1378	1378	1246	1246	1126	1113	1002	947	847	775	675
	1246	1246	1126	1126	1015	1015	915	902	802	747	647
	1126	1126	1015	1015	915	915	815	815	715	702	602
	1015	1015	915	915	815	815	715	715	615	615	515
	915	915	815	815	715	715	615	615	515	515	416
	815	815	715	715	615	615	515	515	416	416	316
	715	715	615	615	515	515	416	416	316	316	228
Total	33225	31727	30089	28470	26732	24993	23156	21297	19360	17380	15355
Min	715	715	615	615	515	514	416	394	316	273	228
Max	1905	1805	1706	1606	1506	1406	1306	1206	1095	975	854
Avg	1384	1322	1254	1186	1114	1041	965	887	807	724	640

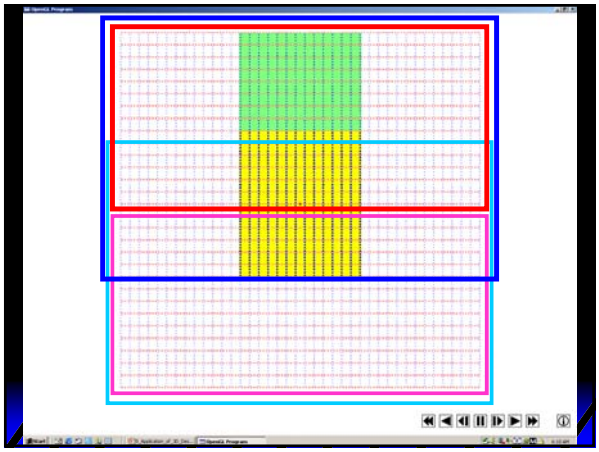
Crossline Channel Summary

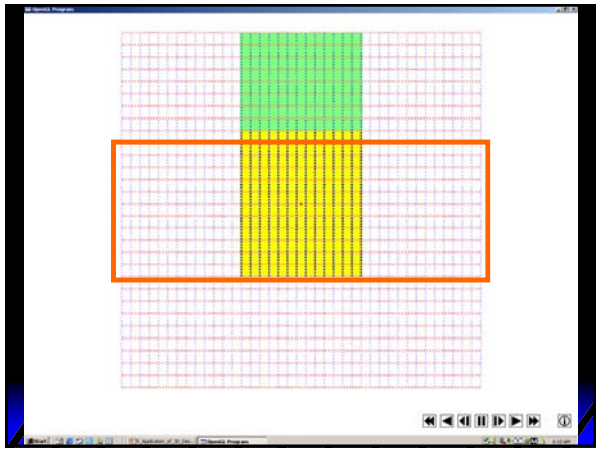
Rolling the Patch - "Zippered" Survey

..\Demonstrations\RollDemo.exe

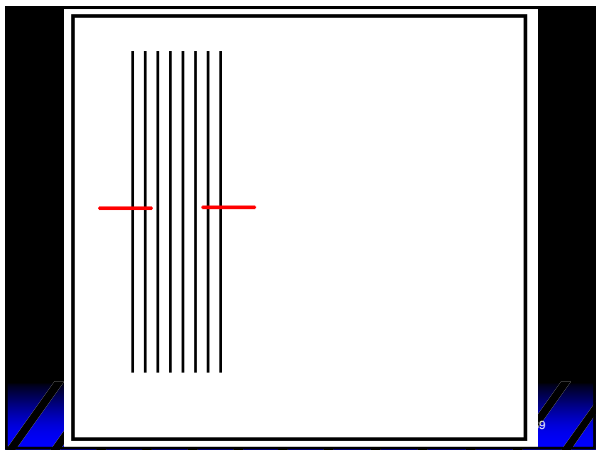


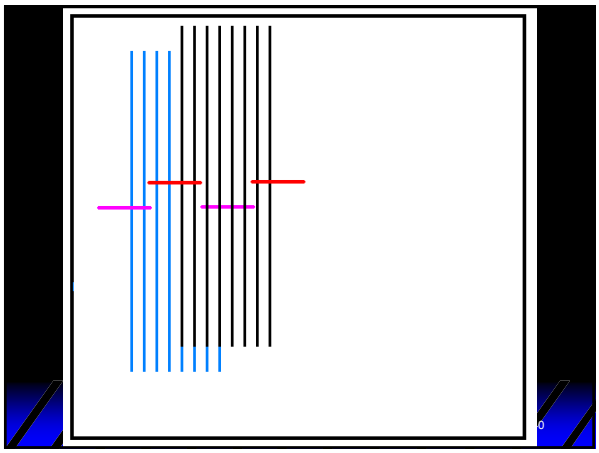


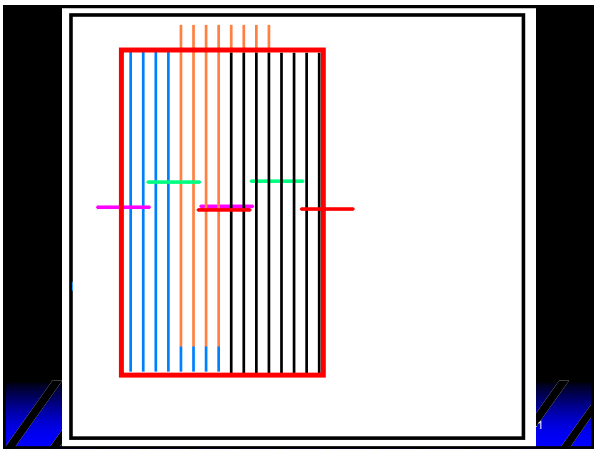




“Half-Patch” and “Ping-Pong”

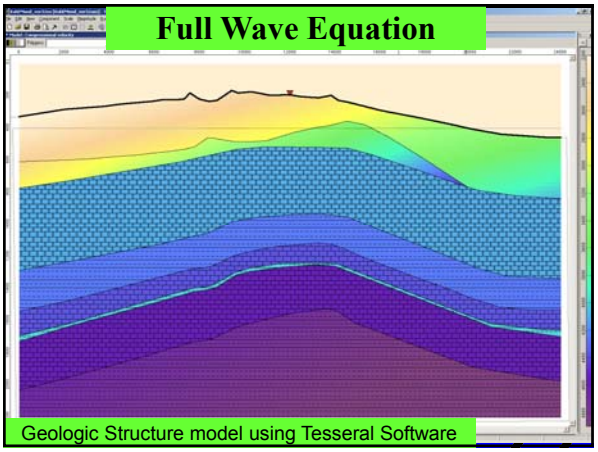






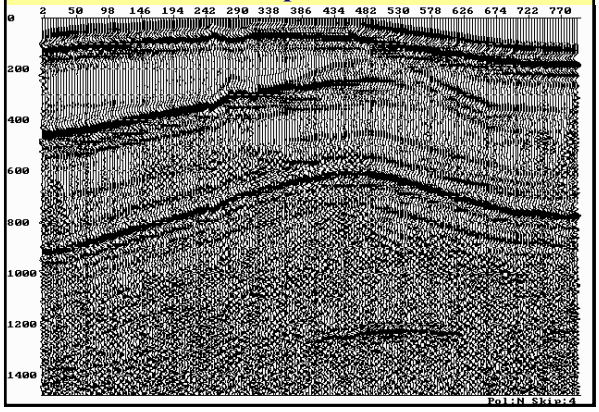
Variable Spacing Models

Full Wave Equation

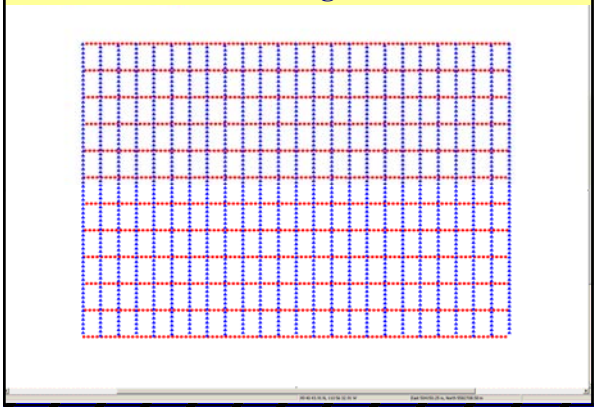


Geologic Structure model using Tesseral Software

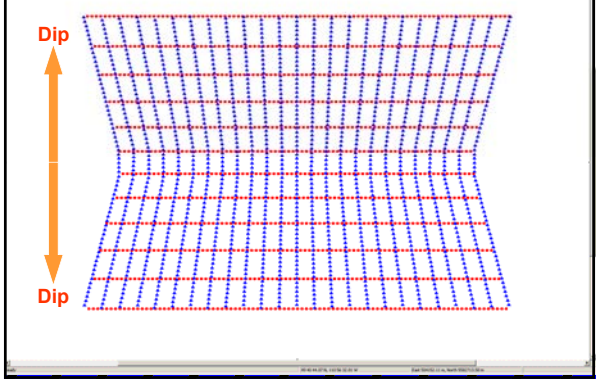
Model Output - Tesseral



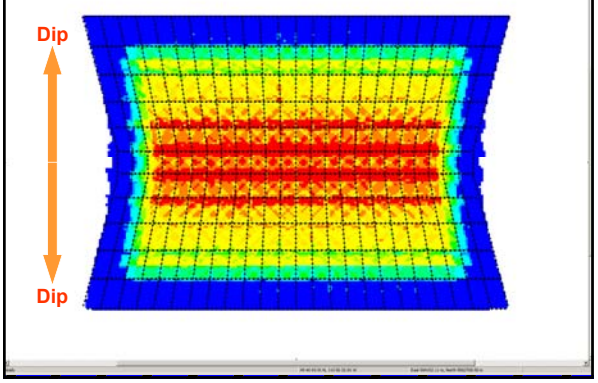
Normal Orthogonal Grid



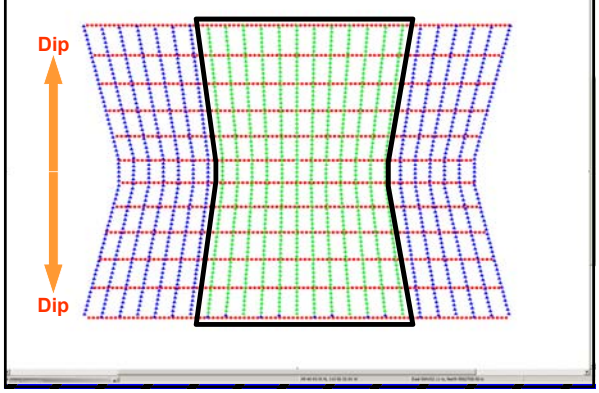
Flared Grid



… With Variable Fold …



… and with Flared Patch



False Efficiencies

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False Efficiencies

- Double recorded traces by halving inexpensive receiver interval …
- … then halve recorded traces by doubling expensive source interval
- Net Fold (as gathered in original bins) will Remain the same !

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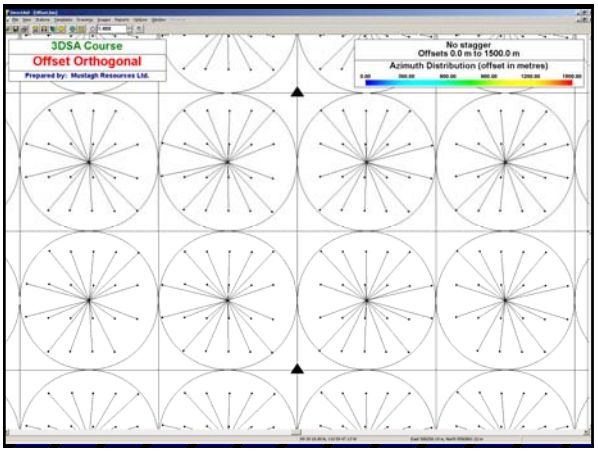

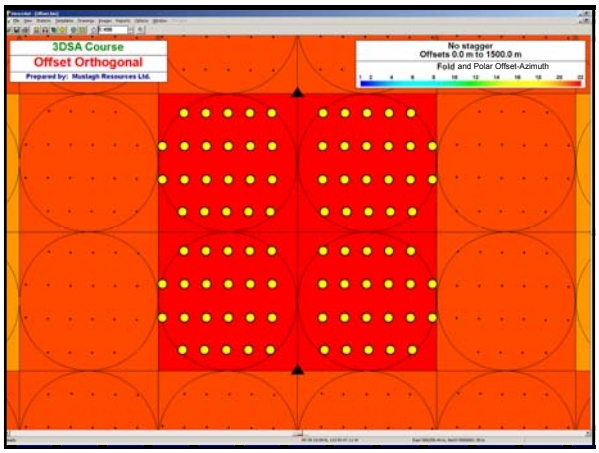

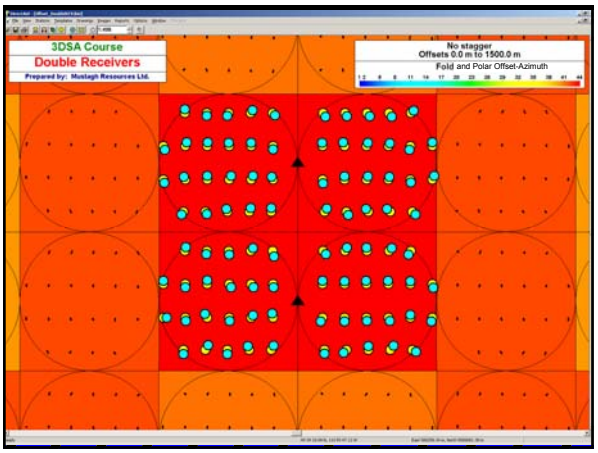

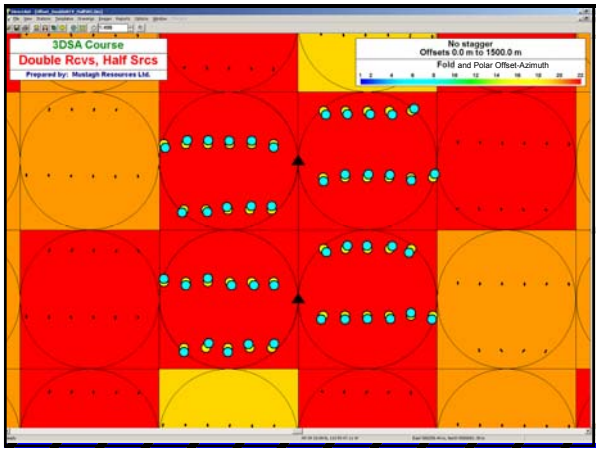

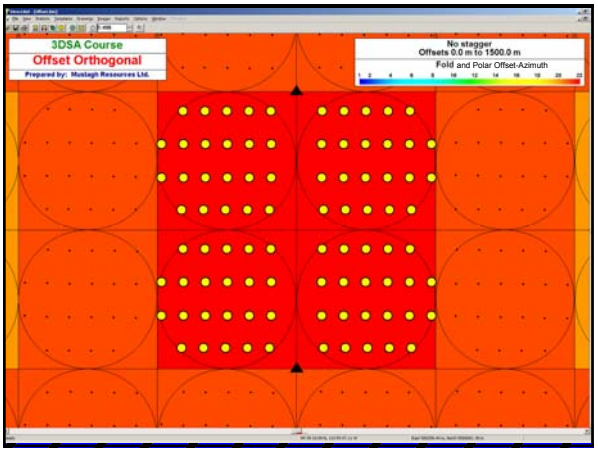

False Efficiencies

- Increase Fold by decreasing receiver interval and gathering in original bin size
- This generates non-diverse statistics within the over-sized bin as per the previous argument
- Fold is not our key consideration, **Sampling Diverse Statistics** within each bin is important

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Cost Factors

Receiver line density	1.60	km per km^2
Source line density	1.08	km per km^2
Active patch lines	14	

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Most Important Factors:

Preservation of the Wavefield
– bin size, patch size

Statistical Diversity
– grid density, aspect ratio

Robustness under Perturbation
- model type
- skidding and offsetting

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But Also :

Minimize Costs

Optimize Operational Efficiency

Minimize Environmental Impact

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If you desire more information or would like a copy of this tutorial, please contact Norm Cooper or Yajaira Herrera

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