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Harris Methodist Hospital, Fort Worth Building Demolition February 20, 2000



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Quick Look Field Data Report

Introduction

On February 18, 2000, Edward Jakubowski¹ suggested that there could be an opportunity for SMU to record the acoustic and seismic events associated with the explosive demolition on February 20 of the building at 800 Fifth Avenue in Fort Worth, near the Harris Methodist Hospital (Figure 1). This would provide an opportunity for SMU to test its sensors and practices related to the upcoming near-source mine deployments. Although this was short notice relative to normal SMU deployment practices, it was too interesting not to record. Chris Hayward made a one hour site visit on Friday to survey the area and discuss the plans for making a reconnaissance instrument deployment during the blast.

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Figure 1. Map of the area. The red start is 1300 Terrell, across the street from the demolition on 5th Ave. Map from http://www.mapquest.com.

The demolition was of a 6-story 60,000 square foot structure (Figure 2) surrounded by a parking garage, construction site, and hospital and associated buildings. In initial discussions it was decided to try to deploy at least 3 SMU systems within the secured area so that the security of the equipment could be assured and problems associated with access and site permission would be minimized.



Figure 2. Photo of the building scheduled for demolition. The photo was taken from the parking garage to the southwest.

Ed had distributed 4 Instantel systems with three-component geophones and microphones to record the maximum ground motion and pressure during the demolition. We briefly discussed possible locations and agreed that at least one SMU system should be collocated with one of the calibrated Instantel systems.

¹ Edward Jakubowski, Senior Staff Geologist, Schnabel Engineering (ejakubowski@schnabel-eng.com)

Equipment Description



Figure 3. Site 4 as initially deployed. The red Validyne sensor is on top the bale of hay. The S6000 is near the curb. The top of the Chaparral can barely be seen just in back of the RefTek recorder.

With such short notice, it was not possible to test or configure equipment prior to deployment. Five RefTek DAS72A/06 and associated disk drives were pulled from the shelves. Only three GPS clocks were available. Five S6000 three-component seismometers along with three Chaparral model-2 infrasound microphones, and five Validyne DP350 low range pressure sensors and one GS-13. Systems were powered from salvaged gel cell batteries (Figure 3).

Two of the DAS72A/06 systems were configured in backpacks to allow them to be quickly deployed by one person

in areas that might not be easily accessible. Both systems included a GPS clock.

The S6000's were selected from the equipment previously deployed in the most recent mine experiment and hence were felt to be in proper working order.

The Chaparral microphone cables were repined to operated from the DAS internal 12-volt power supply. While designed to operate from 24 volts, it is possible to operate them from a well-regulated 12-volt supply. Doing so reduces the gain and dynamic range of the microphones. In the available time, it was not practical to use an additional 24-volt system for each microphone. The microphones were left set for high gain (low range) to avoid opening the case. At the time of preparation, SMU sites had not yet been chosen and hence the expected signal levels were completely unknown.

The Validyne DP350's were salvaged units first tested during the McKinney Huddle Test. These units have backing volumes that are too small and hence are too over damped to provide a flat frequency response. The units were also deemed too insensitive and band limited for deployment in the Western US mine experiments. However, they were available while all high range systems were in the field.

One GS-13 was taken as an instrument with sufficient sensitivity that it might be able to record longer period signals (> 10 seconds).

A Sony EVW-300 Hi8 video camera with external microphone was taken to the site to document the shot. This camera had arrived about a day before. Instruction on its use and setting the many controls (while not a professional camera, it has many of the controls of a professional unit) was necessarily limited. Three battery packs were charged on a 1-Amp-Hour constant current power supply for 85 minutes each. The charge was aborted when the battery pack temperature began to rise. One pack was opened and converted to an external power supply adapter such that the camera could be operated for extended periods from a gel cell. The internal packs are 10-cell packs and include an internal thermal circuit breaker and charge temperature sensor. A fully charged battery pack powered the camera and viewfinder for 105 minutes before indicating low battery condition.

Deployment

Equipment was deployed from 6:00-7:00 Sunday morning February 20, 2000. Initial deployment started before sunrise. In order to simplify matters three SMU instruments were collocated with blast monitors (Figure 4). A fourth instrument was put on the second floor of a parking garage opposite the blast.

Figure 4. Site location



photograph. The red dots are instrument locations. The green dot is the observation point for the SMU video. The building circled in yellow was demolished.

All instruments were configured to record at 250 SPS in 32-bit mode. Channels 1-3 were assigned to the seismometer, channel 4 was assigned to the Validyne DP350, and channel 5 was assigned to the Chaparral if present. Site 3 included a GS-13 on channel 6. All channels were run with a preamp gain of 0 dB. Data was set for continuous record, but to preserve the limited battery power, recording was delayed for 30 minutes to an hour. The shot was scheduled for 8 am.

Site 1

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Figure 5. Site 1 with microphones on railings.



(Figure 5) was on the third level of a parking garage even second story of the building. This was nearly the same site 2, but we felt that that direct horizontal path might larger signal. The seismometer was omitted from this Validyne DP350 S/N 16627 and Chaparral M2 S/N 1298 were on the railing of the garage, as was the RefTek GPS clock. recorded on DAS S/N 0967.

conclusion of the experiment, the GPS clock had not obtained probably because the sky was too obscured at this location. video camera looking down at the top of the building was the roof of the garage.

conclusion of the shot (Figure 6), instruments were clean even distance. The dust cloud had moved in the other direction and overhang protected the equipment from falling debris. Such a was protected enough that it would have been suitable for leaving the SMU video system.



Site 2

The



Site 2 (Figure 7) was at street level in front of the Harris Methodist Breast Feeding Resource Center. The system included a S6000 SN 9399 and Validyne DP350 SN 16622. The S6000 was put on the sidewalk and the DP350 on top a bale of hay. Data was recorded on DAS S/N 1011.

system did not include an clock.

Figure 7. Site 2 at street level. Site 3 is off the left side of the picture.

Site 3 Site 3 secured a 1317, and the locked to RefTek



Figure 8. Site 3 looking

(Figures 8 and 9) was on a vacant grassy lot just inside the area. The system included an S6000 SN 9400 set on the grass, Validyne DP350 SN 16625 in the grass, a Chaparral M2 SN a GS-13 positioned 10 feet away from the S6000 and towards building on a sidewalk. The system included a GPS clock that the correct time prior to the shot. Data was recorded on DAS SN 1098.



Figure 9. Site 3 as viewed from site 1.

Site 4



Site 4 (Figures 3 and 10) was at street level at the valet entrance to the Harris Methodist Klabzuba Tower. The system included a S6000 SN9398, a Validyne DP350 SN16614, a Chaparral M2 SN1316, and a GPS clock.

At the conclusion of the recording, this site had not obtained a GPS lock. The equipment was in the path of the initial heavy dust cloud. Dust was heavy enough to completely obscure the red paint on the Validyne sensor, but did not otherwise seem to affect the microphones or open connectors on the RefTek recorder.

Figure 10. Site 4 post demolition. Ed Jakubowski retrieving Blast mate. The instrument is the small box near the curb. The sensor was bolted to the curb with a concrete anchor. The equipment was far enough away that except for some chunks of fiberglass insulation, there were no larger pieces of material.

Local News Coverage



Figure 11. About 10 minutes after the demolition when the large dust cloud has dissipated.

The relevant facts related to the blast (Figure 11) were described in the above local stories:

http://www.msnbc.com/local/kxas/22447.asp http://www.startext.com/news/doc/1047/1:METRO13/1:METRO130221100.html http://www.cbs11tv.com/news_story.cfm?DID=2224 http://dallasnews.com/metro/34290_IMPLODE21.html

Of these, the most useful is that in the Star Telegram, reproduced below.

Blasts implode 6-story Fort Worth office building; crowd cheers demise of '50s-era structure

By Paul Bourgeois Star-Telegram Staff Writer

FORT WORTH -- The quiet stillness of a Sunday morning in Fort Worth was broken yesterday by a series of dynamite blasts, a roar and then the cheers of about 2,000 people.

A series of 10 explosions knocked out the supports, and in 13.5 seconds the 60,000- square-foot office building at 800 Fifth Ave., built in 1957, was a pile of busted concrete and gnarled steel.

The roar as the 6-story building fell could be heard at least a mile away. The cheers and applause were almost as loud. A westerly wind was minimal, but a thick cloud of fine white power descended on everyone and everything for a couple of blocks in all directions.

Some spectators quickly donned cloth masks.

Harris Methodist Fort Worth hospital spokeswoman Laura Van Hoosier said, "The site is earmarked for ambulatory services development," but a firm decision has not been made.

With implosion, controlled blasts are designed to cause a building to collapse upon itself rather than blow outward.

"Cool!" was about all an awe-struck Justin Kapp, 10, could manage, but brother Johnny, 9, topped him with, "Really cool!"

Scheduled for 8 a.m., the blast was delayed 10 minutes as a trauma case was rushed into the Harris Methodist emergency room across the street. Aside from a short delay, it went like clockwork, engineers said.

The blasts, triggered by 110 pounds of nitroglycerin-based dynamite, sent a small amount of rubble into the street, but bulldozers and street sweepers immediately cleared it. Within an hour after the blast, all debris was cleared from the streets.

"It was just as we planned, maybe a little better," said Doug Loizeaux, vice president of Controlled Demolition.

"The plan was not only to bring it down safely. It was to fragment it so that it can be removed easily, and we did that," he said.

Denton Wilson, a Harris Methodist project engineer, said the site will be cleared within 30 days.

"With a wrecking ball it would take 45 days and produce a lot of noise and dust. And being near the ER with a lot of ambulance traffic that could be a problem," he said.

Wilson said one quick blast was less of a bother for patients, the hospital and its neighbors.

Mary and Jack Endres trucked in their four children from Muenster just for the blast.

Said Mary Endres: "It's a once-in-a-lifetime experience."

Paul Bourgeois, (817) 390-7796 Send comments to <u>bourgeois@star-telegram.com</u>

Blast Description



Figure 12. Post demolition view on the southwest side of the building looking toward the northeast. Site 4 is at the left of the frame (next to the small street sweeper). Site 3 is in the grassy area at the far right of the frame.



Figure 13. A few frames from the SMU video reel. The initial frame with the fireball is from the first series of detonations. The next three frames are from the final blast.

The explosions (Figures 12 and 13) occurred in two sets, an initial set of 10 explosions spaced at long regular intervals (> 250 ms) designed to weaken the structure and a second set of

explosions a few seconds later so closely timed that they sounded simultaneous. The second set collapsed the building. The initial detonation and explosion produced a brief fireball at the northwest corner of the building. Later explosions in the first stage blew out small amounts of dust from second and third story windows.

The final collapse raised a small dust cloud over 250 feet high that quickly settled within one or two blocks of the explosions.

Photographing the blast with the small 24 mm camera was difficult since the cycle time for the camera is as much as several seconds between frames. Even cycling the camera as quickly as possible produced only two interesting photographs, one showing the initial dust from the initial shots and one showing the collapsed building. Using a high speed 35 mm motor drive would have captured more interesting photographs.

Equipment was recovered as soon as the dust had settled and before the area was open to general traffic (within 30 minutes).

Cleanup was completed within a few hours. The final photographs of the building were taken after the construction crew completed work for the day (Figure 14).



Figure 14. Post demolition view on the east side looking west after street cleanup.

Seismic Data Review

Table 1. List of serial numbers for each of the instruments. This may be used as a key to the following waveform illustrations.

Site	DAS Serial Number	Sensors	Comments
1	0967	Validyne 16627 Chaparral 1298	Clock never locked. Chaparral clipped
2	1011	Validyne 16622 S6000 SN9399	No Clock
3	1098	Validyne 16625 Chaparral 1317 S6000 9400 GS-13	Clock locked to correct time prior to the experiment.
4	1103	Validyne 16614	Clock never locked. Chaparral clipped.

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	Chaparral 1316	
	S6000 9398	
	S6000 9398	

The data was converted from the RefTek raw format using PASSCAL software *ref2segy* on a Sun workstation. This operation produced a SEGY format dataset of 10-minute segments for each channel. Segments were continuous from the record start time, about 45 minutes prior to the shot, until the recorder was retrieved. These segments were then merged into a single waveform for each station-channel (up to 40 minutes of data per channel). The merged SEGY records were converted to CSS 3.0 format using PASSCAL's *segy2css*. The original data was recorded in ten-minute segments. Each channel was then merged to produce a continuous recording. The merged segments were time aligned using the first break on the site 3 recording. Other stations were arbitrarily aligned with the absolute time on site 3. Approximate velocity calibration factors for the S6000, GS-13 and nominal factory calibrations for the Chaparral and Validyne sensors were added to the header. The traces were then trimmed to 45 seconds using *css2tar* and archived in the CSS 3.0 flat file database '*trimed.wfdisc*'. The waveforms in '*trimed.wfdisc*' were used in the rest of this analysis.

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Figure 15. Trimmed dataset. Times shown are relative. The :01:00 time mark is at absolute time 14:11:2.66Z which is the time of first seismic motion at site 3. Tick marks are at 2-second intervals. It probably represents the initial detonation cord event. Traces are labeled with the DAS serial number (see also table 1) and channel name (see table 2). Scaling is trace variable.

Table 2.	Channel i	legend.
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Channel name	Explanation
sd	Validyne acoustic sensor.
hd	High Gain Chaparral acoustic sensor
SZ	Vertical seismometer
sr	Radial seismometer
st	Transverse seismometer
Hz	High gain vertical seismometer (GS-13)

From the overall dataset (Tables 1 and 2 and Figure 15), it is obvious that the Chaparral's (hd channels) are clipped even when operated with a reduced gain on 12 volts rather than 24. It may be that the instruments themselves were unclipped, but that the low 2.5-volt range of the RefTek's produces clipping on the input. The bottom trace (967/hd) shows a slight step function at the end of the signal. There is no physical explanation for this unless the diaphragm has acquired bistable flex. The Validyne channels (1011/sd, 1098/sd, 1103/sd, and 967/sd) all look reasonable, but appear to be deficient in high frequencies relative to the seismic channels. This is a suspected problem in the DP350 design used for this experiment. Current SMU field experiments use an improved design based on the DP250 diaphragm.

Seismic channels (sz, sr, and st) appear valid, although the close correlation of the seismic with the acoustic suggests that in most cases the recorded seismic signal is the result of acoustic to ground (or seismometer) coupling at the recording site. Seismic traces from the S6000 at site 3 (1098/sz, 1098/sr, and 1098/st) show a harmonic ringing at 19 Hz, particularly on the horizontal traces late in the record. The GS-13 (1098/hz) placed about 10 feet away on a sidewalk does not show this behavior. Correlated with this ringing is a large low frequency pulse on the acoustic channel. Site 4 (1103/st) shows a similar but smaller effect on the horizontal channels.

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Figure 16. Enlarged view of seismic channels. Traces have trace variable scaling. Peak velocity was recorded at site $4 \text{ of } 3x \text{ } 10^6 \text{ nm/sec}$ (peak to trough). The corresponding frequency of the waveform at peak velocity is 40.7 Hz. The peak velocity occurred in the second series of shots (building collapse) although one of the first series of shots was nearly as large.

An enlarged view of the seismic channels (Figure 16) shows more similarity in the first series of explosions than in the second. The largest impulse in the first series of shots occurred about one second into the blast, at what is probably the second detonation (excluding the initial detonation cord blast). This is true for all three sites. The second series of explosions shows more variability. The highest velocity at site 4 occurs about 4 seconds into the second blast, while the largest at site 2 is about 2 seconds into the second blast. Furthermore site 2, the nearest to the blast recorded smaller signals than site 4 nearly 5 times further away. During the first series of blasts, the individual explosions are distinct, particularly at high frequencies at site 3 on the GS-13 instrument (1098/hz). During the demolition blast though individual shots are more difficult to distinguish.

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Figure 17. Un corrected velocity power spectra for all three sites (4 instruments since two instruments recorded site 3. The spectrum is an average for both blast sequences. Background noise level is from 80 to 90 dB. The notch in the spectra at 60-70 Hz is not observed in the background noise.

Spectra of the recorded energy (Figure 17) extended through the band from 5 to 7 Hz (above the 2 Hz instrument corner) up to the recording recorder anti-alias filters of 100 Hz. Below 50 Hz, spectral energy is similar on all instruments, but above 100 Hz shows varies by 20 dB. Although the peak energy was recorded at 40 Hz, the average spectra are relatively flat to displacement below 40 Hz.

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Figure 18. Lowpass filters for the GS-13 at site 3. Top trace is unfiltered. Following traces have cutoffs of 1.0, 0.5, 0.25, 0.10, and 0.05 Hz. Traces have individual scaling applied.

Although seismic energy drops off at lower frequencies, the there still is sufficient energy to overcome the GS-13 instrument roll-off at 1 Hz (Figure 18). A positive excursion indicates ground motion towards the surface (seismometer frame up). Amplitudes are relative and traces have not yet been instrument corrected. For these low frequencies, the GS-13 seismometer is effectively an accelerometer and plotted traces are nearly acceleograms.

The small precursor (at :01:07 on figure 18) is interesting in that this occurs late in the first blast sequence, but prior to any significant movement of the building.

Acoustic Data Review

At least 30 minutes prior to the scheduled shot time, there were multiple news helicopters orbiting the building. This resulted in a high acoustic noise background. About five minutes prior to the shot, there were four helicopters making slow circles around the building. About one minute prior to the shot, the helicopters began to hover to provide stable camera platforms during the explosion. This change is seen in the acoustic noise panels (Figure 19).

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Figure 19. Acoustic background noise 2 octave filter panels of helicopter noise. Left panel is from 4 helicopters orbiting the building. Right panel is from four helicopters at hover. Panels are scale with a single scale factor. Trace lowpass corners are none, 0.5, 1.0, 2.0, 4.0, 8.0, 16.0, 32.0, 64.0 Hz. High pass corners are two octaves above.

Acoustic waveforms are similar to seismic although the energy distribution between the first and second series of blasts is noticeably different (Figure 20). In the seismic waveforms the peak amplitudes are recorded in the second series of blasts instead of the first. In addition the seismic waveforms appear to be richer in high frequencies than the acoustic.

The largest acoustic pulse was recorded at site 2 during the first sequence of shots (specifically the second acoustic impulse) approximately 0.5 seconds from the initial shock. Peak pressures vary by a factor of 5 from the most energetic at site 2 to the least energetic at site 3. At all but site 3, the strong peak in the first sequence of shots is larger than succeeding shots.

At :01:15 a long period impulse appears on the acoustic channels just as it has on the seismic channels. Individual shots are easily discerned on the acoustic channels during the first sequence of shots, but are more difficult to distinguish in the second set.

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Figure 20. Overview of the acoustic waveforms. Traces have independent scale factors. Pressures shown (100 Pa for 1011/sd) have not been corrected for a common backing volume factor, but are correct relative to each other.

At all sites, acoustic reflections are visible (Figure 21), but site 3 (1098) shows the clearest separation. The inverted pulse on 1098/sd at roughly 0.3 seconds from the initial impulse end is nearly the same amplitude as the first arrival. This same interval and amplitude is repeated for the second pulse at 0.5 and 0.8 seconds. The multiple arrivals were not stationary enough to be deconvolved from the data, probably because the source itself was not stationary relative to the reflectors.

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Figure 21. Acoustic waveforms for the first 2 seconds. Traces are independently scaled.

Filter panels of the acoustic waveform at site 3 (1098) are typical of all sites (Figure 22), although site 3 is more complex due to the strong reflection. Two octave panels demonstrate that for most of the waveform, in particular that attributed to the direct blast energy, most of the acoustic energy is above 4 Hz. The higher frequencies (32-125 Hz) clearly show the individual blasts in the first series. Although most low frequency amplitudes are smaller than peaks in the high frequency panels, there is still substantial energy received in the low frequency signal after the final shot sequence (at :01:15). Peak pressures in the 0.5-2 Hz band at site 3 are only 6 dB less than the overall pea

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Figure 22. Two-octave filter panel for site 3 acoustic sensor. Traces have panel constant scaling. Top trace is unfiltered. All other traces have two octave bandpass filters applied except the last trace that uses a one-octave filter. Filter low pass corners are 0.5, 1, 2, 4, 8, 16, 32, and 64 Hz.

Long period response at site 3 is similar to the seismic response (Figure 23), particularly below 0.5 Hz. Below 0.5 Hz, the peak is about 12 dB smaller than the peak wideband response. Below 1/20 Hz, the peak is about 5% of the amplitude of the wideband signal. Although such signals are small relative to the audible acoustic signal, they propagate well in the atmosphere with very little attenuation. It is therefore likely that under the right conditions, such a long period signal could have been observed at long distances.

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Figure 23. Lowpass filter panel for acoustic waveforms at Site 3. Top trace is unfiltered. Following traces have low pass corners of 2, 1, 0.5, 0.25, 0.1 and 0.05 Hz. Panel has trace variable gain. The bottom trace amplitudes are about 1/20 of the unfiltered top trace.

Conclusions

- 1. With proper preparation, it should be possible to deploy similarly configured systems in less than 5 minutes per site. The use of light weight gel-cell batteries makes backpack deployments feasible.
- 2. The Chaparral microphones as currently configured are unsuited for near-source recording or operation from RefTek internal 12 volt power. For the pressures encountered in this experiment, Chaparral microphones would come close to clipping even if set at low gain and properly attenuated in the RefTek recorder.
- 3. Validyne DP350 units with the SMU model 6 enclosures have sufficient dynamic range, but have an as yet uncalculated instrument response due to an insufficient backing volume. This was first demonstrated during the McKinney Rubber Mirror experiment.
- 4. The Sony EVW camera is complex enough that a one or two page quick setup sheet is needed. In the experiment footage, balancing the aperture against the shutter speed and video noise was not optimum (too much video noise). Although a dust cover was prepared, it was not deployed for the experiment. The camera proved to be more stable resting on a concrete pillar than tripod.
- 5. The interesting portion of the waveforms lasted about 30 seconds, far longer than close experiments for quarry shots. Even with the relatively long delay between individual blasts, individual blasts are not always clearly distinguishable at all sites.
- 6. Even with 1 Hz seismometers, there is good S/N for all sites from under 1/20 Hz to the 100 Hz nyquist recording filter.
- 7. The strong acoustic and seismic pulse appears to be correlated with the fireball seen in frame 1 of Figure 13.
- 8. The similarity between the seismic lowpass recordings (Figure 18) and acoustic lowpass recordings (Figure 23) suggests that the principle origin of low frequency seismic energy is from the acoustic impulse. The sign of the acoustic impulse is consistent with acoustic loading.
- Distinct strong acoustic reflections recorded at site 3 (Figure 21) are consistent with position of the site relative to an effective acoustic corner reflector formed by the hospital and surrounding buildings.
- 10. The demolition produced significant long period energy that could have been observed at greater distances.