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Vibro-Acoustic Response of Buildings Due to Sonic Boom Exposure: July 2007 Field Test

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September 2008

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CHAPTER 1: INTRODUCTION

Civilian supersonic flight over land is restricted in part due to the environmental impact of sonic booms on populations over which the aircraft would fly. These restrictions were put in place based on research performed in the 1960's which studied boom intrusiveness from conventional supersonic aircraft designs that produce overpressures on the ground in the range of 1 lb_f/ft^2 or more during straight and level flight. The sound produced on the ground by sonic booms, characterized by a classic N shaped pressure signature with a high overpressure and fast rise time, was found to be intrusive enough to a populace to warrant these blanket restrictions. However, there is currently a desire among airplane manufacturers to design, build, and market supersonic business jets capable of supersonic flight over land through the use of advanced technology to mitigate boom intrusiveness. This goal has been motivated in part by the demonstration of sonic boom shaping by DARPA, NASA, and industrial partners during a recent experiment.[1] In that experiment, it was shown that the peak overpressure of a sonic boom could be reduced in a predictable way by shaping the airframe. By shaping future aircraft to modify the shock structure, several airframe builders are pursuing novel small aircraft designs that should result in significantly lower boom overpressures and slower rise times than those produced by current supersonic aircraft. Thus, there is hope that, due to the modified pressure signature observed on the ground, these designs could be capable of flying supersonically over populated land without creating objectionable noise.

However, supersonic flight over land will only be possible after modification of restrictions that are currently in place. Such modifications will require substantial justification that boom signatures generated on the ground by low boom aircraft are not objectionable to citizens. Thus, to evaluate the effects of low amplitude sonic booms, and ultimately affect decisions regarding supersonic flight restrictions, knowledge and tools need to be developed to enable study and prediction of the noise generated by low overpressure booms. One aspect of this effort needs to focus on commonly populated environments, such as inside residential buildings. For the purposes of development and validation of indoor structural acoustic modeling tools, a series of tests was conducted in July 2007 by NASA personnel, industry and academic partners on a house exposed to several sonic booms of varying peak overpressure. The test conducted in July 2007 is similar to a test which took place during June of 2006.[2] However, in contrast to the house instrumented in 2006, which was more than 40 years old at the time of the test, the house instrumented in July 2007 was built in 1997 and was constructed using modern building elements (such as tight fitting, insulated glass windows). Many of the audible effects observed in the 2006 test house, such as significant levels of rattle, were not as pronounced inside the 2007 test house. The focus of this report is to document the vibroacoustic response measurements that were acquired on this house in July 2007.

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[1] K.J. Plotkin, J.A. Page, D.H. Graham, J.W. Pawlowski, D.B. Schein, P.G. Coen, D.A. McCurdy, E.A. Haering, J.E. Murray, L.J. Ehernberger, D.J. Maglieri, P.J. Bobbitt, A. Pilon, J. Salamone, "Ground Measurements of a Shaped Sonic Boom", Proceedings of the 10th AIAA/CEAS Aeroacoustics Conference, Paper number AIAA 2004-2923, 2004.

[2] J. Klos, R.D. Buehrle, "Vibro-Acoustic Response of Buildings Due to Sonic Boom Exposure: June 2006 Field Test", NASA TM 2007-214900.

Section 1.1: Test summary

The single story duplex used in this test is shown in Figures 1.1 and 1.2. More detail about the physical layout of the house is documented in Chapter 2. One hundred and twelve transducers, a mix of accelerometers and microphones, were installed in three bedrooms in the house. Accelerometers were attached to the walls, windows, and ceilings in these three rooms to measure the vibration response of these structures to the sonic boom excitation. Several microphones were placed in random locations in each room to sample the resulting interior noise. In addition, several microphones were placed outside, surrounding the house, to characterize the excitation field and measure the diffraction of the boom around the house. All the transducers were simultaneously sampled and time histories of each transducer were recorded at a sample rate of 25,600 samples per second. More detail is given in Chapter 3 concerning the transducer types used, layout of the transducers, and changes that were made to the hardware as the experiment progressed.

Over the course of five days of testing, the structural acoustic response of the house was measured for 42 sonic booms that ranged in overpressure from 0.1 lb_f/ft^2 to 2.0 lb_f/ft^2, as measured by a ground microphone placed outside the house. This range of overpressures spanned those that are believed to be attainable by supersonic business jets incorporating low boom designs (0.1 to 0.3 lb_f/ft^2) in addition to those typically generated by the current fleet of supersonic aircraft (greater than 1 lb_f/ft^2). All 42 sonic booms studied were generated using F/A 18 aircraft maintained, operated and flown by NASA Dryden personnel. Typically, an F/A 18 aircraft would not be capable of generating a sonic boom with overpressures in the lower portion of the range studied. However, a unique dive maneuver (Figure 1.3) was used to generate sonic booms that resulted in the low overpressure observed at the house. More detail on how the booms were generated, and why low amplitude booms are observed at the house, is given in Chapter 4. Of the 42 sonic booms measured during this experiment, 30 were low overpressure booms generated by the dive maneuver and ranged from 0.10 lb_f/ft^2 to 0.90 lb_f/ft^2. The other 12 booms were generated by straight and level flight of the F/A 18 over the test house. The overpressures observed at the house from these normal amplitude booms ranged from 1.0 lb_f/ft^2 to 2.0 lb_f/ft^2.

In addition to the sonic boom response measurements, several simple tests were conducted to characterize the response of the house's acoustic spaces and structural elements. These tests are documented in Chapter 5 and include shaker excitation of the walls and windows of the three bedrooms, reverberation time measurements, and impulsive brown paper bag pops inside all of the rooms and outside the house at various locations. The response data that are available for the boom measurements and the characterization tests, and the formats used to store the data, are presented in Chapter 6.

Figure 1.1: Photograph of both sides of the duplex, the instrumented side is on the left.

Figure 1.2: Photograph of the left portion of the duplex, which was instrumented.

Figure 1.3: Photograph of the dive maneuver of the F/A 18 aircraft that was used to generate the low amplitude sonic booms.

CHAPTER 2: HOUSE DESCRIPTION

This chapter provides a physical description of the inside and outside of the house and the surrounding area. Chapter 3 provides a description of the transducers, data acquisition equipment, and any other hardware installed in the house during this test, including mounting locations and daily placement variations of the transducers. Many tests were performed to measure the response of the house due to sonic boom exposure. In addition, tests were performed to characterizing the vibroacoustic response of the house due to mechanical shaker and impulsive acoustic excitations. Chapters 4 and 5 document the sonic boom tests and characterization tests, respectively, performed on this house during this experiment.

Section 2.1: Indoor house description

The physical address of the house used in this experiment was 52 Blackbird Street, Edwards, CA. The floor plan of the house at 52 Blackbird Street is shown in Figure 2.1 and Appendix A. This house was a single story, two-family duplex (Figure 2.2), where the floor plans of the two units were a mirror images, which were offset by 5.5 feet (Figure 2.3). Even though the neighboring unit was occupied during this experiment, the wall separating the two units provided sufficient acoustical isolation so there was very little, if any, increase in indoor ambient noise due to presence of the neighbor.

Inside the test house, there were three bedrooms, two bathrooms, an attached garage, and an open living space that included a family room, living area, kitchen, and dining area. The main living area of the house was used as a control room and contained all the data acquisition and signal conditioning equipment that was needed to conduct the tests (Figure 2.4). The equipment in this area did make audible noise during the test, so a microphone was placed in the family room to record the level of ambient noise created by this equipment. Additional noise sources, like the refrigerator, heating, ventilation, and air conditioning (HVAC) system, and sprinkler system, were turned off during measurements to reduce the ambient noise inside and outside the house. Unfortunately, one significant source of ambient noise inside and outside the house was not eliminated. The HVAC compressor for the neighboring duplex was located directly south of the instrumented rooms and, while running, caused a significant increase in ambient noise both inside and outside the house. This source of ambient noise will be discussed in Section 2.2.

All three bedrooms in the house (Figure 2.1) were instrumented with accelerometers and microphones during this test. Accelerometers were mounted to the walls, windows, and ceilings and microphones were randomly placed inside the rooms (Appendix B). It should be noted that several microphones were also placed outside surrounding the house. These microphones are discussed in Section 2.2 and documented in Chapter 3 and Appendix C. The orientation of the floor plan (Figure 2.1) is illustrated relative to the approximate cardinal directions. These cardinal directions are used in this document to identify and discuss the walls of each of the instrumented bedrooms and the transducers attached to those walls. For later discussion and reference purposes, photographs of these three bedrooms are presented in Figures 2.5 through 2.16. Included in these photographs are pictures of the window in each of the rooms.

The dimensions of the three bedrooms and the locations of features in the bedrooms (e.g. doors, windows, lighting fixtures, and acoustical damping) are documented in tables, drawings and photographs provided in Appendices A and B. It should be noted that these are estimates based on measurements made by the researchers involved in this experiment using a tape measure. Architectural plans for this house and all of the surrounding houses were obtained from the Air Force; however, they are not included in this document. They are available upon request. These plans identify room sizes, wall construction, ceiling/roof construction, materials used, and the overall house layout. These architectural plans along with the measurements made by the researchers should be sufficient to define the "as built" layout of the house. A brief discussion of the house interior is given in the following sub-sections, including:

- A description of the general construction
- The notable features in the three-instrumented bedrooms
- Possible sources of rattle type noise in these rooms
- A general identification of transducers used in each room
- A general discussion of measurements made in each room

While a general discussion of the transducers that were used is given in this chapter, the detailed documentation of the locations of those transducers is given in Appendix B and a discussion of the types of transducers used is left until Chapter 3. In addition, the sonic boom tests and structural-acoustic characterization tests performed during this experiment are summarized here and detailed documentation is given in Chapters 4 and 5, respectively.

Subsection 2.1.1: General house construction

The house was built atop a slab foundation and exterior walls were bolted to the slab foundation. Based on similar tests conducted in 2006[1], vibration of the slab was not expected to be significant; thus, no accelerometers were placed on the slab.

The exterior walls of the house consisted of 2x6 wood framing, 16-inches on center, with a 1/2-inch thick gypsum interior finish, stucco over metal lath and plywood sheathed exterior finish, with R-19 thermal insulation in the air cavity. Most of the interior walls were constructed using 2x4 wood framing, 16-inches on center, with 1/2-inch gypsum board on the finished sides of the wall, and 3.5-inches of acoustical insulation in the air cavity. The exceptions to this were the two interior walls separating the "garage bedroom" from the master bathroom and the "front bedroom" from the second bathroom (Figure 2.1). These two walls were framed using 2x6 wood framing, 16-inches on center, with 1/2-inch thick moisture resistant gypsum board on the finished sides of the wall and

[1] J. Klos and R. D. Buehrle, "Vibro-Acoustic Response of Buildings Due to Sonic Boom Exposure: June 2006 Field Test", NASA TM 2007-214900.

no acoustic insulation in the air cavity. For this experiment, accelerometers were attached to the finished, gypsum board side of walls of the instrumented rooms.

The roof was pre-manufactured truss framed, plywood sheathed, and finished with fiberglass shingles. This roof system formed an attic space above all of the rooms. There was scuttle access to the attic in the ceiling right outside the entry door to the master bedroom, and photographs of the attic space were taken from this vantage point. The attic above the master bedroom, looking south, is shown in Figure 2.17 and the attic above the main living area, looking north, is shown in Figure 2.18. The attic above the other two bedrooms was not accessible. Roof sheathing separated the attic above these two rooms from the attic above the master bedroom and main living area (Figure 2.19). Thus, there are no pictures of the roof framing above the other two bedrooms. R-38 fiberglass insulation bats were installed in the attic (Figures 2.17 through 2.19), which affected the reverberation time of the attic. Reverberation time measurements were made in the attic above the master bedroom and living area and are documented in Chapter 5. While accelerometers were attached to the ceiling sheetrock in two of the bedrooms (Chapter 3 and Appendix B), no accelerometers were placed on the roof sheathing. One microphone was placed in the attic above the family room to sense the acoustic response of this acoustic space (Chapter 3 and Appendix B).

The interior of the house was finished, and in "move-in" condition. All of the rooms in the house, except the kitchen, were carpeted with pile carpeting over a carpet pad, which affected the reverberation time of the rooms. In addition to the carpeting present in each room, open cell foam mattress pads were also placed in the bedrooms to increase the acoustical absorption (Figures 2.7, 2.10 and 2.16). The locations of the foam mattress pads are discussed in this Chapter and detailed locations are documented in Appendix B. Reverberation time measurements, which are documented in Chapter 5, were made in each room with the foam mattress pads in place.

Subsection 2.1.2: Description of the master bedroom

The ceiling in the master bedroom was vaulted at an 11.77-degree angle (Figure 2.5a and c). There was an attic space above this vaulted ceiling with R-38 fiberglass insulation placed in the attic (Figure 2.17). The roof framing was a pre-manufactured truss system, where there was a single mechanical connection between the ceiling in the bedroom and the roof sheathing (Figure 2.17). Inside the room, there was a ceiling fan attached to the ceiling in this bedroom, but it did not appear to rattle. Five accelerometers were attached to the ceiling sheetrock (Chapter 3 and Appendix B).

The south wall of the master bedroom was a large, continuous, exterior wall (Figure 2.5a). A significant number of accelerometers were placed on this wall (Chapter 3 and Appendix B). In addition to measuring the response of this wall to the boom excitation, a mechanical shaker was used to excite the wall to characterize the forced vibration response. These shaker tests were performed with the shaker attached to both the interior sheetrock and exterior stucco, and are documented in Chapter 5.

A window was framed into the exterior wall on the west side of the master bedroom (Figure 2.5b). The manufacturer and model of the window was an Alenco series 3822/3822F HS-R25 window. The dimensions of the window opening were 57.875-inches wide by 46-inches high. The window consisted of two glazings where each glazing was a double pane insulated glass assembly (Figure 2.6). An aluminum sash held each glazing, and the glazing was well mounted in the sash so there was no glass-on-metal rattle. A metal frame attached to the house held each sash. In between the sash and the frame was a pile type weather-stripping that reduced the potential for direct metal-on-metal contact. The left sash of the window did not open as it was fixed in the window frame. It did not appear to rattle. Only the right sash of the window was operable (Figures 2.5b and 2.6) and slid horizontally in the metal frame. There was very little mechanical play in this sash-frame interface, but rattle did occur at this interface when the glazing was excited substantially. In particular, rattle appeared to occur along the interface of the right sash and the right jamb of the frame. In addition, the locking mechanism of this window was also a potential source of contact-induced noise. Eight accelerometers were attached to this window and several were mounted to the wall surrounding the window (Chapter 3 and Appendix B). Four microphones were placed in the near field of the operable sash, three near the interior surface and one near the exterior surface (Chapter 3 and Appendix B). These microphones were co-located with some of the accelerometers mounted to the window. All of the microphones were within 1/2-inch of the glass surface.

A closet was framed into the north wall of the master bedroom that divided the master bedroom from the family room (Figure 2.5c). The closet doors and hanger rods were left in place for all the tests documented in this report. The right closet door was left open during testing as is pictured in Figure 2.5c. Foam mattress pads were placed in the closet and attached to the outside of the closet door to decrease the reverberation time of the room (Figure 2.7). The location of these mattress pads are documented in Appendix B. Reverberation time measurements for this room, with the foam mattress pads in place, are documented in Chapter 5. The closet doors were loose at the bottom and were a potential source of low- to mid-frequency rattle noise inside this room. Unfortunately, no accelerometers were mounted to either of the closet doors. The wood shelves in the closet were left in place; however, these shelves were nailed tightly to the walls and did not exhibit rattle. Several accelerometers were placed on the closet wall, inside the closet near the shelves (Chapter 3 and Appendix B). The entry door to the room on the south wall was closed while measurements were made. The door was tight fitting in the frame, but was a potential source of rattle. One accelerometer was placed on this door (Chapter 3 and Appendix B). Above the closet, there was a vent for the HVAC system (Figure 2.5c), which was always turned off during testing.

There was a sliding pocket door in the east wall of the master bedroom (Figure 2.5d) dividing the master bedroom and master bathroom (Figures 2.5e and 2.5f). The pocket door was closed while measurements were made. There was a substantial amount of mechanical play in the pocket door, and this was a potential source of contact-induced noise. No accelerometers were placed on the pocket door itself; however, there were accelerometers located on the wall next to and above the pocket door (Chapter 3 and

Appendix B). The wall above the pocket door was rather flimsy, and appeared to lack typical 16" spaced stud framing found in the other interior walls of this house.

Subsection 2.1.3: Description of the "garage" bedroom

Throughout this report, the bedroom that is adjacent to the garage is referred to as the "garage" bedroom (Figure 2.1). The ceiling in the garage bedroom was not vaulted, and was 8-feet high. There was an attic space above this room; however, the attic above this room was not accessible (Figure 2.19 and Section 2.1.1). Consequently, no photographs of the framing of the attic above this room were taken. The framing of the attic can be inferred from the architectural drawings that are available upon request. There was a ceiling fan attached to this ceiling; however, it did not appear to be a significant source of rattle. Four accelerometers were attached to the ceiling (Chapter 3 and Appendix B).

A window was framed into the south wall of the of the garage bedroom (Figures 2.8a and 2.9). The manufacturer and model of the window was an Alenco series 3822/3822F HS-R25 window. This was the same model as was found in the master bedroom, but with different dimensions. The dimensions of this window opening were 70.625-inches wide by 46-inches high. The measured location of this window within the wall varied slightly from the architectural plans that were obtained from the Air Force. The window was actually located 42.125 inches from the east wall of the garage bedroom (Figure 2.8a). The construction of this double pane, insulated glass window is the same as is described in Section 2.1.1 for the master bedroom window. However, the apparent sources of rattle for this window were slightly different. The dominant source of potential contact-induced noise appeared to be from where the fixed and operable sashes joined. Eight accelerometers were attached to this window and several accelerometers were mounted to the wall containing this window (Chapter 3 and Appendix B). During this experiment, two microphones were placed in the near field of the fixed sash, one near the interior surface and one near the exterior surface (Chapter 3 and Appendix B). Both were within 1/2-inch of the glass surface. In addition to the sonic boom response measurements, data were also acquired for mechanical excitation of both the wall and window. These shaker measurements are documented in Chapter 5.

A closet was framed into the west wall of the garage bedroom (Figure 2.8b), the wall that separates the garage bedroom from the master bathroom (Figure 2.1). The closet doors and hanger rods were left in place for all the tests documented in this report. The left closet door was left open during testing, as is pictured in Figure 2.8b, and foam mattress pads were placed inside the closet (Figure 2.10) to increase the acoustic absorption in the room. The closet doors were loose at the bottom and were a potential source of low- to mid-frequency rattle noise inside this room. Unfortunately, no accelerometers were mounted to either of the closet doors. The wood shelves in the closet were left in place; however, these shelves were nailed tightly to the walls and did not exhibit rattle. Several accelerometers were placed on the closet wall inside the closet behind the foam mattress pads (Chapter 3 and Appendix B).

The north wall of the garage bedroom contained the entry door to the room. This door remained closed during measurements, and was tight fitting but rattle was possible. One accelerometer was placed on this door and one was placed near the middle of the north wall (Chapter 3 and Appendix B). To decrease the reverberation time of the room, foam mattress pads were attached to the wall next to the entry door (Figure 2.10) in addition to those that were placed in the closet. The location of these mattress pads are documented in Appendix B. Reverberation time measurements were made with the foam mattress pads in place and are documented in Chapter 5.

The east wall of the garage bedroom separated the room from the garage (Figures 2.1 and 2.8d). Several accelerometers were placed on this wall (Chapter 3 and Appendix B). In addition to the sonic boom response measurements, data were also acquired for mechanical excitation of this wall to characterize the forced vibration of the wall. These shaker measurements are documented in Chapter 5.

Subsection 2.1.4: Description of the "front" bedroom

Throughout this report, the bedroom that is adjacent to the front door is referred to as the "front" bedroom (Figure 2.1). The ceiling in the front bedroom was not vaulted, and was 8-feet high. There was an attic space above this room; however, the attic above this room was not accessible (Figure 2.19 and Section 2.1.1). Consequently, no photographs of the framing of the attic above this room were taken. The framing of the attic can be inferred from the architectural drawings that are available upon request. There was a ceiling fan attached to this ceiling; however, it did not appear to be a significant source of rattle. No accelerometers were attached to the ceiling in this room.

The only wall instrumented in this room was the north wall that contained a window (Figure 2.11a). This window differed significantly from the other two, and was an Alenco series 3722/3722F HS-R25 window. This window had optional, simulated muntin bars installed in-between the two insulated glass panes (Figure 2.12 through 2.15). These fake muntin bars were attached to the insulated glass spacer at the ends of each bar (Figure 2.13 inset), but were not attached to either of the glass panes. Consequently, this lattice was free to vibrate in the gap in-between the two panes. The muntin lattice would vibrate significantly under even modest excitation of the insulated glass panes, and would "slap" each pane as it oscillated back and forth. This caused significant and audible impact noise that is present in many of the measurements made in this experiment for both sonic boom excitation as well as several tests involving mechanical shaker excitation (Chapters 4 and 5, respectively). The impact of the lattice on the glass panes was the dominant source of contact-induced noise from this window. The right sash of the window was operable and the left portion was fixed (Figures 2.11a and 2.12). Eight accelerometers were located on this window and several more were place on the wall near the window (Chapter 3 and Appendix B). Two microphones were placed in the near field of the operable sash, one near the interior surface and one near the exterior surface (Chapter 3 and Appendix B). Both were within 1/2-inch of the glass surface.

The east wall of this bedroom was an interior wall that separated the room from the laundry room. No transducers were mounted to this wall. Foam mattress pads were attached to the east wall and placed in the closet framed into the west wall (Figure 2.16) to reduce the reverberation time. The locations of these mattress pads are documented in Appendix B. Reverberation time measurements, documented in Chapter 5, were made with the foam mattress pads in place.

Section 2.2: Outdoor house description

The exterior of 52 Blackbird Street is shown in Figures 2.20 through 2.29. Aerial photography of the house and surrounding area is shown in Figures 2.30 and 2.31 and a schematic of the different houses surrounding the test house is shown in Figure 2.32. Architectural drawings of the test house and surrounding area are available upon request. These plans not only define the design of the test house, but also document the design of the houses surrounding the house used in this experiment.

A Global Positioning System (GPS) survey of the house and garage was performed by NASA Dryden and is provided in Appendix D. These survey locations should be helpful in orienting the house relative to the aircraft position data documented in Chapter 4. In addition, measurements of relevant exterior features of the house were made using a tape measure. These measurements are documented in Appendix A. Several microphones were placed outside of the house to measure the exterior sound field exciting the structure and the diffraction of the sonic booms as they propagated past the house. For brevity, a summary of the transducers is given in this chapter and a detailed discussion of the exterior transducers and their layout is documented in Chapter 3 and Appendix C. A discussion of some of the exterior features of the house and surrounding area follows, including a discussion of potential sources of ambient noise.

The duplex had a horseshoe shape (Figures 2.3, 2.20, 2.30 and 2.31), where the sonic booms observed during this experiment were nominally propagating from east to west. Thus, the sonic booms were incident on the front side of the house (Figures 2.1, 2.30 and 2.31). The front bedroom was at the inside corner of the front of the duplex (Figures 2.1, 2.22 and 2.23). The front eave overhung the outside wall of the front bedroom (Figure 2.22). This eave may have shadowed the wall and window of the front bedroom from the sonic boom excitation. Microphones were placed outside the front bedroom window, on nearby walls and on the nearby roof (Appendix C) to quantify the boom excitation near this room and the diffraction of the boom around the house.

The entry door to the house was located right outside of the front bedroom (Figure 2.1), and was a potential source of rattle during the boom measurements. For the sonic boom tests on July 18th, two accelerometers were removed from the front bedroom and were mounted to the front entry door of the house to quantify the door rattle. These changes to the transducers for sonic boom measurements made on the 18th are documented in Chapter 3 and in Appendix E. In addition, several measurements were taken with a mechanical shaker attached to the entry door to quantify the forced response of the door. These are documented in Chapter 5.

There was a large garage door on the front of the house (Figure 2.24) that rattled significantly when excited by sonic booms. During all of the sonic boom measurements, there were several microphones placed outside the front of the house that were within 30 feet of the garage door (Appendix C) and these may have recorded audible rattle radiated from the garage door. For the sonic boom measurements on the last day of testing, July 18th, one accelerometer was removed from the front bedroom and placed on the garage door. In addition, two microphones were moved and placed inside and outside of the garage in the near-field of the garage door to quantify the rattle. These changes to the transducers for sonic boom measurements made on the 18th are documented in Chapter 3 and in Appendix E. In addition, on this day several measurements were taken with a shaker attached to the garage door to quantify the forced response of the door (Chapter 5).

The master bedroom and garage bedroom were both on the southwestern side of the house (Figure 2.1), and consequently were shadowed from direct exposure to the booms by the rest of the house. Diffraction of the sonic boom around the house is expected to be important in determining the pressure field exciting the exterior walls of these rooms. Several microphones were placed along the southern and western exterior walls of the house (Appendix C) to identify the excitation field. Two microphones were also placed on top of the roof to help quantify the diffraction of the boom around the house (Appendix C).

A large electrical panel was mounted directly to the exterior wall of the garage bedroom next to the garage bedroom window (Figure 2.25). Several mechanical shaker measurements were made on the interior, gypsum board surface of this wall (Chapter 5), and this mass likely influenced the response of this wall to both the shaker excitation and the boom excitation.

The large, continuous south wall of the master bedroom, discussed in Section 2.1.2, is shown from the exterior in Figure 2.26. A microphone was placed high on the wall (Figure 2.26) and is documented in Appendix C. In addition to the boom response measurements, several measurements were taken with a mechanical shaker attached to the wall to quantify the forced response of the structure (Chapter 5). These shaker tests were performed with the shaker attached to both the interior sheetrock and exterior stucco (Chapter 5).

The back yard of the test house is shown in Figures 2.27 through 2.29. The proximity of the master and garage bedrooms to the neighboring house can be identified in these figures. The HVAC unit of the neighboring house (Figure 2.27) was running during some of the measurements and this caused a noticeable increase in ambient noise both inside and outside of the test house, particularly at the harmonics of the HVAC compressor rotation speed. No notes were made as to when the HVAC system was running, but it is audible in recordings of the microphones placed on this side of the test house. In addition, the sprinkler system of the neighboring house was running during some of the tests. The sound of the sprinkler system was audible outside on these occasions. In particular, the sound of the sprinkler water hitting the neighbors' driveway was audible in the recordings of the microphones in the front yard (Appendix C). No notes were made as to when the sprinkler system was running, but the sound from the sprinkler system is audible on the microphone placed in the driveway of the test house (Appendix C).

A chain link fence separated the back yard of the test house from the two neighboring backyards (Figures 2.27, 2.28 and 2.30). A cinderblock wall, identifiable in the photographs shown in Figures 2.28 through 2.30, separated the back yard from the desert and varied in height off the ground (Figure 2.28). The locations of the intersection of the chain link fences and cinderblock wall are included in the GPS survey data presented in Appendix D. Diffraction around and reflection from this wall may be important when considering the microphone measurements made in the backyard. The grade of the back yard of the test house sloped up to the cinderblock wall (Figure 2.28). The yard rose roughly 2 to 3 feet from the base of the house slab to the base of the wall, where most of the rise occurred within 6 feet of the cinderblock wall. The precise heights of the ground at the base of the fence and the base of the slab can be found from the GPS data given in Appendix D. Detailed photos of the fence in the backyard are available on request.

Two trees were in the back yard of the test house (Figure 2.28). The presence of these trees may have had an impact on the measurements recorded by the microphones placed in the back yard (Appendix C). The most significant effect of the trees on these measurements appeared to be increased ambient noise due to leaf rustling, which is audible in recordings made on windy days.

There were two vents in the roof of the test house (Figure 2.28) and one in the south wall of the house (Figure 2.26) that vented straight into the attic. Soffit vents were also present in the eaves of the house, which vented into the attic. These may have had an effect on the sound pressures observed inside the attic due to the sonic booms.

Aerial photography of the house and surrounding area is shown in Figure 2.30. Directly to the east of the house was a park. Noises from the park, such as children playing and pedestrian noise were possibly recorded on the exterior microphones in the front yard (Appendix C); however, during most of the recordings there were no people present in the park. The house was on a dead end street, and there was no traffic noise during any of the measurements.

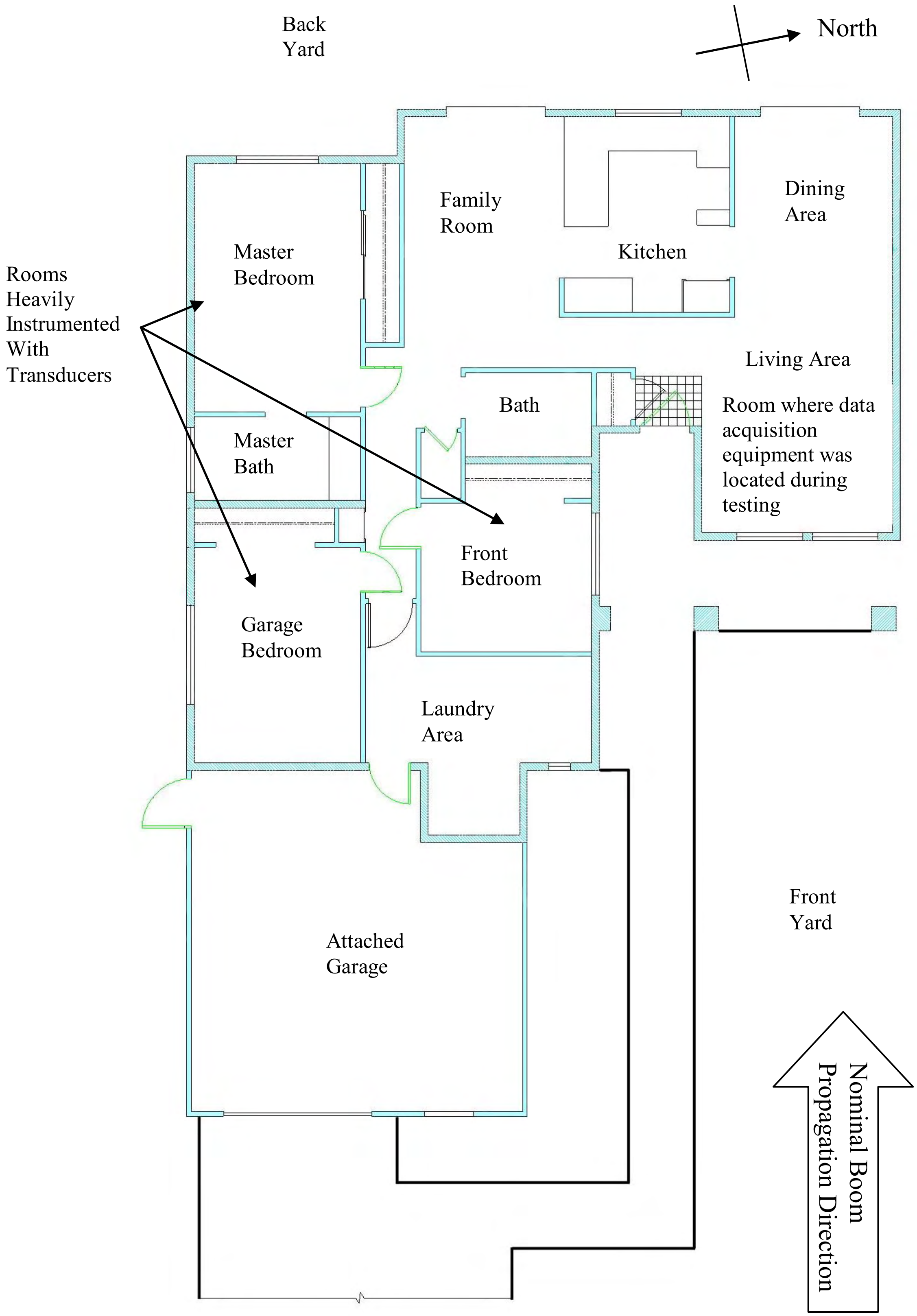

Figure 2.1: Floor plan of 52 Blackbird Street illustrating the bedrooms instrumented for structural acoustical measurements.

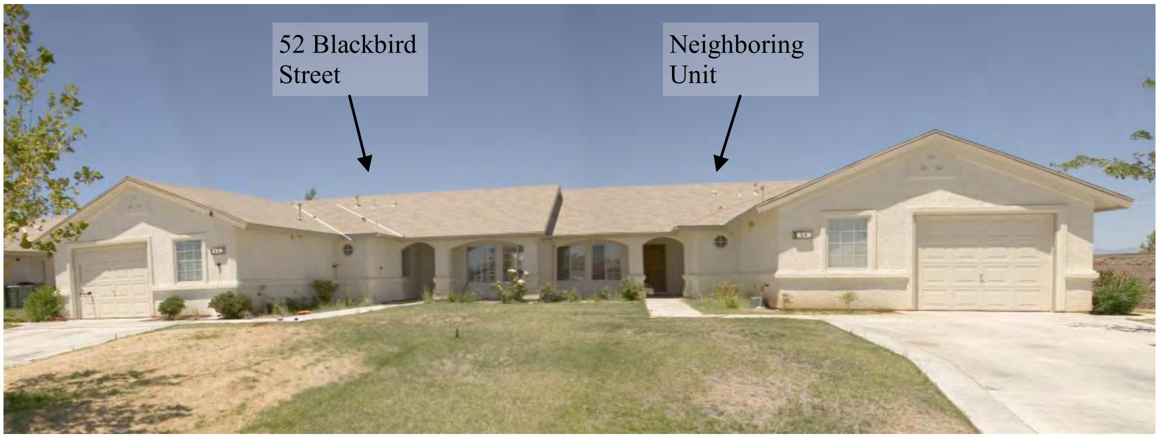

Figure 2.2: Front of the duplex. 52 Blackbird Street is the left portion of the duplex.

Figure 2.3: Floor plan of the duplex illustrating both sides of the house. The floor plans are mirror images of each other, offset by 5.5 feet.

Figure 2.4: Photographs of the main living area where equipment was placed; a) equipment area looking east, b) equipment in the dining area looking west, c) kitchen looking north, and d) family room and kitchen looking north west.

Figure 2.5: Photographs of the walls of the master bedroom; a) south wall, b) west wall, c) north wall, d) east wall, e) master bath south wall, and f) master bath north wall. See Appendix A for larger photographs and detailed drawings of this room.

Figure 2.6: Photograph of the window in the master bedroom. The right side of the window slides open, the left side is fixed.

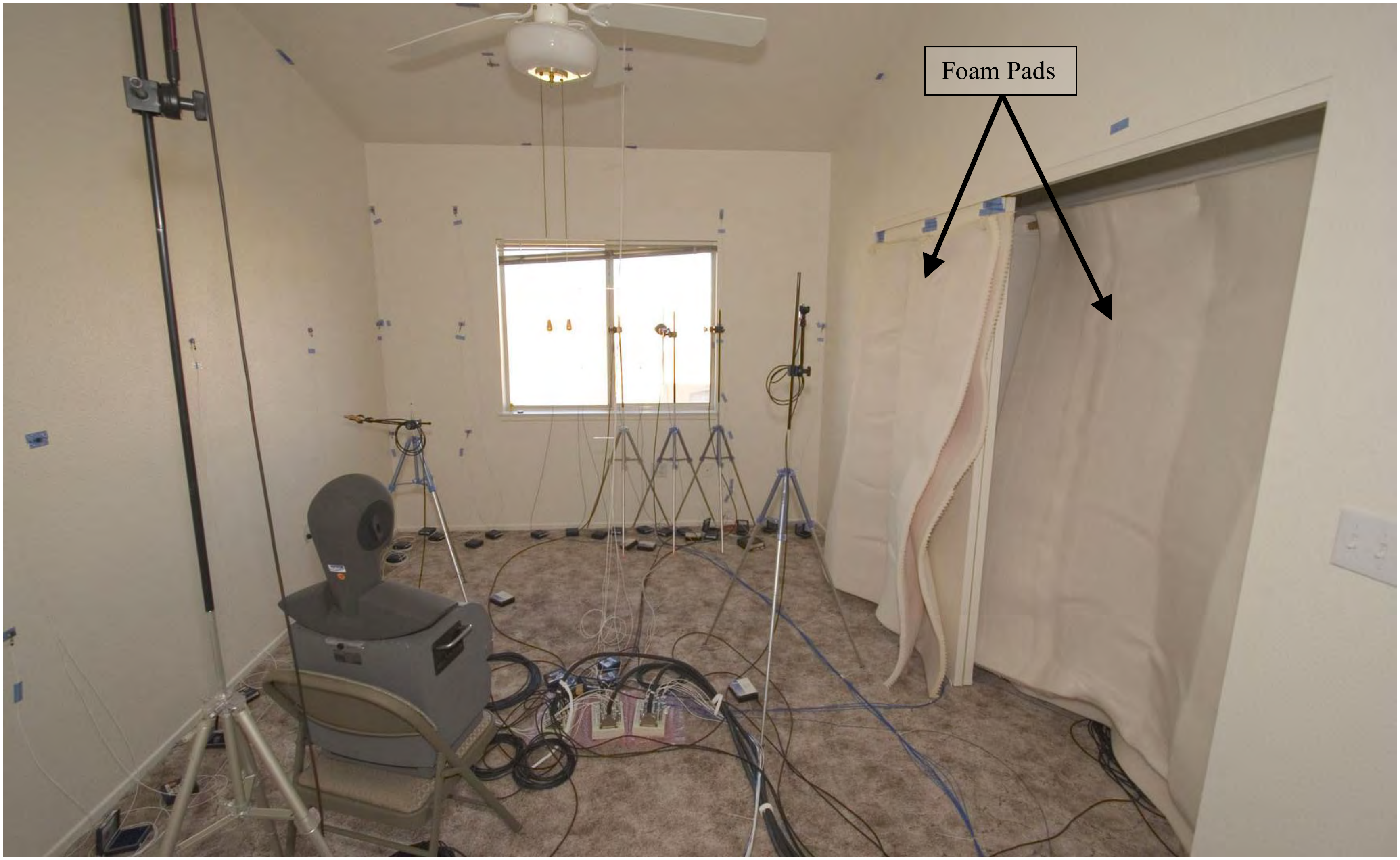

Figure 2.7: Foam mattress pads placed in the master bedroom to reduce the reverberation time of the room.

Figure 2.8: Photographs of the walls of the garage bedroom; a) south wall, b) west wall, c) north wall, and d) east wall. See Appendix A for larger photographs and detailed drawings of this room.

Figure 2.9: Photograph of the window in the garage bedroom. The right side of the window slides open, the left side is fixed.

Figure 2.10: Foam mattress pads placed in the garage bedroom to reduce the reverberation time of the room.

a) b) c) d)

Figure 2.11: Photographs of the walls of the garage bedroom; a) north wall, b) east wall, c) south wall, and d) west wall. See Appendix A for larger photographs and detailed drawings of this room.

Figure 2.12: Photograph of the window in the front bedroom. The right side of the window slides open, the left side is fixed.

Figure 2.13: Detailed photograph of the sliding portion of the front bedroom window.

Figure 2.14: Detailed photograph of both the sliding and fixed portion of the front bedroom window.

Figure 2.15: Detailed photograph of the fixed portion of the front bedroom window.

Figure 2.16: Foam mattress pads placed in the front bedroom to reduce the reverberation time of the room.

Figure 2.17: View of the attic above the main living area and master bedroom, looking south, over the master bedroom.

Figure 2.18: View of the attic above the main living area and master bedroom, looking north, over the main living area.

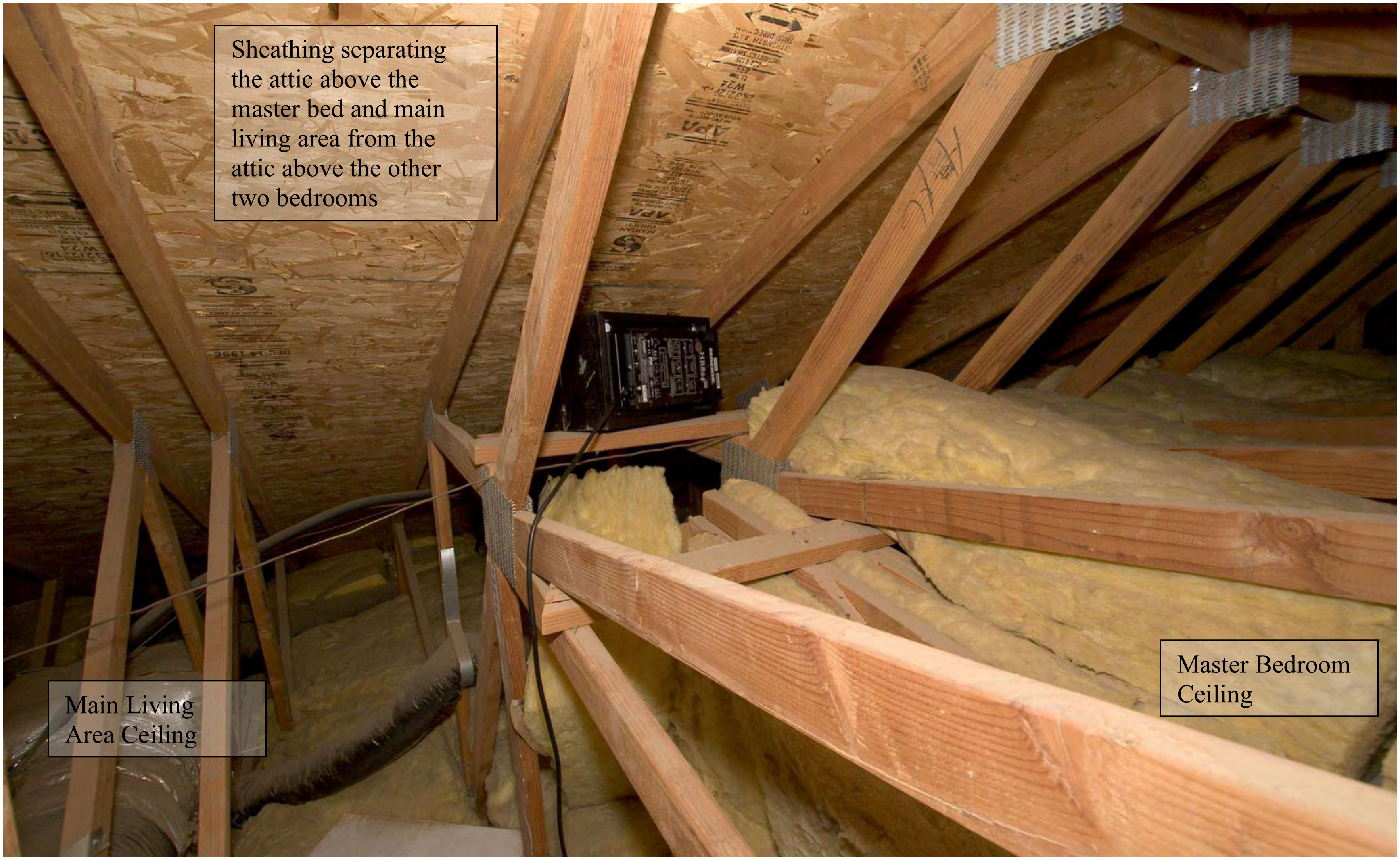

Figure 2.19: View of the attic above the main living area and master bedroom, looking east, at the sheathing that separates this attic space from the attic above the other two-instrumented rooms.

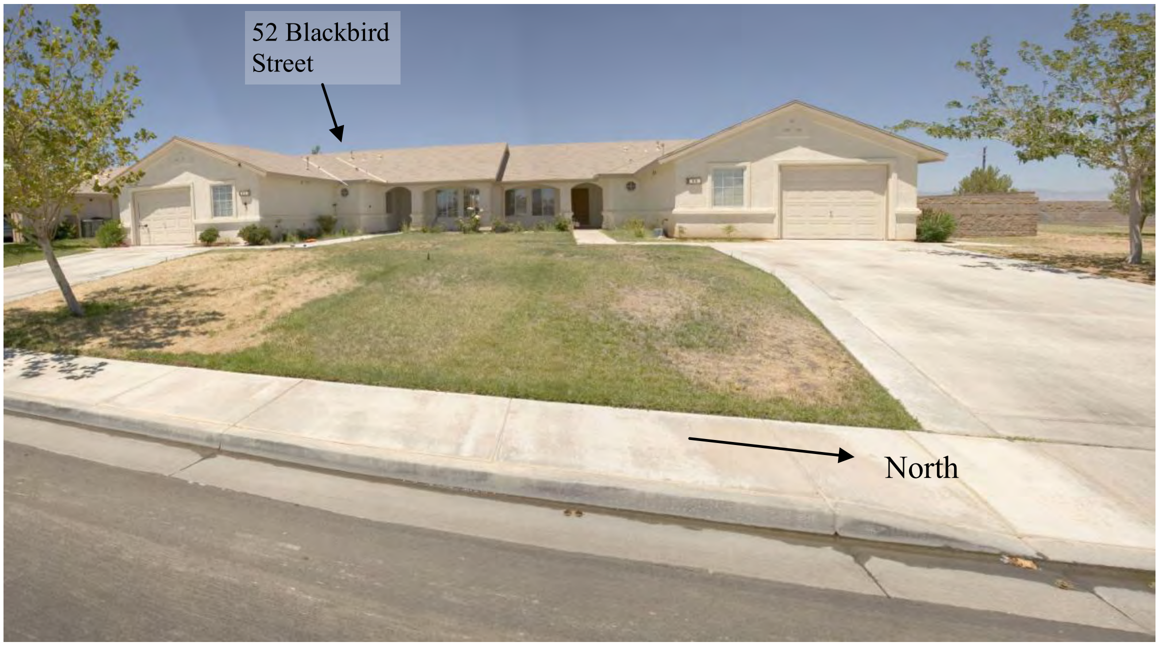

Figure 2.20: Front of the duplex.

Figure 2.21: Front of the test house.

Figure 2.22: View of the front of the house looking south west at the exterior walls of the front bedroom and main living area.

Figure 2.23: View of the front of the house looking south at the exterior wall of the front bedroom.

Figure 2.24: View of the side of the house looking northwest at the exterior of the garage.

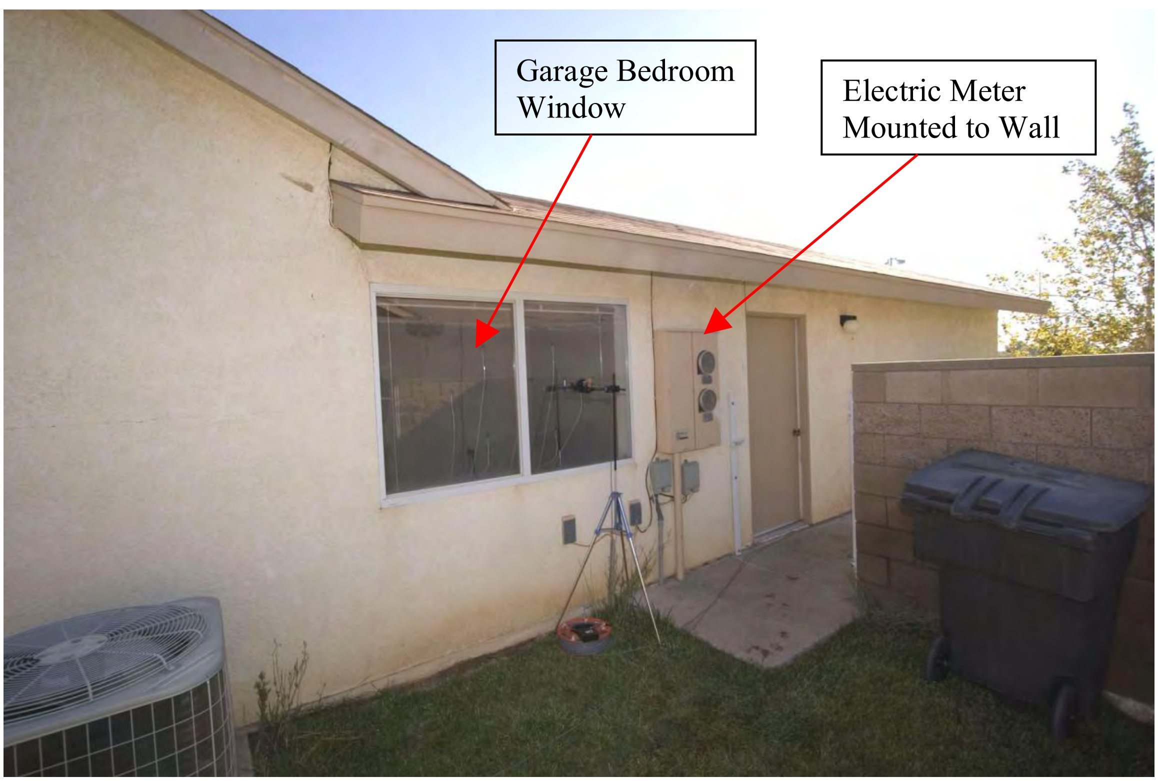

Figure 2.25: View of the side of the house looking north at the exterior wall of the garage bedroom.

Figure 2.26: View of the side of the house looking southeast at exterior wall of the master bedroom.

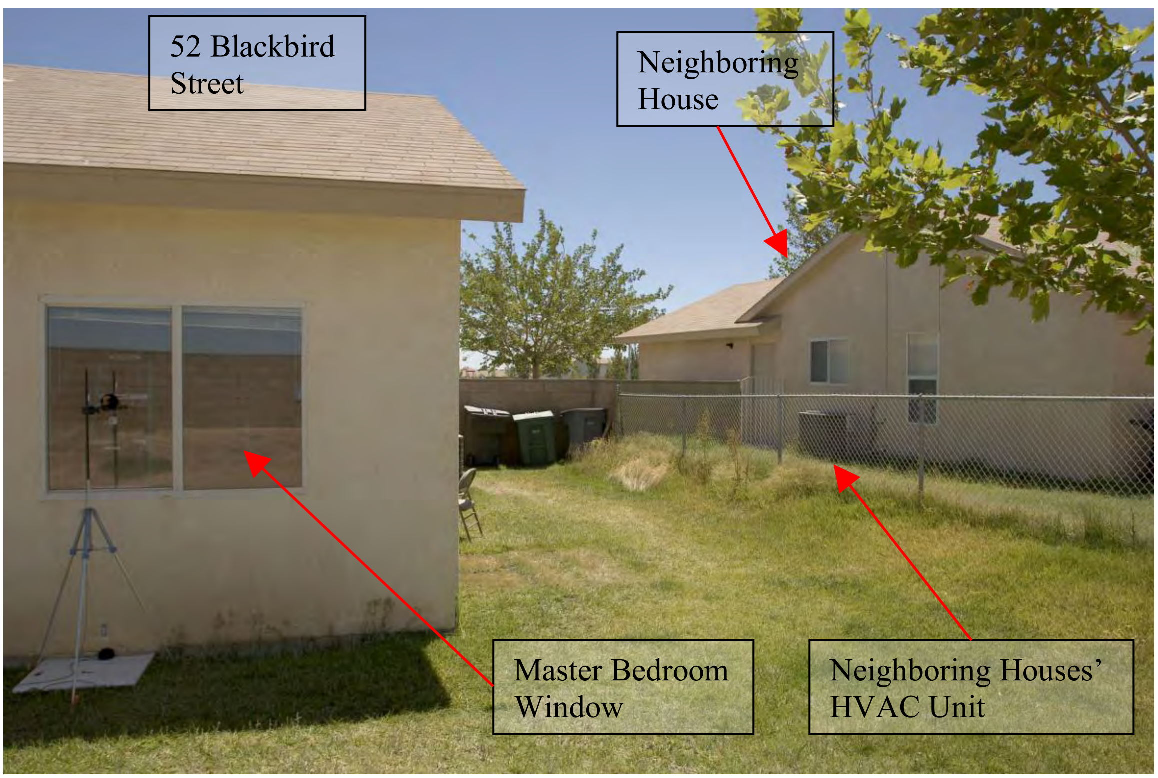

Figure 2.27: View of the master bedroom relative to the neighboring house illustrating the proximity to the neighboring air conditioning unit that was running during some tests.

Figure 2.28: Panorama of the back yard of the test house.

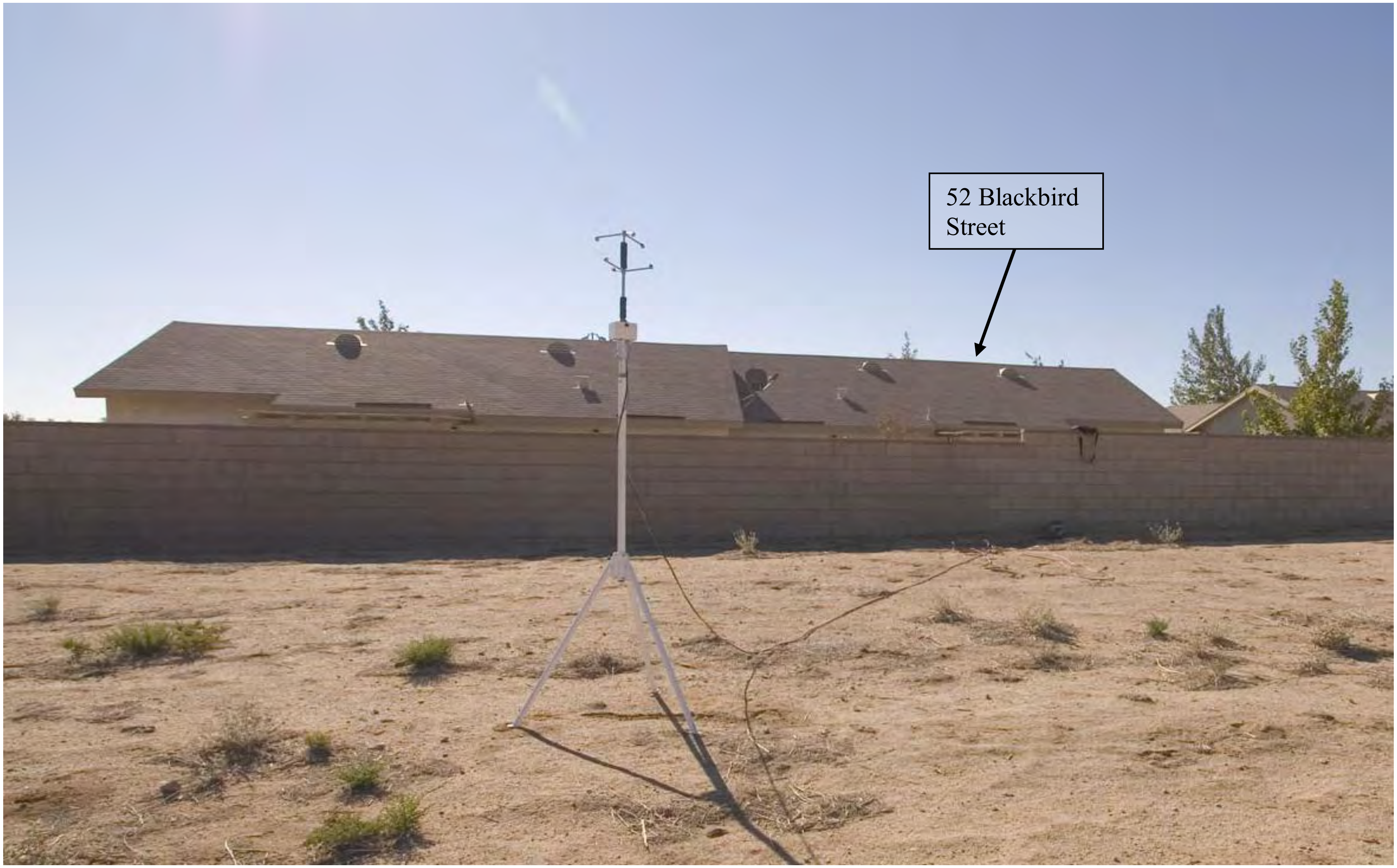

Figure 2.29: View of the duplex from the desert behind the duplex.

Figure 2.30: Aerial photograph of the test house and surrounding area.

Figure 2.31: Aerial photograph of 52 Blackbird Street, Edwards, CA.

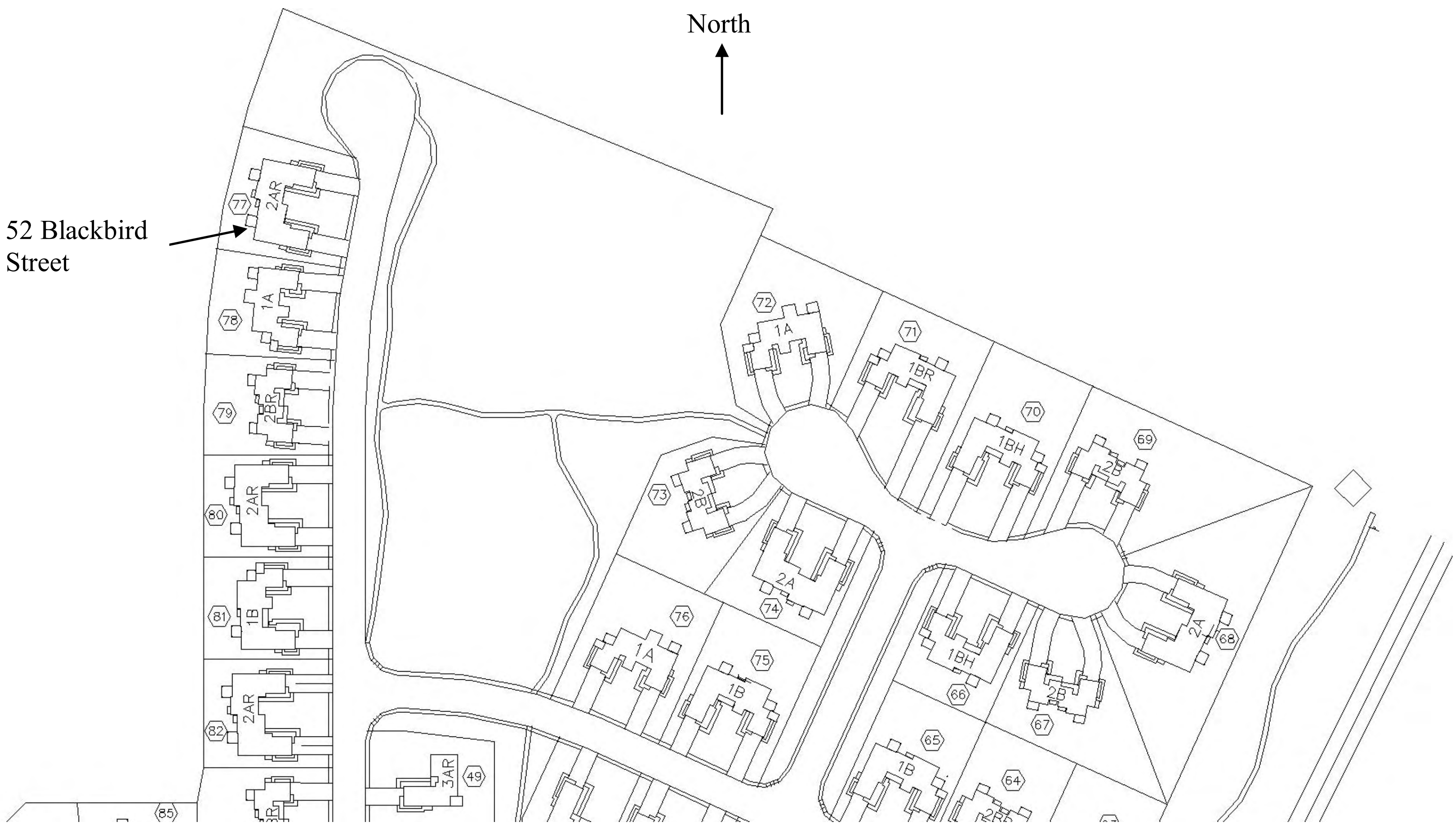

Figure 2.32: Layout of the housing area with nearby housing layouts identified. Different floor plans for these houses are defined in the architectural drawings that are available upon request.

CHAPTER 3: HARDWARE DESCRIPTION

Measurements were made with transducers located inside and outside the house on the 11th, 12th, 13th, 17th and 18th of July 2007. In total, the house response was measured for 42 sonic booms over the course of these five test days. The flights flown during these days and the data collected are documented in Chapters 4 and 6 respectively. In addition, characterization tests were also performed to quantify the dynamic and acoustic response of the house, which are documented in Chapter 5. Several different types of microphones and accelerometers were used during this experiment to make these measurements and this chapter focuses on instrumentation used and documents:

- Transducers installed in the house
- Nominal transducer layout
- Data acquisition system used to acquire data
- Calibration procedures used, transducer sensitivities and daily gains
- Day-to-day hardware changes made over the course of the five test days

Section 3.1: Description of the transducers used

Accelerometers were attached to the walls, windows and ceilings in three bedrooms of the house to measure the vibration response of the structure due to sonic boom exposure. Microphones were placed in each room in random locations to sample the interior noise and several microphones were placed outside, surrounding the house, to characterize the excitation field and measure the diffraction of the boom around the house. A detailed discussion of the locations and mounting methods used for these transducers is given in Section 3.2 and are illustrated in Appendix B. A list of the pertinent transducer information including data acquisition channel number, serial number, nominal sensitivities, in-situ sensitivities and a description of the mounting location is given in Table 3.1. A summary of the manufacturers specification sheets for all the transducers, signal conditioning and data acquisition hardware used in this test are included in Appendix F.

Various quantities of four types of accelerometers were used during this experiment:

Accelerometer Types Used

Quantity	Accelerometer model	Sensitivity (mV/g)
2	Endevco model 2250A-10	10
39	PCB Piezotronics model 333B32	100
17	PCB Piezotronics model 333B42	500
20	PCB Piezotronics model 333B52	1000

The PCB 333B series of accelerometers are high sensitivity, low noise ceramic shear accelerometers. The masses of the 333B32, B42 and B52 accelerometers are 4 grams, 7.5 grams and 7.5 grams, respectively. Due to the lower mass and lower sensitivity, the PCB 333B32 model of accelerometers were mounted primarily on windows (Table 3.1, Figures 3.1, 3.3, 3.4 and Appendix B) where mass loading was a concern and higher sensitivities were not needed. With a higher mass and higher sensitivity, the PCB 333B42 and B52 series of accelerometers were mounted primarily on walls (Table 3.1, Figures 3.1, 3.2, 3.5, 3.6 and Appendix B) where mass loading was not a concern and where higher sensitivities were desired due to an expected lower response level. In addition to the PCB accelerometers, two Endevco model 2250A-10 accelerometers were used. These accelerometers are lightweight 0.4 gram, ceramic shear accelerometers. These were used in two locations on the windows in the master and front bedrooms, and were mounted to the back of two of the PCB 333 series accelerometers (Table 3.1, Figures 3.3, 3.4 and Appendix B). The frequency response of the PCB 333B series of accelerometers starts to roll-off at about 3,000 Hz, and these two Endevco accelerometers, which begin to roll-off at 15,000 Hz, were used to quantify the high frequency error in the measurements made with the PCB accelerometers to which they were mounted. All accelerometers used in this test require ICP power. The data acquisition system, documented in Section 3.3, was used to power these ICP transducers. A description of the placement of the accelerometers is given in Section 3.2.

Thirty-one precision condenser microphones were used indoors and outdoors to sample the indoor acoustic response and exterior excitation field. A detailed discussion of the placement of these microphones is discussed in the next section of this chapter and documented in Appendices B and C. Three types of precision microphones and a binaural head were placed in and around the house:

Precision Microphone Types Used

Quantity	Microphone model	Nom. Sensitivity (mV/Pa)
1	HEAD Acoustics HMM II.2 Binaural Head	100
17	Brüel and Kjær Type 4193	12.5
12	Gras model 40AQ	50
2	Gras model 40AE-S1	50

The binaural head is powered by a self-contained power supply. There were a couple of tests where the binaural head was mistakenly not powered on. These tests should be identifiable by listening to the recorded time data for these channels. The binaural head was placed either inside the master bedroom (Appendix B) or outside on a patio (Appendix C). The Gras model 40AQ microphones are a standard frequency range microphone designed for random incidence sound measurements. Since the building will act as a high pass filter, filtering the frequency content of sonic booms below the first resonance of the structure, these microphones are well suited to measure the indoor response of houses exposed to sonic booms even though the response starts to roll off at about 3.5 Hz (Appendix F). These Gras microphones were placed at arbitrary locations inside the instrumented rooms of the house (Figures 3.1, 3.6 and 3.7 and Appendix B). They were used to sense the near-field pressure response at the inside surface of the windows (Appendix B). All the Gras microphones used in this test require ICP power. The data acquisition system, documented in Section 3.3, was used to power these ICP transducers. The Brüel and Kjær Type 4193 and Gras model 40AE-S1 microphones are specifically designed for low frequency acoustic measurements and are well suited for use in measuring sonic booms outdoors. Two Gras 40AE-S1 microphones were used and were placed in the attic and in the family area of the house (Appendix B). Due to the low frequency capability, several Type 4193 microphones were placed at locations of interest outside the house (Figures 3.7 through 3.11 and Appendix C). The Brüel and Kjær Type 4193 microphones require a capacitive power supply. Thus, several Brüel and Kjær Nexus signal conditioners were used to power these microphones. Gain was applied to the Type 4193 microphones using the Nexus signal conditioners to maximize the dynamic range of the signal measured by the data acquisition system. The gains used each day varied, are listed in Table 3.2, and are documented in Section 3.4. It should be noted that the very low frequency adapters Type UC0211 supplied with the Type 4193 microphones were not used during this test. A description of the placement of the Gras and the Brüel and Kjær precision microphones is given in Section 3.2.

Section 3.2: Transducer layout and mounting methods

Seventy-eight accelerometers were placed on the walls, windows and ceilings inside the house (Figure 3.1 and Appendix B). Forty-one were placed in the master bedroom, 24 were placed in the garage bedroom and 13 were placed in the front bedroom. The interior accelerometer and microphone layout is documented in the drawings, tables and photographs included in Appendix B. The table included in Appendix B identifies the (x,y,z) position of the transducers with respect to datums and coordinate system identified on drawings in that appendix. These locations can be cross-referenced with the measurements of the rooms given in Appendix A to identify exact mounting locations. The locations where the accelerometers and microphones were mounted are also labeled on photos of each of the bedrooms (Appendix B). The number in each label identifies the channel number of the data acquisition system to which the transducer was connected. These channel numbers can be cross-referenced with the channel table (Table 3.1) to identify the specific transducer placed at each position. It should be noted that, on the last day of testing, some changes were made to the nominal transducer locations documented in this section. These changes made on July 18th are documented in Section 3.5.

Accelerometers were always mounted so that the measurement direction was oriented normal to the mounting surface, where positive acceleration pointed in the direction of the room interior (Figures 3.2 through 3.4). The direction of the normal for each accelerometer is also indicated in the table included in Appendix B. Accelerometers were mounted to the walls, windows and ceilings using superglue. To avoid damage, a 1-mil thick layer of polyester flashbreaker tape was applied to the mounting surface, and the accelerometers were adhered to the back of this tape using superglue. The accelerometer wires were always taped to the mounting surface at several locations to avoid noise and vibration due to the wire contacting the wall during the boom events. Before the first day of testing, the accelerometers were checked to ensure that the bond of accelerometer to mounting surface was sound. At the conclusion of the experiment, the bond was also checked as the accelerometers were removed. No accelerometers were found to have come loose throughout the duration of this experiment. While the mounting of the transducers has been discussed in this section, wiring of the transducers to the data acquisition system is documented in Section 3.3.

In addition to the accelerometer locations, the locations of the indoor Gras microphones are indicated in the drawings, tables and photographs of Appendix B. The interior microphones were mounted in microphone holders that were attached to tripods (Figure 3.5 through 3.7). Windscreens were not used on the interior microphones. The positions of the microphones in each room typically did not vary from day-to-day except for placement variations caused by removal and replacement of the microphones in the holders during daily calibrations. No rigorous estimate of this variation was made during the testing; however, it is suspected that any variation was approximately an inch or two at most.

A binaural head (Table 3.1), which is used to measure sounds as they would be heard by humans, was placed either inside or outside the house. For the majority of the tests, the binaural head was placed on a chair inside the master bedroom (Figure 3.5). For tests on July 17^{th}, the binaural head was placed outside on a chair located on the patio outside the family room. Unfortunately, no pictures were taken of the outside location. The indoor and outdoor locations of the ears for these two configurations are indicated in Appendices B and C, respectively.

The nominal locations of the B&K precision microphones placed outside the house are illustrated in Appendix C. The table included in Appendix C identifies the (x,y,z) position of the transducers with respect to datums and coordinate system identified on drawings in that appendix. These locations can be cross-referenced with the measurements of the rooms given in Appendix A to identify exact mounting locations. Some of the exterior microphones are shown in Figures 3.8 through 3.13.

The exterior microphones were either held in holders attached to tripods (Figure 3.9), affixed to the house using Velcro (Figure 3.10), placed on the roof (Figure 3.11), or placed on ground boards (Figures 3.12 and 3.13). All exterior microphones were fitted with 3-inch diameter windscreens except for microphones on channels 98 and 104, which were fitted with 6-inch diameter windscreens. Windscreens were cut in half (Figures 3.9, 3.10, 3.12 and 3.13) or quarters (Figure 3.12) for microphones that were mounted to the house or placed on ground boards to ensure that the microphone diaphragm was as close as possible to the rigid surface. Some day-to-day deviation from the nominal layout of the exterior microphone is likely because, unlike the interior microphones, the exterior microphones, tripods and ground boards were disassembled and put away each evening and re-placed each morning. This was done to avoid potential problems caused by weather and wildlife if the microphones were left outside overnight. Thus, over the five days of testing, some placement variation in the exterior microphones should be expected. No rigorous estimate of this variation was made during the testing; however, it is suspected that any variation was approximately a few inches at most.

Section 3.3: Data acquisition system and cabling description

One National Instruments (NI) PXI chassis, connected to a controller computer, was used to implement the data acquisition system used during this experiment (Figure 3.14). A total of 112 data acquisition channels were available, all of which were used throughout the duration of testing (Table 3.1). The interface connection between the PXI chassis and the controlling computer was made using a NI PXI to PCI 8331 MXI-4 copper interface kit. Eight channel NI 4472B data acquisition cards, instead of the standard 4427 cards, were used in this experiment due to a lower cutoff frequency of the high-pass filter when AC coupling is selected. The NI 4472B cards have a 0.5 Hz high-pass AC coupling filter (Appendix F). Since AC coupling must be enabled when ICP conditioning is used for ICP accelerometers and microphones, the 4472B cards were seen as offering an advantage in making measurements of sonic boom responses that contain substantial low frequency content. The 4472B cards were used to supply ICP conditioning for all the accelerometers and the Gras microphones. The only transducers that were not powered by ICP conditioning from the 4472B cards were the Brüel and Kjær Type 4193 microphones and the binaural head. The Type 4193 microphones were powered by Nexus signal conditioners and the binaural head was powered by an internal power supply, as discussed in Section 3.1. All of the data acquisition channels, including the Type 4193 microphones and binaural head, were AC coupled.

To sustain fast transfer rates of time history data to disk, a RAID 5 hard drive array was implemented in the controller computer using an Areca model ARC-1220 PCI-Express x8 SATA II controller card and six 250 GB hard drives. Initial benchmarks with this storage system configured with 112 channels showed that a continuous acquisition of time data to disk at sample rates up to 80 kHz per channel could be attained. The amount of continuous time data that could be streamed to disk was only limited by the size of the RAID array. Above 80 kHz, the acquisition would become discontinuous after short periods due to data rate limits of the NI PXI to PCI 8331 MXI-4 copper interface kit. For the tests documented in this report, continuous time data was acquired using sampling rates of 25.6 kHz. Thus, there was sufficient headroom in both disk throughput and PXI interface throughput to ensure a reliable acquisition of continuous time data for this experiment.

A custom NI LabVIEW™ acquisition program was written for use in this test. Programming the acquisition requirements for the hardware configuration described above was straightforward using LabVIEW™ due to the tight integration of the NI-DAQmx device drivers into LabVIEW™. The software serves four basic functions: configuration of the DAQmx task, acquisition of time data from the 4472B's, streaming time data to disk and computation of RMS voltages during calibration (see Section 3.4 concerning calibrations). The user specifies the sample rate, the number of points per ensemble and the total number of ensembles to be acquired. A continuous acquisition was made using these settings and each ensemble of time data was stored on the RAID array as a separate file. The data formats available for distribution are discussed in Chapter 6.

High-density cables were used to simplify cabling of all the transducers placed inside the house. 16-channel high-density cables were connected to the NI 4472B data acquisition cards on one end (Figure 3.14) and to small 16-channel breakout boxes on the other (Figure 3.15). The cable length of these high-density cables running between the breakout boxes and the data acquisition system was about 60 feet. The breakout boxes were placed in the instrumented rooms near clusters of transducers. Groups of 16 transducers were wired to the breakout boxes with short, transducer specific cables (Figure 3.15). For the PCB model 333B32, 333B42 and 333B52 accelerometers, standard microdot-to-BNC cables were used to connect the transducers to the breakout boxes. The lengths of these cables varied from 10 feet to roughly 25 feet, and no record was made of which cables were connected to which transducers. For the Endevco accelerometers, the standard cables supplied with those transducers were used along with a microdot-to-BNC cable to connect these transducers to the breakout boxes. The wires for both the PCB and Endevco accelerometers were always taped to the mounting surface to avoid noise and vibration due to the wire contacting the surface during the boom events. The Gras microphones were wired to the breakout boxes using various lengths of BNC cables. No record was made of the lengths of the cables used for the Gras microphones. The Brüel and Kjær microphones were not wired to the breakout boxes. Instead, LEMO cables were run from the B&K microphones placed outside to Nexus power supplies located in the equipment room. The length of these LEMO cables varied from 30-meters to 150-meters. The lengths of LEMO cable used for each microphone were not noted. The outputs of the Nexus were wired directly to the acquisition system using 3-foot BNC cables and 1-foot BNC-to-SMB cables.

Section 3.4: Equipment calibrations

In-situ calibrations were performed on all transducers installed in the test house prior to the start of the experiment in accordance with LMS-TD-0558 (Appendix F). For the in-situ calibrations, a PCB Piezotronics model number 394C06 accelerometer calibrator, serial number 1856, was used to calibrate the accelerometers. This calibrator outputs a 1g RMS vibration at 159.2 Hz, and automatically adjusts for different accelerometer masses. A Brüel and Kjær pistonphone Type 4228, serial number 2034885, was used for in-situ microphone calibrations. The nominal RMS output of this pistonphone is 124 dB re 20 μPa. For all microphone calibrations documented in this section, a pressure correction based on the ambient pressure was applied to the nominal calibration level of the pistonphone. The pressure correction was found from a Brüel and Kjær UZ-0004 pressure indicator, serial number 2034885, included with the pistonphone. The only microphones not calibrated with a pistonphone during this experiment were the microphones in the binaural head. The binaural head has a built in calibrator, which was used to calibrate its' microphones.

The in-situ calibrations were carried out while the transducers were connected to the data acquisition system and cabling described in the previous section. The software used to acquire data included a routine that would compute the RMS voltage of a selected channel, high-pass filtered at 70 Hz. A high-pass filter was applied before the RMS voltage was computed to remove DC bias in the signal and to remove any low frequency content caused by hand holding the calibrator while performing the calibration. While either a microphone or accelerometer was excited by a calibrator, the RMS voltage was compared to the RMS output of the calibrator to determine the sensitivity of the transducer. The operator of the data acquisition system then noted the sensitivity.

Subsection 3.4.1: Accelerometer calibrations

The accelerometers were calibrated in-situ at the test house on July 8th prior to mounting them to the walls, windows and ceilings. Only this pre-test, in-situ calibration was performed. The gains of the accelerometers, powered by the NI 4472B's, could not be changed and were always unity. The time histories of the pre-test calibrations are available for distribution in a binary format that is discussed in Chapter 6. The accelerometer sensitivities from this pre-test calibration are summarized in Table 3.1. These pre-test calibrations were typically within 4% of the sensitivities provided by the manufacturer at the time of purchase (Table 3.1).

Subsection 3.4.2: Microphone calibrations

The Gras and Brüel and Kjær precision microphones were calibrated in-situ at the test house using a Brüel and Kjær Type 4228 pistonphone. Both pre- and post-test calibrations were performed each test day. The time histories of the daily calibrations are available for distribution in a binary format that is discussed in Chapter 6. The microphone sensitivities from these daily end-to-end calibrations are summarized in Table 3.2. The gains of the Gras microphones, powered by the NI 4472B's, could not be changed and were always unity. The Brüel and Kjær Type 4193 microphones were always calibrated using a gain of 3.16 on the Nexus power supplies. Thus, the calibrated sensitivities listed in Table 3.1 for these microphones differ from the nominal sensitivities by this gain factor. Also, the gain used to make measurements with the Type 4193 microphones was altered throughout the test to attempt to optimize the dynamic range of the data acquisition system. These gain changes applied to the Type 4193 microphones, which varied from day-to-day and channel-to-channel, are listed in Table 3.3. Note that the gains of the Type 4193 microphones listed in Table 3.2 are negative. This is to reflect that a positive change in pressure results in a negative change in output voltage for these microphones; whereas, for the Gras microphones, a positive change in pressure results in a positive change in output voltage.

Section 3.5: Day-to-day transducer placement variations

Four accelerometers and five microphones were moved during the last test day of this experiment on July 18th, 2007 (Table 3.4 and Appendix E). All of these changes are documented in the drawings, tables and photographs included in Appendix E, and are briefly discussed here. The four accelerometers that were moved were initially mounted to the front bedroom wall during the sonic boom tests on the 11th through 17th. Two were removed from the wall and were mounted to the front entry door of the house (Channels 67 and 68). The third, Channel 65, was placed on the garage door. The fourth, Channel 66, was placed on the wall in the garage. The microphone outside the garage bedroom window (on channel 100) was moved to the exterior near-field of the garage door. Two microphones located inside the front bedroom (on channels 77 and 78) and one located outside the front bedroom window (on channel 91) were moved. Channel 78 was placed in the interior near-field of the garage door. The other two were moved to the outside, and placed under the roof microphones. Finally, the microphone that was located in the family room (on channel 109) was moved and placed in the interior near-field of the front entry door to the house. Unfortunately, no photograph of the microphone 109 in this position was taken; however, the measured location is identified in the tables included in Appendix E. No other transducers were moved from the nominal locations illustrated in Appendices B and C.

Section 3.6: Day-to-day room variations

During the final test day, transducers were removed from the front bedroom as documented in the previous section and Appendix E. To locate some of these transducers outside on July 18th, the cables were run through the window in the front bedroom. Thus, the window in the front bedroom was left partly opened, about 6 inches (Figure 3.16), for the tests on July 18, 2007. No other modifications were made to the bedrooms during this experiment.

Each test day consisted of either one or two measurement sessions, each approximately 45 minutes in duration. On days with two sessions, there was a 45-minute pause between the two sessions. The temperature of the HVAC system was set very low in the mornings to cool the house interior before the start of the first measurement session. In addition, the HVAC system was run in between the first and second measurement sessions to maintain a reasonably consistent interior temperature from session-to-session. Consequently, while the HVAC system was turned off during testing and the temperature outside was high, none of the bedrooms appeared to increase in temperature significantly during the measurement sessions. Unfortunately, no measurements were made of the actual temperature indoor temperature.

Table 3.1: List of transducers, locations, and data acquisition channel mapping.

Channel Number	Nominal Placement Location		Location Changed for Measurements Made on 7/18/07	Measurement Type	Manufacturer	Transducer Model	Transducer Serial Number	Preamplifier Serial Number	Factory Calibration	Pre-test In-situ Calibration	Units	Gain During Pre-test Calibration	Factory to Pre-test Cal Ratio
1	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	29200	N/A	98.8	95.6	mV/g	1	0.968
2	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	29201	N/A	97.4	95.4	mV/g	1	0.979
3	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	29202	N/A	96.4	94.1	mV/g	1	0.976
4	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	29203	N/A	97.2	94.4	mV/g	1	0.971
5	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	30033	N/A	97.6	94.9	mV/g	1	0.972
6	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	30034	N/A	98.6	96.2	mV/g	1	0.976
7	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	30035	N/A	99.2	96.1	mV/g	1	0.969
8	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	30036	N/A	99.7	96.4	mV/g	1	0.967
9	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B52	31595	N/A	987	954	mV/g	1	0.967
10	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B52	31596	N/A	952	916	mV/g	1	0.962
11	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B52	31597	N/A	1011	970	mV/g	1	0.959
12	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B52	31598	N/A	941	908	mV/g	1	0.965
13	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B42	14728	N/A	526	520	mV/g	1	0.989
14	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B42	14732	N/A	510	497	mV/g	1	0.975
15	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B42	14734	N/A	510	499	mV/g	1	0.978
16	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B42	14737	N/A	519	509	mV/g	1	0.981
17	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B52	31599	N/A	975	943	mV/g	1	0.967
18	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B52	31600	N/A	981	952	mV/g	1	0.970
19	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B52	31601	N/A	976	949	mV/g	1	0.972
20	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B52	31602	N/A	991	957	mV/g	1	0.966
21	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B52	31603	N/A	986	955	mV/g	1	0.969
22	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B52	31604	N/A	964	935	mV/g	1	0.970
23	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B52	31605	N/A	951	923	mV/g	1	0.971
24	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B42	14740	N/A	517	513	mV/g	1	0.992
25	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B42	14743	N/A	501	493	mV/g	1	0.984
26	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B42	14747	N/A	502	492	mV/g	1	0.980
27	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B52	31606	N/A	961	926	mV/g	1	0.964
28	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B42	14749	N/A	479	470	mV/g	1	0.981
29	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B42	14754	N/A	520	509	mV/g	1	0.979
30	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B42	14755	N/A	495	492	mV/g	1	0.994
31	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B42	14756	N/A	514	512	mV/g	1	0.996
32	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B42	14758	N/A	485	478	mV/g	1	0.986
33	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30037	N/A	98.7	95.7	mV/g	1	0.970
34	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30038	N/A	100.4	96.7	mV/g	1	0.963
35	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30039	N/A	99	96	mV/g	1	0.970
36	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30040	N/A	97.4	94.3	mV/g	1	0.968
37	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30071	N/A	98.4	95.2	mV/g	1	0.967
38	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B52	31607	N/A	955	922	mV/g	1	0.965
39	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B52	31608	N/A	952	911	mV/g	1	0.957

Table 3.1: Continued.

Channel Number	Nominal Placement Location		Location Changed for Measurements Made on 7/18/07	Measurement Type	Manufacturer	Transducer Model	Transducer Serial Number	Preamplifier Serial Number	Factory Calibration	Pre-test In-situ Calibration	Units	Gain During Pre-test Calibration	Factory to Pre-test Cal Ratio
40	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B52	31609	N/A	966	935	mV/g	1	0.968
41	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B52	31610	N/A	971	937	mV/g	1	0.965
42	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B52	31611	N/A	985	960	mV/g	1	0.975
43	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B52	31612	N/A	951	918	mV/g	1	0.965
44	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B52	31613	N/A	959	924	mV/g	1	0.964
45	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B42	14760	N/A	496	491	mV/g	1	0.990
46	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B42	14764	N/A	512	504	mV/g	1	0.984
47	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B42	14767	N/A	484	472	mV/g	1	0.975
48	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B42	14951	N/A	515	505	mV/g	1	0.981
49	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30072	N/A	100.3	95.5	mV/g	1	0.952
50	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30073	N/A	98.5	96.1	mV/g	1	0.976
51	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30074	N/A	97.6	95.7	mV/g	1	0.981
52	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30075	N/A	96.8	94.1	mV/g	1	0.972
53	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30076	N/A	99.6	96.8	mV/g	1	0.972
54	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30077	N/A	99.8	97.3	mV/g	1	0.975
55	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30078	N/A	99.1	95.1	mV/g	1	0.960
56	interior	garage bedroom	No	Accelerometer	PCB Piezotronics	333B32	30079	N/A	99.8	98.1	mV/g	1	0.983
57	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	30080	N/A	99.6	96.6	mV/g	1	0.970
58	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	30510	N/A	96.6	93.8	mV/g	1	0.971
59	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	31314	N/A	108.7	105	mV/g	1	0.966
60	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	31315	N/A	102.2	99.1	mV/g	1	0.970
61	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	31316	N/A	106.5	103	mV/g	1	0.967
62	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	31317	N/A	99.8	96.9	mV/g	1	0.971
63	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	31318	N/A	106.9	103.4	mV/g	1	0.967
64	interior	master bedroom	No	Accelerometer	PCB Piezotronics	333B32	31319	N/A	99.5	95.4	mV/g	1	0.959
65	interior	front bedroom	Yes (Appendix E)	Accelerometer	PCB Piezotronics	333B32	31320	N/A	106.6	102.9	mV/g	1	0.965
66	interior	front bedroom	Yes (Appendix E)	Accelerometer	PCB Piezotronics	333B52	31614	N/A	960	923	mV/g	1	0.961
67	interior	front bedroom	Yes (Appendix E)	Accelerometer	PCB Piezotronics	333B42	14955	N/A	531	522	mV/g	1	0.983
68	interior	front bedroom	Yes (Appendix E)	Accelerometer	PCB Piezotronics	333B32	31321	N/A	96.8	94.2	mV/g	1	0.973
69	interior	front bedroom	No	Accelerometer	PCB Piezotronics	333B32	31322	N/A	102.6	99.2	mV/g	1	0.967
70	interior	front bedroom	No	Accelerometer	PCB Piezotronics	333B32	31323	N/A	99.1	95	mV/g	1	0.959
71	interior	front bedroom	No	Accelerometer	PCB Piezotronics	333B32	31324	N/A	100.5	96.5	mV/g	1	0.960
72	interior	front bedroom	No	Accelerometer	PCB Piezotronics	333B32	31325	N/A	100.1	96.2	mV/g	1	0.961
73	interior	front bedroom	No	Accelerometer	PCB Piezotronics	333B32	31616	N/A	99.3	97	mV/g	1	0.977
74	interior	front bedroom	No	Accelerometer	PCB Piezotronics	333B32	31617	N/A	100.9	97.5	mV/g	1	0.966
75	interior	front bedroom	No	Accelerometer	PCB Piezotronics	333B32	31618	N/A	107.7	104	mV/g	1	0.966
76	interior	front bedroom	No	Accelerometer	PCB Piezotronics	333B32	31619	N/A	105.6	102.5	mV/g	1	0.971
77	interior	front bedroom	Yes (Appendix E)	Reverberant Microphone	Gras	40AQ	48291	58461	50.82	48.9	mV/Pa	1	0.962
78	interior	front bedroom	Yes (Appendix E)	Reverberant Microphone	Gras	40AQ	48292	58462	51.66	49.7	mV/Pa	1	0.962
79	interior	front bedroom	No	Reverberant Microphone	Gras	40AQ	48293	58463	51.64	49.5	mV/Pa	1	0.959

Table 3.1: Concluded.

Channel Number	Nominal Placement Location		Location Changed for Measurements Made on 7/18/07	Measurement Type	Manufacturer	Transducer Model	Transducer Serial Number	Preamplifier Serial Number	Factory Calibration	Pre-test In-situ Calibration	Units	Gain During Pre-test Calibration	Factory to Pre-test Cal Ratio
80	interior	garage bedroom	No	Reverberant Microphone	Gras	40AQ	48294	58464	50.99	47.1	mV/Pa	1	0.924
81	interior	master bedroom	No	Reverberant Microphone	Gras	40AQ	48295	58465	49.29	47.2	mV/Pa	1	0.958
82	interior	master bedroom	No	Reverberant Microphone	Gras	40AQ	48296	58466	53.38	50.7	mV/Pa	1	0.950
83	interior	master bedroom	No	Reverberant Microphone	Gras	40AQ	48297	58467	47.98	45.6	mV/Pa	1	0.950
84	interior	master bedroom	No	Reverberant Microphone	Gras	40AQ	48298	58468	50.79	48.3	mV/Pa	1	0.951
85	interior	master bedroom	No	Reverberant Microphone	Gras	40AQ	48299	58469	46.49	44.5	mV/Pa	1	0.957
86	interior	master bedroom	No	Reverberant Microphone	Gras	40AQ	48300	58470	52.07	50	mV/Pa	1	0.960
87	interior	master bedroom	No	Binaural Head	Sonic Perceptions		12066028	12066028	N/A	99	mV/Pa	1	N/A
88	interior	master bedroom	No	Binaural Head	Sonic Perceptions		12066028	12066028	N/A	99.2	mV/Pa	1	N/A
89	interior	garage bedroom	No	Reverberant Microphone	Gras	40AQ	48301	58471	51.75	49.3	mV/Pa	1	0.953
90	interior	garage bedroom	No	Reverberant Microphone	Gras	40AQ	48302	58472	49.08	46.8	mV/Pa	1	0.954
91	exterior	front yard	Yes (Appendix E)	Low Freq Microphone	Brüel & Kjær	4193	2151208	2526878	13.5	42.2	mV/Pa	3.16	3.126
92	exterior	front yard	No	Low Freq Microphone	Brüel & Kjær	4193	2151223	2526877	14	43.9	mV/Pa	3.16	3.136
93	exterior	front yard	No	Low Freq Microphone	Brüel & Kjær	4193	2151225	2526883	11.9	35.9	mV/Pa	3.16	3.017
94	exterior	front yard	No	Low Freq Microphone	Brüel & Kjær	4193	2151227	2526885	13.5	42.2	mV/Pa	3.16	3.126
95	exterior	front yard	No	Low Freq Microphone	Brüel & Kjær	4193	2151232	1828322	13.8	40.2	mV/Pa	3.16	2.913
96	exterior	front yard	No	Low Freq Microphone	Brüel & Kjær	4193	2305432	2526881	12.86	40.6	mV/Pa	3.16	3.157
97	exterior	front yard	No	Low Freq Microphone	Brüel & Kjær	4193	2305433	1865306	14.4	44.9	mV/Pa	3.16	3.118
98	exterior	driveway	No	Low Freq Microphone	Brüel & Kjær	4193	2305435	2526884	13.4	41.9	mV/Pa	3.16	3.127
99	exterior	side yard	No	Low Freq Microphone	Brüel & Kjær	4193	2305436	2351710	13.8	41.4	mV/Pa	3.16	3.000
100	exterior	side yard	Yes (Appendix E)	Low Freq Microphone	Brüel & Kjær	4193	2305437	2526882	14.2	43.1	mV/Pa	3.16	3.035
101	exterior	side yard	No	Low Freq Microphone	Brüel & Kjær	4193	2305438	2526876	12.9	40.7	mV/Pa	3.16	3.155
102	exterior	backyard	No	Low Freq Microphone	Brüel & Kjær	4193	2305439	2526880	13	40.8	mV/Pa	3.16	3.138
103	exterior	backyard	No	Low Freq Microphone	Brüel & Kjær	4193	2305441	2352747	13.5	42	mV/Pa	3.16	3.111
104	exterior	300' west of house	No	Low Freq Microphone	Brüel & Kjær	4193	2368551	2404974	Unknown	41.1	mV/Pa	3.16	N/A
105	exterior	roof top	No	Low Freq Microphone	Brüel & Kjær	4193	2368556	2404977	Unknown	40.1	mV/Pa	3.16	N/A
106	exterior	front yard	No	Low Freq Microphone	Brüel & Kjær	4193	2368547	2404970	Unknown	40.7	mV/Pa	3.16	N/A
107	exterior	roof top	No	Low Freq Microphone	Brüel & Kjær	4193	2368548	2404971	Unknown	39.9	mV/Pa	3.16	N/A
108	interior	attic	No	Low Freq Microphone	Gras	40AE-S1	Unknown	Unknown	Unknown	50.9	mV/Pa	3.16	N/A
109	interior	family room	Yes (Appendix E)	Low Freq Microphone	Gras	40AE-S1	Unknown	Unknown	Unknown	44.2	mV/Pa	3.16	N/A
Channel 110-112 Configuration for Boom Measurements:													
110	interior	equipment room	No	IRIG Time Code Generator	Unknown	N/A	N/A	N/A	1	N/A	Volts	N/A	N/A
111	interior	master bedroom	No	Accelerometer	Endevco	2250a-10	Unknown	N/A	N/A	10.32	mV/g	1	N/A
112	interior	front bedroom	No	Accelerometer	Endevco	2250a-10	Unknown	N/A	N/A	10.27	mV/g	1	N/A
Channel 110-112 Configuration for Shaker Measurements:													
110	interior	N/A	N/A	Shaker Amplifer Input Signal	N/A	N/A	N/A	N/A	1	N/A	Volts	N/A	N/A
111	varied	varied (Appendix G)	N/A	Impedance Head, Force	PCB Piezotronics	288D01	2430	N/A	22	N/A	mV/N	N/A	N/A
112	varied	varied (Appendix G)	N/A	Impedance Head, Acceleration	PCB Piezotronics	288D01	2430	N/A	101	N/A	mV/g	N/A	N/A

Table 3.2: Daily sensitivities of the precision microphones found from in-situ field calibrations

	Gain During	Checkout	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Pre-test	Pre-test	Post-test	Pre-test	Post-test
	Calibration	7/8/2007	7/11/2007	7/11/2007	7/12/2007	7/12/2007	7/13/2007	7/13/2007	7/15/2007	7/16/2007	7/17/2007	7/17/2007	7/18/2007	7/18/2007
77	1	48.9	49.2	48.5	49.2	48.6	49.4	48.4	49.6	49.2	49.2	48.2	50.9	50.7
78	1	49.7	49.5	49.1	49.6	49.2	49.7	48.6	50	49.7	48.5	49.3	50.8	49.5
79	1	49.5	49.4	48.7	49.3	49.2	49.2	47.9	49.7	49.3	48.9	48.6	49.6	49.4
80	1	47.1	47	46.6	46.9	46.6	46.6	46.2	47.5	47.2	46.8	47	47.4	46.4
81	1	47.2	47.1	46.6	46.6	46.6	46.8	45.7	47.9	46.4	46.6	46.3	47.1	47.4
82	1	50.7	50.5	50.1	50.6	50.4	50.5	49.3	51.3	50.6	50.4	50.4	50.5	50.7
83	1	45.6	45.8	44.9	45.3	44.7	45.5	44.4	46.1	45.3	44.9	44.8	45.5	45.3
84	1	48.3	48	47.9	48	47.4	48	46.3	48.7	47.9	47.7	47.7	48.4	47.7
85	1	44.5	44.6	43.8	44.2	43.8	44.3	43	44.7	44	44	43.9	44.5	44.3
86	1	50	49.9	49.8	49.7	48.8	49.3	48.9	50.1	49	49	48.6	49.2	49.9
87	1	99	-	-	99	98.9	99	98.9	-	-	98.9	98.8	98.9	98.9
88	1	99.2	-	-	99.2	99.2	99.2	99.2	-	-	99.2	99	99.2	99.2
89	1	49.3	49.2	49.1	49.2	49.1	48.9	48.7	50	49.6	49	49.1	49.3	48.7
90	1	46.8	47	46.2	46.5	46.4	46.4	46.3	46.7	46.5	46.2	46.1	46.5	45.7
91	3.16	42.2	43.2	41.7	43.5	42.4	42.5	42	42.5	42	42.2	42.2	44	41.4
92	3.16	43.9	46.4	43.1	42.9	43.9	44.5	43.9	44.3	45.1	44.3	44	44.6	43.3
93	3.16	35.9	37	36.1	37.6	36	36.5	35.8	36.3	37.2	37.4	35.9	36.7	35.8
94	3.16	42.2	41.8	43.1	43.5	42.6	42.9	41.9	43.9	45.9	42.2	42.8	44.2	42.4
95	3.16	40.2	40.8	42.7	40.8	42.7	39.7	42.4	-	42.3	39.5	42.4	39.4	43
96	3.16	40.6	40.7	40.6	40.8	40.2	40.8	41.2	-	40.6	40.7	40.8	40.8	40.3
97	3.16	44.9	44.9	45.6	45.3	45.8	45.3	45.5	-	44.9	45	45.2	45.1	45.2
98	3.16	41.9	41.8	42.1	41.6	41.7	-	41.6	-	42.3	41.4	42.1	-	-
99	3.16	41.4	40.1	40.4	40.5	40.6	39.5	40.9	44.2	40.5	40.5	41.1	40	40.5
100	3.16	43.1	42.3	42.7	42.6	42.5	42.7	42.4	43.2	42.7	42.5	42.7	43.9	43.3
101	3.16	40.7	40	40.3	40.2	40.2	39.6	40.3	-	40.4	40.3	40.2	39.9	40.3
102	3.16	40.8	40.5	40.5	40.5	40.9	40.3	40.6	-	40.5	40.5	40.5	40.4	40.5
103	3.16	42	41	41.4	41.2	41.3	41	41.1	-	41.1	41.3	41.2	42.2	41.9
104	3.16	41.1	41.6	42.4	41.9	42	41.7	41.9	-	41.7	41.4	42	41.6	41.9
105	3.16	40.1	40.3	40.2	40.1	40.7	40.8	40.5	42.1	40.8	40.3	40	40.2	39.8
106	3.16	40.7	41	41.4	40.8	41.1	41	41.3	-	40.9	40.7	41.1	40.8	41.1
107	3.16	39.9	39.9	40.3	39.9	40.4	40.2	40.3	40.5	40	39.6	40.2	40	39.9
108	1	50.9	51.6	51.7	51.3	53.2	52	51.9	50.5	51.8	52.4	-	52.2	52
109	1	44.2	44.4	44.1	44.2	44.4	44.6	43	43.4	44.7	44.6	44.5	44.8	44.9

Table 3.3: Gains settings used during the response measurements (see Chapters 4 and 6 for explanation of the date stamps).

Date Stamps for Sonic Boom Response Measurements	Gain Settings On Channels 1 through 90	Gain Settings On Channels 91 through 96	Gain Settings On Channels 97 through 107	Gain Settings On Channels 108 through 112
7_11_2007 8_09_40 AM	1	31.6	31.6	1
7_11_2007 8_17_17 AM	1	31.6*	31.6*	1
7_11_2007 8_23_29 AM	1	3.16	3.16	1
7_11_2007 8_28_30 AM	1	3.16	3.16	1
7_11_2007 8_37_38 AM	1	3.16	3.16	1
7_12_2007 8_01_48 AM	1	3.16	3.16	1
7_12_2007 8_09_00 AM	1	3.16	3.16	1
7_12_2007 8_15_51 AM	1	3.16	3.16	1
7_12_2007 8_21_42 AM	1	3.16	3.16	1
7_12_2007 8_28_02 AM	1	3.16	3.16	1
7_12_2007 8_34_40 AM	1	3.16	3.16	1
7_12_2007 8_39_59 AM	1	3.16	3.16	1
7_12_2007 10_32_37 AM	1	3.16	3.16	1
7_12_2007 10_38_36 AM	1	3.16	3.16	1
7_12_2007 10_44_21 AM	1	3.16	3.16	1
7_12_2007 10_50_40 AM	1	3.16	3.16	1
7_13_2007 9_41_06 AM	1	3.16	3.16	1
7_13_2007 9_46_42 AM	1	3.16	3.16	1
7_13_2007 9_53_23 AM	1	3.16	3.16	1
7_13_2007 9_59_05 AM	1	3.16	3.16	1
7_13_2007 10_05_30 AM	1	3.16	3.16	1
7_13_2007 10_13_02 AM	1	3.16	3.16	1
7_13_2007 10_19_58 AM	1	3.16	3.16	1
7_17_2007 8_10_22 AM	1	3.16	3.16	1
7_17_2007 8_17_19 AM	1	3.16	3.16	1
7_17_2007 8_23_04 AM	1	3.16	3.16	1
7_17_2007 8_29_35 AM	1	3.16	3.16	1
7_17_2007 8_35_43 AM	1	3.16	3.16	1
7_17_2007 8_42_59 AM	1	3.16	3.16	1
7_17_2007 8_48_07 AM	1	3.16	3.16	1
7_17_2007 10_32_08 AM	1	1	3.16	1
7_17_2007 10_39_18 AM	1	1	3.16	1
7_17_2007 10_46_23 AM	1	1	3.16	1
7_17_2007 10_54_17 AM	1	1	3.16	1
7_17_2007 11_01_12 AM	1	1	3.16	1
7_17_2007 11_07_30 AM	1	1	3.16	1
7_18_2007 8_06_20 AM	1	1	3.16	1
7_18_2007 8_13_02 AM	1	1	3.16	1
7_18_2007 8_19_08 AM	1	1	3.16	1
7_18_2007 8_25_12 AM	1	1	3.16	1
7_18_2007 8_31_16 AM	1	1	3.16	1
7_18_2007 8_37_15 AM	1	1	3.16	1
All characterization tests	1	3.16	3.16	1
* indicates some channels overloaded at this gain setting for this boom				

Table 3.4: Summary of the changes made to transducers on July 18th, 2007

Channel	Type	Original Location	New Location
65	Accelerometer	Front bedroom wall	Garage door
66	Accelerometer	Front bedroom wall	Garage wall
67	Accelerometer	Front bedroom wall	Front entry door
68	Accelerometer	Front bedroom wall	Front entry door
77	Microphone	Interior front bedroom window near-field	On the eave under roof microphone array
78	Microphone	Front bedroom interior	Interior garage door near-field
91	Microphone	Exterior front bedroom window near-field	On the wall under roof microphone array
100	Microphone	Exterior garage bedroom window near-field	Exterior garage door near-field
109	Microphone	Family room	Interior front entry door near-field

Notes: All other transducers remained mounted in the locations documented in Appendices B and C.
Pictures and locations of these transducers for the July18th, 2007 measurements are included in Appendix E.
The front bedroom window was left open 6 inches on the boom tests on July 18th, 2007.

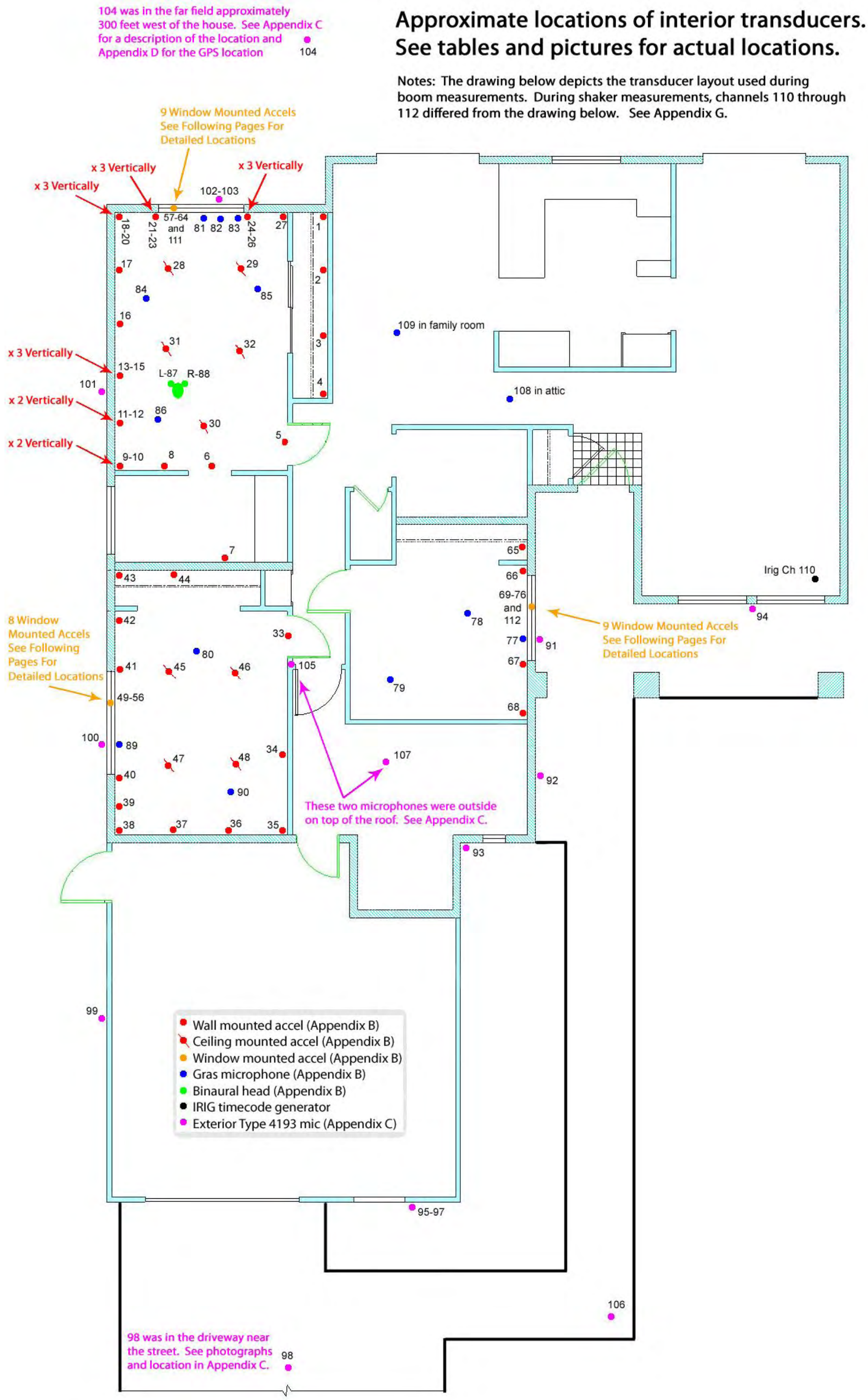

Figure 3.1: Nominal transducer layout for tests on July 11th, 12th, 13th and 17th, 2007. See Appendix E for the transducer changes made for tests on July 18th, 2007.

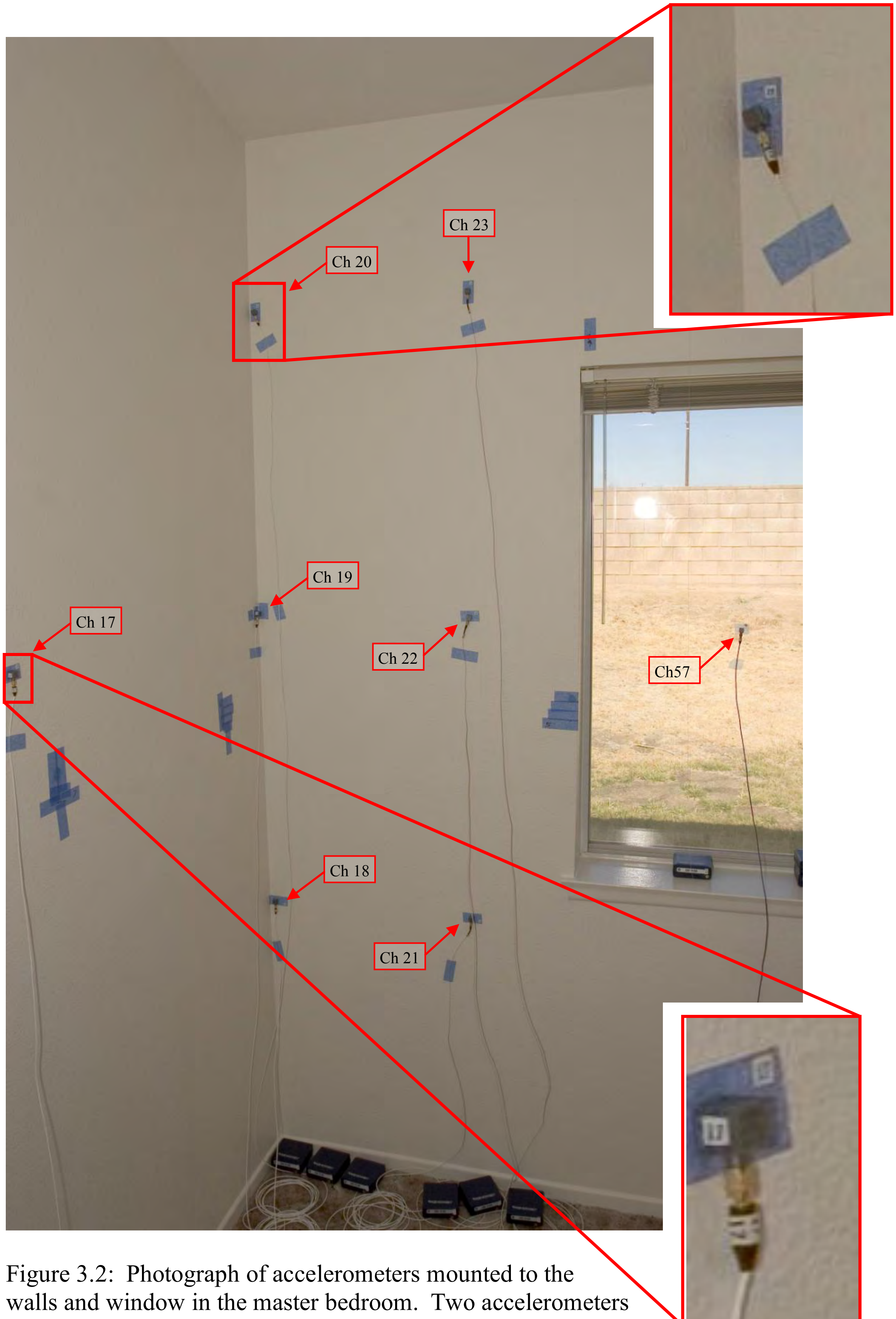

Figure 3.2: Photograph of accelerometers mounted to the walls and window in the master bedroom. Two accelerometers mounted to the walls shown in insets.

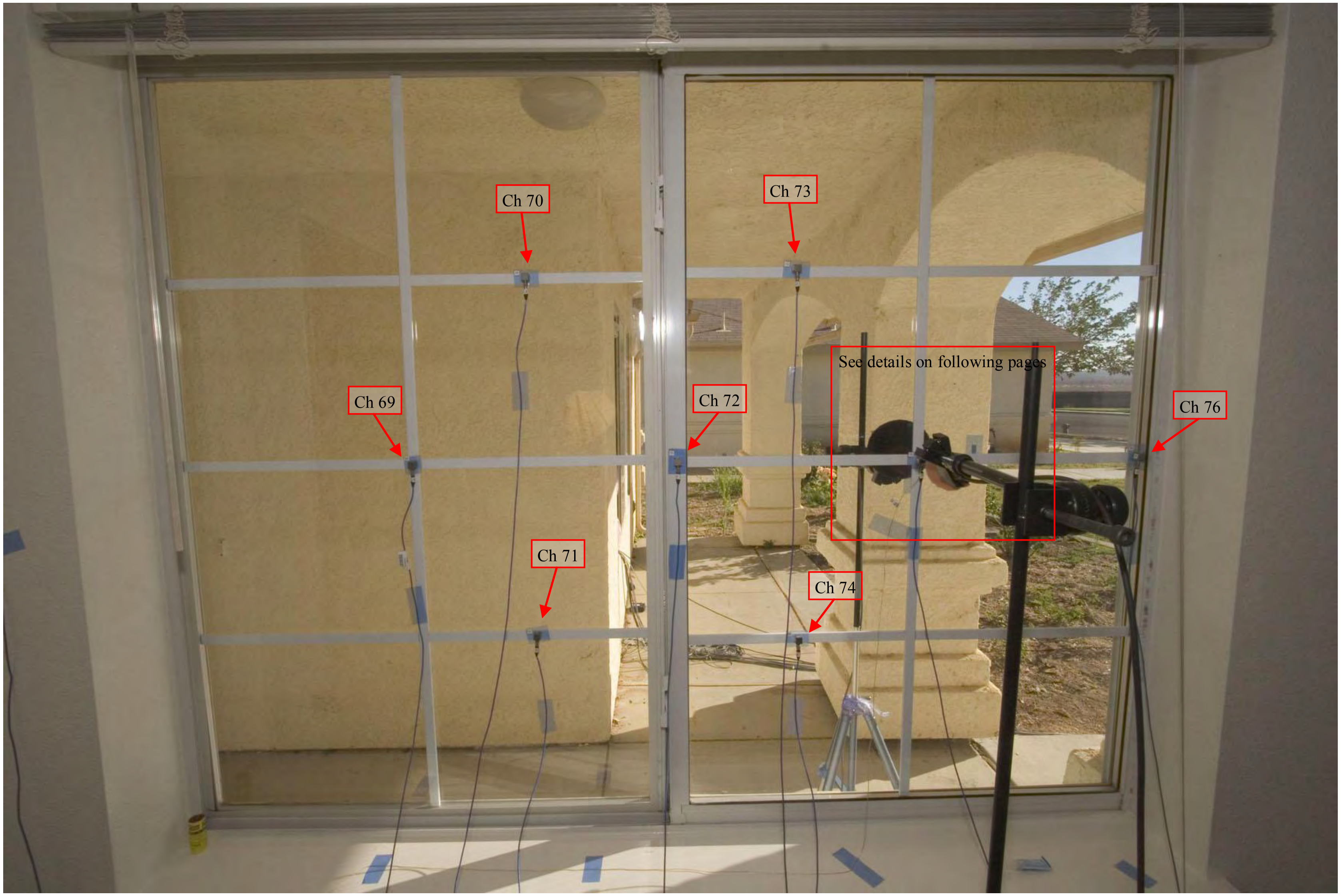

Figure 3.3: Photograph of accelerometers mounted to the window in the front bedroom.

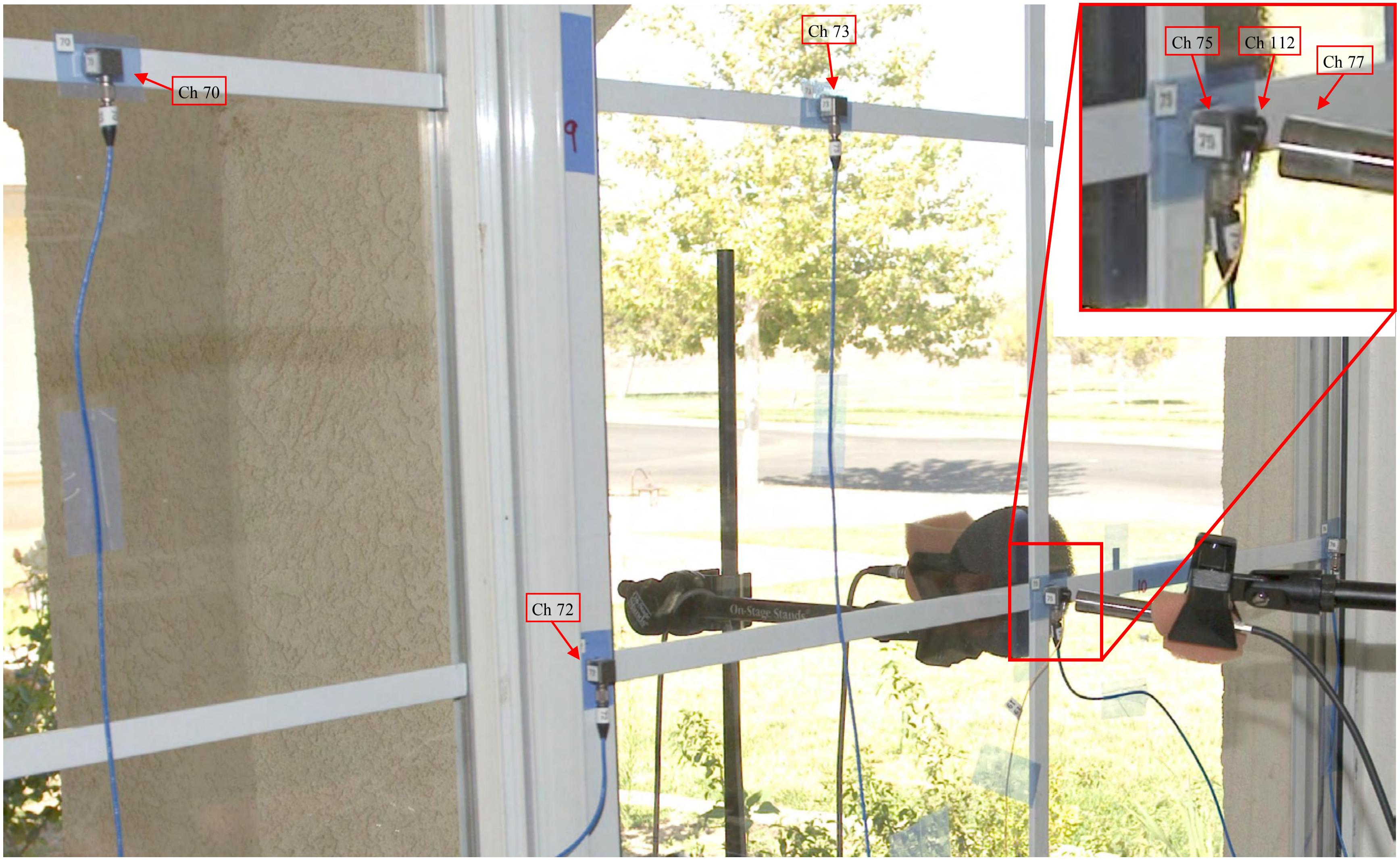

Figure 3.4: Photograph of accelerometers mounted to and microphones placed near the front bedroom window. An Endevco accelerometer mounted to the back of a PCB accelerometer in front of a co-located microphone shown in inset.

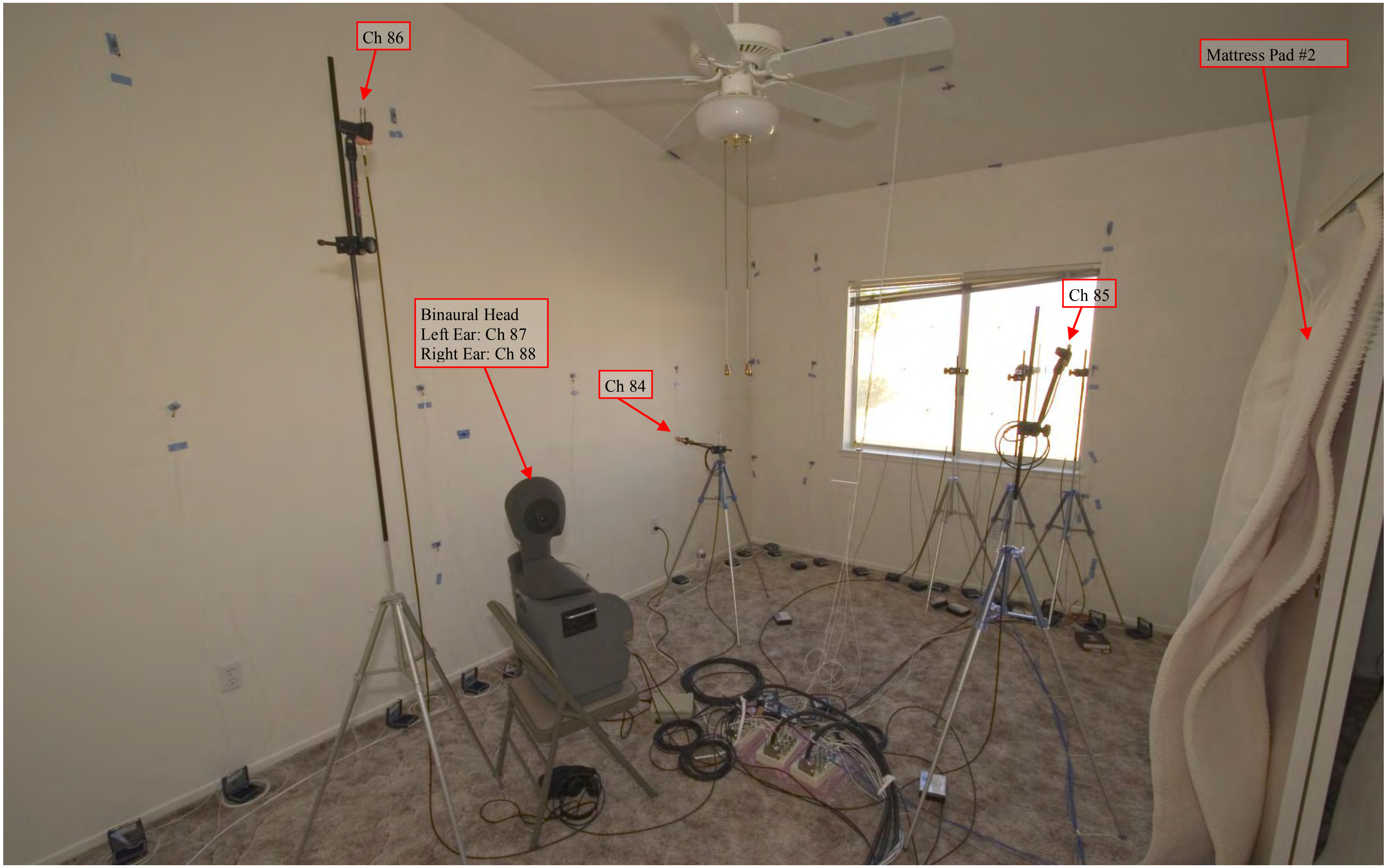

Figure 3.5: Photograph of microphones inside the master bedroom and accelerometers mounted to the walls. A foam mattress pad used to increase the absorption in the room is also pictured.

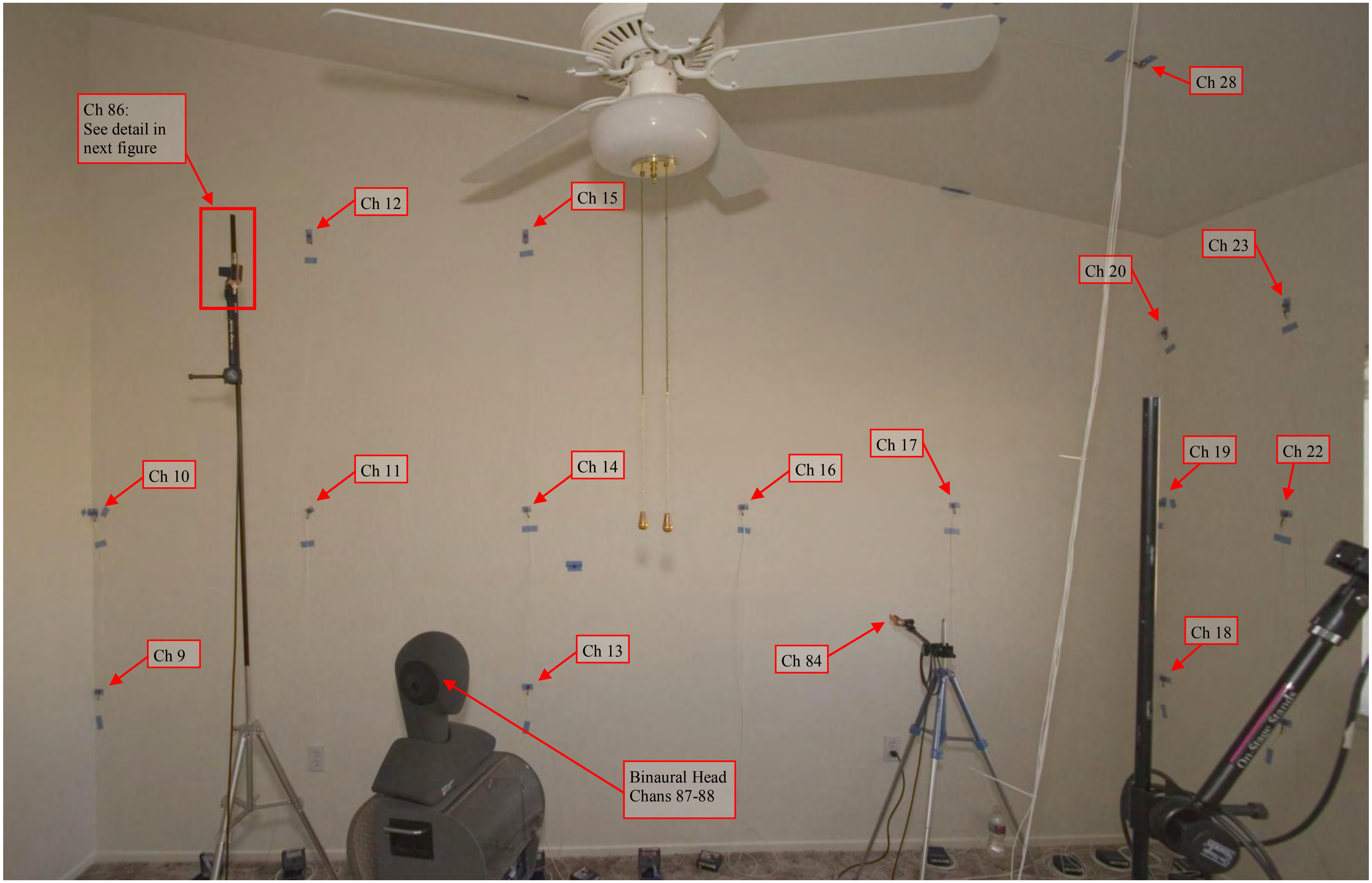

Figure 3.6: Picture of accelerometers on the wall and an indoor microphone mounted to a tripod in the master bedroom.

Figure 3.7: Detail of a typical indoor microphone mounted in a holder. Channel 86 is shown.

Figure 3.8: Microphones placed in the front corner of the house near the front bedroom.

Figure 3.9: Typical exterior window near-field microphone. Microphone and windscreen were held in a holder mounted to a tripod. Channel 91 is shown.

Figure 3.10: Typical exterior wall mounted microphone. Velcro pads were used to hold the microphone and windscreen to the wall. Channel 92 is shown.

Figure 3.11: Exterior rooftop microphones mounted to a pole for easy installation. Channels 105 and 107 shown.

Figure 3.12: Typical exterior ground microphone. Channel 93 shown.

Figure 3.13: The far field microphone.

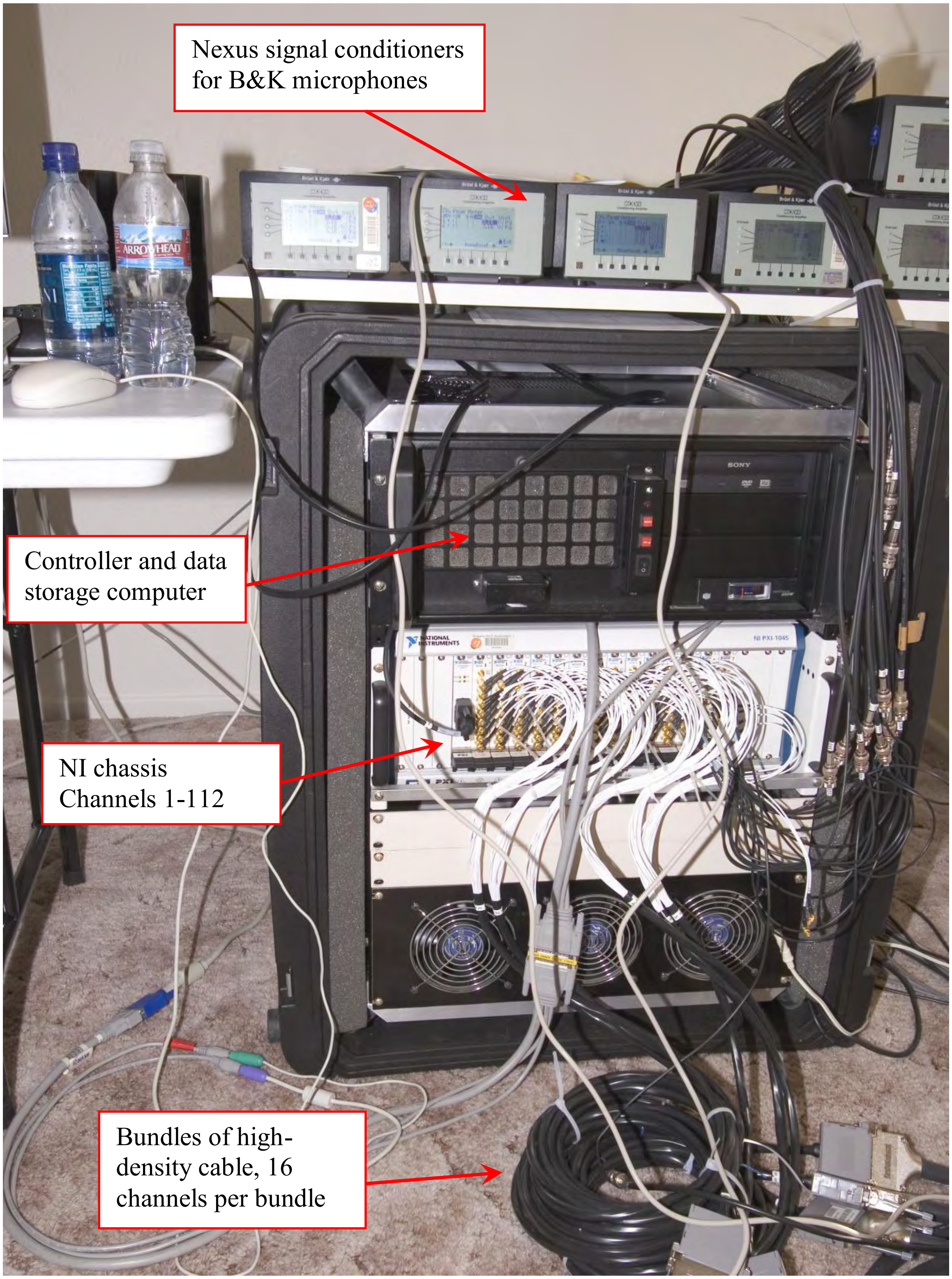

Figure 3.14: Data acquisition hardware.

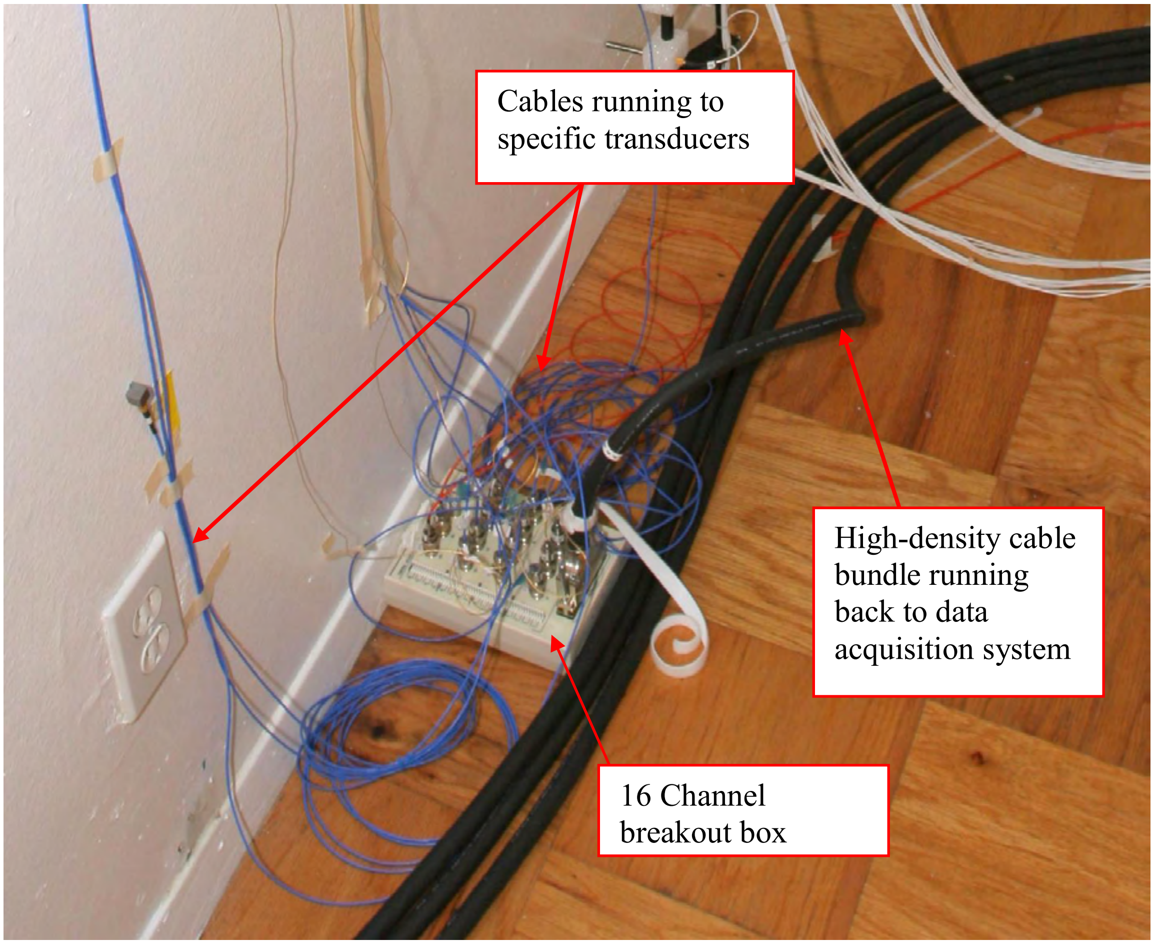

Figure 3.15: A 16-channel breakout box used with the high-density cables.

Figure 3.16: Front bedroom window was opened approximately 6-inches for the tests on July 18th, 2007.

CHAPTER 4: DESCRIPTION OF THE FLIGHTS

The number of sonic booms observed at the test house for each of seven flights is summarized in Table 4.1. In total, the house response was measured for 30 low amplitude and 12 normal amplitude booms with the data acquisition system and transducers documented in Chapter 3. These recordings are summarized in Table 4.2. The low amplitude sonic booms were generated by a unique dive maneuver described in Section 4.1. The peak overpressure of these low amplitude booms, as measured by the ground microphone on channel 98 in the front yard, ranged from 0.1 lb_f/ft^2 to 0.9 lb_f/ft^2 (see Chapter 6). In addition to the low amplitude sonic booms, an aircraft flying straight and level over the house at speeds greater that Mach 1 generated twelve normal amplitude sonic booms that were recorded at the house. These normal amplitude booms ranged from 1.0 lb_f/ft^2 to 2.0 lb_f/ft^2 (see Chapter 6) as measured by the microphone on channel 98.

Section 4.1: Description of the maneuver used to generate low amplitude sonic booms

Existing supersonic aircraft in straight and level flight are not capable of generating the low amplitude sonic booms that were required for this test. Thus, a unique dive maneuver was used that results in low amplitude sonic booms far forward (10 to 20 miles forward) of the dive point. A description of the dive used to generate low amplitude sonic booms was documented by Edward Haering of NASA's Dryden Flight Research Center in a report given at the International Sonic Boom Forum[1]. A portion of the report describing the maneuver is quoted below:

> "The inspiration for producing low overpressure N-wave sonic booms originated with the recent measurement of a sonic boom generated by a sounding rocket upon descent. This vehicle was in a very steep dive at a high altitude and low Mach number when it generated the sonic boom that hit the recorder. Sonic booms of this type were desired for recording and analysis, so the sonic boom propagation code PCBoom4 was used to look at similar trajectories. Because additional flights of this sounding rocket would be infrequent or nonexistent, alternative available aircraft trajectories were modeled with a multitude of PCBoom4 runs. An aircraft in a steep dive at a high supersonic Mach number was found to generate low overpressures far forward of the dive point. It is hypothesized that these low amplitude booms could be used for human acceptability studies leading to a supersonic aircraft quiet enough for overland flight."

> "The current dive profile involves flying at a level attitude, high subsonic speed, and altitude of nearly 50,000 ft. The aircraft is rolled to an inverted attitude; a positive g pull to the desired dive angle of 53° downward then is initiated, while the throttle is pulled to the idle position to avoid excessive speed. When the

[1] Edward A. Haering, Jr., James W. Smolka, James E. Murray, and Kenneth J. Plotkin, "Flight Demonstration Of Low Overpressure N-Wave Sonic Booms And Evanescent Waves", International Sonic Boom Forum, State College, Pennsylvania, USA, July 21-22, 2005.

> desired dive angle is reached, the aircraft is rolled to an upright attitude, and a Mach number of approximately 1.1 is achieved. At an altitude of 38,000 ft a pull-up is executed to recover the aircraft at an altitude of approximately 32,000 ft. The F/A-18B aircraft has an angle-of-attack limit in this supersonic flight regime, so angle of attack is closely monitored. The F/A-18 avionics allows a dive point to be displayed on the head-up display (HUD), which greatly aids in maintaining the proper dive angle and heading."

Photographs illustrating the F/A-18B at various stages of a dive, as viewed from the test house, are shown in Figures 4.1 through 4.4. The dive profile is illustrated in Figure 4.5. More information regarding the dive maneuver is available upon request.

Section 4.2: Daily waypoints for the dives and weather considerations

Low amplitude booms occur when a receiver location is about 10 to 20 miles forward of the airplane dive point. This large propagation distance allows the boom to attenuate before reaching the receiver, in this case the test house. Larger distances result in more attenuation, yielding lower amplitude booms at the receiver location. Thus, the amplitudes of low booms observed at the test house were manipulated by changing locations of the dive points of the aircraft relative to the house. However, in addition to the relative distance between dive point and receiver, the boom attenuation is also sensitive to atmospheric refraction and atmospheric absorption, which is affected by humidity and temperature. Thus, the waypoints where the aircraft dives were initiated were not only determined based on desired boom amplitudes but were also updated daily based on the atmospheric conditions measured each morning.

To update the dive points each morning prior to the flights, NASA Dryden personnel refined the GPS waypoints for the aircraft dives using PCBoom4 analyses and the current atmospheric profile obtained from weather balloon measurements made each morning. For test days with single flights, data from an early morning weather balloon were used for these analyses. For test days with two flights, data from an early morning balloon were used to refine the waypoints for the first flight. Data from a second, mid-morning balloon were used to refine the waypoints for the second flight. These weather data are available upon request.

Section 4.3: Description of the normal amplitude boom flights

On July 17th and 18th, several normal amplitude booms were observed at the house. These normal amplitude booms were generated by straight and level supersonic flight of the F/A-18B aircraft over the test house. Several different flight paths were used to generate the normal amplitude booms on these days. All these paths requested that the aircraft fly at a specified speed and altitude. Once at this speed and altitude, the aircraft would fly a predetermined heading through a target waypoint. After passing through the waypoint, the plane would continue on straight and level flight for a few seconds. This portion of straight and level flight, after passing through the waypoint, is the portion of the flight that generated the boom that arrived at the house. As with the low amplitude booms discussed in the previous section, the waypoints for the normal amplitude booms were adjusted for both the current weather conditions and the desired overpressure prior to flight. PCBoom4 analyses were used to determine the speed, altitude, heading and waypoint combinations.

Section 4.4: Aircraft flight data recordings

For most of the flights, the aircraft with tail number 852 was used, and the flight path of the aircraft was recorded using GPS instrumentation onboard the aircraft. These carrier-phase differential GPS data are available upon request. These data can be used to locate the path that the aircraft actually flew relative to the test house location identified in Appendix D. In addition, the 1553 aircraft bus data such as Mach number, altitude, and Inertial Navigation System (INS) data are available on request for some of the flights. It should be noted, however, that some or all these data might be subject to International Traffic in Arms Regulations (ITAR) restrictions. For the flight on July 13th, some of these data may not be available because an un-instrumented aircraft, with tail number 850, was used. However, a video recording of the head-up display was made during this flight. This can be used to recover some of the relevant information, such as Mach and altitude, and the video is available upon request. Requests for any of these data discussed in this section may require substantial lead-time to fulfill.

Section 4.5: Boom amplitude and direction (BADS) measurements

When the dive points are varied to change the amplitude observed at the test house as described in Section 4.2, the azimuth and elevation angles at which the boom hits the house change. Thus, an outdoor array of microphones was used to measure the direction of the incident sonic boom (Figure 4.6). The microphone array consisted of six pressure sensors spaced several feet apart on the vertices of an octahedral metal frame. The azimuth and elevation of each incident sonic boom were computed from knowledge of the array orientation and the different arrival times of the front shock observed at each pressure sensor. The estimates of the incident angles of each sonic boom are available upon request.

Section 4.6: Daily weather conditions

As mentioned in Section 4.1, several measurements of the atmospheric profile were made each day using weather balloons to quantify the atmospheric weather conditions. In addition, portable weather stations were setup in close proximity to the test house to monitor temperature, wind speed, wind direction, and humidity near the house. These data were recorded at a one-second interval. Up to four weather stations were located near the house, however; some of these stations may not have been functional on some test days due to equipment failures. The data gathered from the weather balloons and weather stations near the house are available upon request. The weather data that are available for particular days will be identified when a request is made.

Table 4.1: Flights that occurred.

Date	Flight	Aircraft Used (Tail Number)	Number of Booms Measured at the House	Type of Booms Generated
7/11/2007	Flight 1	852	5	Low amplitude booms[1]
7/12/2007	Flight 2	852	7	Low amplitude booms[1]
7/12/2007	Flight 3	852	4	Low amplitude booms[1]
7/13/2007	Flight 4	850	7	Low amplitude booms[1]
7/17/2007	Flight 5	852	7	Low amplitude booms[1]
7/17/2007	Flight 6	852	6	Normal amplitude booms[2]
7/18/2007	Flight 7	852	6	Normal amplitude booms[2]

[1] Produced by a maneuver of an F/A-18 aircraft described in Section 4.1.

[2] Produced by straight and level flight of an F/A-18 aircraft over the house at speeds greater than Mach 1.

Table 4.2: Summary of the sonic boom response recordings made at the house.

Date Stamps for Sonic Boom Response Measurements	Location	Excitation Location	Excitation Signal Description	Additional Notes
7_11_2007 8_09_40 AM	N/A	N/A	Low amplitude sonic boom	Nexi overloaded, the binaural head was off
7_11_2007 8_17_17 AM	N/A	N/A	Low amplitude sonic boom	Nexi overloaded, the binaural head was off
7_11_2007 8_23_29 AM	N/A	N/A	Low amplitude sonic boom	Changed gains for this and subsequent booms to prevent overloads
7_11_2007 8_28_30 AM	N/A	N/A	Low amplitude sonic boom	The binaural head was off
7_11_2007 8_37_38 AM	N/A	N/A	Low amplitude sonic boom	The binaural head was off
7_12_2007 8_01_48 AM	N/A	N/A	Low amplitude sonic boom	Sprinkler in yard of neighbor to the south was on and hitting neighboring driveway which caused increased noise on the microphones in the front yard
7_12_2007 8_09_00 AM	N/A	N/A	Low amplitude sonic boom	
7_12_2007 8_15_51 AM	N/A	N/A	Low amplitude sonic boom	
7_12_2007 8_21_42 AM	N/A	N/A	Low amplitude sonic boom	
7_12_2007 8_28_02 AM	N/A	N/A	Low amplitude sonic boom	
7_12_2007 8_34_40 AM	N/A	N/A	Low amplitude sonic boom	
7_12_2007 8_39_59 AM	N/A	N/A	Low amplitude sonic boom	
7_12_2007 10_32_37 AM	N/A	N/A	Low amplitude sonic boom	None
7_12_2007 10_38_36 AM	N/A	N/A	Low amplitude sonic boom	None
7_12_2007 10_44_21 AM	N/A	N/A	Low amplitude sonic boom	None
7_12_2007 10_50_40 AM	N/A	N/A	Low amplitude sonic boom	None
7_13_2007 9_41_06 AM	N/A	N/A	Low amplitude sonic boom	None
7_13_2007 9_46_42 AM	N/A	N/A	Low amplitude sonic boom	None
7_13_2007 9_53_23 AM	N/A	N/A	Low amplitude sonic boom	None
7_13_2007 9_59_05 AM	N/A	N/A	Low amplitude sonic boom	None
7_13_2007 10_05_30 AM	N/A	N/A	Low amplitude sonic boom	None
7_13_2007 10_13_02 AM	N/A	N/A	Low amplitude sonic boom	None
7_13_2007 10_19_58 AM	N/A	N/A	Low amplitude sonic boom	None
7_17_2007 8_10_22 AM	N/A	N/A	Low amplitude sonic boom	The binaural head was outside but overloaded due to incorrect range
7_17_2007 8_17_19 AM	N/A	N/A	Low amplitude sonic boom	
7_17_2007 8_23_04 AM	N/A	N/A	Low amplitude sonic boom	
7_17_2007 8_29_35 AM	N/A	N/A	Low amplitude sonic boom	
7_17_2007 8_35_43 AM	N/A	N/A	Low amplitude sonic boom	
7_17_2007 8_42_59 AM	N/A	N/A	Low amplitude sonic boom	
7_17_2007 8_48_07 AM	N/A	N/A	Low amplitude sonic boom	
7_17_2007 10_32_08 AM	N/A	N/A	Normal amplitude sonic boom	
7_17_2007 10_39_18 AM	N/A	N/A	Normal amplitude sonic boom	
7_17_2007 10_46_23 AM	N/A	N/A	Normal amplitude sonic boom	
7_17_2007 10_54_17 AM	N/A	N/A	Normal amplitude sonic boom	
7_17_2007 11_01_12 AM	N/A	N/A	Normal amplitude sonic boom	
7_17_2007 11_07_30 AM	N/A	N/A	Normal amplitude sonic boom	
7_18_2007 8_06_20 AM	N/A	N/A	Normal amplitude sonic boom	Front door was locked
7_18_2007 8_13_02 AM	N/A	N/A	Normal amplitude sonic boom	Front door was locked
7_18_2007 8_19_08 AM	N/A	N/A	Normal amplitude sonic boom	Front door was locked
7_18_2007 8_25_12 AM	N/A	N/A	Normal amplitude sonic boom	Front door was unlocked, plane taking off was audible
7_18_2007 8_31_16 AM	N/A	N/A	Normal amplitude sonic boom	Front door was unlocked
7_18_2007 8_37_15 AM	N/A	N/A	Normal amplitude sonic boom	Front door was unlocked

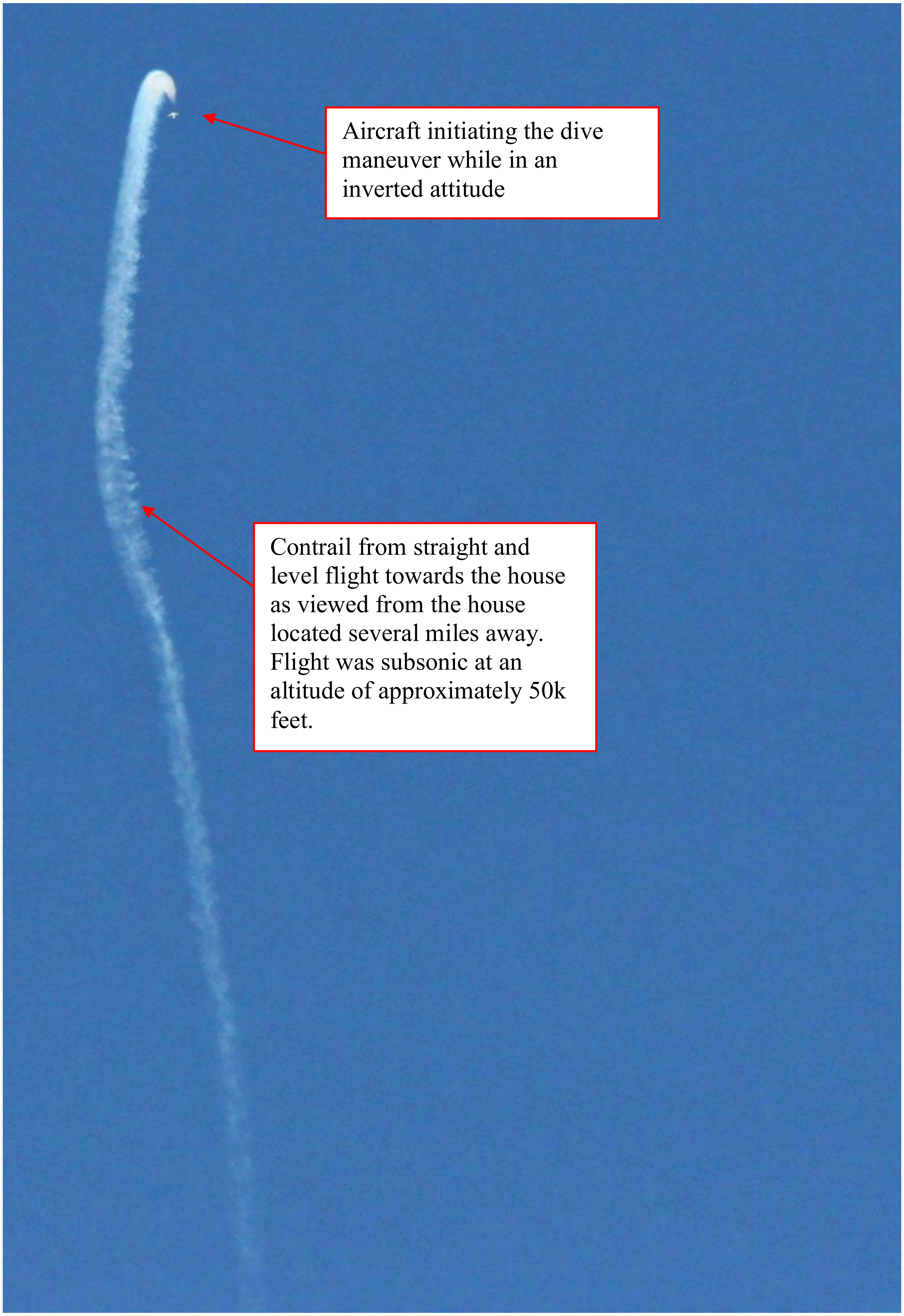

Figure 4.1: F/A-18B is initiating a 53-degree dive after rolling to an inverted position.

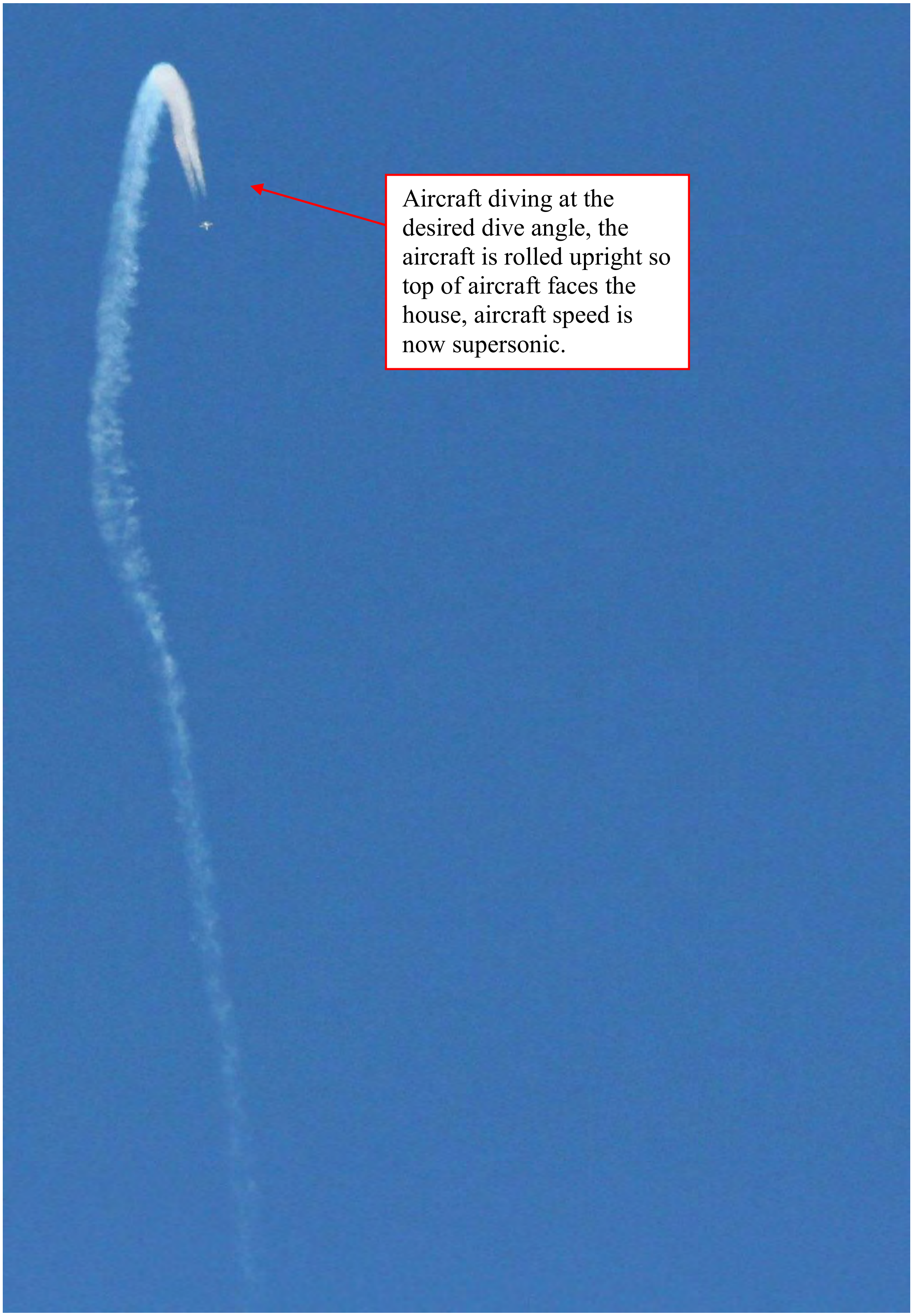

Figure 4.2: F/A-18B aircraft is rolled upright while in a dive at an angle of 53 degrees.

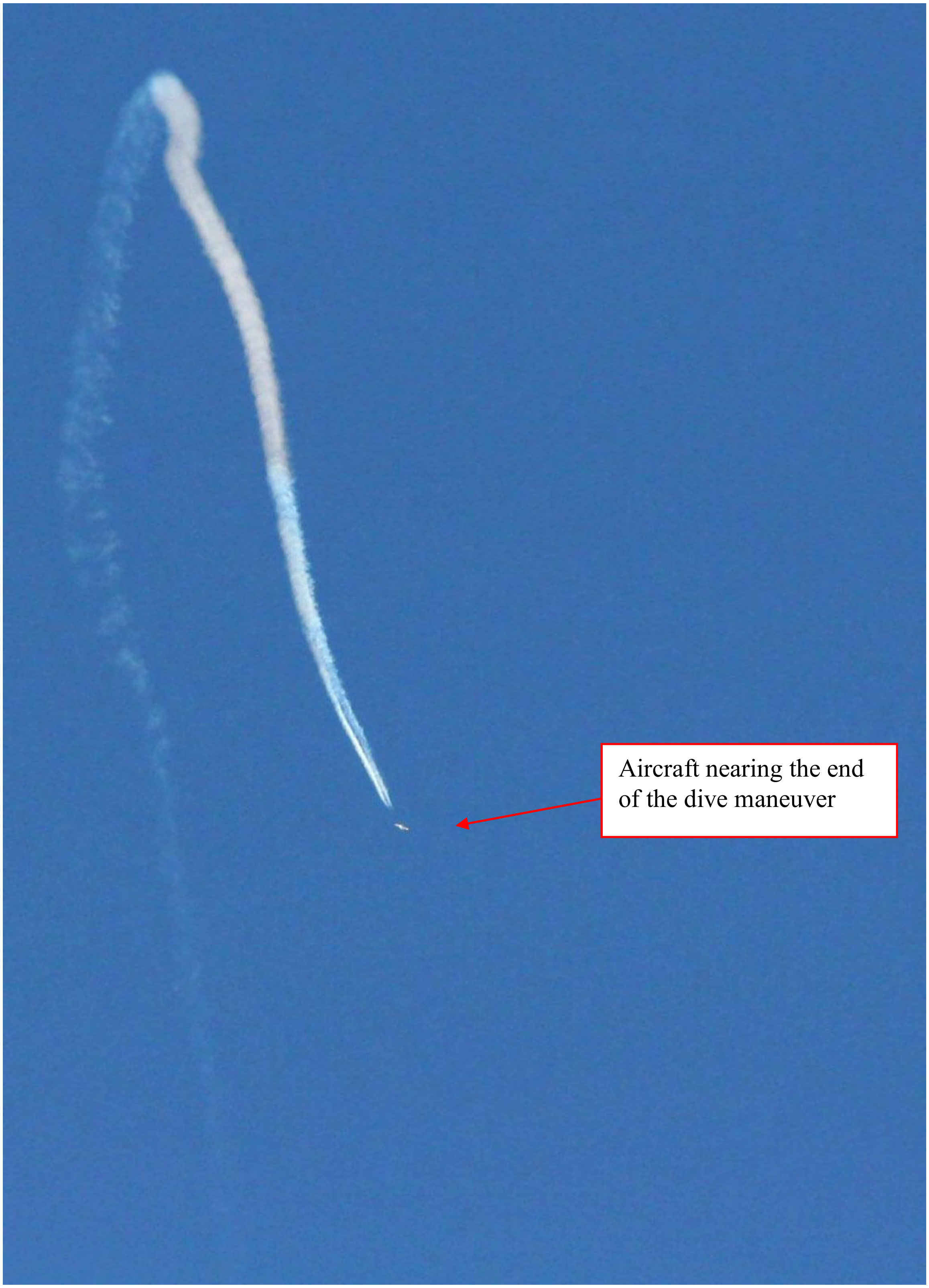

Figure 4.3: F/A-18B throttling up near the end of the 53 degree dive.

Figure 4.4: F/A-18B pulling out at the end of a dive.

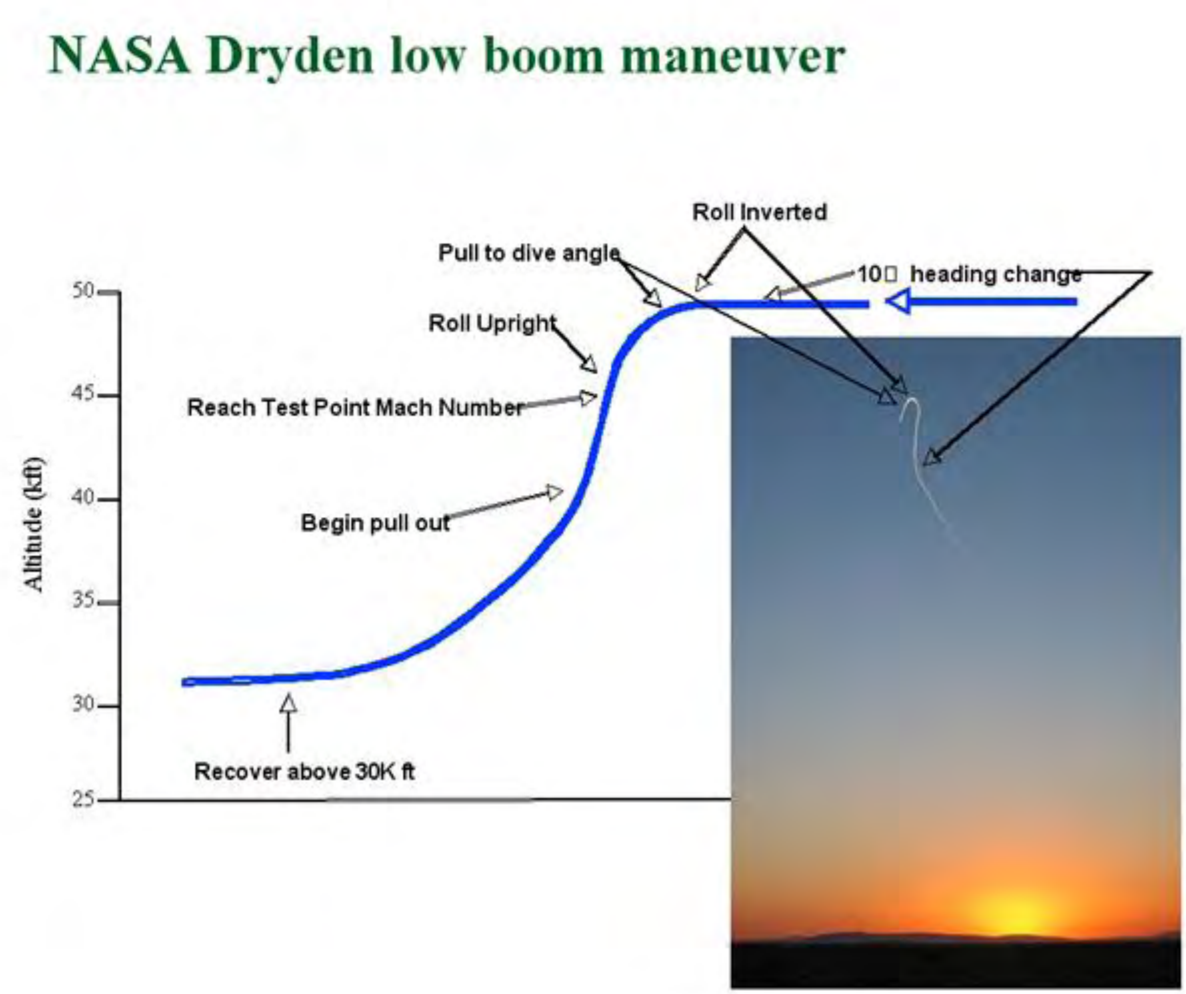

Figure 4.5: Illustration of the dive maneuver.

Figure 4.6: System used to measure the boom direction and amplitude.

CHAPTER 5: HOUSE CHARACTERIZATION TESTS

Several tests were performed in July 2007 to characterize the house's vibroacoustic response to excitations other than the sonic booms documented in Chapter 4. These simple tests are summarized in Table 5.1. These were designed to measure the response of the house's structure or acoustic spaces to simple excitations, such as point force excitation from a mechanical shaker or acoustic balloon pops. For all the characterization tests performed in July 2007, the data acquisition system documented in Chapter 3 was used to record the responses of all 112 channels. However, some of the outdoor B&K microphones were not powered on during these tests. Notes of which microphones were powered on or off during individual tests were not taken, but the presence of these microphones during these tests should be audible in the recordings.

Section 5.1: Acoustic characterization tests

Reverberation time measurements (Appendix G) were recorded in the three bedrooms and the attic using a Brüel and Kjær Type 2231 sound level meter running reverberation processor software BZ 7108. A Brüel and Kjær Type 1625 octave-band filter module was also used. The serial numbers of the sound level meter, the octave-band filter module, and the Type 4134 microphone attached to the sound level meter were 1413682, 1418440, and 478911, respectively. These instruments were sent to Simco, the calibration provider for NASA Langley Research Center, for calibration prior to use in this test. The calibration expiration on these instruments was May 2008. The sound level meter automatically plays a band-limited pulse of sound through a speaker, measures the reverberation response of the acoustic space, and computes and stores the EDT, T(20), and T(30) in a user-defined range of one-third-octave bands. Measurements of these quantities were made in each of the one-third-octave bands ranging from 50 Hz to 5,000 Hz. Measurements at frequencies lower than 50 Hz were not possible because that is lower limit of the BZ 7108 software. To generate the required band-limited pulse of sound, a Mackie studio speaker was attached to the output of the sound level meter. The speaker was placed in one of the corners in a room, spaced approximately 12 to 18-inches from the walls, facing the walls at an oblique angle (Figure 5.1). The sound level meter was located at an approximate height of 4 feet from the floor and was placed near the middle of the room (Figure 5.1). It should be noted that the sound level meter performs data quality checks on the estimates, and indicates reverberation estimates that are possibly of poor quality. These values are indicated by text that is bolded and underlined in Appendix G.

Reverberation measurements were made for the nominal room configurations, which included the carpet and foam mattress pads inside the rooms that are discussed in Chapter 2. The bedroom doors were always closed during these measurements. The attic reverberation time was also measured (Figures 5.2 and 5.3). For each space, the reverberation time was measured at least twice. For measurements in the master bedroom and attic, neither the sound level meter nor the speaker was moved between the two repeat tests. For measurements in the garage bedroom and front bedroom, both the sound level meter and the speaker were moved between the repeat tests. Notes of the locations of the sound level meter and speaker were not made. The measured values of EDT, T(20), and T(30) are shown in Appendix G and are typically in close agreement for the repeat tests in these four spaces. It should be noted that while the reverberation tests were performed with the sound level meter, the time histories of all 112 channels of instrumentation described in Chapter 3 were recorded with the data acquisition system at a sample rate of 25,600 Hz. The time and date stamps of the binary data records for each of these tests are:

- Master bedroom room
    - Run 1: 7/11/2007 9:10:47 AM (with microphones outside powered on)
    - Run 2: 7/11/2007 9:14:42 AM (with microphones outside powered on)
- Front bedroom
    - Run 1: 7/11/2007 12:28:34 PM
    - Run 2: 7/11/2007 12:33:07 PM
    - Run 3: 7/11/2007 9:32:40 AM (with microphones outside powered on)
- Garage bedroom
    - Run 1: 7/11/2007 12:12:37 AM
    - Run 2: 7/11/2007 12:18:17 AM
- Attic
    - Run 1: 7/18/2007 12:45:48 PM
    - Run 2: 7/18/2007 12:56:17 PM

Measurement data in binary format are available upon request for each one of these tests. The format of the binary data files is discussed in more detail in Chapter 6, Section 6.1. Several of the reverberation time measurements were made with the exterior microphones powered on, as noted above. Some of the exterior microphones may have been powered on for the other tests as well, but no notes were made to that effect. However, whether or not exterior microphones were powered on for the other tests should be audible in those recorded data. For tests performed on the 11th, the locations of the microphones and accelerometers correspond to those documented in Appendices B and C. For tests performed on the 18th, the locations of the microphones and accelerometers correspond to those documented in Appendices B and C but include the location changes identified in Appendix E.

In addition to the reverberation time measurements documented above, acoustic impulse response measurements were made both outside and inside the house on July 18th, 2007 (Table 5.1). For the outdoor acoustic impulse response measurements, the locations of the microphones and accelerometers correspond to those documented in Appendices B and C but include the location changes identified in Appendix E. Inflated brown paper bags were popped outdoors at several different locations to characterize the outdoor propagation of an acoustic impulse and the diffraction of the pulse around the house. It should be noted, though, that it was windy at the house during these tests. The weather stations near the house were used to record the ambient weather conditions, including wind speed and direction, during these tests and these data are available upon request. To perform these bag pop tests, a person knelt on the ground facing the house, holding the paper bag at ground level roughly a few inches above the ground and popped it. The data acquisition system described in Chapter 3 was used to record the time histories of all 112 transducers for each paper bag pop. The locations of each outdoor paper bag pop, and the date and time stamp of the binary data record, are listed in Appendix H. The format of the binary data files is discussed in more detail in Chapter 6, Section 6.1.

In addition to the outdoor impulsive measurements, inflated balloons were popped inside each of the instrumented bedrooms, as well as the garage, to characterize the impulse response of these acoustic spaces. The locations of the microphones and accelerometers correspond to those documented in Appendices B and C but include the location changes identified in Appendix E. Four balloons were popped in each of the rooms, and five were popped in the garage, at arbitrary locations near the center of the room. No notes of the precise locations of the pops were made. The data acquisition system described in Chapter 3 was used to record the time histories of all 112 transducers for each balloon pop. The locations of each balloon pop and the date and time stamp of the binary data records are listed in Appendix H. The format of the binary data files is discussed in more detail in Chapter 6, Section 6.1.

Section 5.2: Structural characterization tests

Several structures in the house were excited using a mechanical shaker to characterize the forced response of these components of the house (Appendix I). The structures that were excited were:

- Master bedroom:
    - Window
    - South wall
    - West wall
    - Ceiling
    - Entry door
- Garage bedroom:
    - Window
    - South wall
    - East wall
- Front bedroom window
- Garage door
- Front entry door to the house

The date and time stamps of the tests on these structures are noted in Appendix I. For tests conducted prior to July 18^{th}, the locations of the microphones and accelerometers correspond to those documented in Appendices B and C. For tests on or after the 18^{th}, the locations of the microphones and accelerometers correspond to those documented in Appendices B and C but include the location changes identified in Appendix E. Some, but not all, of the exterior microphones may have been powered off for these tests, but no notes were made to that effect. Whether or not exterior microphones were powered on should be audible in the recorded data.

The data acquisition system described in Chapter 3 was used to record the response of the accelerometers and microphones while the shaker was exciting the structure. An impedance head was used at the drive point locations (Figures 5.4 through 5.6) to sense both excitation force and acceleration at the drive point. The model and serial number of the impedance head is listed in Table 3.1 (Chapter 3). The force and acceleration signals were connected to channels 111 and 112 (Table 3.1), respectively, of the data acquisition system. The two Endevco accelerometers that were typically connected to these two channels (Table 3.1) for sonic boom response measurements were disconnected for these shaker tests. 1-mil thick polyester flashbreaker tape was applied to the mounting surface at the drive point to avoid causing damage to the paint or glass (Figures 5.4 and 5.5). The impedance head was mounted to the shaker using a stinger, and the driving side of the impedance head was adhered to the tape at the drive point using either super glue or mounting wax (Figures 5.4 and 5.5). The adhesive used is identified in Appendix I. It should be noted that for the exterior point force measurements on the south wall of the master and garage bedrooms (Appendix I), an improvised table was attached to the impedance head to create a larger contact surface, and the table was adhered to the stucco directly using a large amount of wax (Figure 5.6).

The shaker used in these tests was a Labworks Inc. model ET-126B, serial number 126-405. The amplifier used to drive the shaker was a Labworks Inc. model PA-138, serial number 138-0598. LabVIEW™ software running on a laptop computer was used to generate the signals used to drive the amplifier. The drive signal was output through the sound card onboard the laptop, and was measured on channel 110 of the data acquisition system for these shaker tests. The IRIG time code that was typically measured on channel 110 during boom measurements was disconnected for these shaker measurements. For structural response measurements, a variety of signals was used to excite the shaker and these are summarized in Appendix I. The signals used were:

- Band-limited white noise
- Pure tones at different amplitudes
- Amplitude swept pure tones (where the amplitude of a pure tone was slowly increased as the test progressed)

The amplitude swept pure tones were used to characterize the rattle of the windows and doors. The onset of rattle is identifiable in these data. The date and time stamp of the binary data record for each excitation location and signal type are listed Appendix I. The format of the binary data files is discussed in more detail in Chapter 6, Section 6.1.

Table 5.1: Summary of the characterization tests performed at the test house.

Date Stamps for Shaker Response Measurements of the Walls	Location	Excitation Location	Excitation Signal Description	Additional Notes
7_15_2007 11_23_06 AM	Bad data			None
7_16_2007 12_26_25 PM	Garage Bed, South Wall	11 (Appendix I)	White noise (2 to 2kHz)	Glue mount
7_16_2007 1_24_29 PM	Garage Bed, South Wall	12 (Appendix I)	White noise (2 to 2kHz)	Glue mount
7_16_2007 2_58_54 PM	Garage Bed, South Wall	13 (Appendix I)	White noise (2 to 2kHz)	Glue mount
7_16_2007 3_40_15 PM	Garage Bed, East Wall	14 (Appendix I)	White noise (2 to 2kHz)	Glue mount
7_17_2007 2_09_12 PM	Garage Bed, East Wall	14 (Appendix I)	White noise (2 to 2kHz)	Wax mount
7_17_2007 2_25_47 PM	Garage Bed, South Wall	8 (Appendix I)	White noise (2 to 2kHz)	Wax mount, on stud, master bed door was open for test
7_17_2007 2_35_26 PM	Garage Bed, South Wall	9 (Appendix I)	White noise (2 to 2kHz)	Wax mount, on drywall, master bed door was open for test
7_17_2007 2_56_30 PM	Master Bed, South Wall	7 (Appendix I)	White noise (2 to 2kHz)	Wax mount, drywall, microphones 101-104 were off
7_17_2007 3_08_07 PM	Master Bed, South Wall	7 (Appendix I)	White noise (2 to 2kHz)	Wax mount, drywall
7_17_2007 3_26_40 PM	Master Bed, South Wall	6 (Appendix I)	White noise (2 to 2kHz)	Wax mount, stud
7_17_2007 3_31_52 PM	Master Bed, South Wall	5 (Appendix I)	White noise (2 to 2kHz), higher amplitude	Wax mount, stud
7_17_2007 4_38_25 PM	Master Bed, South Wall	4 (Appendix I)	White noise (2 to 2kHz)	Wax mount, stud, lots of wind noise on outside microphones
7_18_2007 6_26_53 AM	Master Bed, South Wall	5 (Appendix I)	White noise (2 to 2kHz)	Wax mount, spoke during meas, outside mics on, car dove past
7_18_2007 1_33_12 PM	Not in notes, possibly master bed, west wall	Possibly 0 (App. I)		None
7_18_2007 1_41_48 PM	Master Bed, West Wall	3 (Appendix I)	White noise (2 to 2kHz)	Wax mount
7_18_2007 1_53_01 PM	Master Bed, South Wall	4 (Appendix I)	White noise (2 to 2kHz)	Wax mount, dog was barking next door
7_18_2007 1_56_55 PM	Master Bed, South Wall	4 (Appendix I)	White noise (2 to 2kHz)	Wax mount, aircraft overhead
7_18_2007 2_22_38 PM	Master Bed, Ceiling	See Photos App. I	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 9_06_42 AM	Master Bed, South Wall, Outside	18 (Appendix I)	White noise (2 to 2kHz)	Wax mount, large table on impedance head
7_19_2007 9_19_35 AM	Master Bed, South Wall, Outside	19 (Appendix I)	White noise (2 to 2kHz)	Wax mount, large table on impedance head
7_19_2007 9_31_53 AM	Master Bed, South Wall, Outside	20 (Appendix I)	White noise (2 to 2kHz)	Wax mount, large table on impedance head
7_19_2007 10_00_46 AM	Master Bed, South Wall, Outside	21 (Appendix I)	White noise (2 to 2kHz)	Wax mount, large table on impedance head
7_19_2007 10_05_41 AM	Master Bed, South Wall, Outside	21 (Appendix I)	White noise (2 to 2kHz)	Wax mount, large table on impedance head

Date Stamps for Shaker Response Measurements of the Windows	Location	Excitation Location	Excitation Signal Description	Additional Notes
7_15_2007 3_23_14 PM	Front Bed, Window Frame	17 (Appendix I)	White noise	Glue mount
7_15_2007 3_29_03 PM	Front Bed, Window Frame	17 (Appendix I)	White noise	Glue mount
7_15_2007 4_38_57 PM	Front Bed, Window Pane	16 (Appendix I)	White noise	Glue mount
7_15_2007 4_59_54 PM	Front Bed, Window Pane	16 (Appendix I)	18.5 Hz tone, low amplitude	Glue mount
7_15_2007 5_03_31 PM	Front Bed, Window Pane	16 (Appendix I)	18.5 Hz tone, high amplitude	Glue mount
7_15_2007 5_11_34 PM	Front Bed, Window Pane	16 (Appendix I)	77.75 Hz tone, high amplitude	Glue mount
7_15_2007 5_13_28 PM	Front Bed, Window Pane	16 (Appendix I)	77.75 Hz tone, low amplitude	Glue mount
7_15_2007 5_59_48 PM	Unknown, not in notes	Unknown		None
7_15_2007 6_16_13 PM	Garage Bed, Window Pane	10 (Appendix I)	White noise, high amplitude	Shaker not clamped to wood support, glue mount
7_15_2007 6_21_49 PM	Garage Bed, Window Pane	10 (Appendix I)	White noise, low amplitude	Shaker not clamped to wood support, glue mount
7_16_2007 10_02_33 AM	Garage Bed, Window Pane	10 (Appendix I)	White noise (2 to 2kHz), low amplitude	Glue mount
7_16_2007 10_11_59 AM	Garage Bed, Window Pane	10 (Appendix I)	White noise (2 to 2kHz), high amplitude	Glue mount
7_16_2007 10_42_50 AM	Garage Bed, Window Pane	10 (Appendix I)	Amplitude swept sine	Glue mount
7_18_2007 10_03_02 AM	Master Bed, Window Pane	1 (Appendix I)	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount
7_18_2007 10_04_26 AM	Master Bed, Window Pane	1 (Appendix I)	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount
7_18_2007 2_09_47 PM	Master Bed, Window Frame	2 (Appendix I)	White noise (2 to 2kHz), low amplitude	Wax mount, hand held shaker
7_18_2007 2_12_39 PM	Master Bed, Window Frame	2 (Appendix I)	White noise (2 to 2kHz), high amplitude	Wax mount, hand held shaker
7_18_2007 8_51_57 AM	Master Bed, Window Pane	1 (Appendix I)	White noise (2 to 2kHz), low amplitude	Wax mount
7_18_2007 8_56_44 AM	Master Bed, Window Pane	1 (Appendix I)	White noise (2 to 2kHz), low amplitude	Wax mount
7_18_2007 9_13_02 AM	Master Bed, Window Pane	1 (Appendix I)	White noise (2 to 2kHz), mid amplitude	Wax mount
7_18_2007 9_23_46 AM	Master Bed, Window Pane	1 (Appendix I)	White noise (2 to 2kHz), mid amplitude	Wax mount
7_18_2007 9_34_17 AM	Master Bed, Window Pane	1 (Appendix I)	White noise (2 to 2kHz), high amplitude	Wax mount
7_18_2007 9_35_40 AM	Master Bed, Window Pane	1 (Appendix I)	White noise (2 to 2kHz), high amplitude	Wax mount
7_19_2007 11_02_53 AM	Front Bed, Outside Window Surface	23 (Appendix I)	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_06_26 AM	Front Bed, Outside Window Surface	24 (Appendix I)	White noise (2 to 2kHz)	Wax mount, hand held shaker, noise contamination
7_19_2007 11_09_07 AM	Front Bed, Outside Window Surface	24 (Appendix I)	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_11_59 AM	Front Bed, Outside Window Surface	25 (Appendix I)	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_15_23 AM	Front Bed, Outside Window Surface	26 (Appendix I)	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_18_57 AM	Front Bed, Outside Window Surface	27 (Appendix I)	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_23_45 AM	Front Bed, Outside Window Surface	23 (Appendix I)	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount, hand held shaker, amplitude sweep log profile
7_19_2007 11_25_19 AM	Front Bed, Outside Window Surface	23 (Appendix I)	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount, hand held shaker, amplitude sweep log profile
7_19_2007 11_28_16 AM	Front Bed, Outside Window Surface	23 (Appendix I)	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount, hand held shaker, amplitude sweep linear profile

Date Stamps for Shaker Response Measurements of the Doors	Location	Excitation Location	Excitation Signal Description	Additional Notes
7_18_2007 2_01_57 PM	Master Bed, Entry Door	See Photos App. I	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_18_2007 2_31_00 PM	Front Entry Door, Inside Surface	No Photographs	White noise (2 to 2kHz), low amplitude	Wax mount, hand held shaker
7_18_2007 2_32_46 PM	Front Entry Door, Inside Surface	No Photographs	White noise (2 to 2kHz), high amplitude	Wax mount, hand held shaker
7_18_2007 2_39_43 PM	Front Entry Door, Outside Surface	No Photographs	White noise (2 to 2kHz), high amplitude	Wax mount, hand held shaker
7_19_2007 10_30_04 AM	Garage Door	22 (Appendix I)	White noise (2 to 2kHz)	Wax mount
7_19_2007 10_42_50 AM	Garage Door	22 (Appendix I)	Amplitude swept sine at 40 Hz	Wax mount
7_19_2007 10_44_44 AM	Garage Door	22 (Appendix I)	Amplitude swept sine at 40 Hz	Wax mount
7_19_2007 10_49_11 AM	Garage Door	22 (Appendix I)	Amplitude swept sine at 29 Hz	Wax mount

Table continued on next page.

Table 5.1: Concluded.

Date Stamps for the Indoor Reverberation Measurements	Location	Excitation Location	Excitation Signal Description	Additional Notes
7_11_2007 9_10_47 AM	Master Bedroom	N/A	Band limited chirps from sound level meter	Outdoor microphones were powered on
7_11_2007 9_14_42 AM	Master Bedroom	N/A	Band limited chirps from sound level meter	Outdoor microphones were powered on
7_11_2007 9_32_40 AM	Front Bedroom	N/A	Band limited chirps from sound level meter	Outdoor microphones were powered on
7_11_2007 12_12_37 AM	Garage Bedroom	N/A	Band limited chirps from sound level meter	None
7_11_2007 12_18_17 AM	Garage Bedroom	N/A	Band limited chirps from sound level meter	None
7_11_2007 12_28_34 AM	Front Bedroom	N/A	Band limited chirps from sound level meter	None
7_11_2007 12_33_07 AM	Front Bedroom	N/A	Band limited chirps from sound level meter	Did not record the 50 Hz pulse
7_18_2007 12_45_48 PM	Attic	N/A	Band limited chirps from sound level meter	None
7_18_2007 12_56_17 PM	Attic	N/A	Band limited chirps from sound level meter	None

Date Stamps for Indoor Impulse Response Measurements (Balloon Pops)	Location	Excitation Location	Excitation Signal Description	Additional Notes
7_18_2007 3_55_48 PM	Master Bedroom	N/A	Balloon pop near center of room	None
7_18_2007 3_56_05 PM	Master Bedroom	N/A	Balloon pop at a random location	None
7_18_2007 3_56_22 PM	Master Bedroom	N/A	Balloon pop at a random location	None
7_18_2007 3_56_39 PM	Master Bedroom	N/A	Balloon pop at a random location	None
7_18_2007 3_57_29 PM	Front Bedroom	N/A	Balloon pop near center of room	None
7_18_2007 3_57_47 PM	Front Bedroom	N/A	Balloon pop at a random location	None
7_18_2007 3_58_04 PM	Front Bedroom	N/A	Balloon pop at a random location	None
7_18_2007 3_58_21 PM	Front Bedroom	N/A	Balloon pop at a random location	None
7_18_2007 3_58_59 PM	Garage Bedroom	N/A	Balloon pop near center of room	None
7_18_2007 3_59_16 PM	Garage Bedroom	N/A	Balloon pop at a random location	None
7_18_2007 3_59_31 PM	Garage Bedroom	N/A	Balloon pop at a random location	None
7_18_2007 3_59_49 PM	Garage Bedroom	N/A	Balloon pop at a random location	None
7_18_2007 4_01_03 PM	Garage	N/A	Balloon pop near center of the garage	None
7_18_2007 4_01_17 PM	Garage	N/A	Balloon pop at a random location	None
7_18_2007 4_01_36 PM	Garage	N/A	Balloon pop at a random location	None
7_18_2007 4_02_06 PM	Garage	N/A	Balloon pop at a random location	None
7_18_2007 4_03_36 PM	Garage	N/A	Balloon pop at a random location	None

Date Stamps for Outdoor Impulse Response Measurements (Bag Pops)	Location	Excitation Location	Excitation Signal Description	Additional Notes
7_18_2007 3_21_18 PM	Outside position 1	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_22_03 PM	Outside position 1	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_22_33 PM	Outside position 1	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_23_47 PM	Outside position 2	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_24_09 PM	Outside position 2	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_24_43 PM	Outside position 2	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_25_25 PM	Outside position 3	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_25_56 PM	Outside position 3	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_26_18 PM	Outside position 3	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_26_42 PM	Outside position 3	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_28_33 PM	Outside position 4	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_30_29 PM	Outside position 4	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_31_00 PM	Outside position 4	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_31_59 PM	Outside position 4	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_32_27 PM	Outside position 4	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_33_43 PM	Outside position 4	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_35_37 PM	Outside position 5	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_35_54 PM	Outside position 5	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_36_29 PM	Outside position 5	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_37_07 PM	Outside position 5	See Appendix H	Brown paper bag pop near the ground	None
7_18_2007 3_37_37 PM	Outside position 5	See Appendix H	Brown paper bag pop near the ground	None

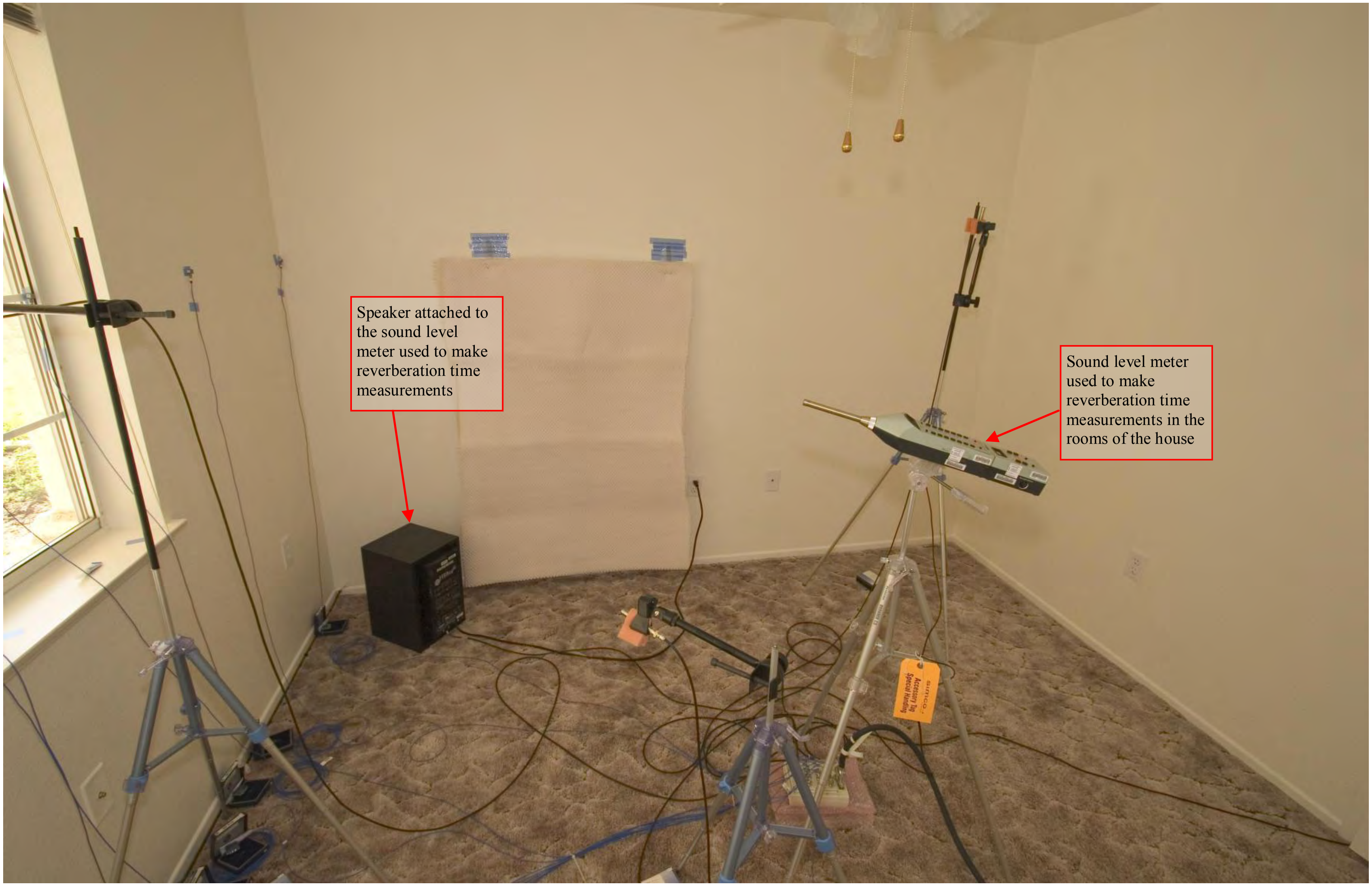

Figure 5.1: Typical setup used to measure the reverberation time in the rooms, front bedroom shown.

Figure 5.2: Photograph of the sound level meter in the attic for reverberation time measurements.

Figure 5.3: Photograph of the Mackie speaker in the attic for the reverberation time measurements.

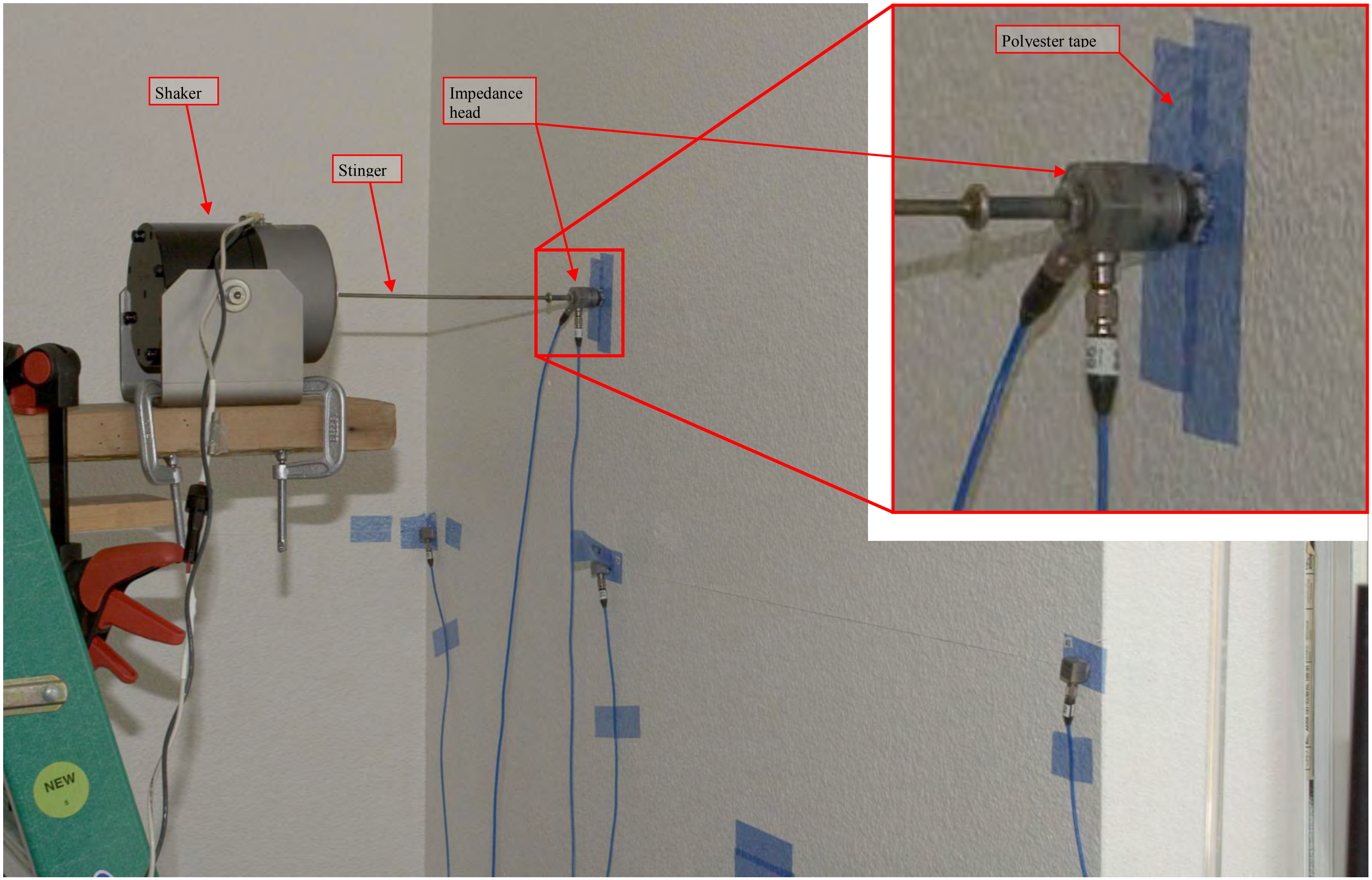

Figure 5.4: Shaker attached to the south wall in the garage bedroom.

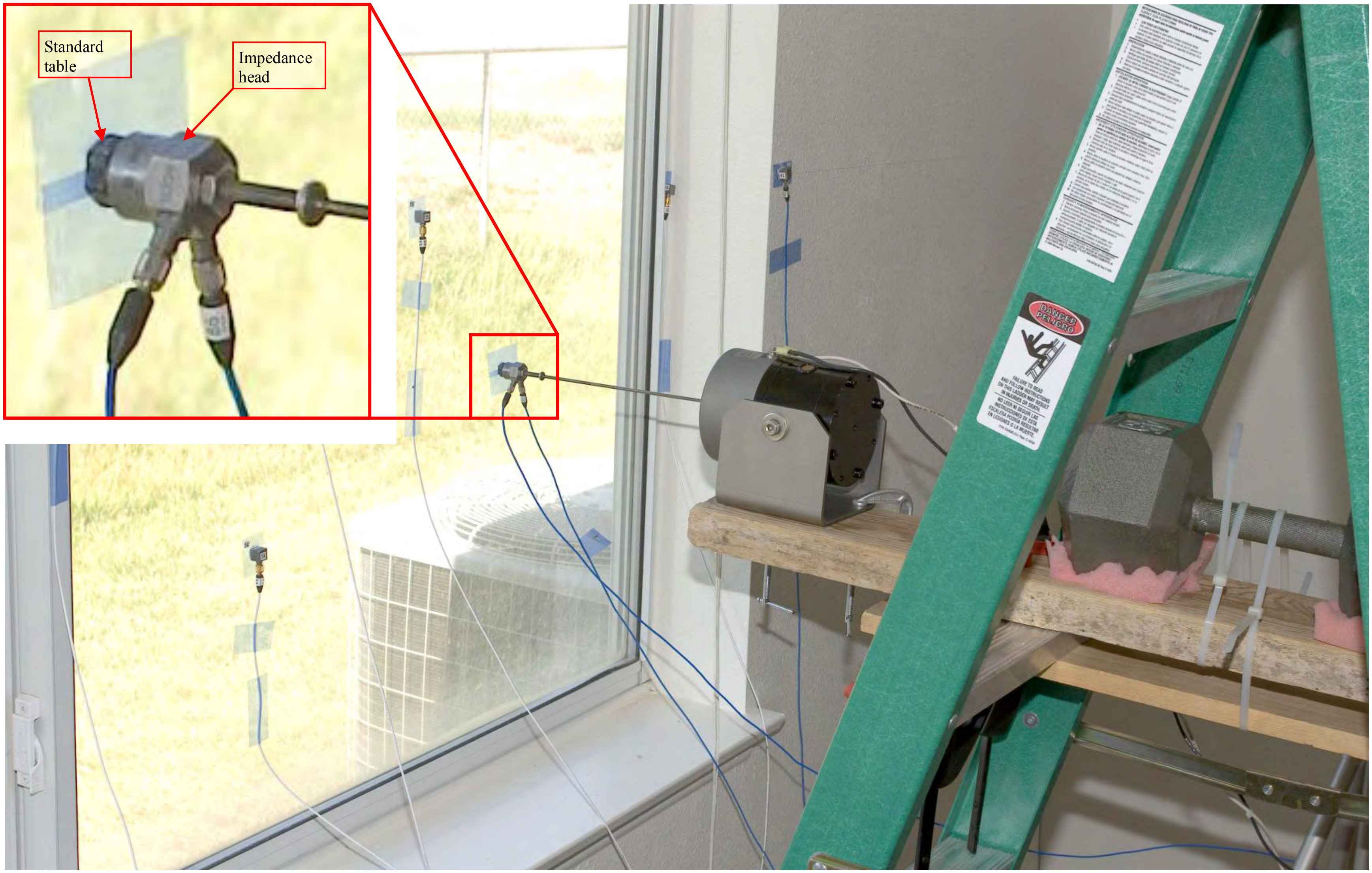

Figure 5.5: Shaker attached to the window in the garage bedroom.

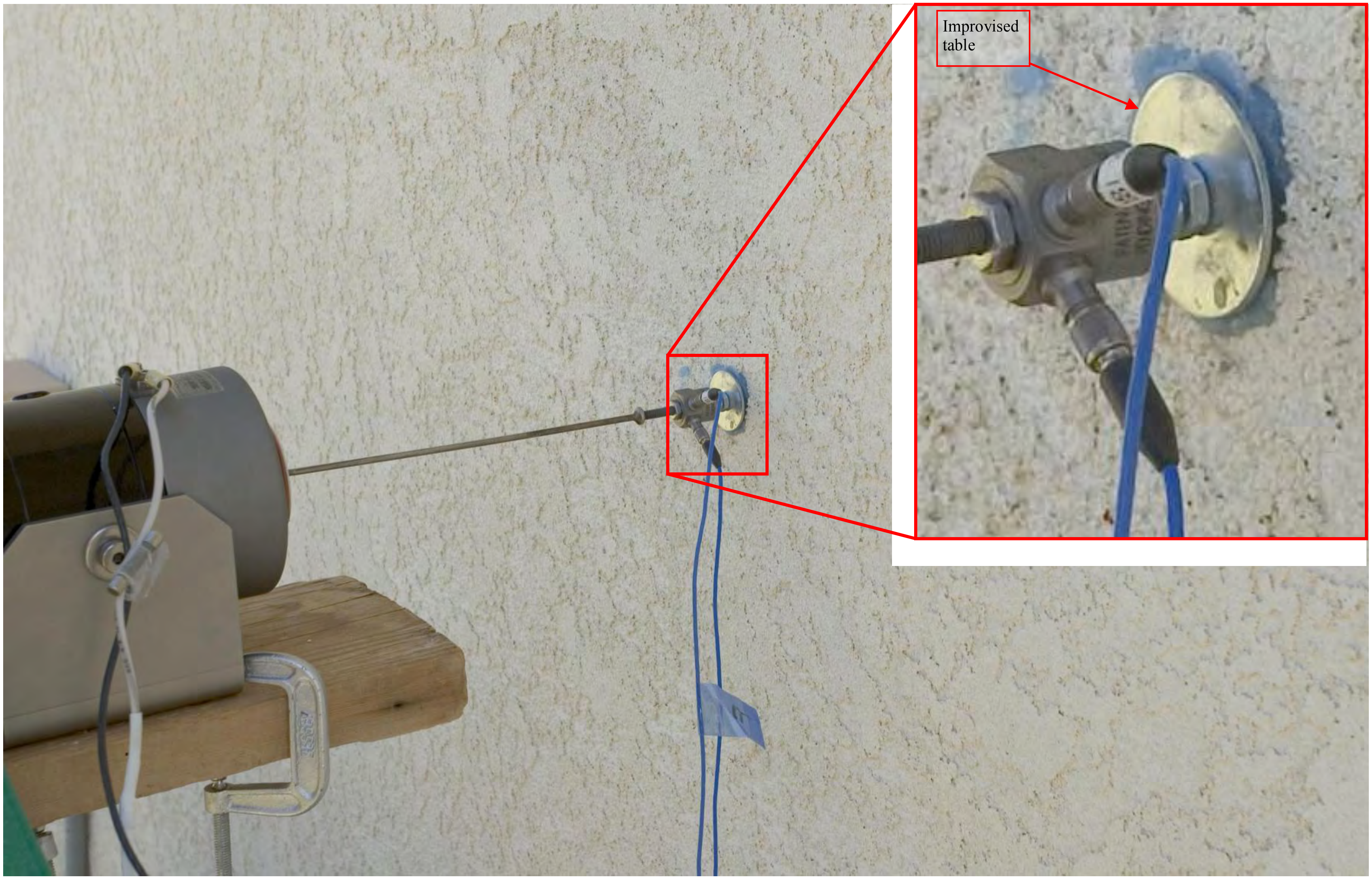

Figure 5.6: Shaker attached to the stucco on the exterior of the south wall of the master bedroom.

CHAPTER 6: VIBRO-ACOUSTIC DATA FORMATS

In this chapter, the data and data formats that are available for distribution are discussed.

Section 6.1: Sampling parameters and binary data formats

The sampling parameters and binary data formats are discussed in this section for both the sonic boom measurements documented in Chapter 4 and the characterization tests documented in Chapter 5. The data acquisition system and transducers that were used to collect these data are documented in Chapter 3.

Subsection 6.1.1: Sampling parameters and binary data formats for the sonic boom measurements

All sonic boom response measurements were recorded at a sample rate of 25,600 Hz (Table 6.1). Approximately two minutes of continuous time data were recorded for each of the sonic booms observed at the house, where at least 30 seconds of ambient noise was recorded before the boom arrived at the house. These continuous time data were acquired for all 112 channels using ensembles that were 32,768 samples long. Each ensemble, containing 112 channels and 32,768 samples, was written to disk as a separate file in a binary format that is explained below. Prior to using the data acquisition system in this test, throughput benchmarks were completed to ensure ensemble-to-ensemble data continuity. Data continuity was demonstrated up to a sample rate of 80,000 Hz and 112 channels for long duration acquisitions. Thus, continuous time histories longer than 32,768 samples can be reliably constructed by reading and appending data from sequential binary data files. It should be noted that the ensemble length and sample rate that were used during the characterization tests documented in Chapter 5 may have varied from those used for the sonic boom measurements. These changes are identified in Subsection 6.1.2. However, the format of the binary data files discussed in this section still applies to the files for the characterization tests.

Each binary data file, containing one ensemble of time data (32,768 samples) for all 112 measurement channels, is written to disk as un-scaled, signed 32 bit integers (int32 format). The machine format of each binary data file is IEEE floating point with big-endian byte ordering. The order of the channel data in the binary data files is shown in Table 6.2. The first two int32's stored in the binary data files indicate the number of channels and number of samples contained in the data file, respectively. The remaining int32's contained in the data files correspond to the time histories of the measurement channels. For the NI 4472B data acquisition cards, the scale factor to convert from the signed int32's to voltage is 9.3132257462E-9. An example of how to read the voltage data into Matlab™ from one of the binary data files for a single channel is:

```
% Define the file and path names
PathName = 'c:\PutPathToFileHere\';
FileName = 'PutFileNameHere';
```

```
% Open the file for read access
fid = fopen([PathName,FileName],'r','ieee-be');
% Read the number of channels and number of
% samples contained in the file
NumChannels = fread(fid,1,'int32');
NumSamples = fread(fid,1,'int32');
% Define the channel to be read from the file
ChannelToRead = 96;
% Seek to the position in the file containing the
% data for the defined channel. Note that the seek
% is performed from the current position in the file
fseek(fid,(ChannelToRead-1)*NumSamples*4,0);
% Define the scaling from int32 to voltage
Scaling = 9.3132257462E-9;
% Read the data from the file and scale it to voltage
ChannelData = fread(fid,NumSamples,'int32')*Scaling;
```

The above Matlab™ example would read data for channel 96 from a binary data file defined by the variables "PathName" and "FileName" and return the voltage time history for that channel to the Matlab™ vector "ChannelData". It should be noted that an int32 is 4 bytes long, which is why the **fseek** command in the above script includes a multiplication by four.

Subsection 6.1.2: Binary data file naming convention

The binary data are stored in files with names that included the ensemble number as well as a time and date stamp corresponding to the starting time and date of the measurement. The time and date stamps for each of the sonic booms observed at the test house are shown in Table 6.1 and Table 4.2 of Chapter 4. The names of several binary data files for the response measurement at 8:17:17 AM on July 11th, 2007 are shown in Figure 6.1. All the ensembles of time data are stored individually in these files, and are placed into a time and date stamped directory located in the "Booms" parent directory. The directory structure of the "Booms" parent directory is illustrated in Figure 6.2, which shows all the sonic boom response measurements that were recorded during the six flight days. Each subdirectory in the "Booms" directory contains a file naming convention similar to that illustrated in Figure 6.1. The size of a single binary data file, containing 112 channels and 32,768 samples, is 14 MB. The total size of all the binary sonic boom response data is roughly 40 GB. The total size of all the binary data, including the characterization tests discussed in the next section and Chapter 5, is roughly 155 GB. If requests for binary data are made by external organizations, it is recommended that the request for the smallest data set, based on research requirements, be made.

Subsection 6.1.3: Summary of the binary data that are available including sonic boom measurements, characterization tests and calibrations

In addition to the data recordings of the sonic boom responses, data were also recorded for the characterization tests documented in Chapter 5, the daily calibration of the precision microphone documented in Section 3.4 and the pretest calibration of the accelerometers and microphones. The binary data format for these measurements is nearly identical to that described in the above section, however; the following were varied:

- The number of samples per ensemble of time data
- The number of channels recorded
- The sample rate of the acquisition, Fs

The values of these parameters for the characterization tests are given in Table 6.1. The file naming convention used for these files is the same as described in Subsection 6.1.2 and includes an ensemble number as well as a date and time stamp. Time histories longer than a single ensemble can be assembled by reading and appending data from sequential binary data files. In the case of characterization tests or calibrations, the date and time stamp corresponds to the starting time and date of the characterization test or calibration sequence. The total size of all the binary data for the characterization and calibration tests is roughly 115 GB. These data are only available in binary format.

Section 6.2: Matlab™ formatted data

For convenient distribution, the voltage time histories for all 112 channels and 42 booms measured during July 2007 were extracted from the binary data files and stored in Matlab™ version 7 files. One Matlab™ file containing time histories for all 112 channels was created for each of the 42 sonic booms. Each Matlab™ file contains 12.8 seconds of time history data, where the front shock of the sonic boom occurs approximately 1 second into the time history stored in the ".mat" file. Thus, these Matlab™ data files contain a short pre-boom ambient response, the boom event, and 11 seconds of post boom response data.

In each file, the voltage time history for each channel is stored into separate arrays named "Channel_N_Voltage", where N indicates the channel number and ranges from 1 to 112. This allows individual channels to be loaded from the files into Matlab™ using the **load** command as follows:

```
load 'Run 7_18_2007 8_37_15 ...
AM_Boom1_AllChans_Ensembles_25 to 34.mat' ...
Channel_98_Voltage
```

The script above would load the voltage time history for channel 98 out of the Matlab™ data file for the sonic boom response measurement started at 8:37:15 AM on July 18th, 2007. When analyzing data, memory requirements can be easily managed with this Matlab™ data set by only loading the required time data out of the desired Matlab™ data files. Uncalibrated voltages were stored into these files, thus the sensitivities and gain settings presented in Chapter 3 must be used to extract the engineering units. The Matlab™ data set for all 42 sonic booms and all 112 measurement channels is approximately 5.56 GB in size, which is significantly more portable than the binary data sets documented in Section 6.1. If requests for time history data are made by external organizations, it is recommended that the request for the smallest data set, based on research requirements, be made.

For reference purposes, the overpressure observed at the microphone on channel 98 in the front driveway (Appendix C) is listed in Table 6.3 for each of the 42 sonic booms. These were estimated from the sensitivities found during the pre-test calibrations. If response data for a subset of booms with specific overpressures are desired, these data (Table 6.3) will aid in making such a request.

Section 6.3: Data requests

Requests for data should be made by contacting the author of this report:

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Table 6.1: Description of all binary data collected.

Date Stamps for Sonic Boom Response Measurements	Location	Excitation Location	Fs (Hz)	Ensemble Length (Samples)	Number Of Channels In Raw Data Files	Size of One Raw Data File (bytes)	Excitation Signal Description	Additional Notes
7_11_2007 8_09_40 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	Nexi overloaded, the binaural head was off
7_11_2007 8_17_17 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	Nexi overloaded, the binaural head was off
7_11_2007 8_23_29 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	Changed gains for this and subsequent booms to prevent overloads
7_11_2007 8_28_30 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	The binaural head was off
7_11_2007 8_37_38 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	The binaural head was off
7_12_2007 8_01_48 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	Sprinkler in yard of neighbor to the south was on and hitting neighboring driveway which caused increased noise on the microphones in the front yard
7_12_2007 8_09_00 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	
7_12_2007 8_15_51 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	
7_12_2007 8_21_42 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	
7_12_2007 8_28_02 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	
7_12_2007 8_34_40 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	
7_12_2007 8_39_59 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	
7_12_2007 10_32_37 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	None
7_12_2007 10_38_36 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	None
7_12_2007 10_44_21 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	None
7_12_2007 10_50_40 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	None
7_13_2007 9_41_06 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	None
7_13_2007 9_46_42 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	None
7_13_2007 9_53_23 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	None
7_13_2007 9_59_05 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	None
7_13_2007 10_05_30 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	None
7_13_2007 10_13_02 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	None
7_13_2007 10_19_58 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	None
7_17_2007 8_10_22 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	The binaural head was outside but overloaded due to incorrect range
7_17_2007 8_17_19 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	
7_17_2007 8_23_04 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	
7_17_2007 8_29_35 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	
7_17_2007 8_35_43 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	
7_17_2007 8_42_59 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	
7_17_2007 8_48_07 AM	N/A	N/A	25600	32768	112	14680072	Low amplitude sonic boom	
7_17_2007 10_32_08 AM	N/A	N/A	25600	32768	112	14680072	Normal amplitude sonic boom	
7_17_2007 10_39_18 AM	N/A	N/A	25600	32768	112	14680072	Normal amplitude sonic boom	
7_17_2007 10_46_23 AM	N/A	N/A	25600	32768	112	14680072	Normal amplitude sonic boom	
7_17_2007 10_54_17 AM	N/A	N/A	25600	32768	112	14680072	Normal amplitude sonic boom	
7_17_2007 11_01_12 AM	N/A	N/A	25600	32768	112	14680072	Normal amplitude sonic boom	
7_17_2007 11_07_30 AM	N/A	N/A	25600	32768	112	14680072	Normal amplitude sonic boom	
7_18_2007 8_06_20 AM	N/A	N/A	25600	32768	112	14680072	Normal amplitude sonic boom	Front door was locked
7_18_2007 8_13_02 AM	N/A	N/A	25600	32768	112	14680072	Normal amplitude sonic boom	Front door was locked
7_18_2007 8_19_08 AM	N/A	N/A	25600	32768	112	14680072	Normal amplitude sonic boom	Front door was locked
7_18_2007 8_25_12 AM	N/A	N/A	25600	32768	112	14680072	Normal amplitude sonic boom	Front door was unlocked, plane taking off was audible
7_18_2007 8_31_16 AM	N/A	N/A	25600	32768	112	14680072	Normal amplitude sonic boom	Front door was unlocked
7_18_2007 8_37_15 AM	N/A	N/A	25600	32768	112	14680072	Normal amplitude sonic boom	Front door was unlocked

Table continued on next page.

Table 6.1: Continued.

Date Stamps for Shaker Response Measurements of the Walls	Location	Excitation Location	Fs (Hz)	Ensemble Length (Samples)	Number Of Channels In Raw Data Files	Size of One Raw Data File (bytes)	Excitation Signal Description	Additional Notes
7_15_2007 11_23_06 AM	Bad data			16384	112	7340040		None
7_16_2007 12_26_25 PM	Garage Bed, South Wall	11 (Appendix I)	12800	32768	112	14680072	White noise (2 to 2kHz)	Glue mount
7_16_2007 1_24_29 PM	Garage Bed, South Wall	12 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Glue mount
7_16_2007 2_58_54 PM	Garage Bed, South Wall	13 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Glue mount
7_16_2007 3_40_15 PM	Garage Bed, East Wall	14 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Glue mount
7_17_2007 2_09_12 PM	Garage Bed, East Wall	14 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount
7_17_2007 2_25_47 PM	Garage Bed, South Wall	8 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, on stud, master bed door was open for test
7_17_2007 2_35_26 PM	Garage Bed, South Wall	9 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, on drywall, master bed door was open for test
7_17_2007 2_56_30 PM	Master Bed, South Wall	7 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, drywall, microphones 101-104 were off
7_17_2007 3_08_07 PM	Master Bed, South Wall	7 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, drywall
7_17_2007 3_26_40 PM	Master Bed, South Wall	6 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, stud
7_17_2007 3_31_52 PM	Master Bed, South Wall	5 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), higher amplitude	Wax mount, stud
7_17_2007 4_38_25 PM	Master Bed, South Wall	4 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, stud, lots of wind noise on outside microphones
7_18_2007 6_26_53 AM	Master Bed, South Wall	5 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, spoke during meas, outside mics on, car dove past
7_18_2007 1_33_12 PM	Not in notes, possibly master bed, west wall	Possibly 0 (App. I)		16384	112	7340040		None
7_18_2007 1_41_48 PM	Master Bed, West Wall	3 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount
7_18_2007 1_53_01 PM	Master Bed, South Wall	4 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, dog was barking next door
7_18_2007 1_56_55 PM	Master Bed, South Wall	4 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, aircraft overhead
7_18_2007 2_22_38 PM	Master Bed, Ceiling	See Photos App. I	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 9_06_42 AM	Master Bed, South Wall, Outside	18 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, large table on impedance head
7_19_2007 9_19_35 AM	Master Bed, South Wall, Outside	19 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, large table on impedance head
7_19_2007 9_31_53 AM	Master Bed, South Wall, Outside	20 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, large table on impedance head
7_19_2007 10_00_46 AM	Master Bed, South Wall, Outside	21 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, large table on impedance head
7_19_2007 10_05_41 AM	Master Bed, South Wall, Outside	21 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, large table on impedance head

Table continued on next page.

Table 6.1: Continued.

Date Stamps for Shaker Response Measurements of the Windows	Location	Excitation Location	Fs (Hz)	Ensemble Length (Samples)	Number Of Channels In Raw Data Files	Size of One Raw Data File (bytes)	Excitation Signal Description	Additional Notes
7_15_2007 3_23_14 PM	Front Bed, Window Frame	17 (Appendix I)	6400	16384	112	7340040	White noise	Glue mount
7_15_2007 3_29_03 PM	Front Bed, Window Frame	17 (Appendix I)	6400	16384	112	7340040	White noise	Glue mount
7_15_2007 4_38_57 PM	Front Bed, Window Pane	16 (Appendix I)	6400	16384	112	7340040	White noise	Glue mount
7_15_2007 4_59_54 PM	Front Bed, Window Pane	16 (Appendix I)	6400	16384	112	7340040	18.5 Hz tone, low amplitude	Glue mount
7_15_2007 5_03_31 PM	Front Bed, Window Pane	16 (Appendix I)	6400	16384	112	7340040	18.5 Hz tone, high amplitude	Glue mount
7_15_2007 5_11_34 PM	Front Bed, Window Pane	16 (Appendix I)	6400	16384	112	7340040	77.75 Hz tone, high amplitude	Glue mount
7_15_2007 5_13_28 PM	Front Bed, Window Pane	16 (Appendix I)	6400	16384	112	7340040	77.75 Hz tone, low amplitude	Glue mount
7_15_2007 5_59_48 PM	Unknown, not in notes	Unknown		16384	112	7340040		None
7_15_2007 6_16_13 PM	Garage Bed, Window Pane	10 (Appendix I)	6400	16384	112	7340040	White noise, high amplitude	Shaker not clamped to wood support, glue mount
7_15_2007 6_21_49 PM	Garage Bed, Window Pane	10 (Appendix I)	6400	16384	112	7340040	White noise, low amplitude	Shaker not clamped to wood support, glue mount
7_16_2007 10_02_33 AM	Garage Bed, Window Pane	10 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), low amplitude	Glue mount
7_16_2007 10_11_59 AM	Garage Bed, Window Pane	10 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), high amplitude	Glue mount
7_16_2007 10_42_50 AM	Garage Bed, Window Pane	10 (Appendix I)	12800	32768	112	14680072	Amplitude swept sine	Glue mount
7_18_2007 10_03_02 AM	Master Bed, Window Pane	1 (Appendix I)	12800	16384	112	7340040	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount
7_18_2007 10_04_26 AM	Master Bed, Window Pane	1 (Appendix I)	12800	16384	112	7340040	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount
7_18_2007 2_09_47 PM	Master Bed, Window Frame	2 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), low amplitude	Wax mount, hand held shaker
7_18_2007 2_12_39 PM	Master Bed, Window Frame	2 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), high amplitude	Wax mount, hand held shaker
7_18_2007 8_51_57 AM	Master Bed, Window Pane	1 (Appendix I)	3200	16384	112	7340040	White noise (2 to 2kHz), low amplitude	Wax mount
7_18_2007 8_56_44 AM	Master Bed, Window Pane	1 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), low amplitude	Wax mount
7_18_2007 9_13_02 AM	Master Bed, Window Pane	1 (Appendix I)	12800	16384	112	7340040	White noise (2 to 2kHz), mid amplitude	Wax mount
7_18_2007 9_23_46 AM	Master Bed, Window Pane	1 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), mid amplitude	Wax mount
7_18_2007 9_34_17 AM	Master Bed, Window Pane	1 (Appendix I)	12800	16384	112	7340040	White noise (2 to 2kHz), high amplitude	Wax mount
7_18_2007 9_35_40 AM	Master Bed, Window Pane	1 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), high amplitude	Wax mount
7_19_2007 11_02_53 AM	Front Bed, Outside Window Surface	23 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_06_26 AM	Front Bed, Outside Window Surface	24 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker, noise contamination
7_19_2007 11_09_07 AM	Front Bed, Outside Window Surface	24 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_11_59 AM	Front Bed, Outside Window Surface	25 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_15_23 AM	Front Bed, Outside Window Surface	26 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_18_57 AM	Front Bed, Outside Window Surface	27 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_23_45 AM	Front Bed, Outside Window Surface	23 (Appendix I)	6400	16384	112	7340040	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount, hand held shaker, amplitude sweep log profile
7_19_2007 11_25_19 AM	Front Bed, Outside Window Surface	23 (Appendix I)	6400	16384	112	7340040	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount, hand held shaker, amplitude sweep log profile
7_19_2007 11_28_16 AM	Front Bed, Outside Window Surface	23 (Appendix I)	6400	16384	112	7340040	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount, hand held shaker, amplitude sweep linear profile

Date Stamps for Shaker Response Measurements of the Doors	Location	Excitation Location	Fs (Hz)	Ensemble Length (Samples)	Number Of Channels In Raw Data Files	Size of One Raw Data File (bytes)	Excitation Signal Description	Additional Notes
7_18_2007 2_01_57 PM	Master Bed, Entry Door	See Photos App. I	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_18_2007 2_31_00 PM	Front Entry Door, Inside Surface	No Photographs	6400	16384	112	7340040	White noise (2 to 2kHz), low amplitude	Wax mount, hand held shaker
7_18_2007 2_32_46 PM	Front Entry Door, Inside Surface	No Photographs	6400	16384	112	7340040	White noise (2 to 2kHz), high amplitude	Wax mount, hand held shaker
7_18_2007 2_39_43 PM	Front Entry Door, Outside Surface	No Photographs	6400	16384	112	7340040	White noise (2 to 2kHz), high amplitude	Wax mount, hand held shaker
7_19_2007 10_30_04 AM	Garage Door	22 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount
7_19_2007 10_42_50 AM	Garage Door	22 (Appendix I)	6400	16384	112	7340040	Amplitude swept sine at 40 Hz	Wax mount
7_19_2007 10_44_44 AM	Garage Door	22 (Appendix I)	6400	16384	112	7340040	Amplitude swept sine at 40 Hz	Wax mount
7_19_2007 10_49_11 AM	Garage Door	22 (Appendix I)	6400	16384	112	7340040	Amplitude swept sine at 29 Hz	Wax mount

Table continued on next page.

Table 6.1: Continued.

Date Stamps for Daily Calibration Measurements	Location	Excitation Location	Fs (Hz)	Ensemble Length (Samples)	Number Of Channels In Raw Data Files	Size of One Raw Data File (bytes)	Excitation Signal Description	Additional Notes
7_11_2007 5_24_49 AM	Precision Microphone Cals	N/A	3200	1024	112	458760	Pistonphone at 250 Hz and 123.35 dB	None
7_11_2007 7_02_28 AM	Precision Microphone Cals	N/A	3200	1024	112	458760	Pistonphone at 250 Hz and 123.35 dB	None
7_11_2007 7_17_05 AM	Precision Microphone Cals	N/A	3200	1024	112	458760	Pistonphone at 250 Hz and 123.35 dB	None
7_11_2007 9_42_14 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.35 dB	None
7_12_2007 6_22_46 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.37 dB	None
7_12_2007 7_07_16 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.37 dB	None
7_12_2007 11_09_45 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.37 dB	None
7_13_2007 7_25_06 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.4 dB	None
7_13_2007 10_28_51 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.4 dB	None
7_15_2007 10_39_03 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.35 dB	None
7_16_2007 8_17_01 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.35 dB	None
7_17_2007 6_56_34 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.35 dB	None
7_17_2007 11_24_14 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.35 dB	None
7_18_2007 7_27_28 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.35 dB	None
7_18_2007 10_07_35 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.35 dB	None
7_18_2007 10_26_13 AM	Precision Microphone Cals	N/A	3200	2048	112	917512	Pistonphone at 250 Hz and 123.35 dB	None

Date Stamps for Pretest Calibration Measurements	Location	Excitation Location	Fs (Hz)	Ensemble Length (Samples)	Number Of Channels In Raw Data Files	Size of One Raw Data File (bytes)	Excitation Signal Description	Additional Notes
7_8_2007 12_28_37 PM	Accels 1 through 3	N/A	3200	1024	86	352264	Accel calibrator at 159.2 Hz and 1 g	Only channels 1-86 were enabled and recorded
7_8_2007 12_31_49 PM	Accels 3 through 13	N/A	3200	1024	86	352264	Accel calibrator at 159.2 Hz and 1 g	Only channels 1-86 were enabled and recorded
7_8_2007 12_45_49 PM	Accels 14 through 23	N/A	3200	1024	86	352264	Accel calibrator at 159.2 Hz and 1 g	Only channels 1-86 were enabled and recorded
7_8_2007 12_57_09 PM	Accels 57 through 64 and 24, 25	N/A	3200	1024	86	352264	Accel calibrator at 159.2 Hz and 1 g	Only channels 1-86 were enabled and recorded
7_8_2007 1_08_10 PM	Accels 26 through 33	N/A	3200	1024	86	352264	Accel calibrator at 159.2 Hz and 1 g	Only channels 1-86 were enabled and recorded
7_8_2007 1_22_13 PM	Accels 34 through 40, 49 through 54	N/A	3200	1024	86	352264	Accel calibrator at 159.2 Hz and 1 g	Only channels 1-86 were enabled and recorded
7_8_2007 1_33_24 PM	Accels 55, 56, and 41 through 48	N/A	3200	1024	86	352264	Accel calibrator at 159.2 Hz and 1 g	Only channels 1-86 were enabled and recorded
7_8_2007 1_43_48 PM	Accels 65 through 75 but not 67 or 68	N/A	3200	1024	86	352264	Accel calibrator at 159.2 Hz and 1 g	Only channels 1-86 were enabled and recorded
7_8_2007 1_54_51 PM	Accels 76, 67, and 68	N/A	3200	1024	86	352264	Accel calibrator at 159.2 Hz and 1 g	Only channels 1-86 were enabled and recorded
7_8_2007 6_30_35 PM	Microphones 77 through 86	N/A	3200	1024	86	352264	Pistonphone at 250 Hz and 123.35 dB	Only channels 1-86 were enabled and recorded
7_8_2007 6_56_50 PM	The binaural head	N/A	3200	1024	112	458760	Binaural head calibration	None
7_8_2007 7_00_02 PM	Microphones 89 and 90	N/A	3200	1024	112	458760	Pistonphone at 250 Hz and 123.35 dB	None
7_9_2007 7_49_50 PM	Outdoor microphones	N/A	3200	1024	112	458760	Pistonphone at 250 Hz and 123.35 dB	None
7_9_2007 8_06_01 PM	Outdoor microphones	N/A	3200	1024	112	458760	Pistonphone at 250 Hz and 123.35 dB	None
7_11_2007 5_00_12 AM	Microphones 108 and 109	N/A	25600	32768	112	14680072	Pistonphone at 250 Hz and 123.35 dB	None
7_12_2007 6_42_07 AM		N/A	3200	2048	112	917512		None

Table continued on next page.

Table 6.1: Continued.

Date Stamps for the Indoor Reverberation Measurements	Location	Excitation Location	Fs (Hz)	Ensemble Length (Samples)	Number Of Channels In Raw Data Files	Size of One Raw Data File (bytes)	Excitation Signal Description	Additional Notes
7_11_2007 9_10_47 AM	Master Bedroom	N/A	25600	32768	112	14680072	Band limited chirps from sound level meter	Outdoor microphones were powered on
7_11_2007 9_14_42 AM	Master Bedroom	N/A	25600	32768	112	14680072	Band limited chirps from sound level meter	Outdoor microphones were powered on
7_11_2007 9_32_40 AM	Front Bedroom	N/A	25600	32768	112	14680072	Band limited chirps from sound level meter	Outdoor microphones were powered on
7_11_2007 12_12_37 AM	Garage Bedroom	N/A	25600	32768	112	14680072	Band limited chirps from sound level meter	None
7_11_2007 12_18_17 AM	Garage Bedroom	N/A	25600	32768	112	14680072	Band limited chirps from sound level meter	None
7_11_2007 12_28_34 AM	Front Bedroom	N/A	25600	32768	112	14680072	Band limited chirps from sound level meter	None
7_11_2007 12_33_07 AM	Front Bedroom	N/A	25600	32768	112	14680072	Band limited chirps from sound level meter	Did not record the 50 Hz pulse
7_18_2007 12_45_48 PM	Attic	N/A	25600	32768	112	14680072	Band limited chirps from sound level meter	None
7_18_2007 12_56_17 PM	Attic	N/A	25600	32768	112	14680072	Band limited chirps from sound level meter	None

Date Stamps for Indoor Impulse Response Measurements (Balloon Pops)	Location	Excitation Location	Fs (Hz)	Ensemble Length (Samples)	Number Of Channels In Raw Data Files	Size of One Raw Data File (bytes)	Excitation Signal Description	Additional Notes
7_18_2007 3_55_48 PM	Master Bedroom	N/A	25600	16384	112	7340040	Balloon pop near center of room	None
7_18_2007 3_56_05 PM	Master Bedroom	N/A	25600	16384	112	7340040	Balloon pop at a random location	None
7_18_2007 3_56_22 PM	Master Bedroom	N/A	25600	16384	112	7340040	Balloon pop at a random location	None
7_18_2007 3_56_39 PM	Master Bedroom	N/A	25600	16384	112	7340040	Balloon pop at a random location	None
7_18_2007 3_57_29 PM	Front Bedroom	N/A	25600	16384	112	7340040	Balloon pop near center of room	None
7_18_2007 3_57_47 PM	Front Bedroom	N/A	25600	16384	112	7340040	Balloon pop at a random location	None
7_18_2007 3_58_04 PM	Front Bedroom	N/A	25600	16384	112	7340040	Balloon pop at a random location	None
7_18_2007 3_58_21 PM	Front Bedroom	N/A	25600	16384	112	7340040	Balloon pop at a random location	None
7_18_2007 3_58_59 PM	Garage Bedroom	N/A	25600	16384	112	7340040	Balloon pop near center of room	None
7_18_2007 3_59_16 PM	Garage Bedroom	N/A	25600	16384	112	7340040	Balloon pop at a random location	None
7_18_2007 3_59_31 PM	Garage Bedroom	N/A	25600	16384	112	7340040	Balloon pop at a random location	None
7_18_2007 3_59_49 PM	Garage Bedroom	N/A	25600	16384	112	7340040	Balloon pop at a random location	None
7_18_2007 4_01_03 PM	Garage	N/A	25600	16384	112	7340040	Balloon pop near center of the garage	None
7_18_2007 4_01_17 PM	Garage	N/A	25600	16384	112	7340040	Balloon pop at a random location	None
7_18_2007 4_01_36 PM	Garage	N/A	25600	16384	112	7340040	Balloon pop at a random location	None
7_18_2007 4_02_06 PM	Garage	N/A	25600	16384	112	7340040	Balloon pop at a random location	None
7_18_2007 4_03_36 PM	Garage	N/A	25600	16384	112	7340040	Balloon pop at a random location	None

Table continued on next page.

Table 6.1: Concluded.

Date Stamps for Outdoor Impulse Response Measurements (Bag Pops)	Location	Excitation Location	Fs (Hz)	Ensemble Length (Samples)	Number Of Channels In Raw Data Files	Size of One Raw Data File (bytes)	Excitation Signal Description	Additional Notes
7_18_2007 3_21_18 PM	Outside position 1	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_22_03 PM	Outside position 1	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_22_33 PM	Outside position 1	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_23_47 PM	Outside position 2	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_24_09 PM	Outside position 2	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_24_43 PM	Outside position 2	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_25_25 PM	Outside position 3	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_25_56 PM	Outside position 3	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_26_18 PM	Outside position 3	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_26_42 PM	Outside position 3	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_28_33 PM	Outside position 4	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_30_29 PM	Outside position 4	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_31_00 PM	Outside position 4	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_31_59 PM	Outside position 4	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_32_27 PM	Outside position 4	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_33_43 PM	Outside position 4	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_35_37 PM	Outside position 5	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_35_54 PM	Outside position 5	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_36_29 PM	Outside position 5	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_37_07 PM	Outside position 5	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None
7_18_2007 3_37_37 PM	Outside position 5	See Appendix H	25600	16384	112	7340040	Brown paper bag pop near the ground	None

Table 6.2: Order of the int32 data written to the binary data files

Starting int32	Ending int32	Data
1	1	Number of channels in record
2	2	Number of samples per channel
0*Nsamp+3	1*Nsamp+2	Channel 1 time history data
1*Nsamp+3	2*Nsamp+2	Channel 2 time history data
2*Nsamp+3	3*Nsamp+2	Channel 3 time history data
:	:	:
(N-1)*Nsamp+3	N*Nsamp+2	Channel N time history data

Where Nsamp is the number of samples per channel.

Table 6.3: Peak overpressure measured at the microphone on Channel 98.

Date Stamp	Overpressure, lb_f/ft^2
7_11_2007 8_09_40 AM	0.11
7_11_2007 8_17_17 AM	0.52
7_11_2007 8_23_29 AM	0.78
7_11_2007 8_28_30 AM	0.93
7_11_2007 8_37_38 AM	0.75
7_12_2007 8_01_48 AM	0.11
7_12_2007 8_09_00 AM	0.09
7_12_2007 8_15_51 AM	0.38
7_12_2007 8_21_42 AM	0.45
7_12_2007 8_28_02 AM	0.46
7_12_2007 8_34_40 AM	0.47
7_12_2007 8_39_59 AM	0.55
7_12_2007 10_32_37 AM	0.38
7_12_2007 10_38_36 AM	0.14
7_12_2007 10_44_21 AM	0.23
7_12_2007 10_50_40 AM	0.25
7_13_2007 9_41_06 AM	0.35
7_13_2007 9_46_42 AM	0.56
7_13_2007 9_53_23 AM	0.61
7_13_2007 9_59_05 AM	0.32
7_13_2007 10_05_30 AM	0.32
7_13_2007 10_13_02 AM	0.40
7_13_2007 10_19_58 AM	0.32
7_17_2007 8_10_22 AM	0.50
7_17_2007 8_17_19 AM	0.18
7_17_2007 8_23_04 AM	0.48
7_17_2007 8_29_35 AM	0.38
7_17_2007 8_35_43 AM	0.63
7_17_2007 8_42_59 AM	0.52
7_17_2007 8_48_07 AM	0.51
7_17_2007 10_32_08 AM	1.90
7_17_2007 10_39_18 AM	1.11
7_17_2007 10_46_23 AM	1.02
7_17_2007 10_54_17 AM	1.46
7_17_2007 11_01_12 AM	1.55
7_17_2007 11_07_30 AM	1.33
7_18_2007 8_06_20 AM	1.19
7_18_2007 8_13_02 AM	1.69
7_18_2007 8_19_08 AM	1.39
7_18_2007 8_25_12 AM	1.98
7_18_2007 8_31_16 AM	1.12
7_18_2007 8_37_15 AM	1.09

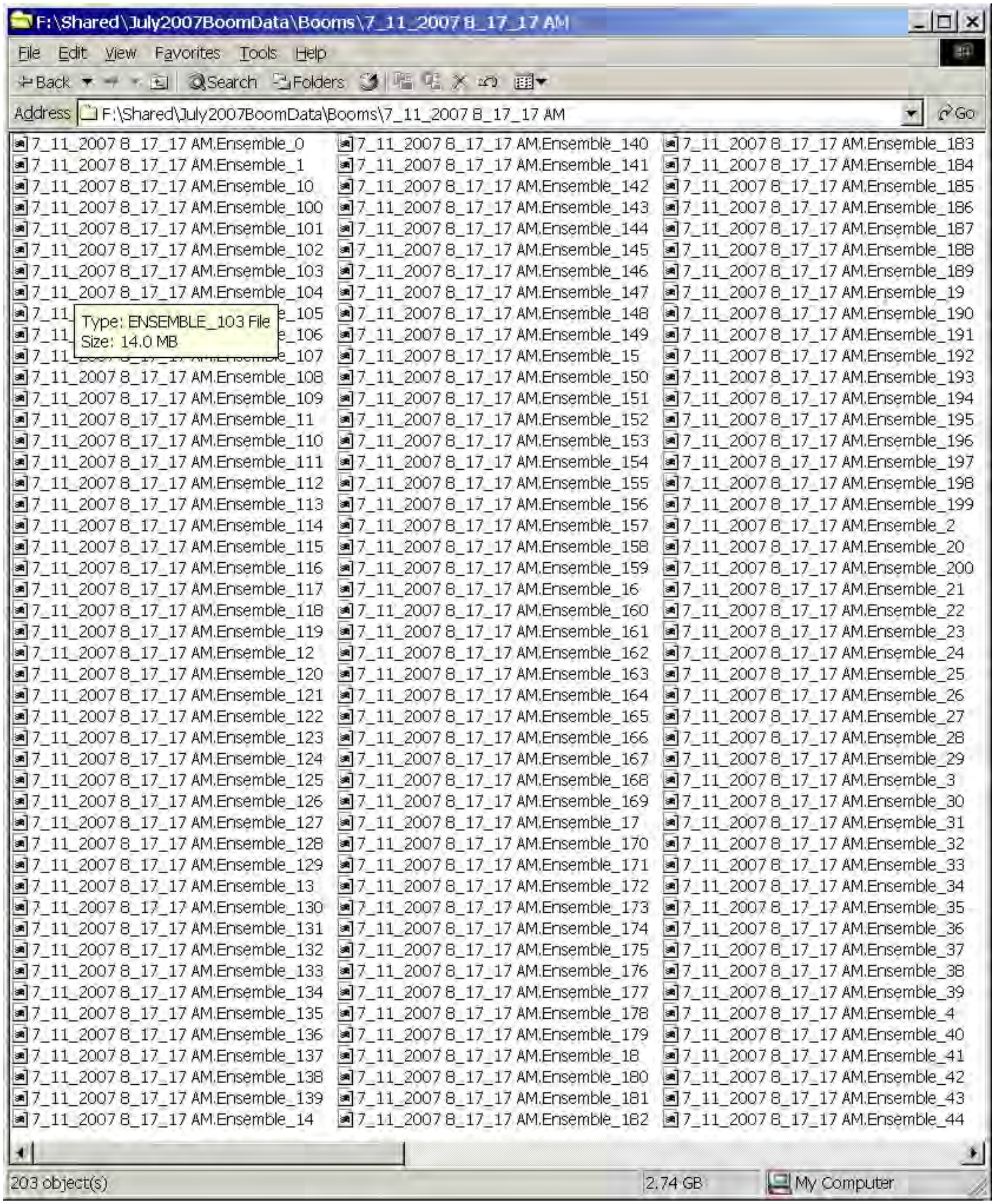


Figure 6.1: Illustration of the file naming convention for the 8:17:17 AM measurement session on July 11th, 2007.

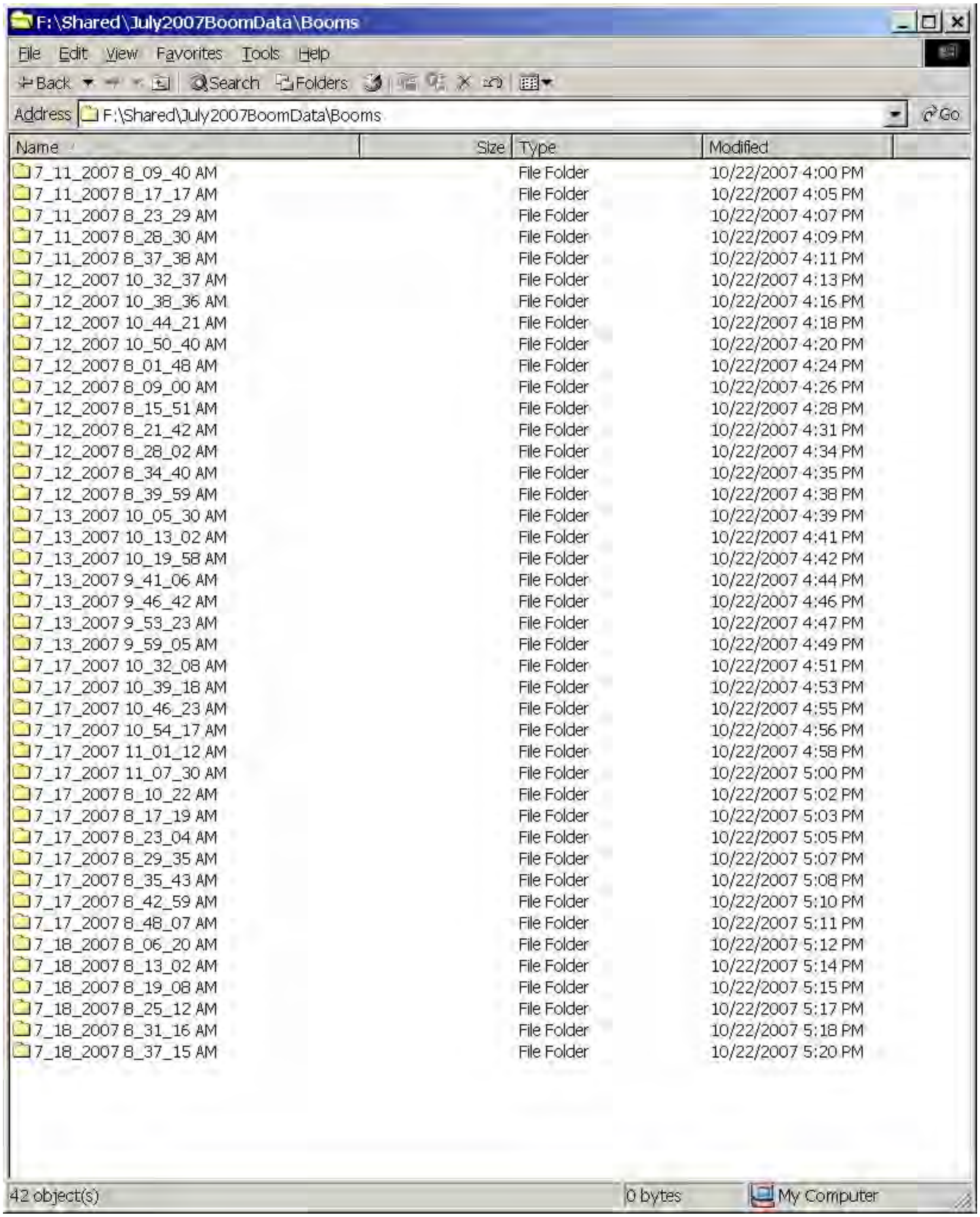


Figure 6.2: Root directory structure of the boom measurement binary data files.

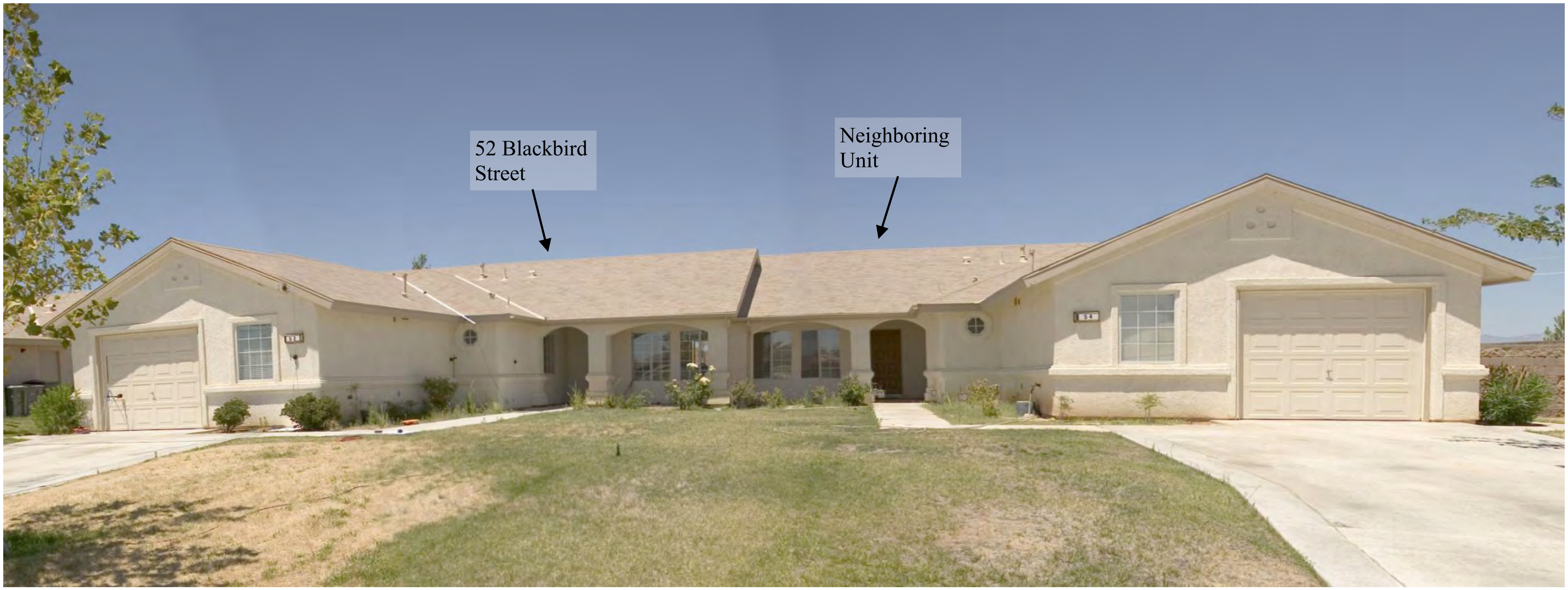
ACKNOWLEDGEMENTS

The author of this report would like to acknowledge the support of all those people involved in this test, and specifically thank Edward Haering of NASA Dryden, Joe Salamone and Joe Gavin of Gulfstream Aerospace Corporation and Denise Miller of the Pennsylvania State University without whom this test could not have taken place. This test was funded by the Supersonics project of the Fundamental Aeronautics program within NASA.

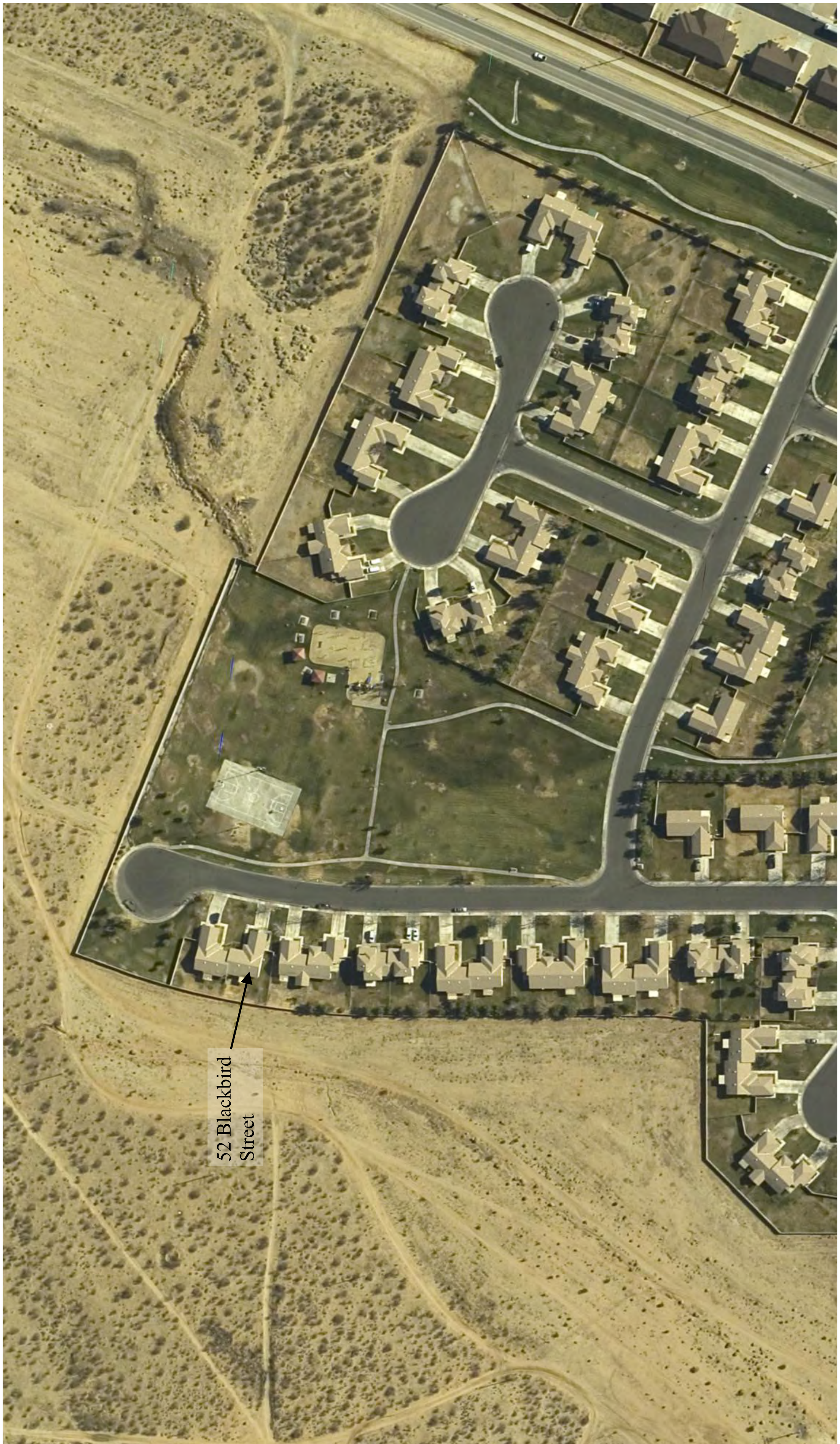
Appendix A

Layout of the house at 52 Blackbird Street, Edwards CA.

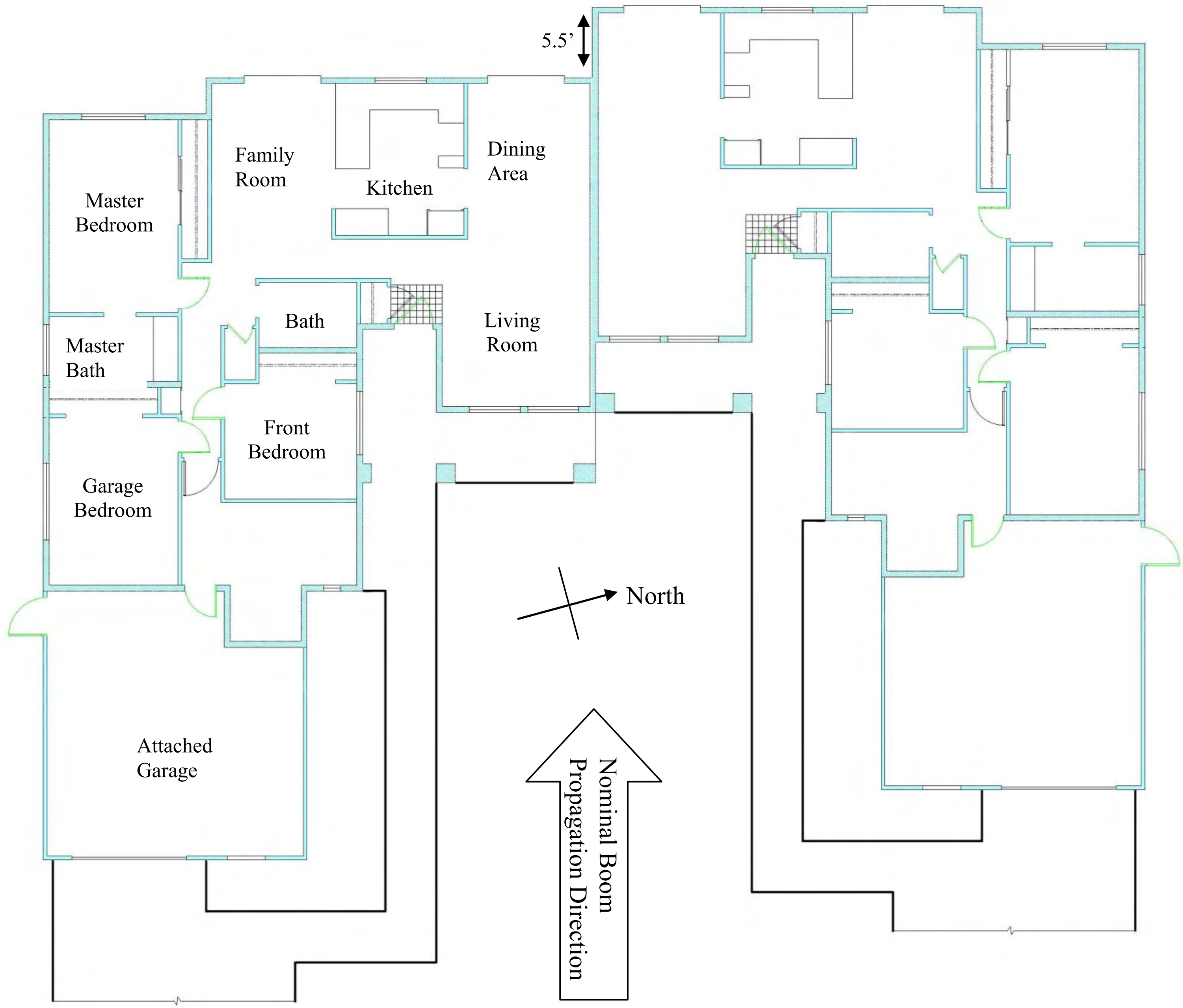
(All dimensions are in inches unless otherwise noted)



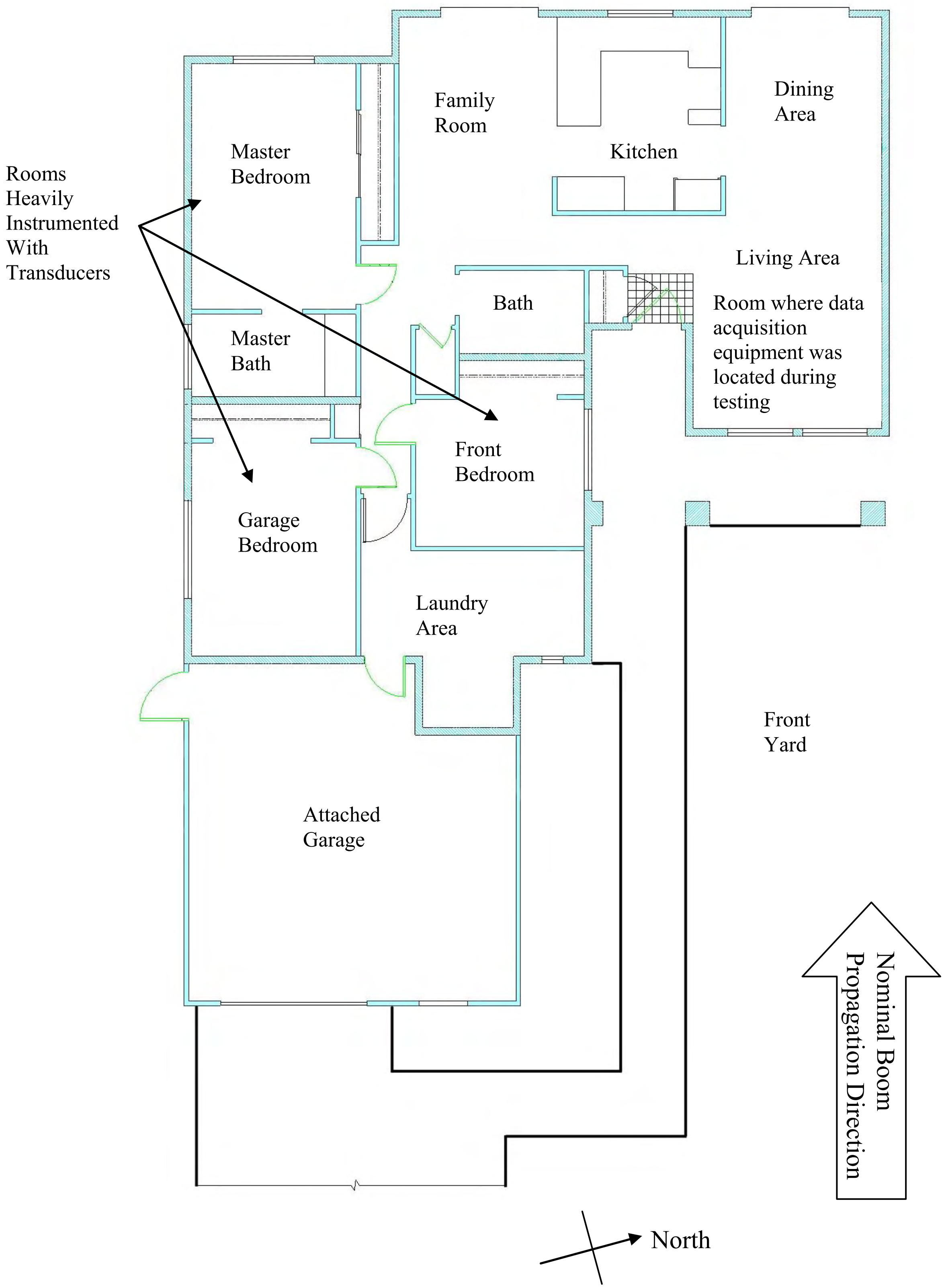
Front of the townhouse. 52 Blackbird Street is the left portion of the townhouse.



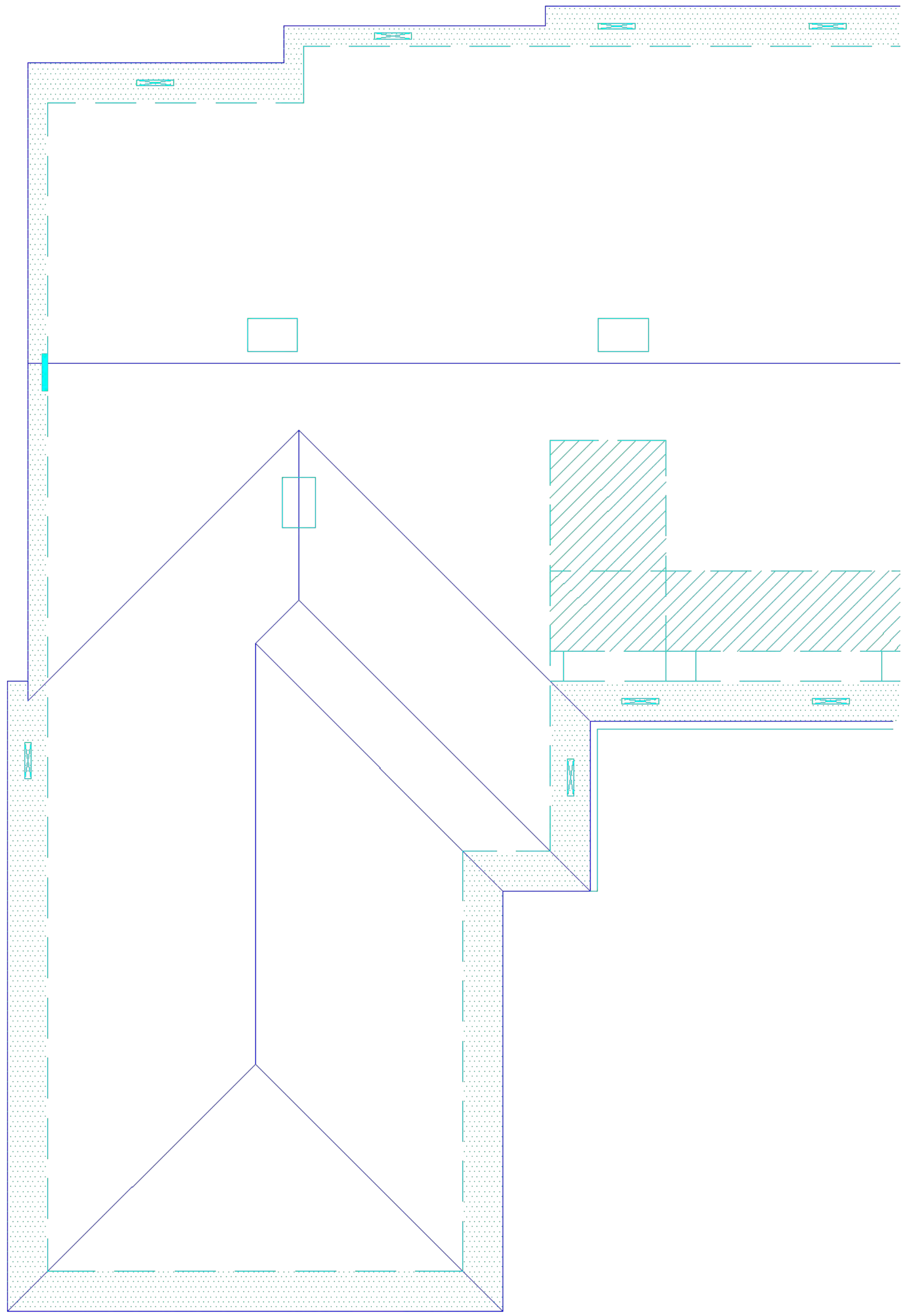
Arial view of the house and surrounding area.



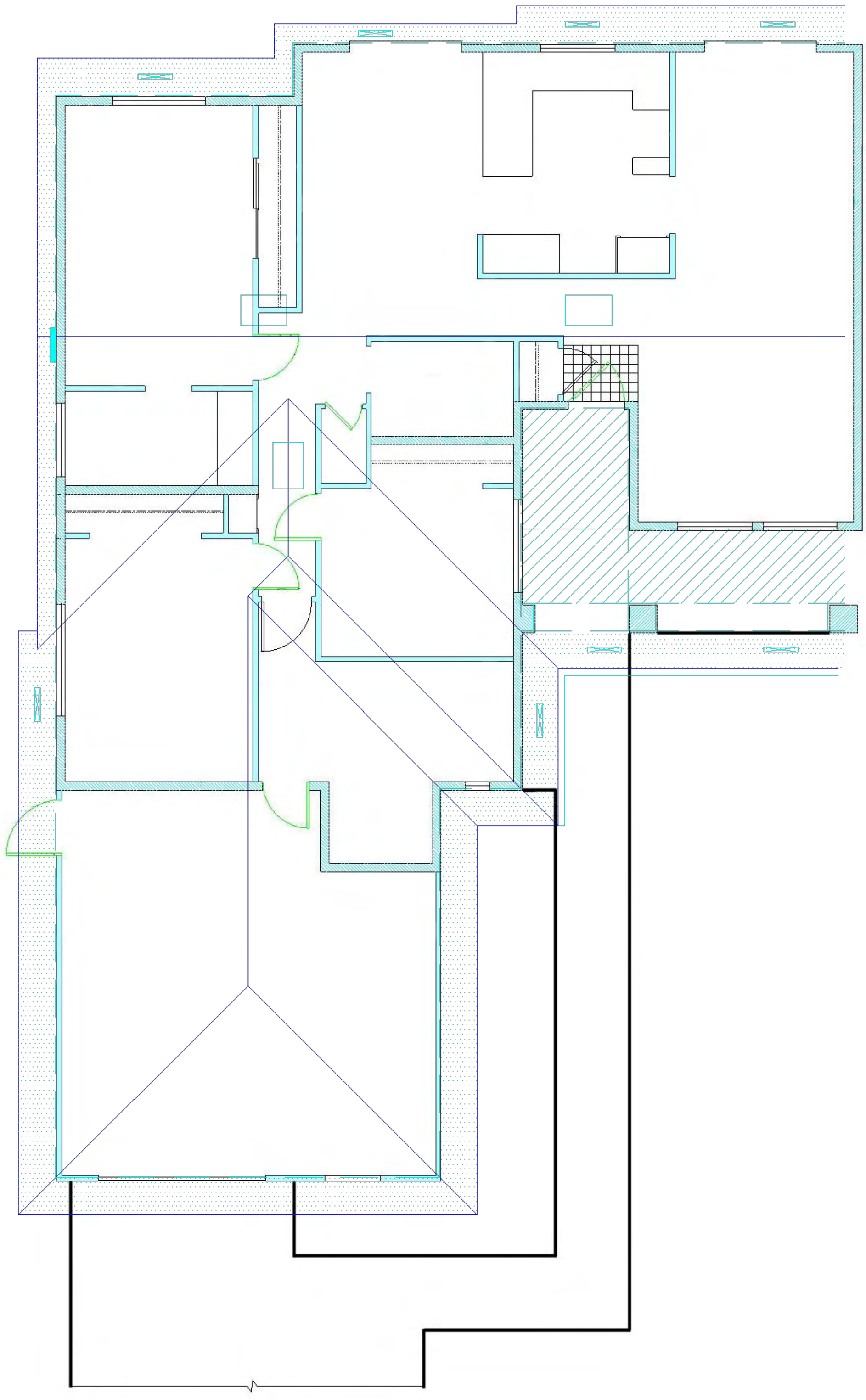
Floor plan of the town house illustrating both sides of the house. The floor plans are mirror images of each other, offset by 5.5 feet.



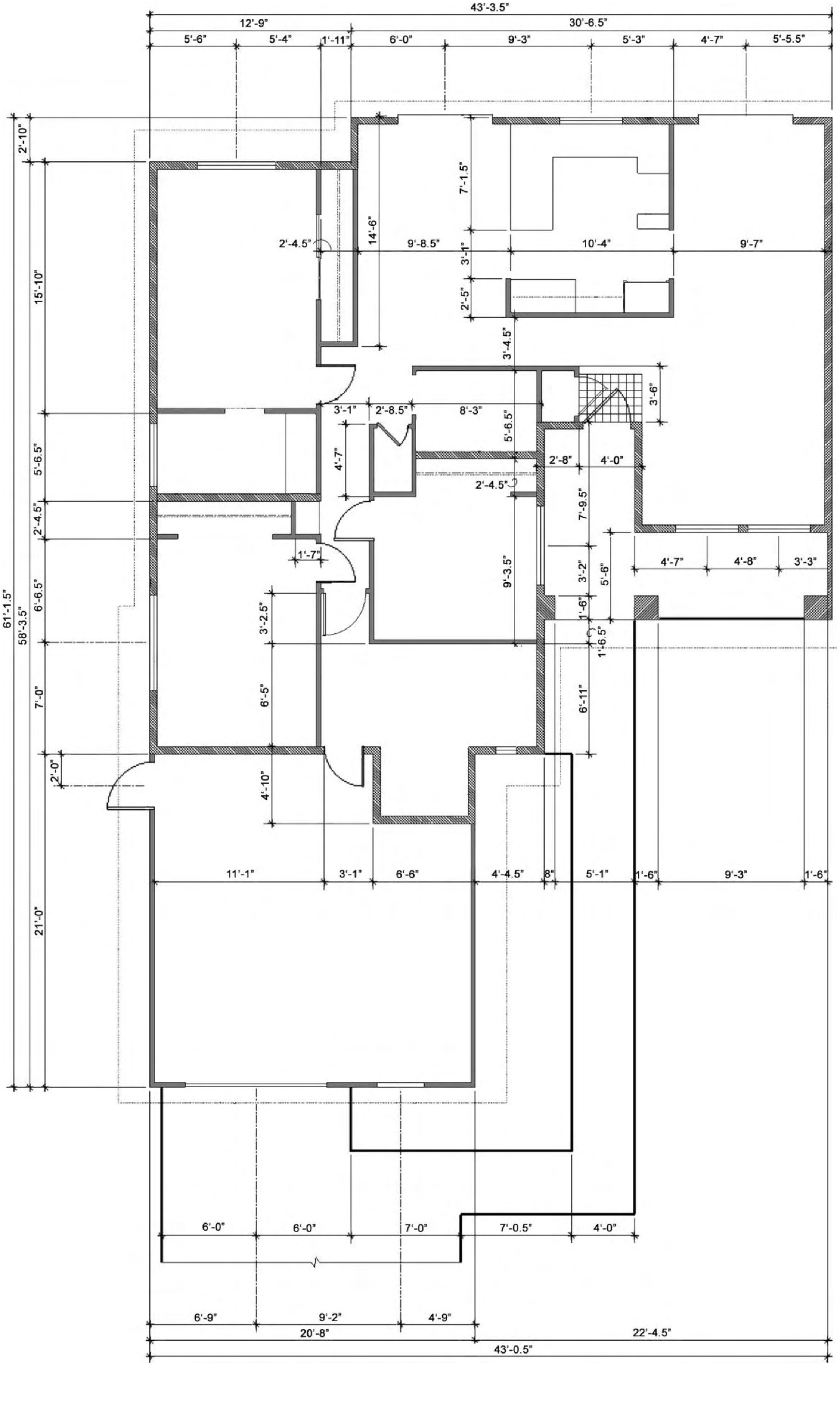
Floor plan of 52 Blackbird Street illustrating the bedrooms instrumented for structural acoustical measurements.



House roof lines



Overlay of the floor plan and the house roof lines.


43'-3.5"
12'-9"
30'-6.5"
5'-6"
5'-4"
1'-11"
6'-0"
9'-3"
5'-3"
4'-7"
5'-5.5"
2'-10"
15'-10"
2'-4.5"
14'-6"
9'-8.5"
7'-1.5"
3'-1"
10'-4"
9'-7"
2'-5"
3'-4.5"
3'-6"
3'-1"
2'-8.5"
8'-3"
5'-6.5"
5'-6.5"
4'-7"
2'-8"
4'-0"
2'-4.5"
2'-4.5"
7'-9.5"
1'-7"
4'-7"
4'-8"
3'-3"
6'-6.5"
61'-1.5"
58'-3.5"
9'-3.5"
3'-2"
5'-6"
3'-2.5"
1'-6"
1'-6.5"
7'-0"
6'-5"
6'-11"
2'-0"
4'-10"
11'-1"
3'-1"
6'-6"
4'-4.5"
8"
5'-1"
1'-6"
9'-3"
1'-6"
21'-0"
6'-0"
6'-0"
7'-0"
7'-0.5"
4'-0"
6'-9"
9'-2"
4'-9"
20'-8"
22'-4.5"
43'-0.5"

View of the kitchen from the family room. Viewpoint relative to floor plan is illustrated in the inset.

View of the kitchen from the family room. Viewpoint relative to floor plan is illustrated in the inset.

Master bedroom, south wall. Viewpoint relative to floor plan is illustrated in the inset.

Master bedroom, west wall. Viewpoint relative to floor plan is illustrated in the inset.

Master bedroom, north wall. Viewpoint relative to floor plan is illustrated in the inset.

Master bedroom, east wall. Viewpoint relative to floor plan is illustrated in the inset.

Master bathroom, looking south. Viewpoint relative to floor plan is illustrated in the inset.

Master bathroom, looking north. Viewpoint relative to floor plan is illustrated in the inset.

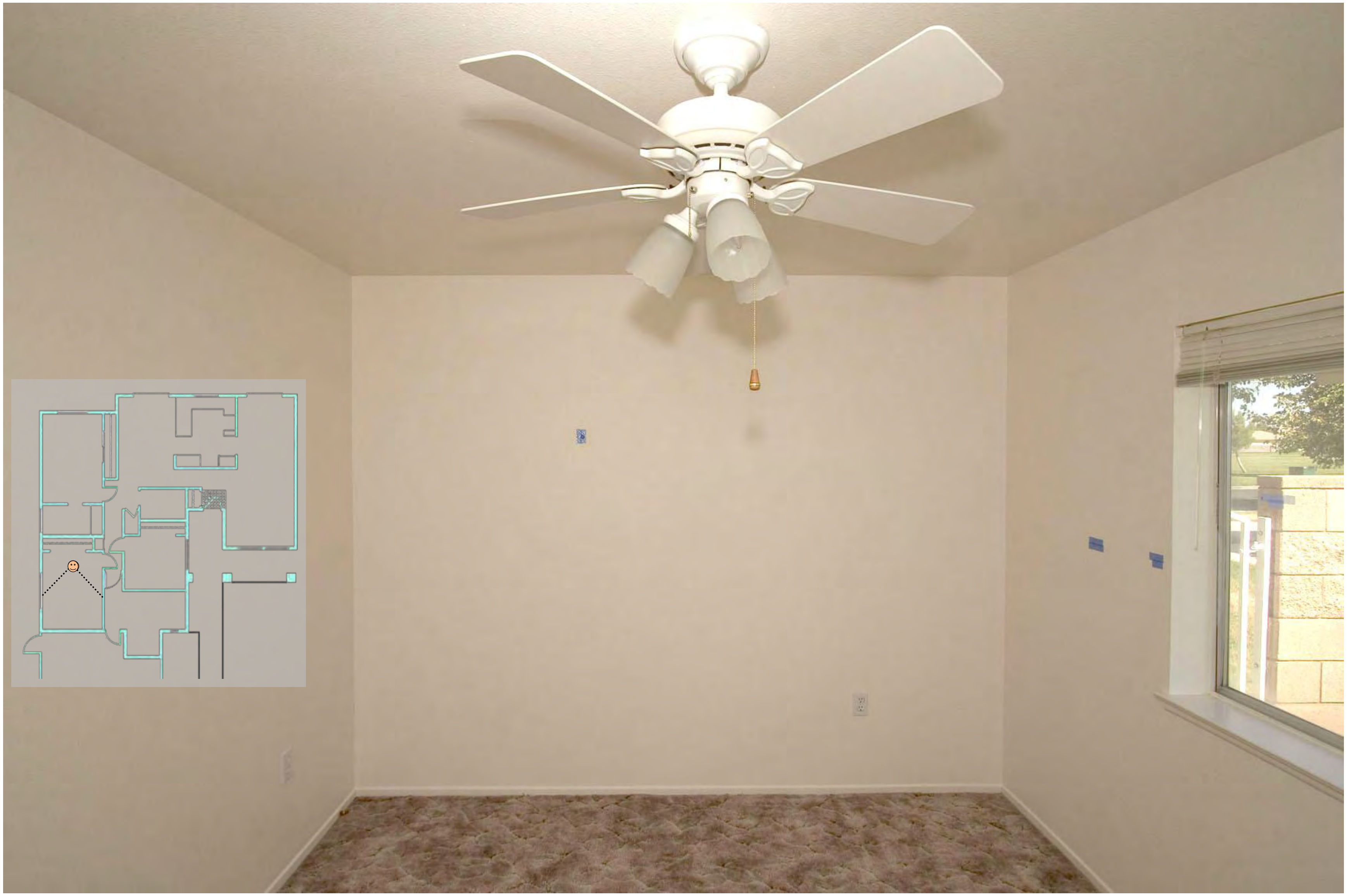
Master bedroom window. Viewpoint relative to floor plan is illustrated in the inset.

Master bedroom window specification label.

Garage bedroom, south wall. Viewpoint relative to floor plan is illustrated in the inset.

Garage bedroom, west wall. Viewpoint relative to floor plan is illustrated in the inset.

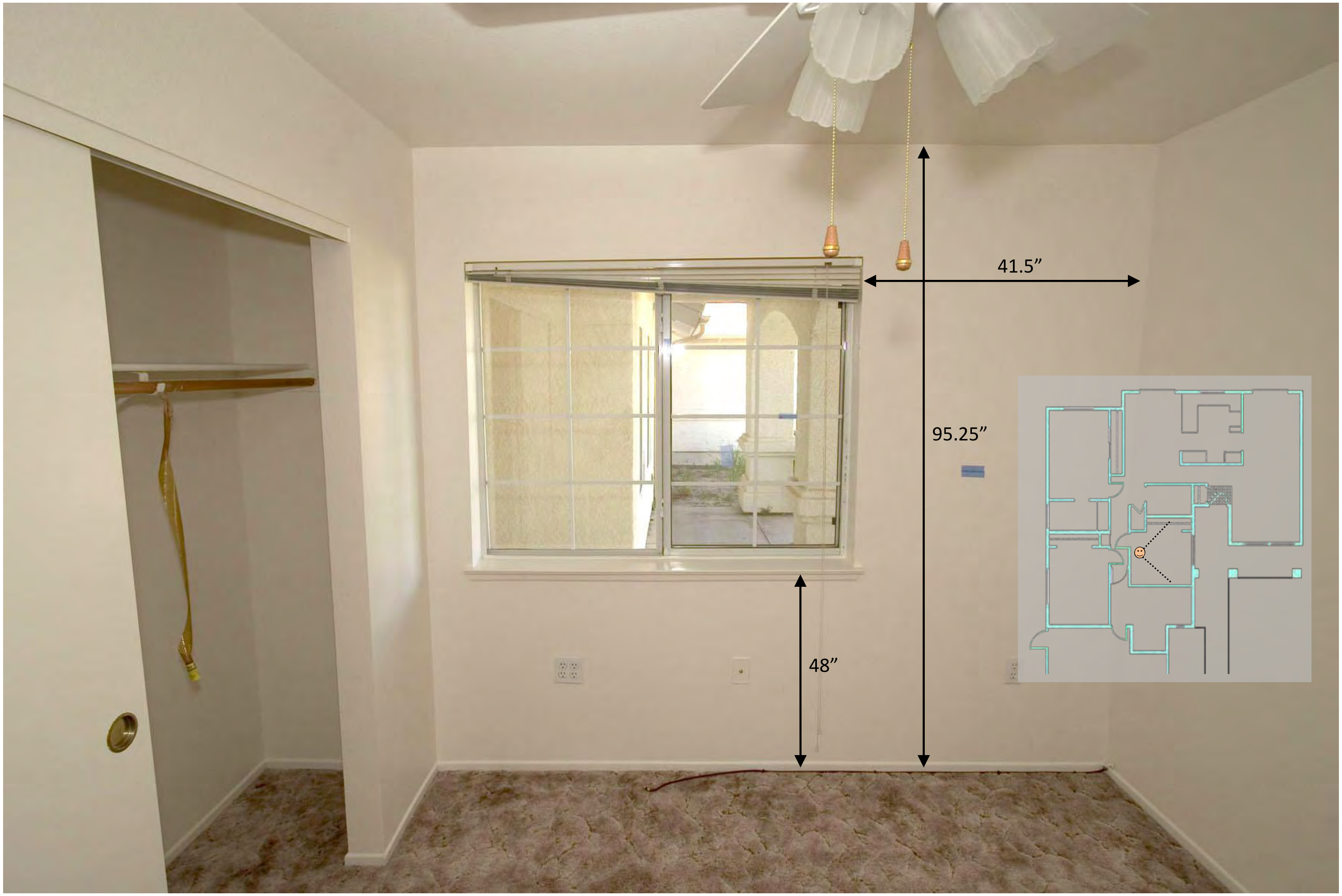
Garage bedroom, north wall. Viewpoint relative to floor plan is illustrated in the inset.



Garage bedroom, east wall. Viewpoint relative to floor plan is illustrated in the inset.

Garage bedroom window. Viewpoint relative to floor plan is illustrated in the inset.

Garage bedroom window specification label.



Front bedroom, north wall. Viewpoint relative to floor plan is illustrated in the inset.

Front bedroom, east wall. Viewpoint relative to floor plan is illustrated in the inset.

Front bedroom, south wall. Viewpoint relative to floor plan is illustrated in the inset.

Front bedroom, west wall. Viewpoint relative to floor plan is illustrated in the inset.

Front bedroom window.   Viewpoint relative to floor plan is illustrated in the inset.

Detailed photograph of the operable sash of the front bedroom window.

Detailed photograph of both the sliding and fixed sash of the front bedroom window.

Detailed photograph of the fixed sash of the front bedroom window.

Front bedroom window specification label.

View of the attic above the main living area and master bedroom, looking south, over the master bedroom. Viewpoint relative to floor plan is illustrated in the inset.

View of the attic above the main living area and master bedroom, looking north, over the main living area. Viewpoint relative to floor plan is illustrated in the inset.

View of the attic above the main living area and master bedroom, looking east, at the sheathing that separates this attic space from the attic above the other two-instrumented rooms. Viewpoint relative to floor plan is illustrated in the inset.

Front of the house at 52 Blackbird Street.

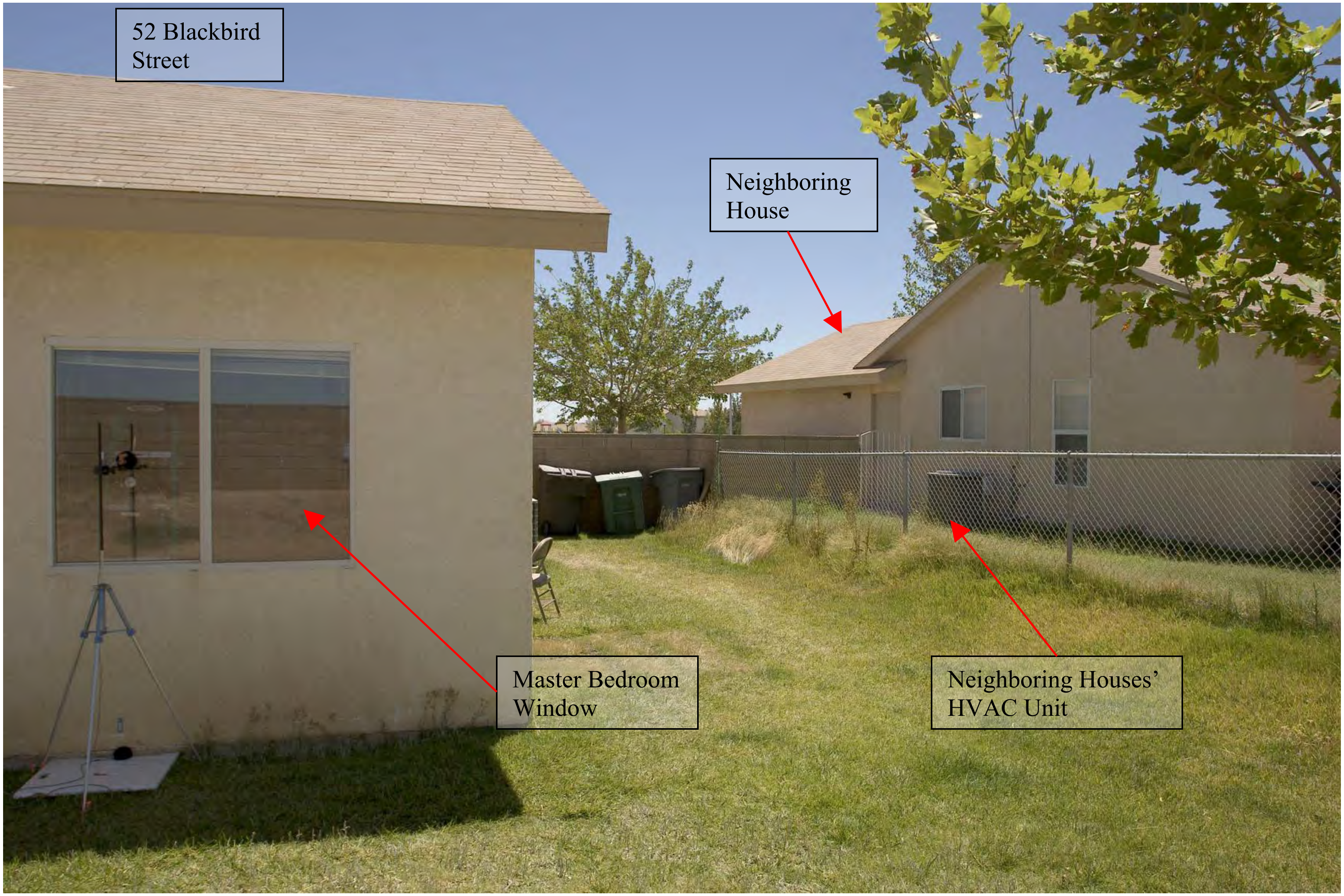
View of the front of the house at 52 Blackbird Street looking south west at the exterior walls of the front bedroom and main living area.

View of the front of the house at 52 Blackbird Street looking south at the exterior wall of the front bedroom.

View of the side of the house at 52 Blackbird Street looking north west at the exterior of the garage.

View of the side of the house at 52 Blackbird Street looking north at the exterior wall of the garage bedroom.

View of the side of the house at 52 Blackbird Street looking south east at exterior wall of the master bedroom.



View of the master bedroom relative to the neighboring house illustrating the proximity to the neighboring air conditioning unit that was running during some tests.

Figure 2.28: Panorama of the back yard of 52 Blackbird Street assembled from several photographs.


Nominal Boom
Propagation Direction
52 Blackbird
Street
North

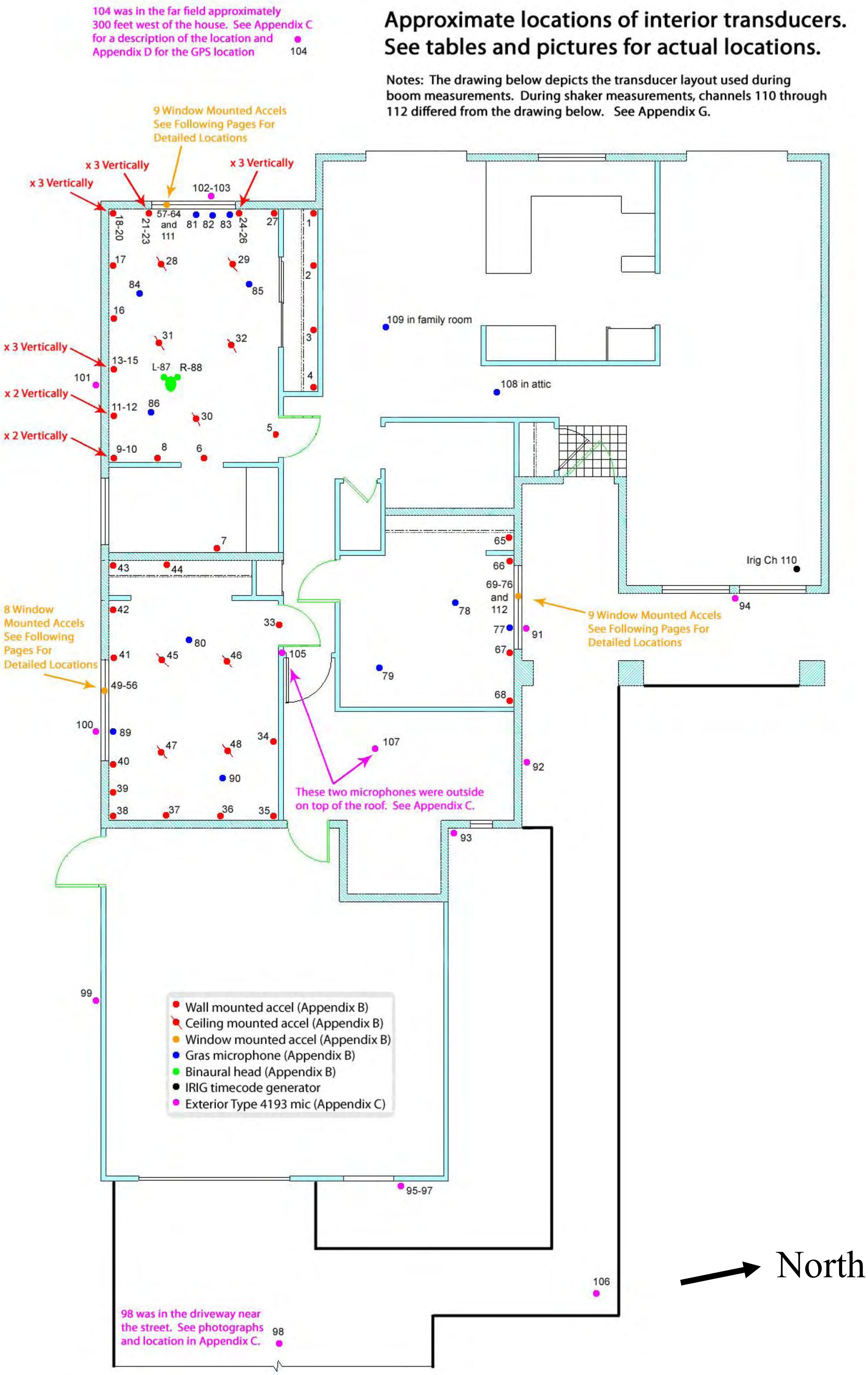
Appendix B

Locations and pictures of the nominal interior transducer layout.

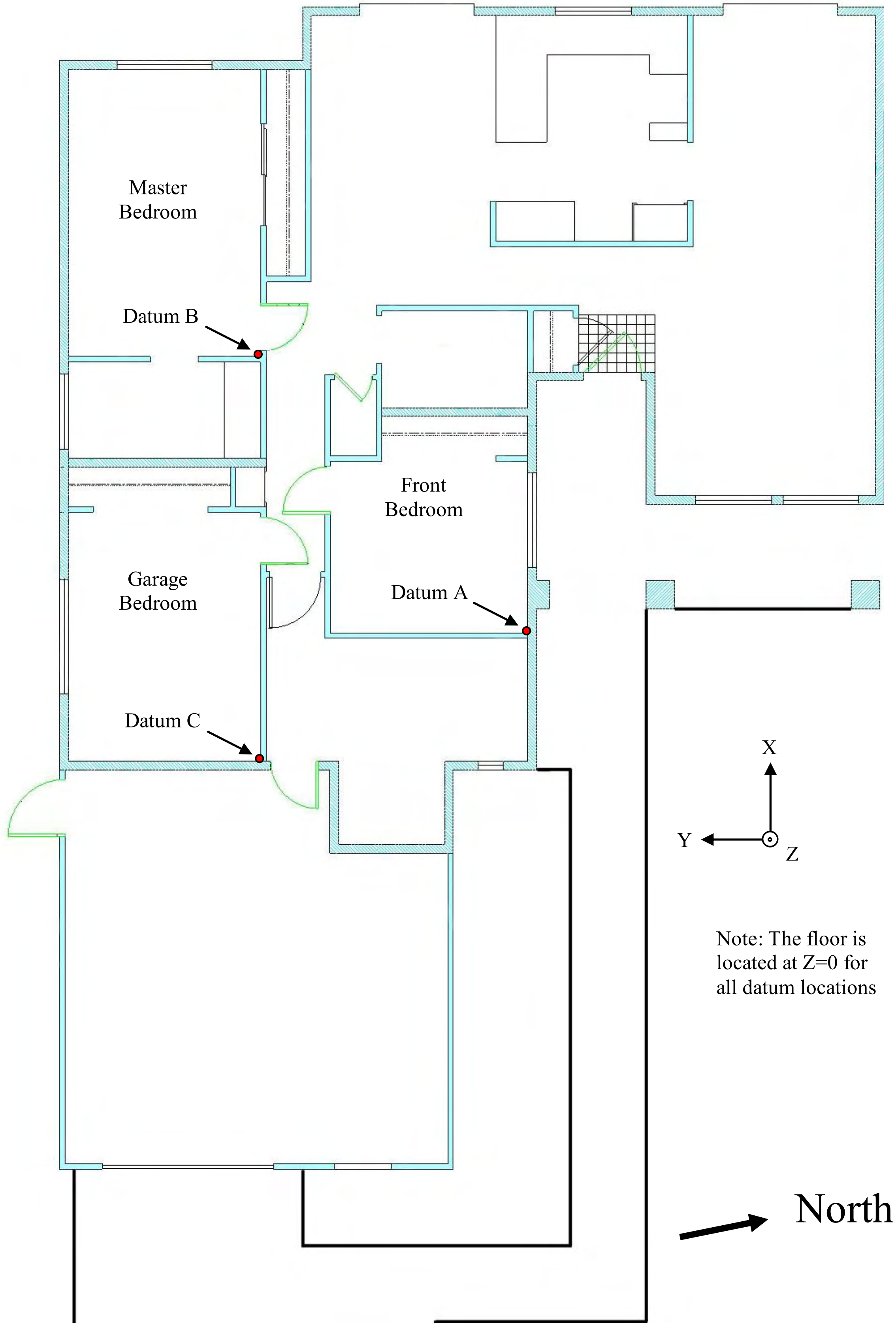
(All dimensions are in inches unless otherwise noted)

Approximate locations of interior transducers. See tables and pictures for actual locations.

Notes: The drawing below depicts the transducer layout used during boom measurements. During shaker measurements, channels 110 through 112 differed from the drawing below. See Appendix G.



Datums and coordinate system used to locate the interior transducers in the bedrooms.



Interior Transducer Locations

July 2007 Sonic Boom Flight Test

local coordinates given in inches from datum as noted in sketch

Channel	Type	Pretest In-situ Cal (mV/EU)	Room	Orientation	DATUM	X	Y	Z
1	accel	95.6	master bedroom	y+	B	179.25	-28.375	58
2	accel	95.4	master bedroom	y+	B	136.75	-28.375	58
3	accel	94.1	master bedroom	y+	B	92	-28.375	58
4	accel	94.4	master bedroom	y+	B	49.75	-28.375	58
5	accel	94.9	master bedroom	y+	B	18	0	58
6	accel	96.2	master bedroom	x+	B	0	51	123.5
7	accel	96.1	master bedroom	x+	B	-63.5	39.75	36
8	accel	96.4	master bedroom	x+	B	0	69.375	58
9	accel	954	master bedroom	y-	B	0.5	120.75	28.375
10	accel	916	master bedroom	y-	B	0.5	120.75	58
11	accel	970	master bedroom	y-	B	36	120.75	102.75
12	accel	908	master bedroom	y-	B	36	120.75	58
13	accel	520	master bedroom	y-	B	72	120.75	28.5
14	accel	497	master bedroom	y-	B	72	120.75	58
15	accel	499	master bedroom	y-	B	72	120.75	102.75
16	accel	509	master bedroom	y-	B	107.75	120.75	58
17	accel	943	master bedroom	y-	B	143.5	120.75	58
18	accel	952	master bedroom	x-	B	180	120.5	28.25
19	accel	949	master bedroom	y-	B	179.5	120.75	58
20	accel	957	master bedroom	x-	B	180	120.5	86.5
21	accel	955	master bedroom	x-	B	180	99.75	28.25
22	accel	935	master bedroom	x-	B	180	99.75	57.75
23	accel	923	master bedroom	x-	B	180	99.75	86.5
24	accel	513	master bedroom	x-	B	180	29.125	28.375
25	accel	493	master bedroom	x-	B	180	29.125	57.5
26	accel	492	master bedroom	x-	B	180	29.125	86.75
27	accel	926	master bedroom	x-	B	180	0.5	58
28	accel	470	master bedroom	z-	B	143.5	78.75	110
29	accel	509	master bedroom	z-	B	143.5	52.75	110
30	accel	492	master bedroom	z-	B	38.75	72.5	132.5
31	accel	512	master bedroom	z-	B	72	78.75	125.5
32	accel	478	master bedroom	z-	B	72	52.75	125.5
33	accel	95.7	garage bedroom	y+	C	134	0	58
34	accel	96.7	garage bedroom	y+	C	60	0	58
35	accel	96	garage bedroom	x+	C	0	0.5	58
36	accel	94.3	garage bedroom	x+	C	0	52.75	58
37	accel	95.2	garage bedroom	x+	C	0	79.5	58
38	accel	922	garage bedroom	y-	C	0.5	119.5	58
39	accel	911	garage bedroom	y-	C	16	119.5	58
40	accel	935	garage bedroom	y-	C	41.5	119.5	58
41	accel	937	garage bedroom	y-	C	113.375	119.5	58
42	accel	960	garage bedroom	y-	C	155.25	119.5	58
43	accel	918	garage bedroom	x-	C	185.5	120	35.625
44	accel	924	garage bedroom	x-	C	185.5	80	35.625
45	accel	491	garage bedroom	z-	C	104	79.5	95.25
46	accel	504	garage bedroom	z-	C	104	52.75	95.25
47	accel	472	garage bedroom	z-	C	52	79.5	95.25
48	accel	505	garage bedroom	z-	C	52	52.75	95.25
49	accel	95.5	garage bedroom	y-	C	60	128	57.25
50	accel	96.1	garage bedroom	y-	C	67.5	128	67.75
51	accel	95.7	garage bedroom	y-	C	67.5	128	46.25
52	accel	94.1	garage bedroom	y-	C	78	128	56.75
53	accel	96.8	garage bedroom	y-	C	87	128	67.75
54	accel	97.3	garage bedroom	y-	C	87	128	46.25

Interior Transducer Locations

July 2007 Sonic Boom Flight Test

local coordinates given in inches from datum as noted in sketch

Channel	Type	Pretest In-situ Cal (mV/EU)	Room	Orientation	DATUM	X	Y	Z
55	accel	95.1	garage bedroom	y-	C	95.5	128	57.5
56	accel	98.1	garage bedroom	y-	C	111.75	128	56.75
57	accel	96.6	master bedroom	x-	B	185	74.75	56.25
58	accel	93.8	master bedroom	x-	B	185	68	67.25
59	accel	105	master bedroom	x-	B	185	68	45.5
60	accel	99.1	master bedroom	x-	B	185	59.5	56
61	accel	103	master bedroom	x-	B	185	51.25	67.25
62	accel	96.9	master bedroom	x-	B	185	51.25	45
63	accel	103.4	master bedroom	x-	B	185	44.5	63
64	accel	95.4	master bedroom	x-	B	185	30.5	56.5
65	accel	102.9	front bedroom	y+	A	122.75	0	36
66	accel	923	front bedroom	y+	A	106.5	0	58
67	accel	522	front bedroom	y+	A	26.75	0	58
68	accel	94.2	front bedroom	y+	A	0.5	0	58
69	accel	99.2	front bedroom	y+	A	85.25	0	58
70	accel	95	front bedroom	y+	A	78	-6.5	67
71	accel	96.5	front bedroom	y+	A	78	-6.5	46.375
72	accel	96.2	front bedroom	y+	A	69.75	-6.5	58
73	accel	97	front bedroom	y+	A	62.25	-6.5	67
74	accel	97.5	front bedroom	y+	A	62.25	-6.5	46.375
75	accel	104	front bedroom	y+	A	55.5	-6.5	58
76	accel	102.5	front bedroom	y+	A	42.5	-6.5	58
77	mic	48.9	front bedroom		A	55.5	-6	58
78	mic	49.7	front bedroom		A	65.5	44	34.75
79	mic	49.5	front bedroom		A	23.5	98	67.5
80	mic	47.1	garage bedroom		C	56	44	33.5
81	mic	47.2	master bedroom		B	184.5	59.5	56
82	mic	50.7	master bedroom		B	184.5	44.5	63
83	mic	45.6	master bedroom		B	184.5	30.5	56.5
84	mic	48.3	master bedroom		B	108	26.25	63.75
85	mic	44.5	master bedroom		B	127.75	108.25	42
86	mic	50	master bedroom		B	44.25	76.75	87.25
87	mic (norm)	99	master bedroom		B	65.75	77	43.5
88	mic (norm)	99.2	master bedroom		B	63.5	82.75	43.5
89	mic	49.3	garage bedroom		C	60	127.5	57.25
90	mic	46.8	garage bedroom		C	120.75	92.5	80
108	mic	50.9	attic		A	204	-38	147
109	mic	44.2	family room		A	299	82	32.5
110*	IRIG	1	living room					
111*	accel	10.32	master bedroom	x-	B	185	30.5	56.5
112*	accel	10.27	front bedroom	y+	A	42.5	-6.5	58
110*	shaker excitation	1	N/A					
111*	impedance head force	22	varied	varied	varied	varied	varied	varied
112*	impedance head accel	101	varied	varied	varied	varied	varied	varied

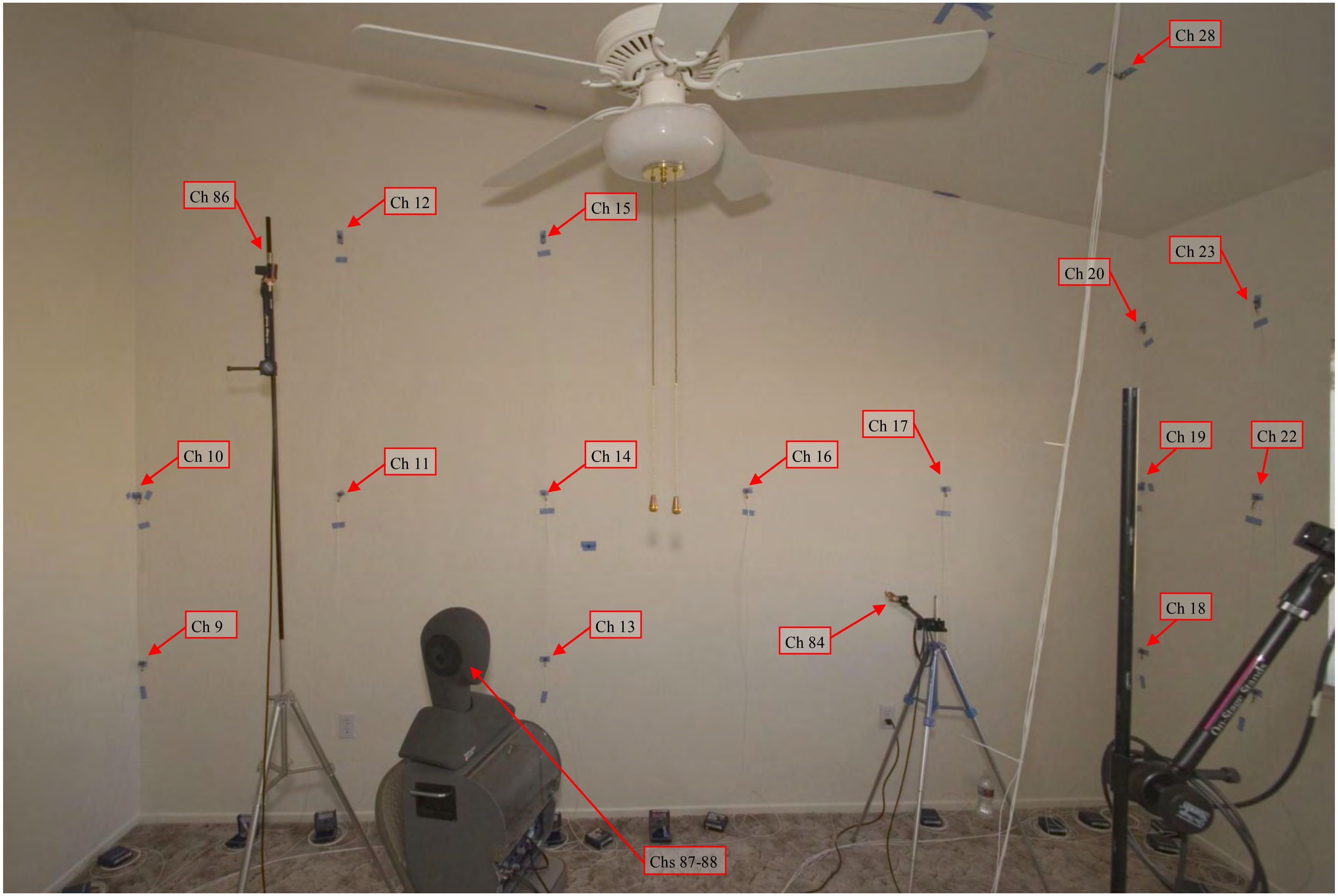
* During boom measurements channel 110 recorded an IRIG time code signal and channels 111 and 112 were connected to 2 Endevco 2250a-10 high frequency accelerometers in the master bedroom and front bedroom. During shaker measurements, channel 110 recorded the excitation to the shaker, and channels 111 and 112 recorded the drive point force and acceleration (at the drive point where the shaker was mounted).

Interior Foam Mattress Pad Locations

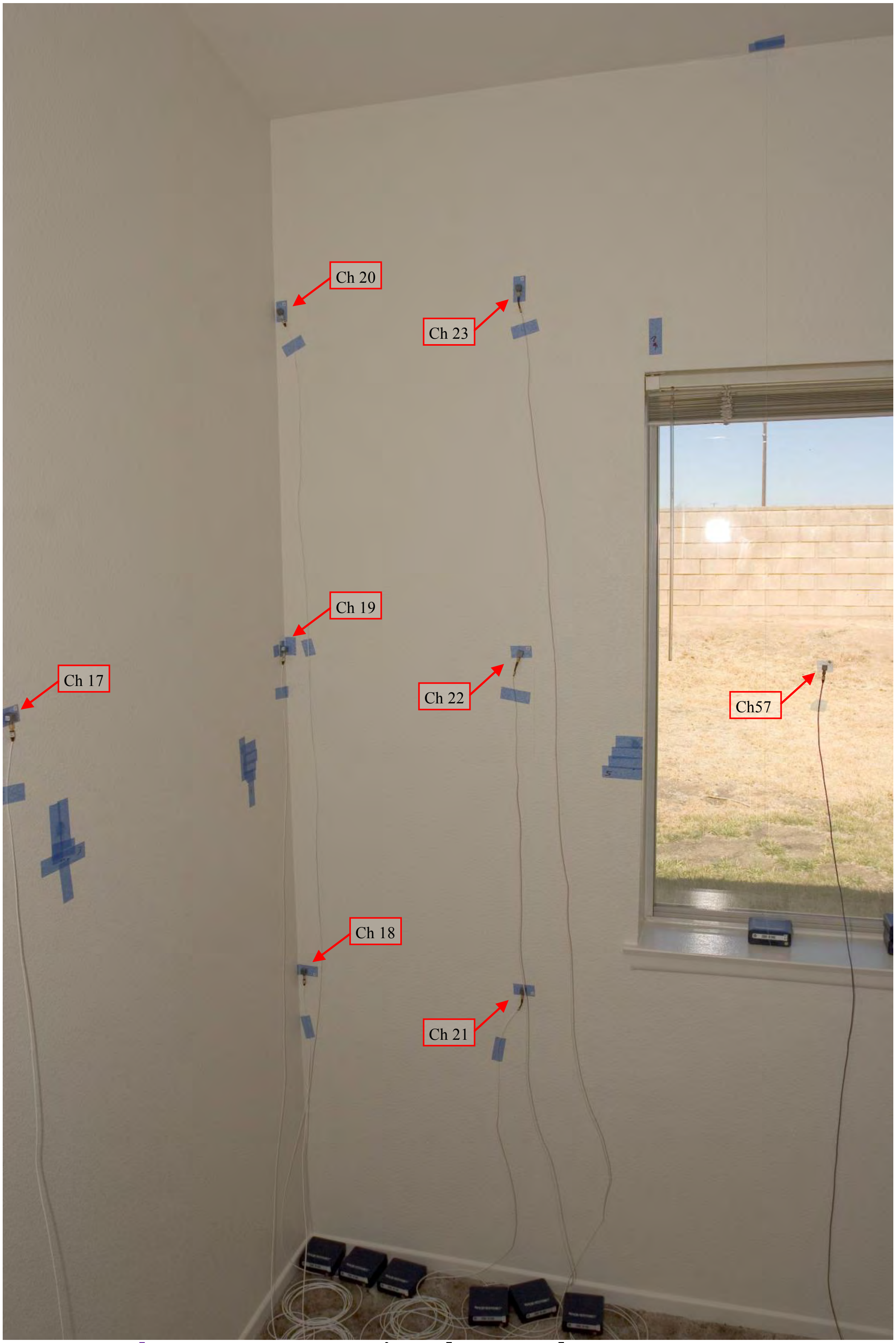
July 2007 Sonic Boom Flight Test

local coordinates given in inches from datum as noted in sketch

	Room		DATUM	X	Y	Z
Pad 1	master bedroom	top right	B	53	-13	77
		bottom right	B	53	-13	0
		top left	B	109	-13	77
		bottom left	B	109	-13	0
Pad 2	master bedroom	top right	B	146	0	77
		bottom right	B	146	0	0
		top left	B	93	0	77
		bottom left	B	93	0	0
Pad 3	front bedroom	top right	A	0	63	58
		bottom right	A	0	63	1
		top left	A	0	23	58
		bottom left	A	0	23	1
Pad 4	front bedroom	top right	A	128	10.5	57
		bottom right	A	128	10.5	1
		top left	A	128	88	57
		bottom left	A	128	88	1
Pad 5	garage bedroom	top right	C	76	0	61
		bottom right	C	76	0	6
		top left	C	118	0	61
		bottom left	C	118	0	6
Pad 6	garage bedroom	top right	C	179	110	59
		bottom right	C	179	110	59
		top left	C	179	35	59
		bottom left	C	179	35	59



Master Bedroom Instrumentation Photograph



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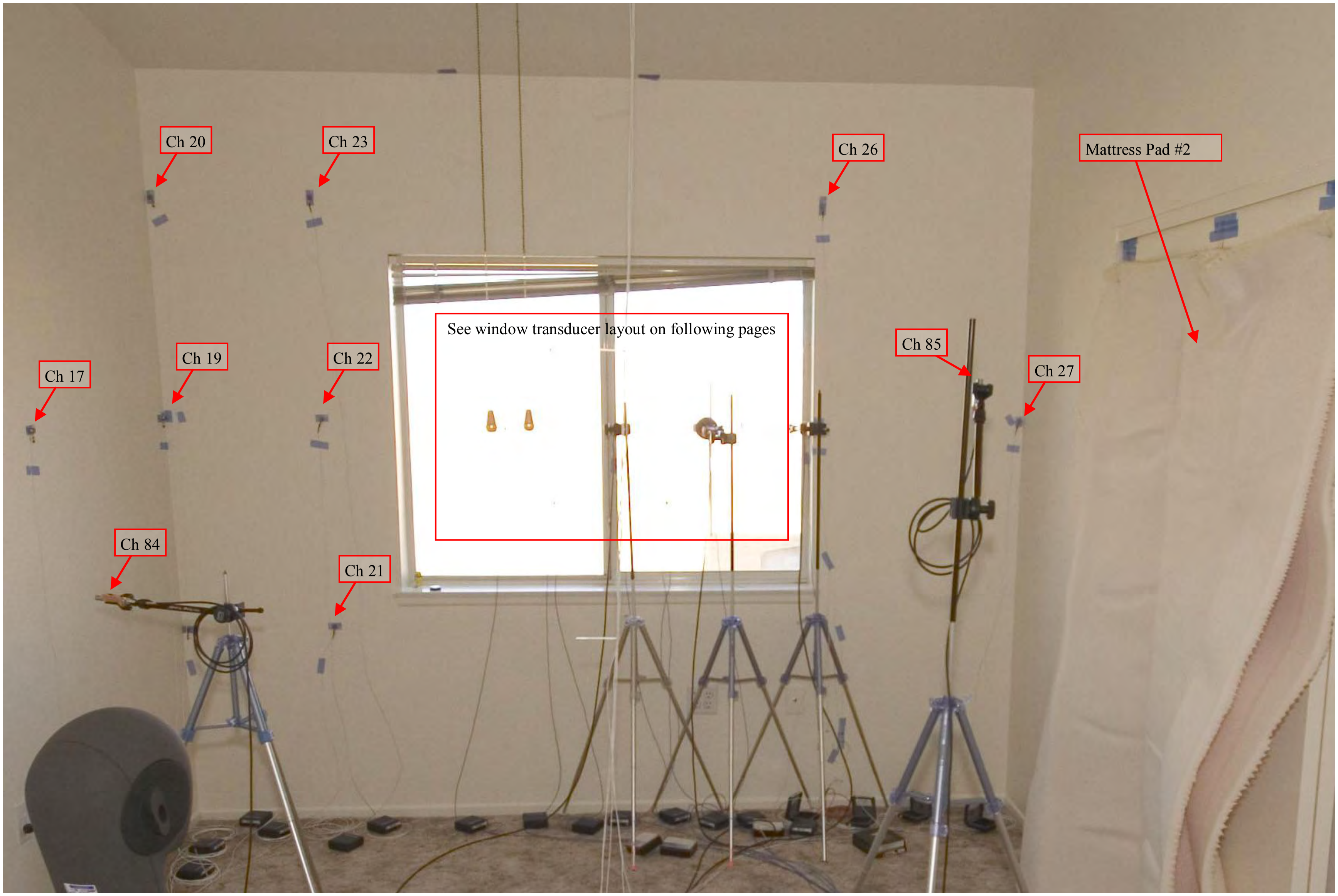

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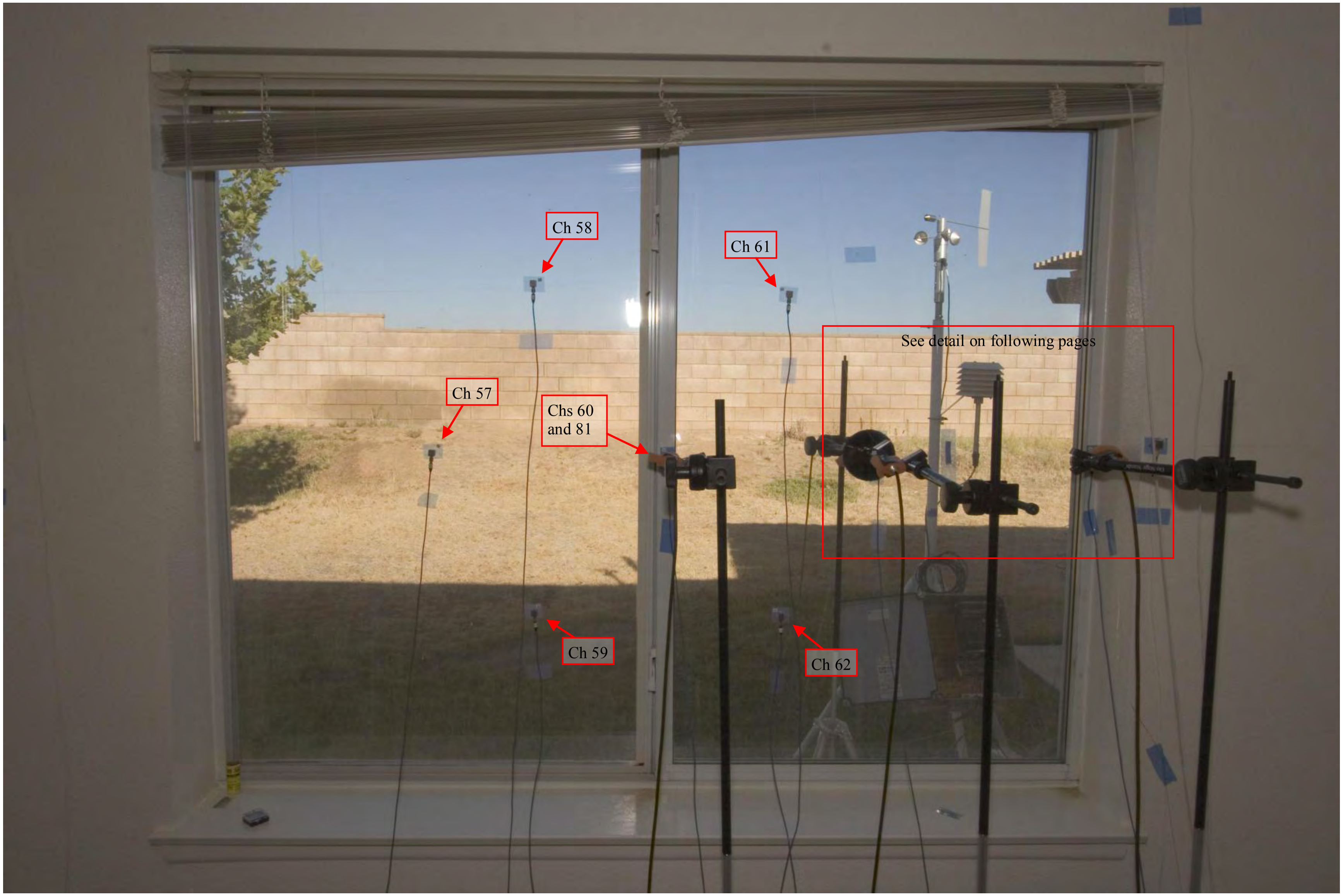

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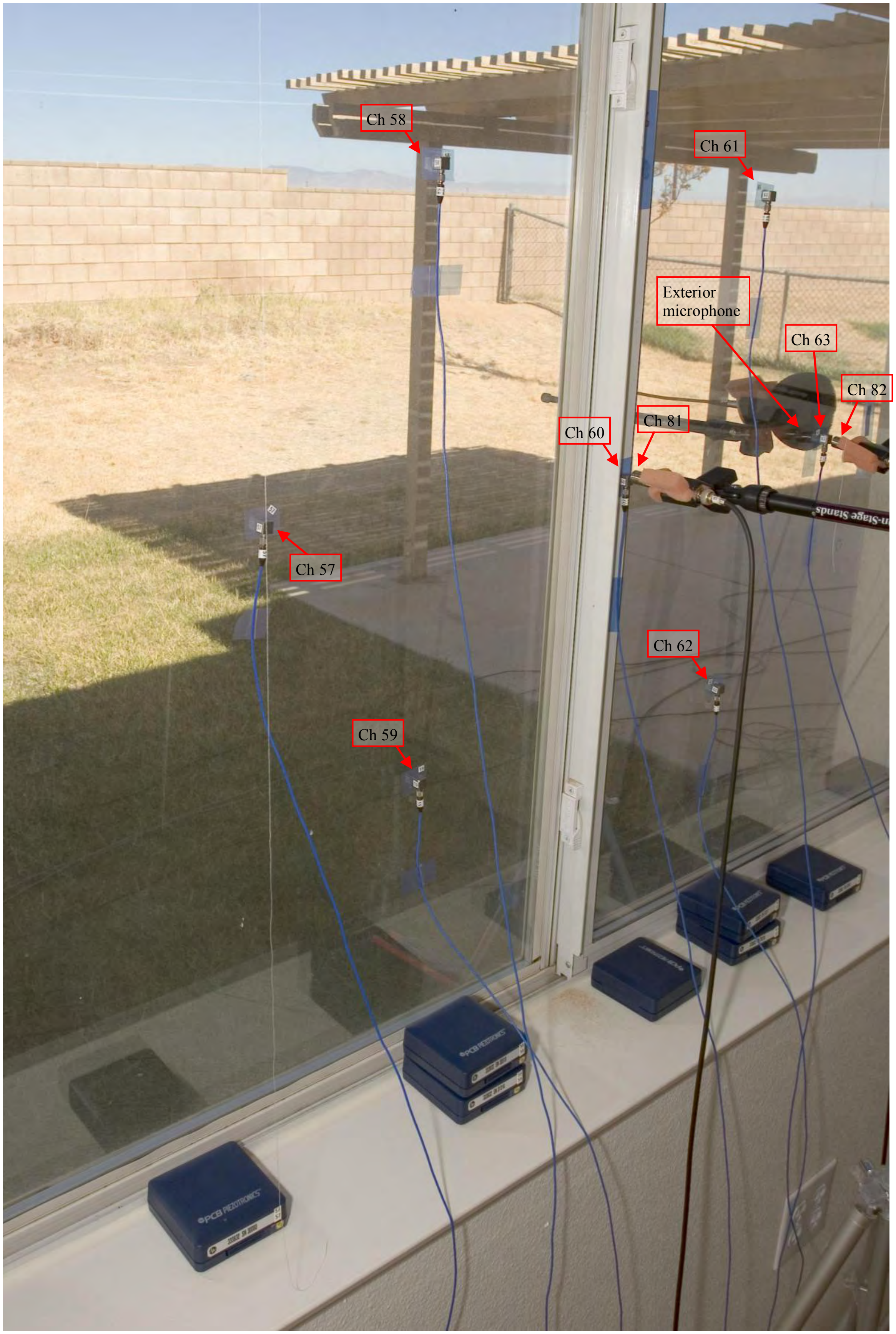

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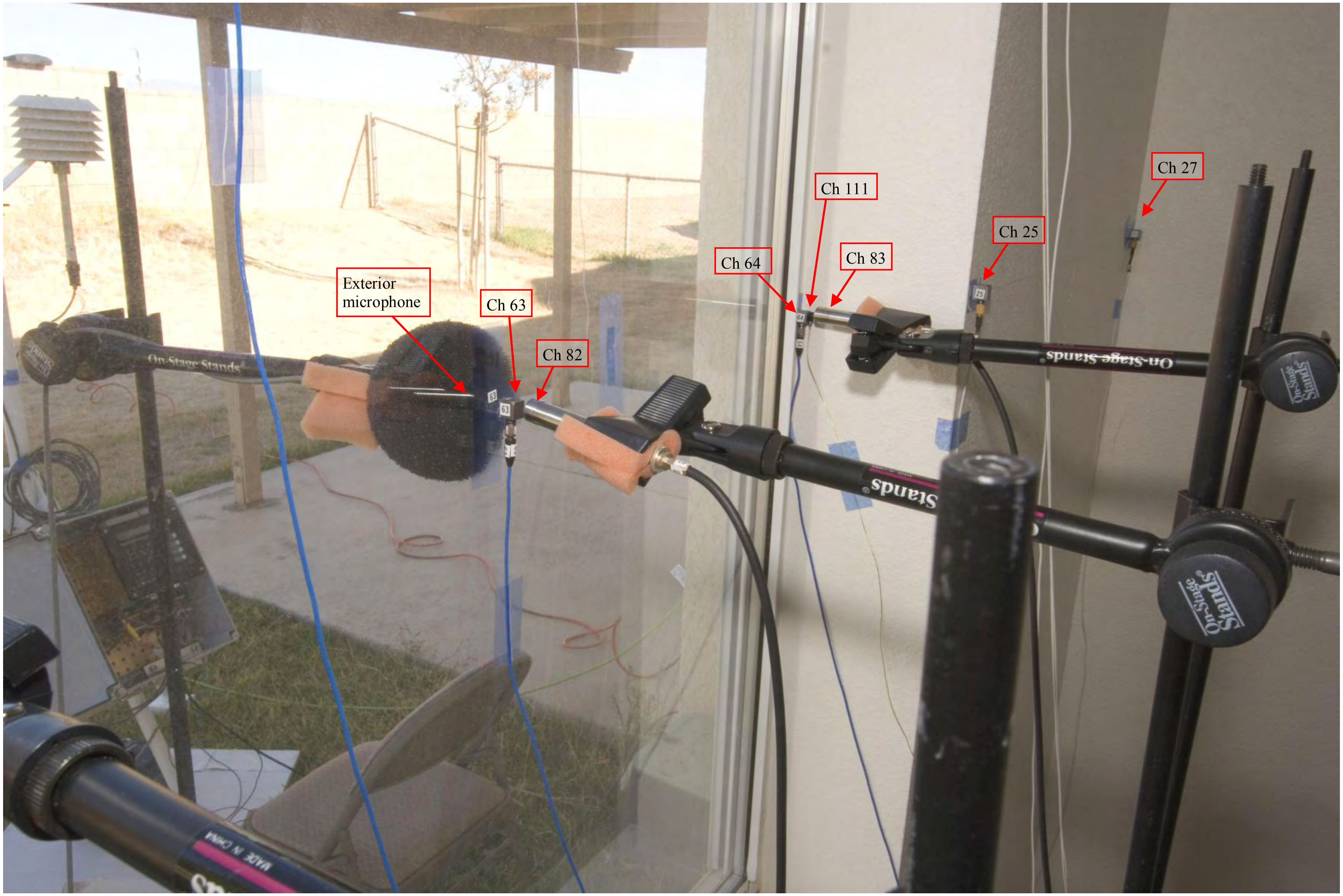

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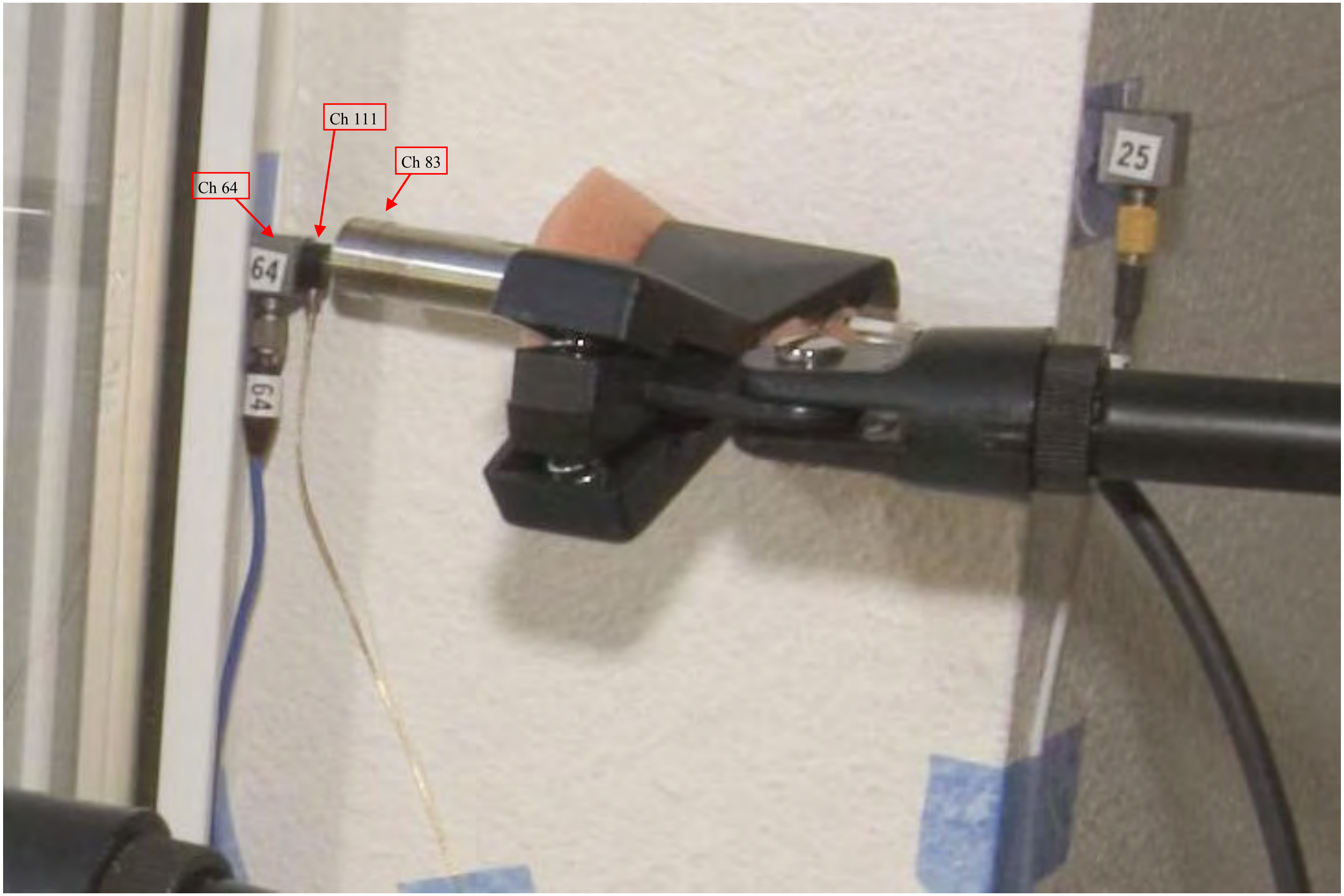

Master Bedroom Instrumentation Photograph

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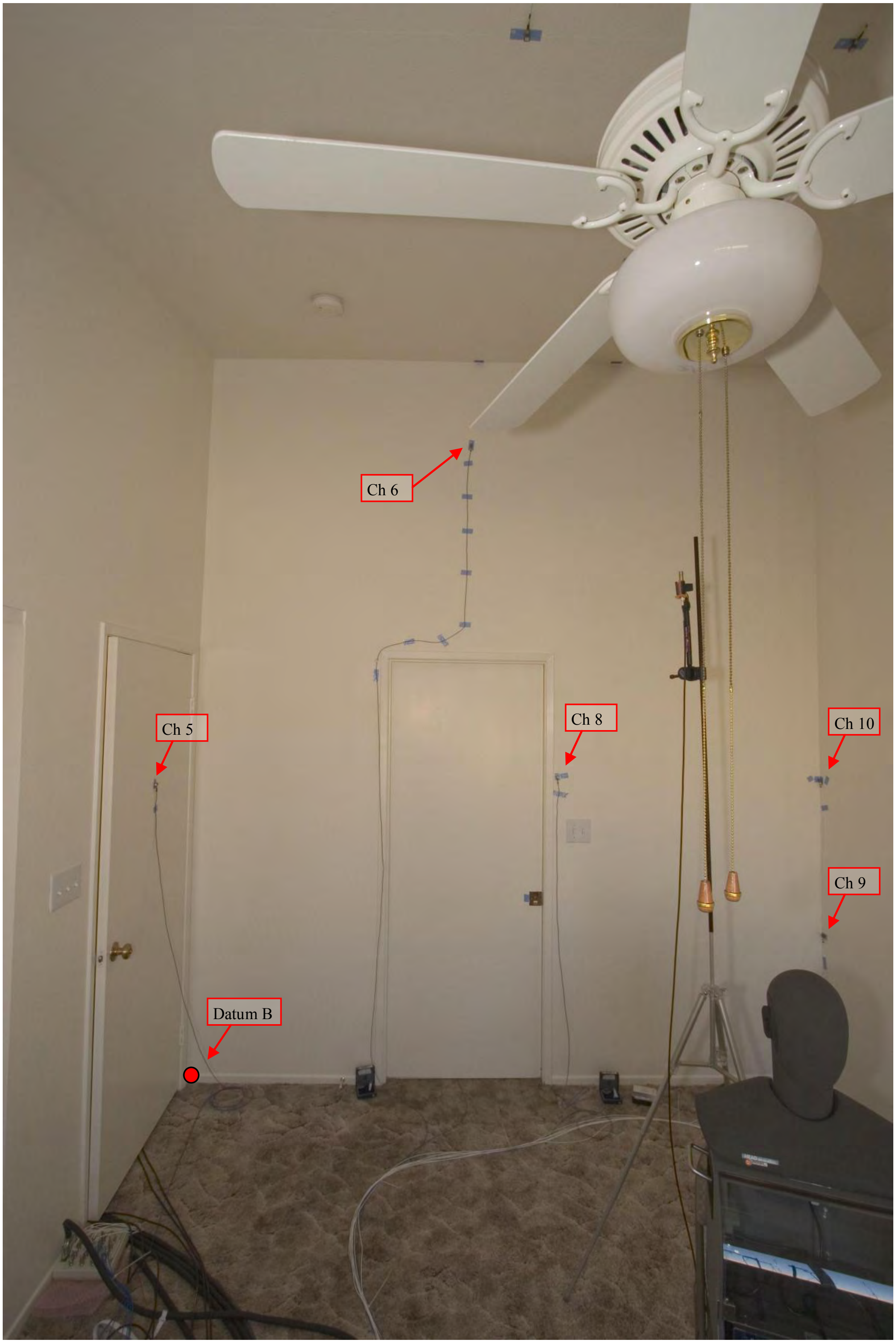

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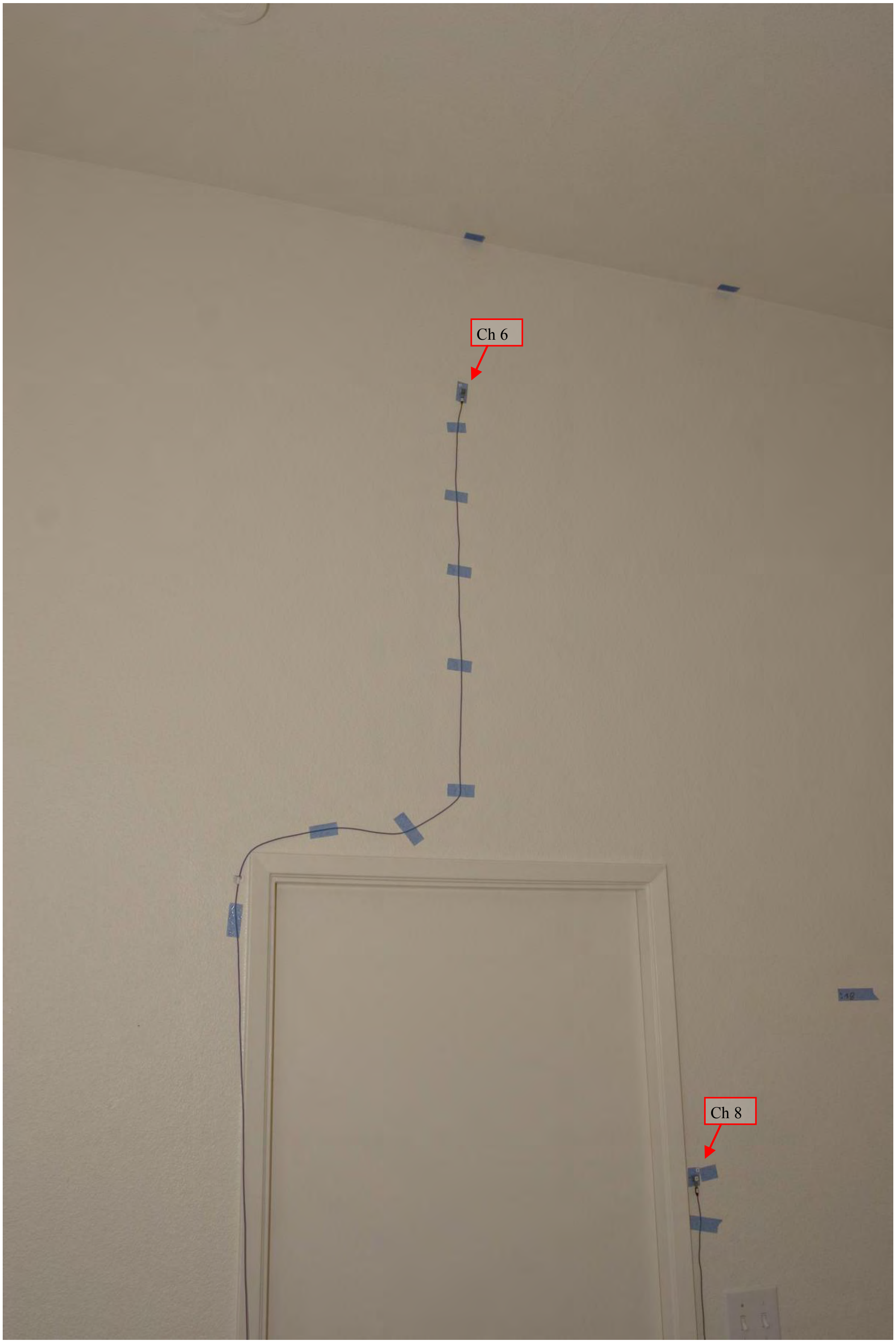

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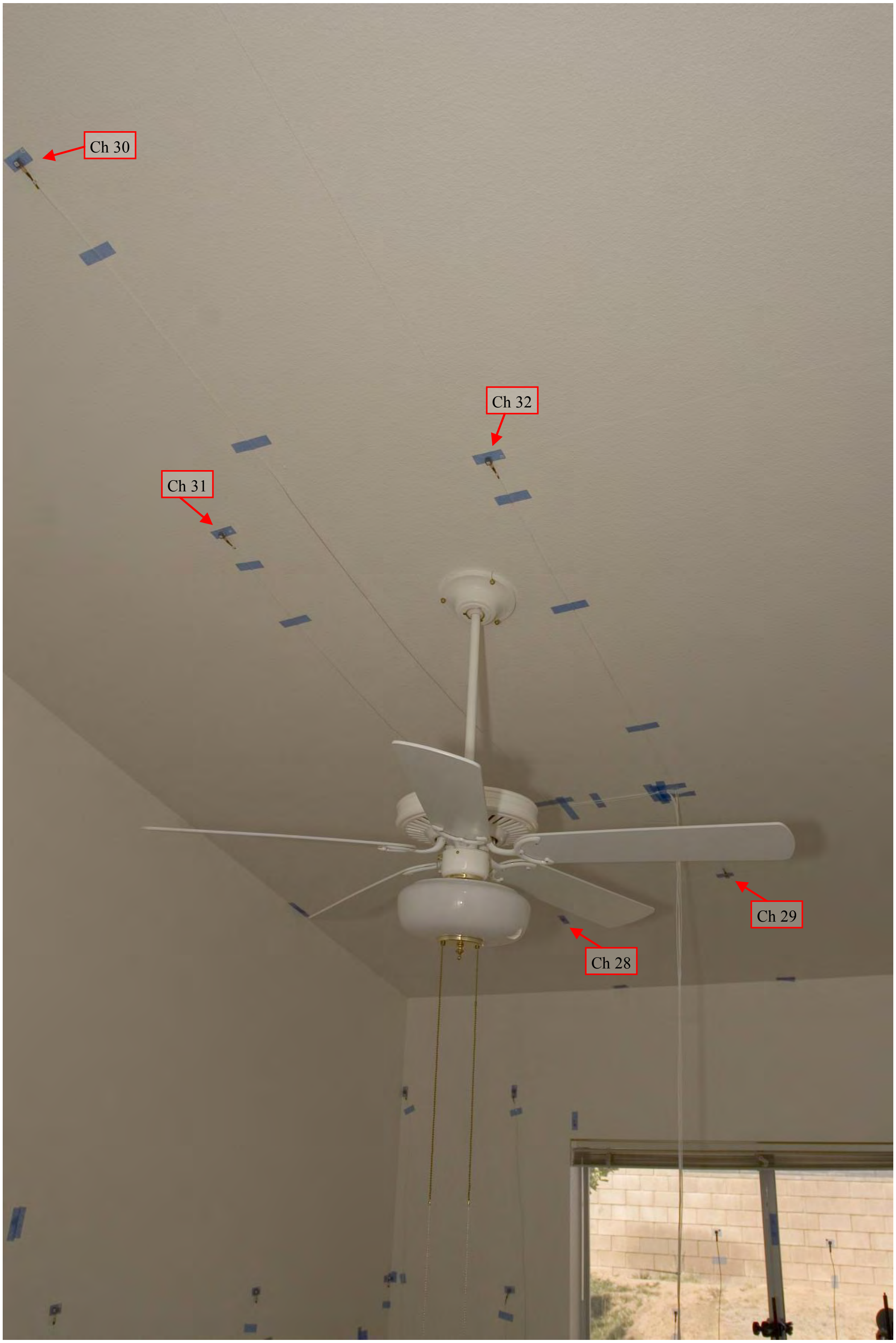

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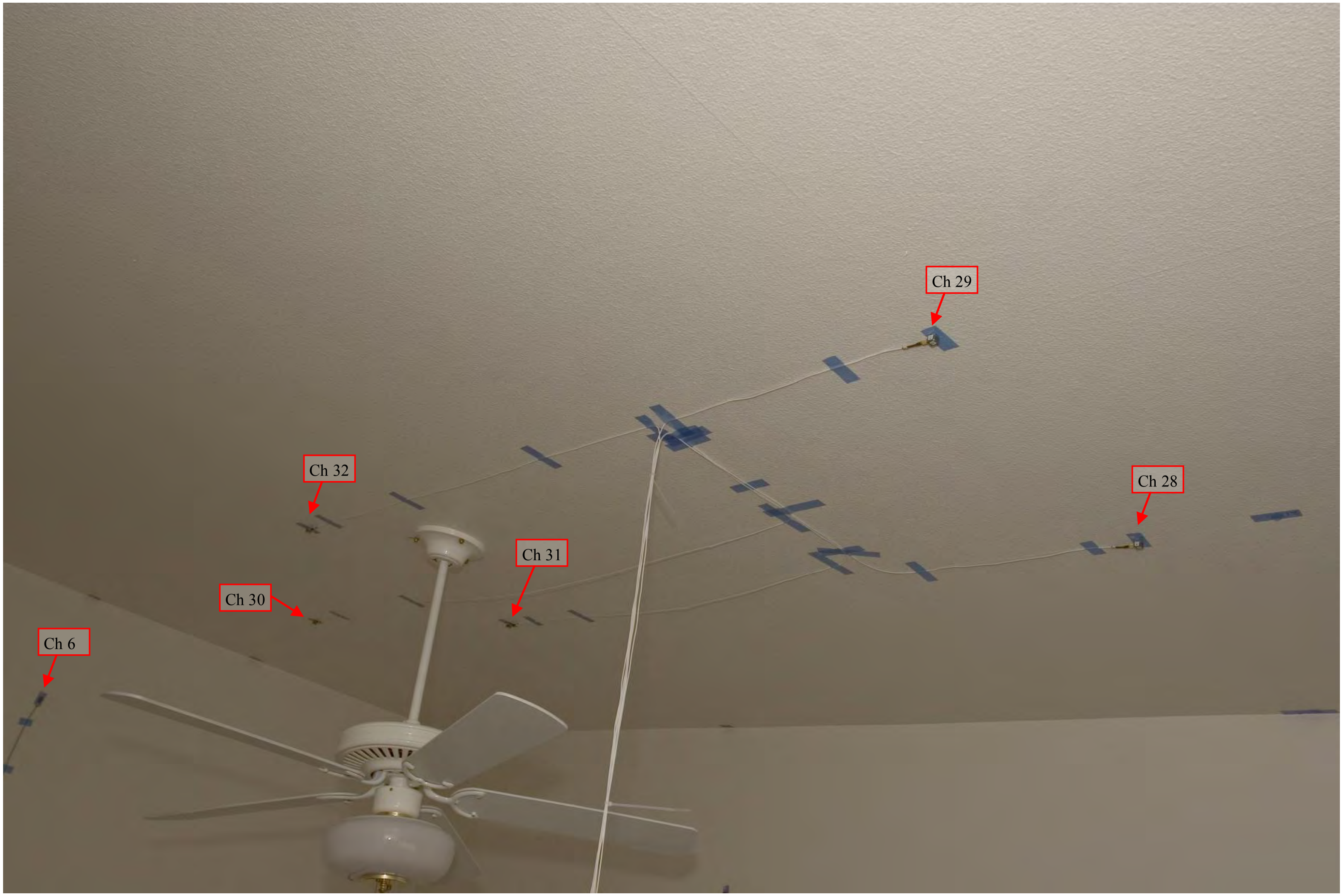

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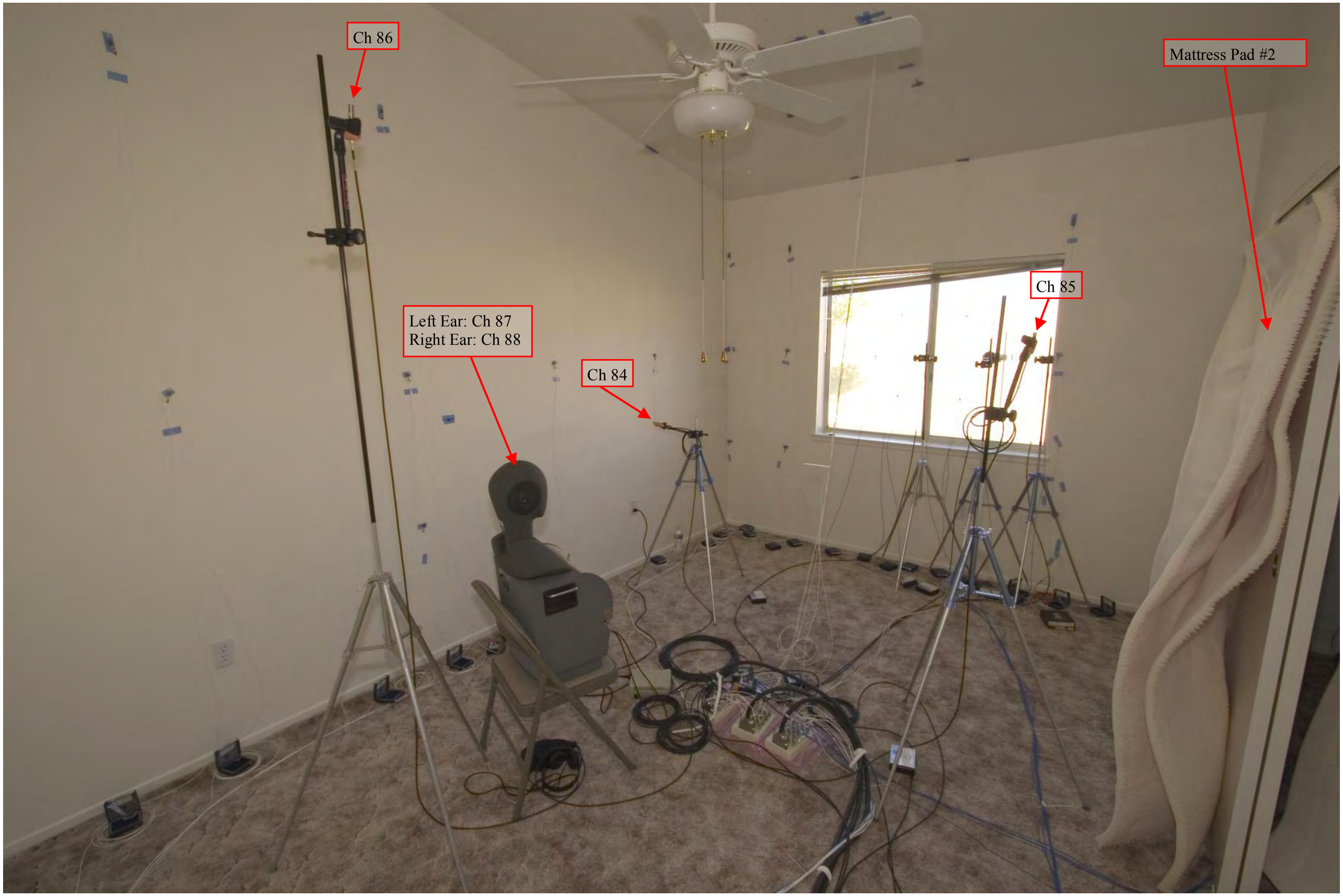

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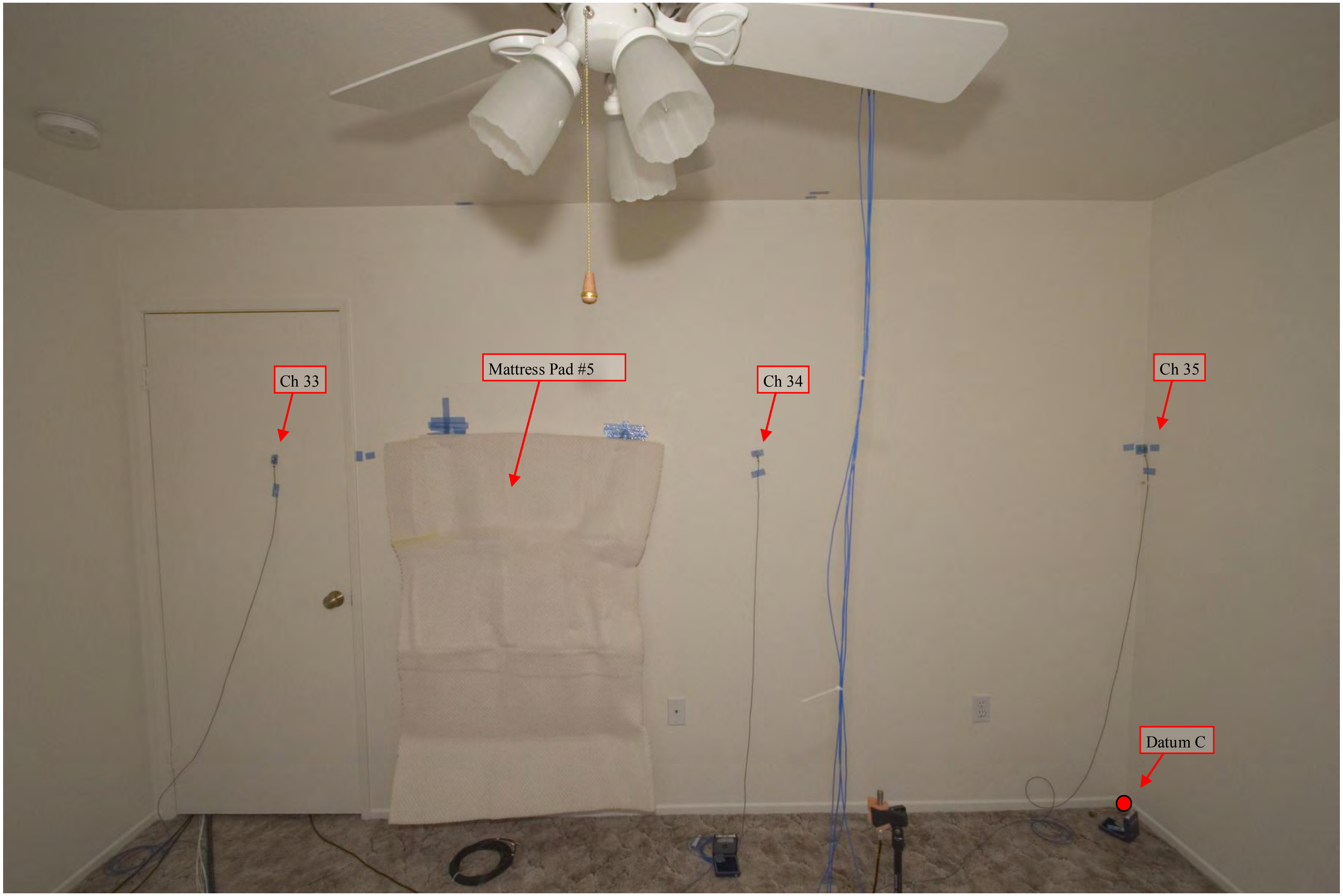
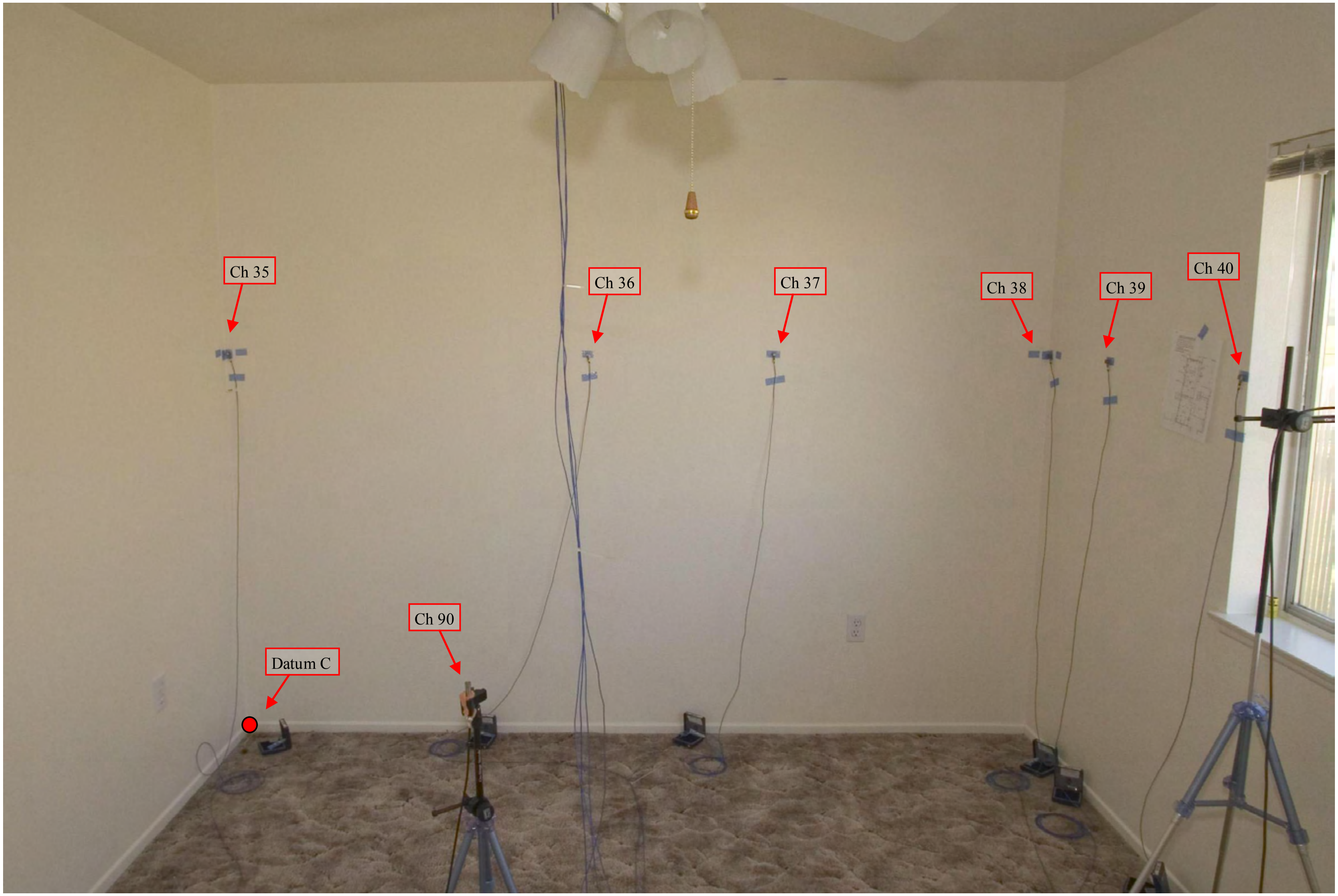


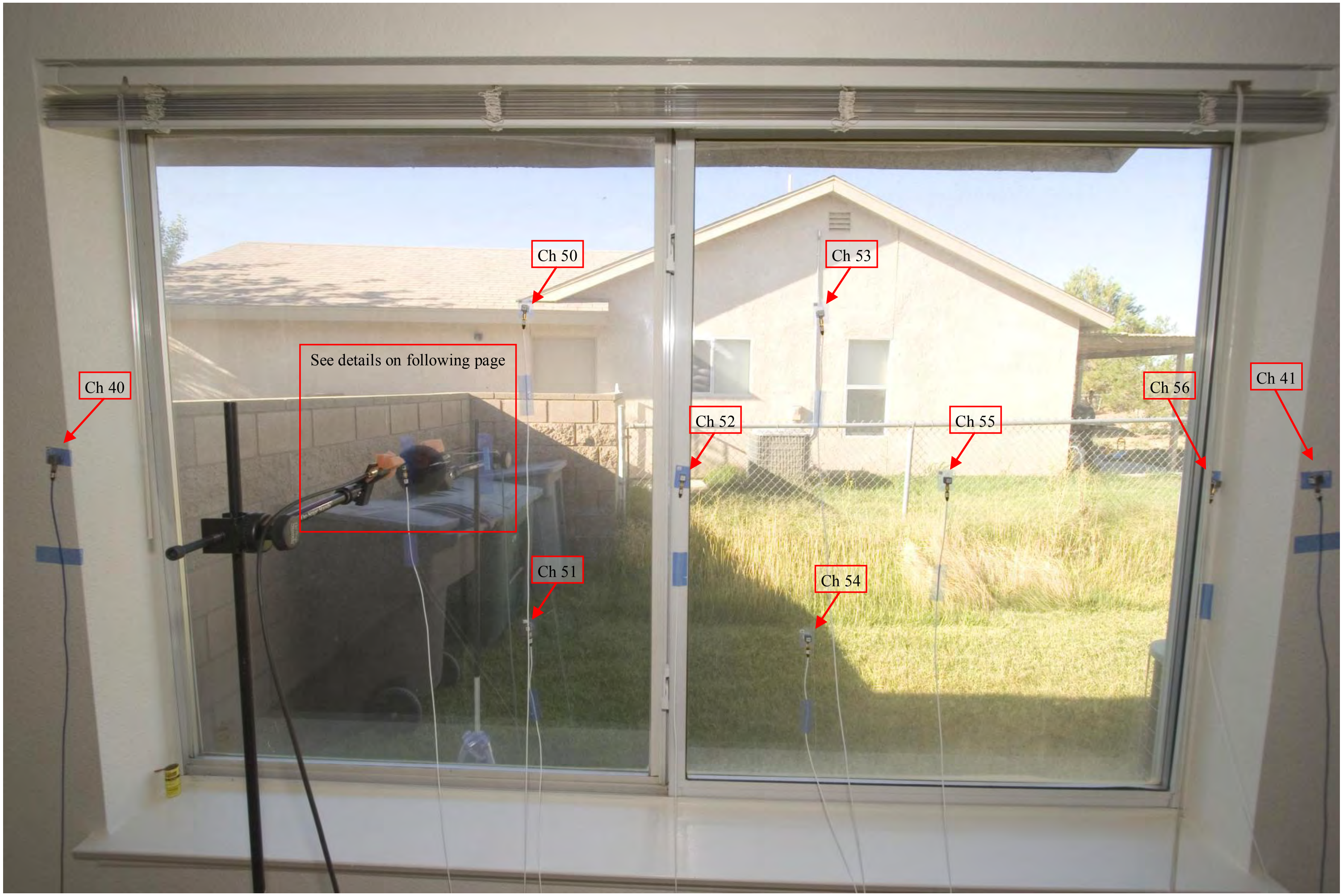
Garage Bedroom Instrumentation Photograph

Garage Bedroom Instrumentation Photograph



Garage Bedroom Instrumentation Photograph

Garage Bedroom Instrumentation Photograph



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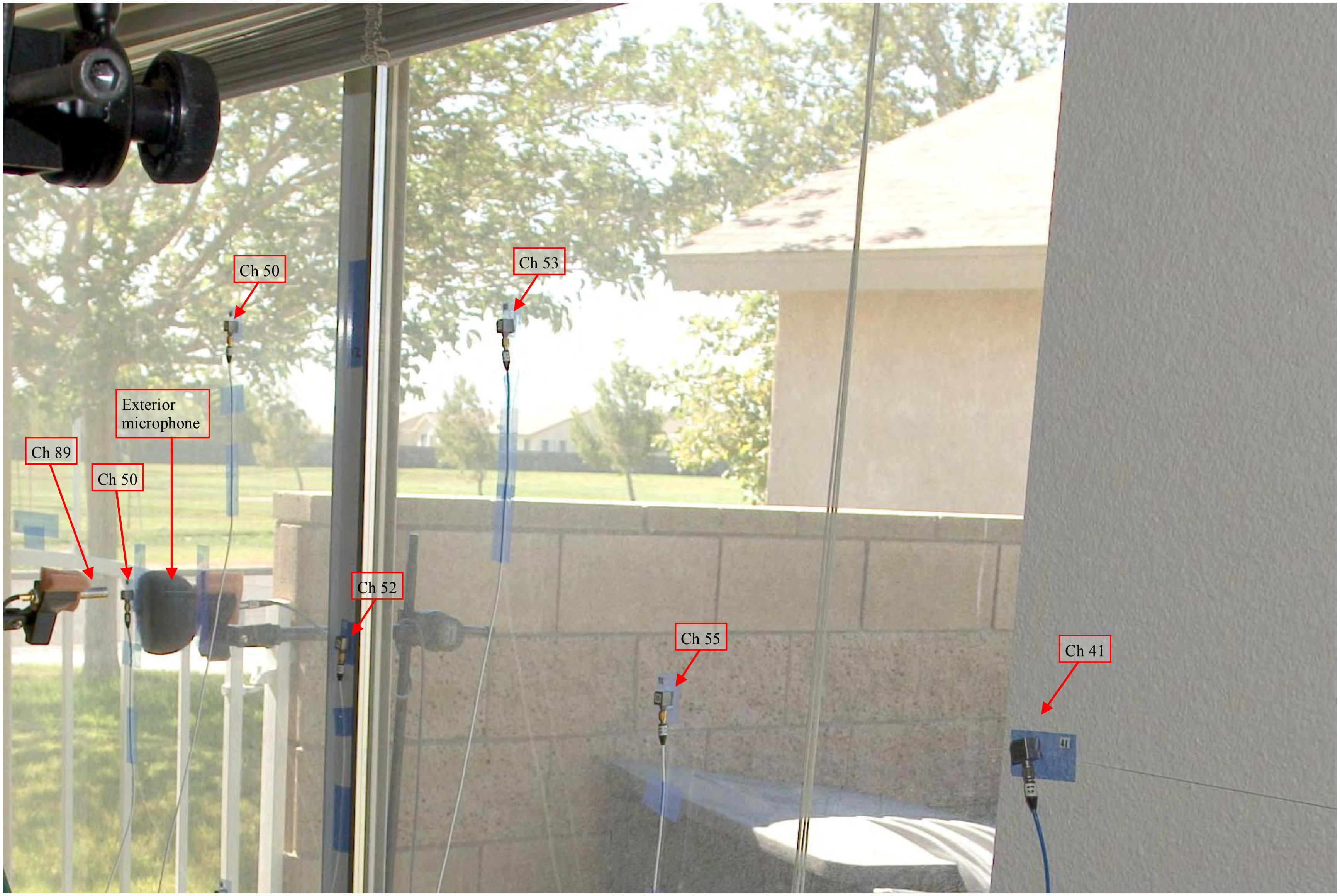
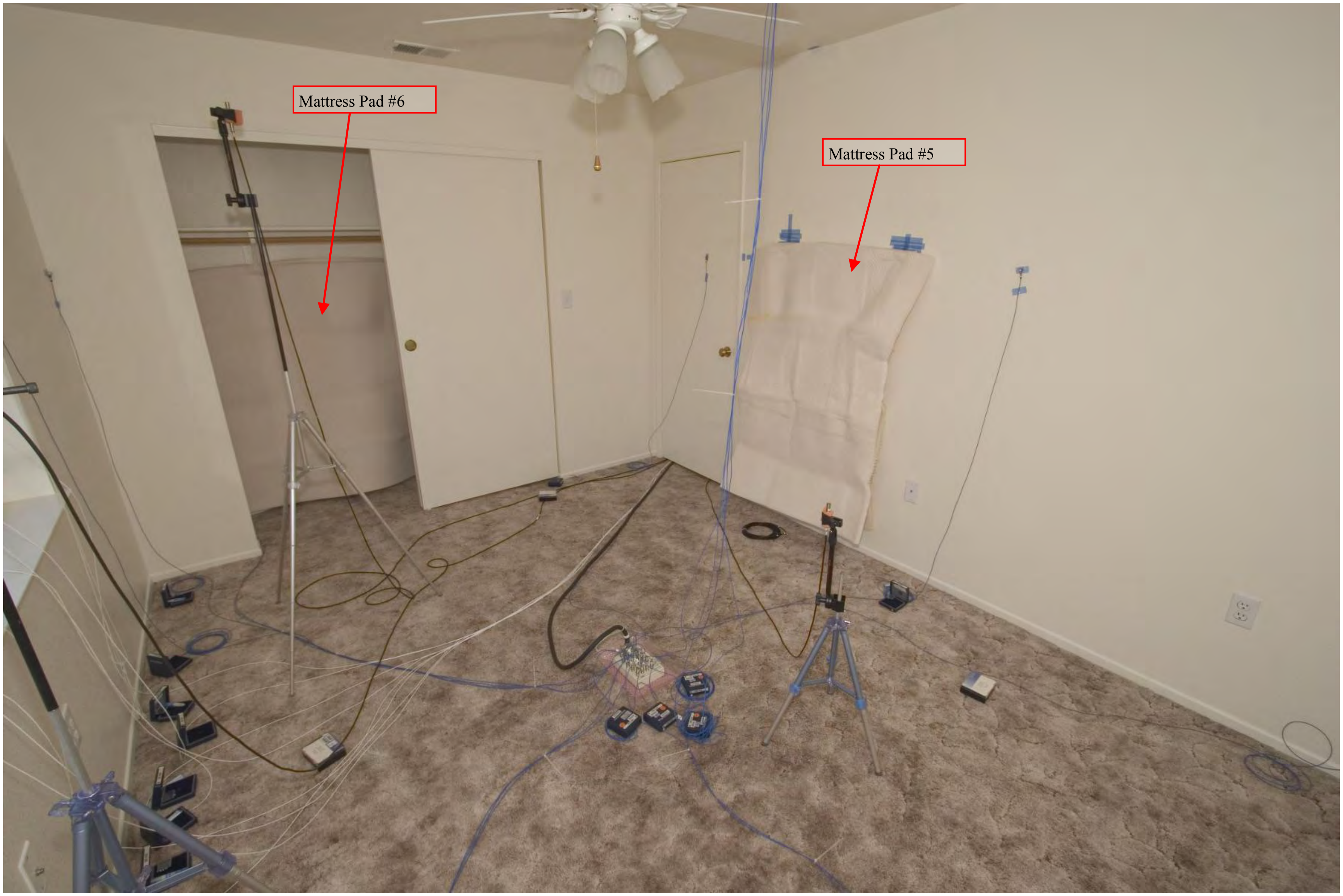


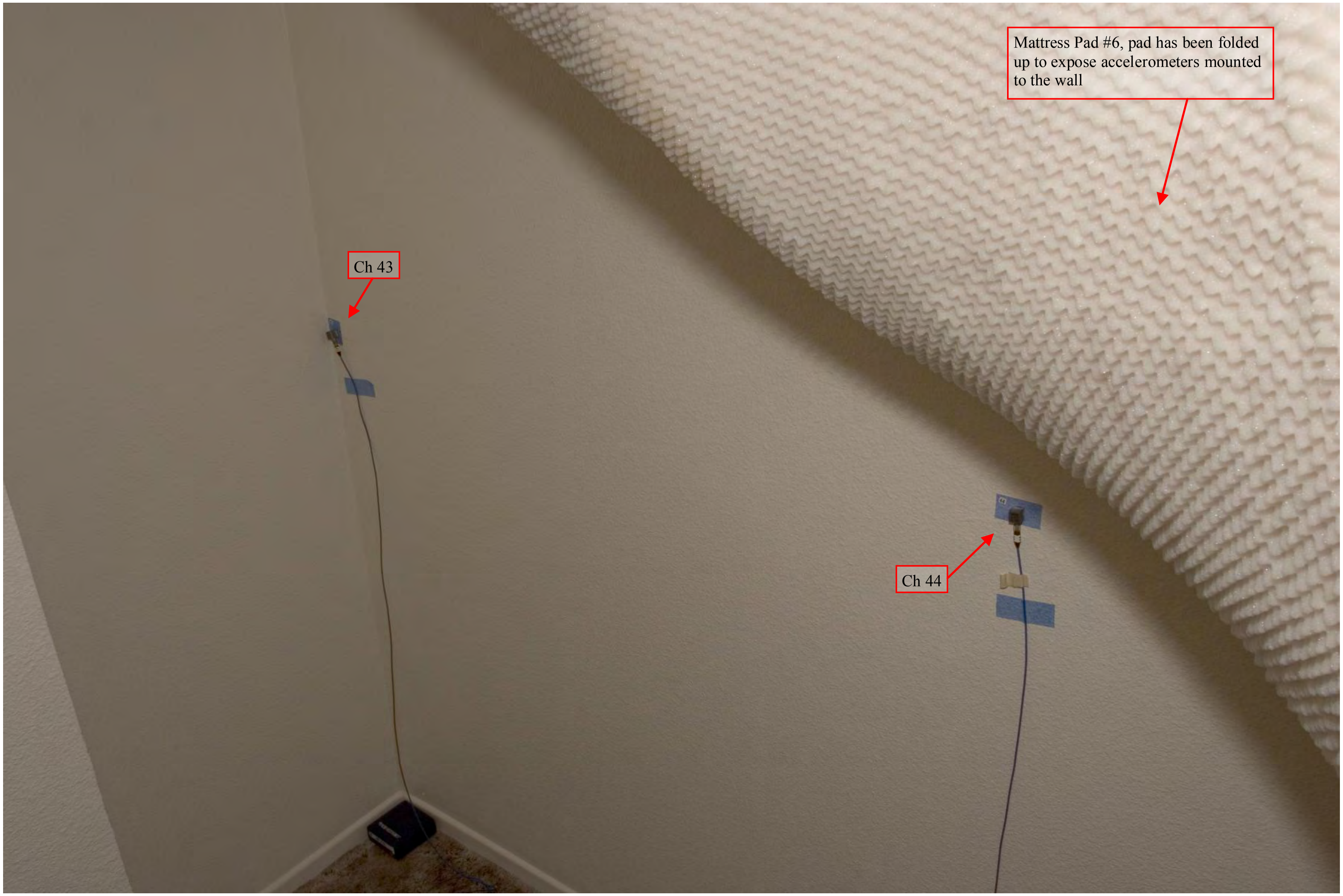
Garage Bedroom Instrumentation Photograph

Garage Bedroom Instrumentation Photograph



Garage Bedroom Instrumentation Photograph

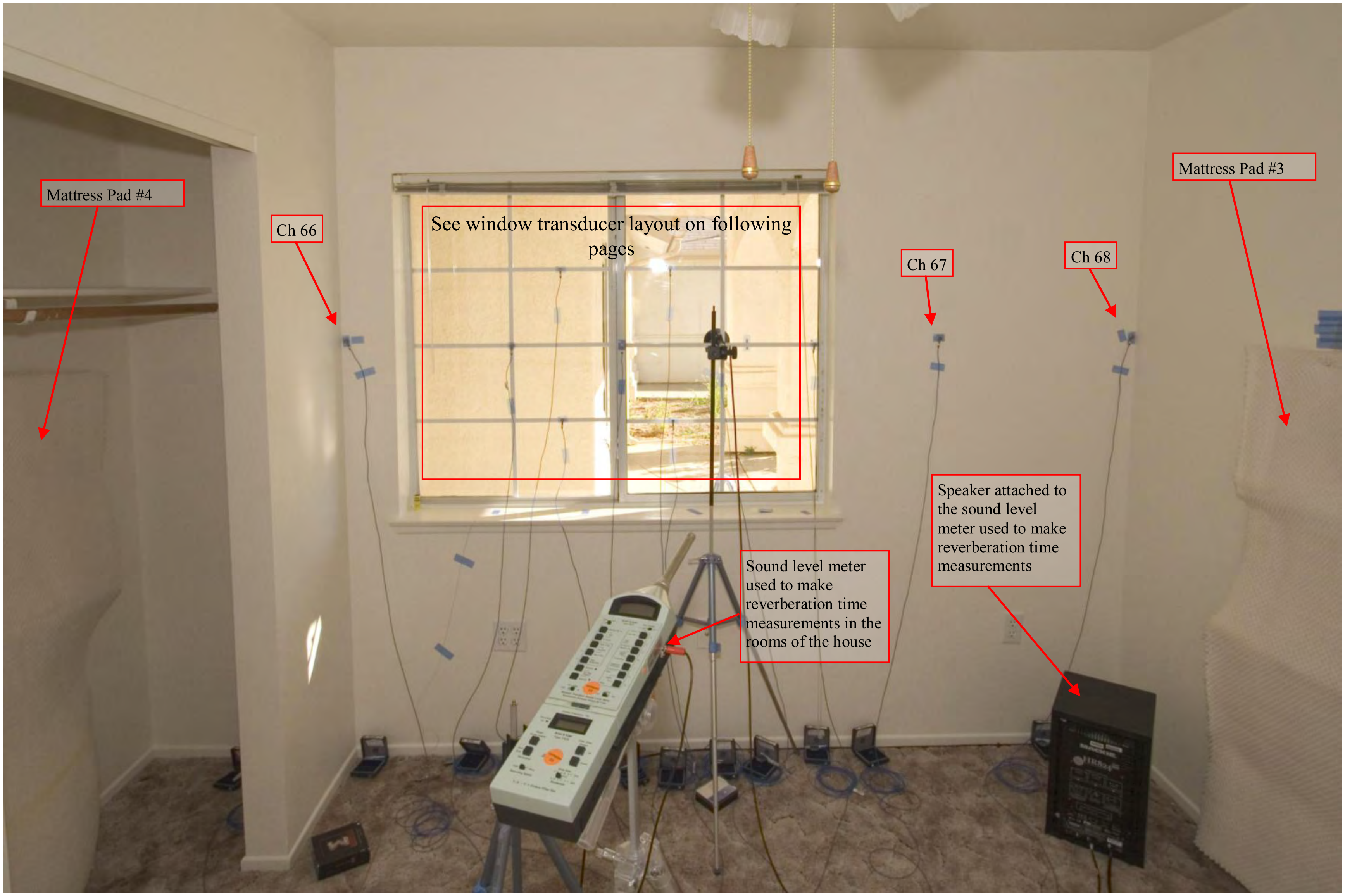
Garage Bedroom Instrumentation Photograph



Garage Bedroom Instrumentation Photograph

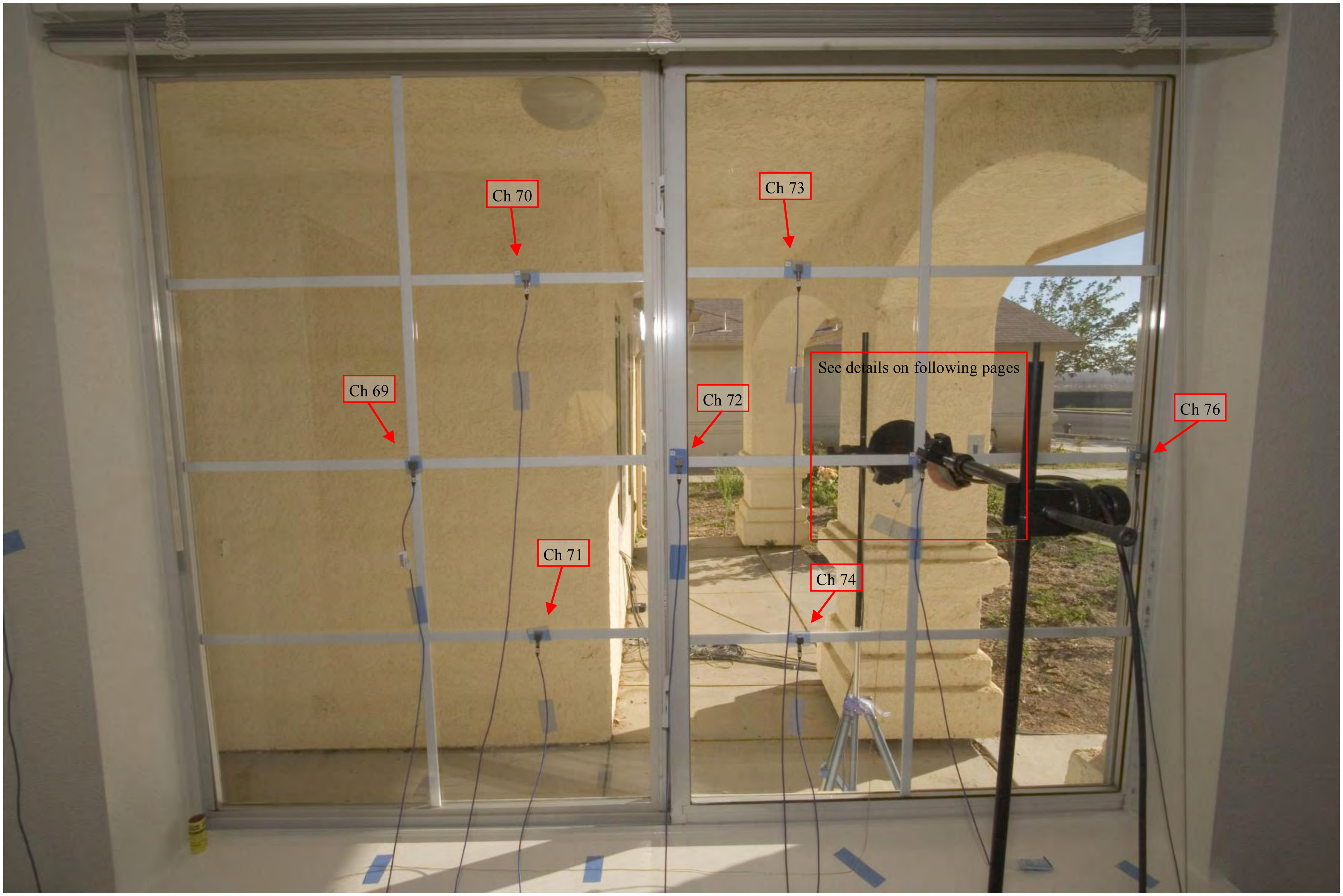
Front Bedroom Instrumentation Photograph

Front Bedroom Instrumentation Photograph

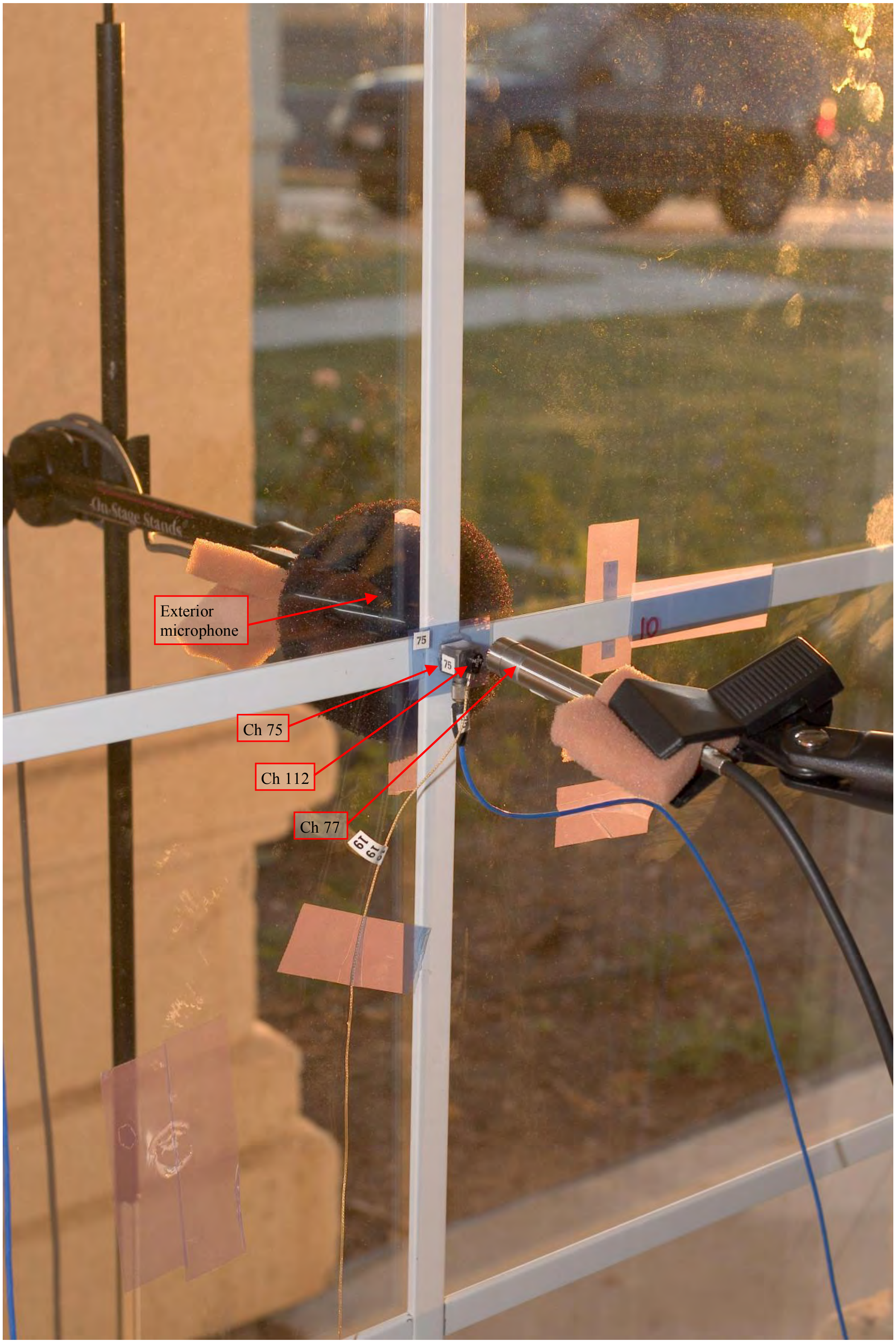


Front Bedroom Instrumentation Photograph

Front Bedroom Instrumentation Photograph

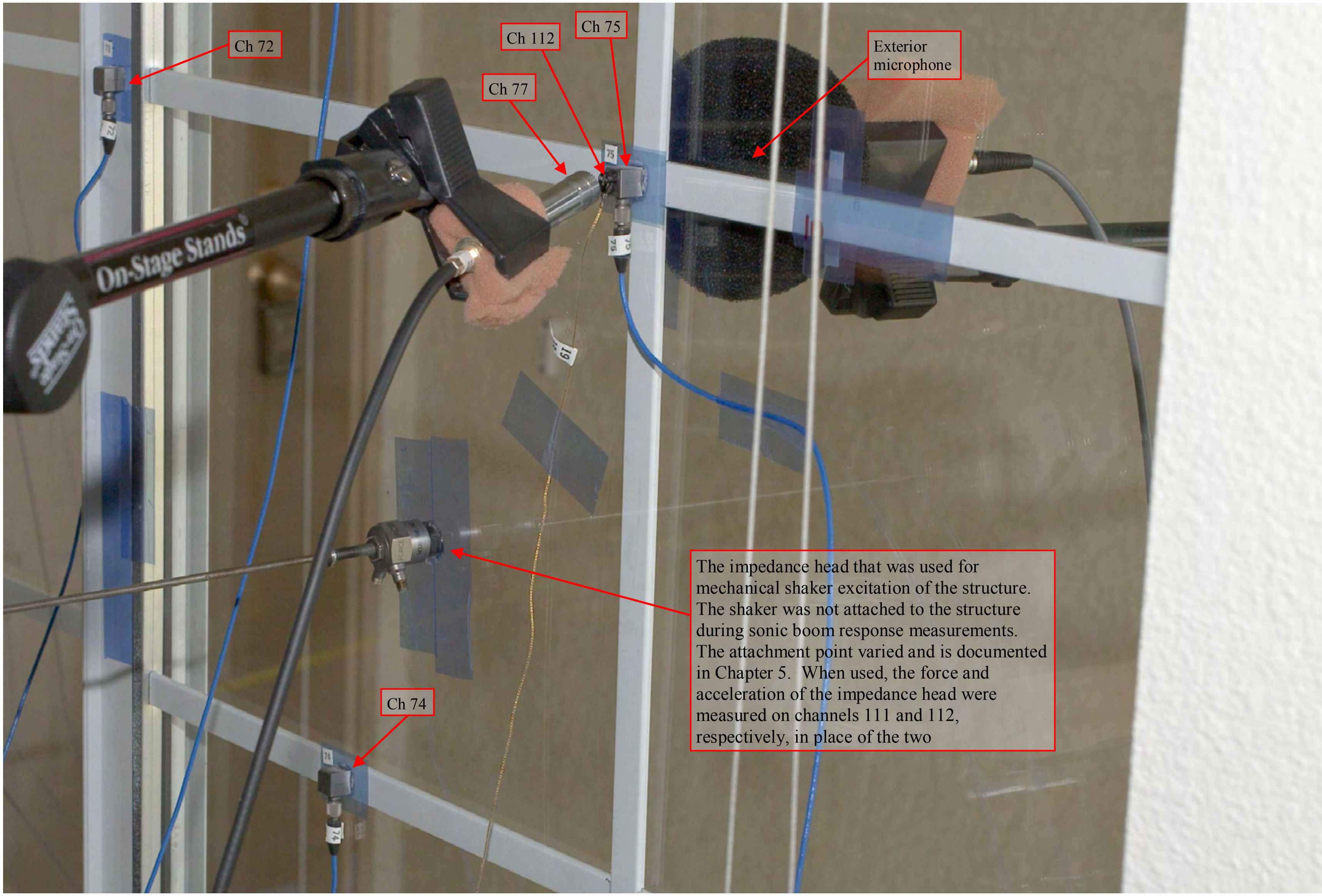


Front Bedroom Instrumentation Photograph

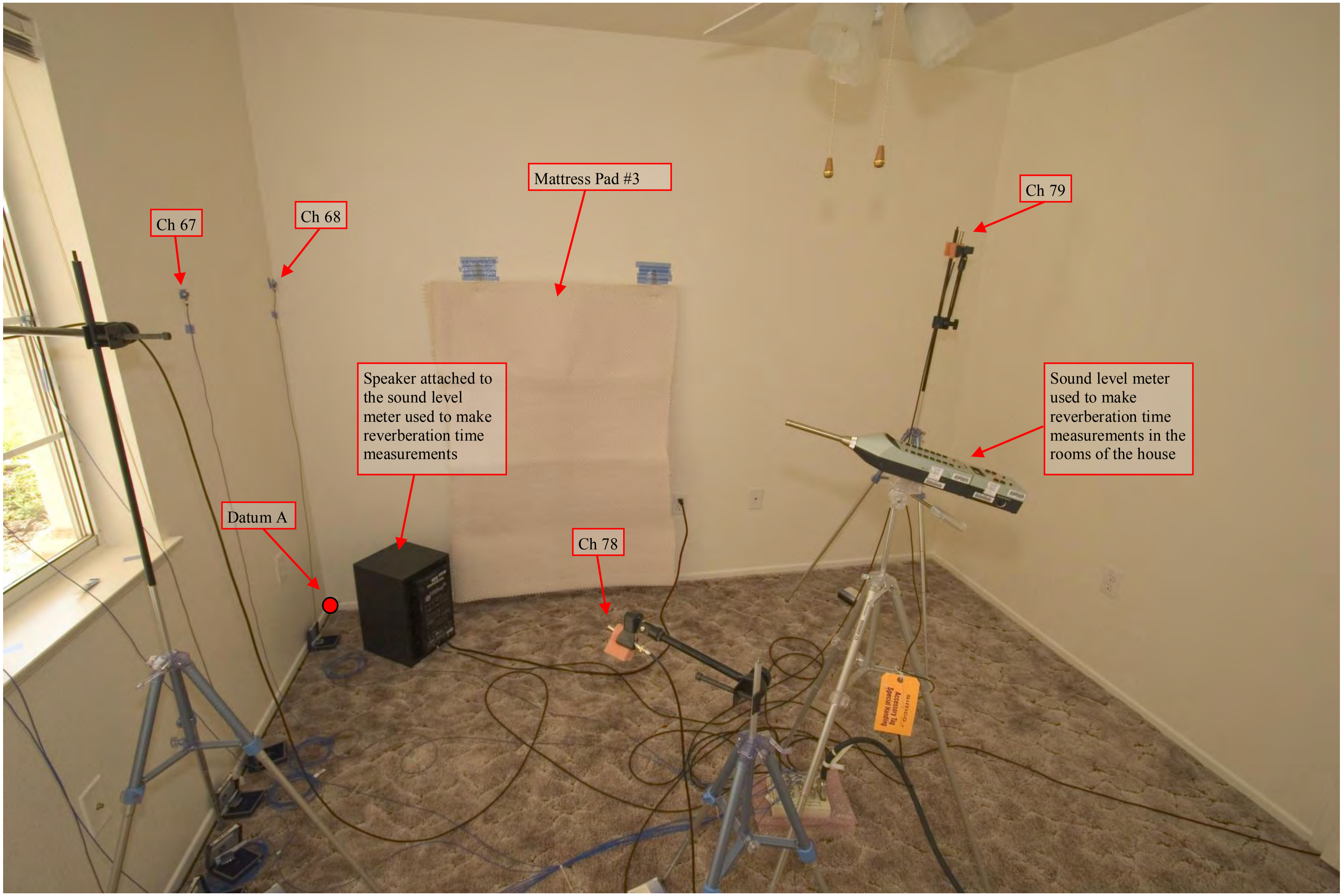


Front Bedroom Instrumentation Photograph

Front Bedroom Instrumentation Photograph



Front Bedroom Instrumentation Photograph



Front Bedroom Instrumentation Photograph

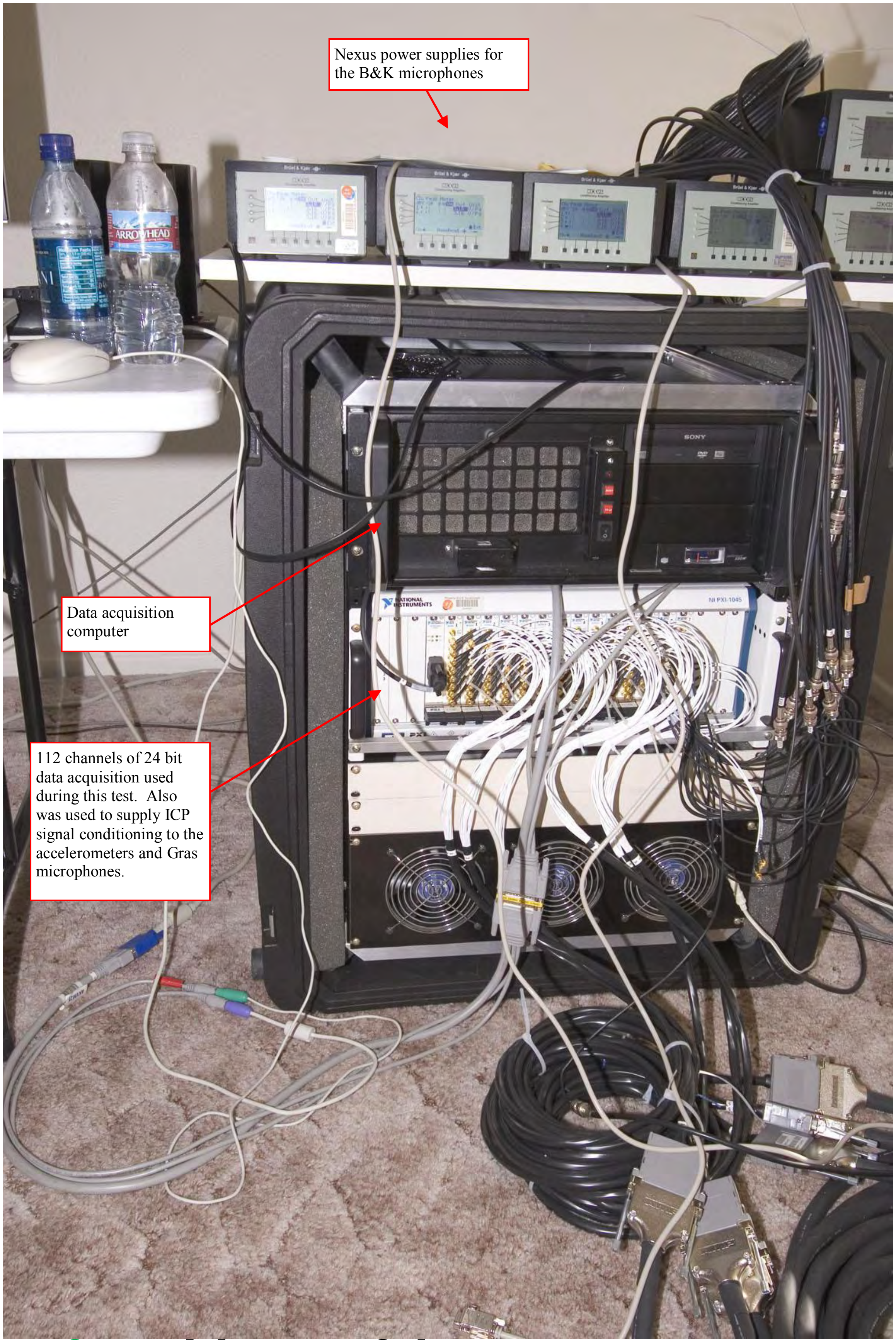
Front Bedroom Instrumentation Photograph

Attic Instrumentation Photograph

Attic Instrumentation Photograph

Living Area Equipment Photograph

Living Area Equipment Photograph


Nexus power supplies for the B&K microphones
Data acquisition computer
112 channels of 24 bit data acquisition used during this test. Also was used to supply ICP signal conditioning to the accelerometers and Gras microphones.
ARROWHEAD
SONY
NATIONAL INSTRUMENTS

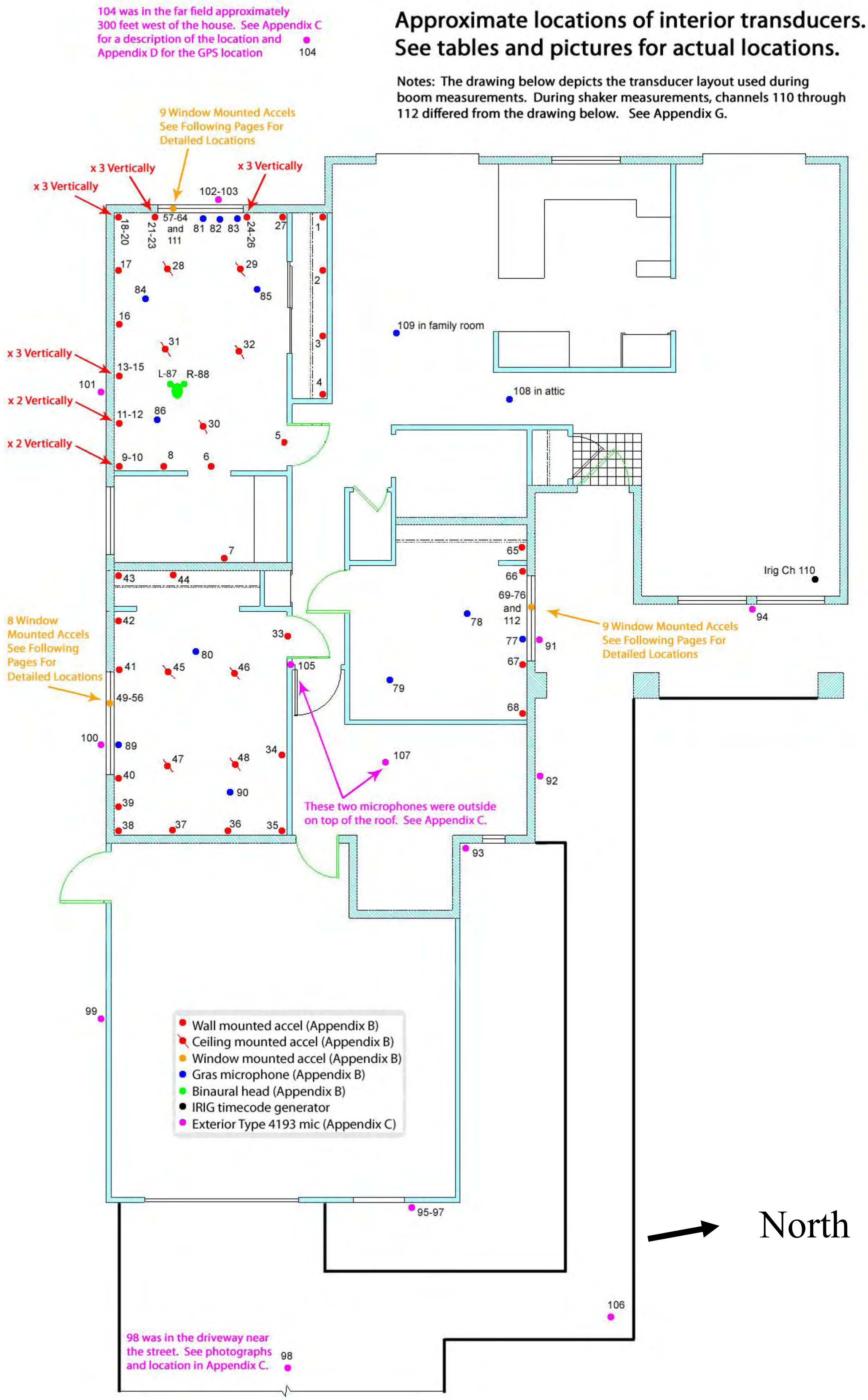
Appendix C

Locations and pictures of the nominal exterior transducer layout.

(All dimensions are in inches unless otherwise noted)

Approximate locations of interior transducers. See tables and pictures for actual locations.

Notes: The drawing below depicts the transducer layout used during boom measurements. During shaker measurements, channels 110 through 112 differed from the drawing below. See Appendix G.



Overlay of the house roofline and the approximate transducer locations

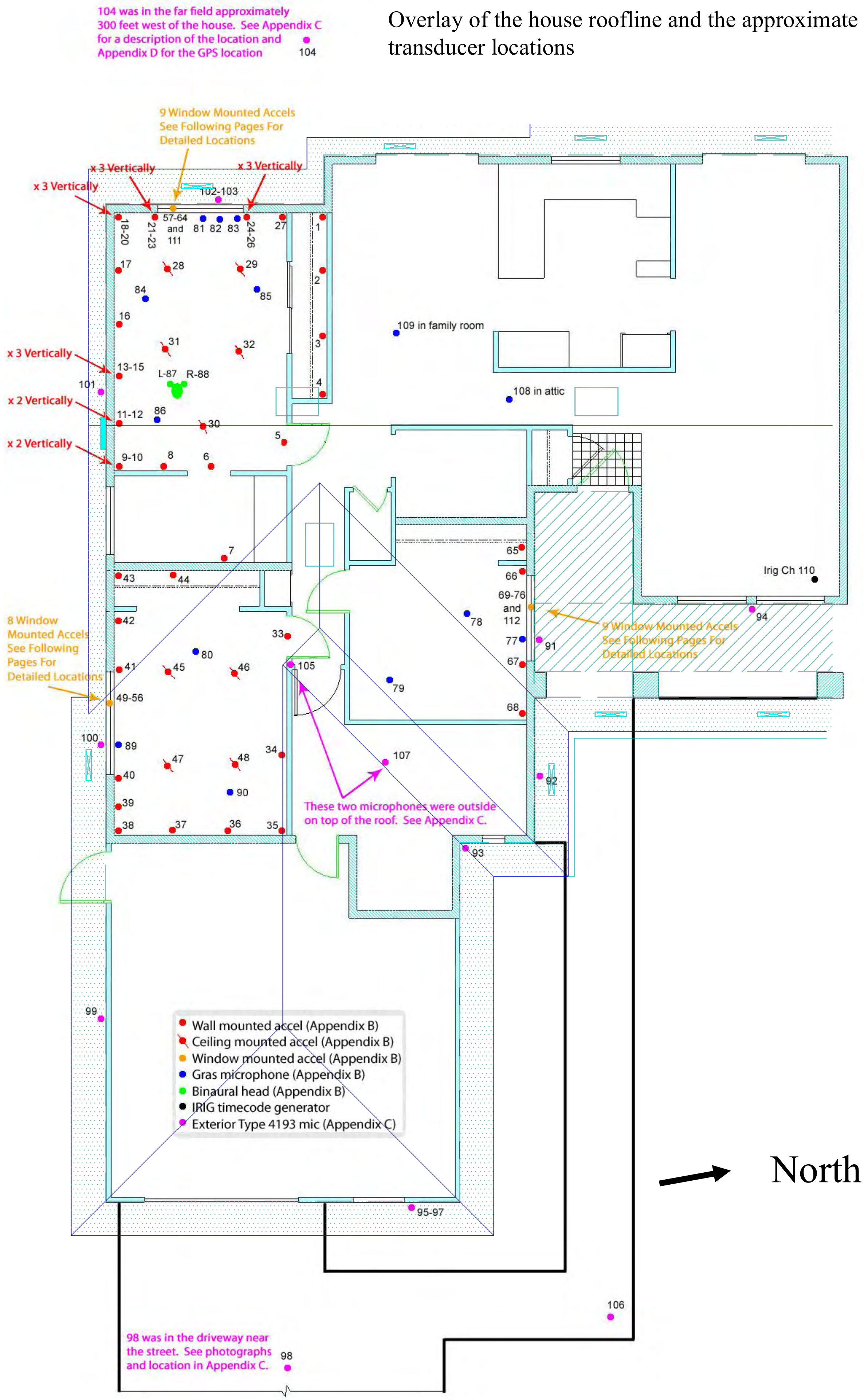
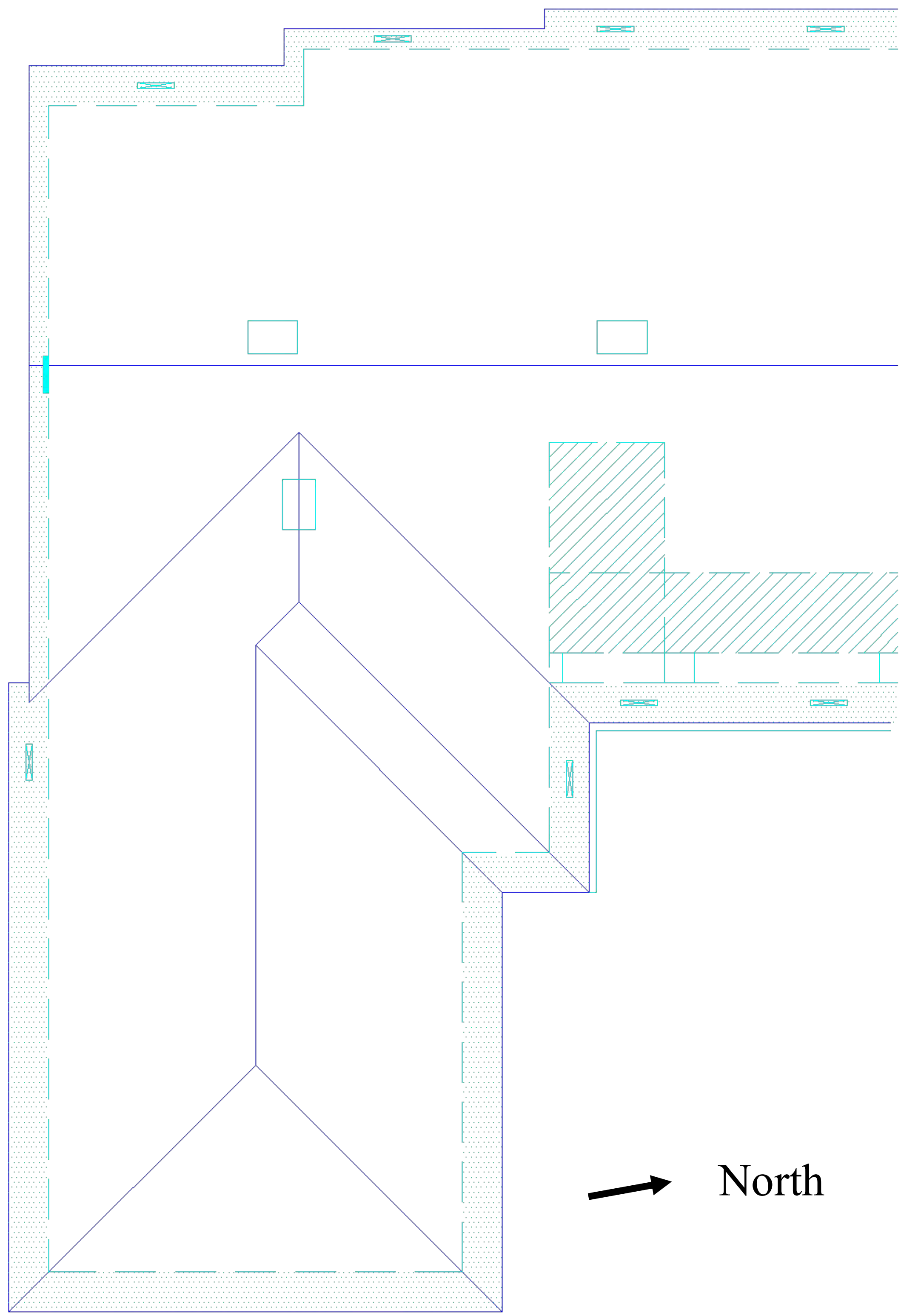
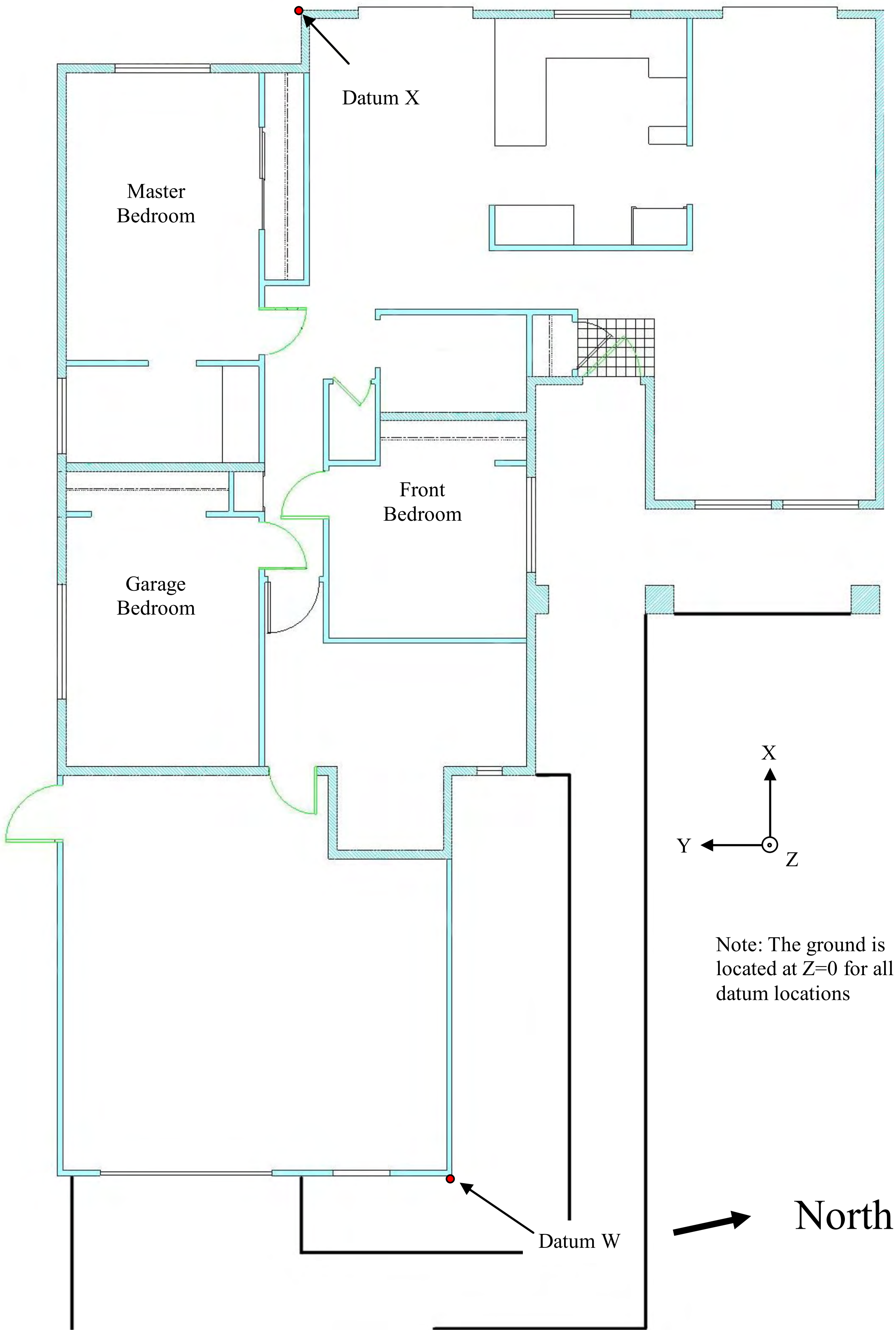


Illustration of the house roofline



The datums and coordinate system used to locate the exterior microphone locations.



Exterior Transducer Locations
July 2007 Sonic Boom Flight Test

coordinates given in inches from datum W in sketch unless otherwise noted

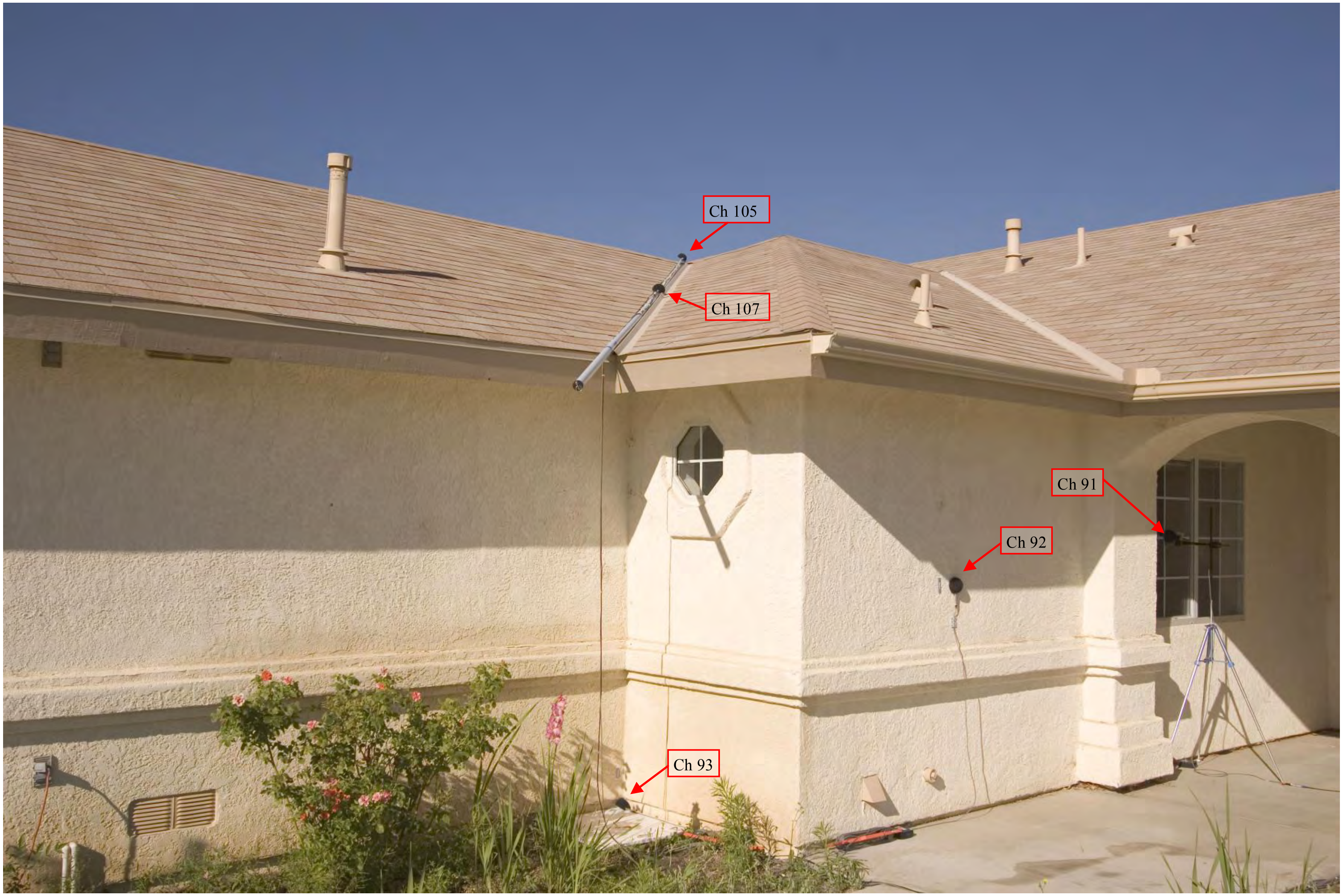
Transducer	Type	Pretest In-situ Cal (mV/EU)	DATUM	X	Y	Z
91	mic	42.2	W	396	-53	60.5
92	mic	43.9	W	297	-53	51
93	mic	35.9	W	251	0	0
94	mic	42.2	W	420	-203.5	0
95	mic	40.2	W	0	25	0
96	mic	40.6	W	0	20.5	56
97	mic	44.9	W	-11	18.5	110
98	mic	41.9	W	-415	124	0
99	mic	41.4	W	162.5	250	48
100	mic	43.1	W	319.5	250	64
101	mic	40.7	W	547.5	250	108
102	mic	40.8	W	705.5	167	59.5
103	mic	42	W	705.5	167	0
104	mic	41.1	In the far-field approximately 300 ft west of the house[1]			
105	mic	40.1	At the peak of the roofline			
106	mic	40.7	W	-84.5	106	0
107	mic	39.9	Mid way between the edge and peak of the roofline			
87	mic (Norm)[2]	99	X	63.5	89	43
88	mic (Norm)[2]	99.2	X	69	85.5	43

[1]See GPS location in Appendix D.
[2]Only for days when the binaural head was placed outside. See Chapter 3.

Exterior Instrumentation Photograph

Exterior Instrumentation Photograph

Exterior Instrumentation Photograph



Exterior Instrumentation Photograph

Exterior Instrumentation Photograph

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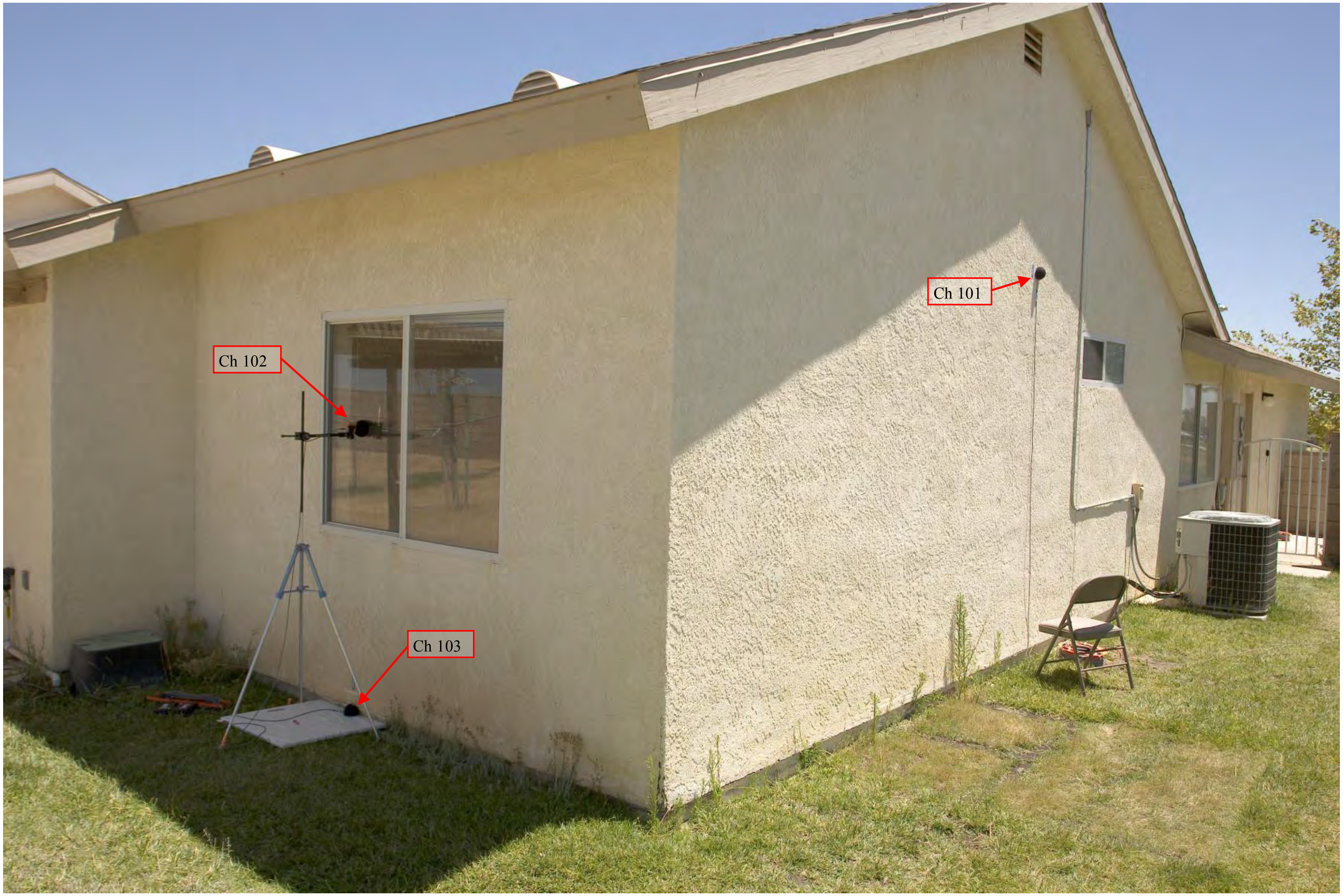


Exterior Instrumentation Photograph

Exterior Instrumentation Photograph

Exterior Instrumentation Photograph

Exterior Instrumentation Photograph

Appendix D

GPS survey of the house and surrounding area.

SNS

Edwards NGA Support Team

Edwards AFB, California

Publication 07-1E11

House Variable Intensity Boom Effect on Structures (VIBES) Program

Edwards AFB, California

July 2007

Know The Earth….Show The Way

House Variable Intensity Boom Effect on Structures (VIBES) Program Edwards AFB,CA

July 2007

TABLE OF CONTENTS **PAGE**

**House Variable Intensity Boom Effect
on Structures (VIBES) Program
Edwards AFB, CA
July, 2007**

1. INTRODUCTION

This report covers the geodetic survey completed by the National Geospatial-Intelligence Agency (NGA), Edwards Range NGA Support Team, in support of NASA Dryden House Variable Intensity Boom Effect on Structures (VIBES) project. The survey was required to position and provide the orientation of the exterior walls, the block walls in back and south side of the house located at 52 Blackbird St., on Edwards AFB, CA. There are also nine additional points located around the house. The latitude, longitude, and ellipsoid height are requested to be in the World Geodetic System 1984 (WGS 84), and the orthometric heights in the Earth Gravity Model 1996 (EGM 96) at ground level. The walls' orientation is to be relative to true north.

2. GENERAL

a. References: National Geospatial-Intelligence Agency Geospatial Sciences Division's Geodetic Survey Request Worksheet. Memorandum for AFFTC/XPI (Mr. Dave Foster), Request for NGA Survey, 26 June 2007.

b. Persons Contacted:

c. Accuracy requirement: The points should be accurate to 0.1 meter, SE, each component, relative to local control and 0.1 meter relative to the local EGM 96 geoid height. The true North orientation of the walls should be better than 0.5 degree.

3. SURVEY OPERATIONS

a. On July 11, 2007 a three man team deployed to 52 Blackbird St. on Edwards AFB, CA to survey sixteen predetermined points. There are three corner points on the house (**NRC**, **SRC**, and **WRC**), two points on the back yard block wall (**NBW** and **SBW**), two points on the block wall on the south side of the house (**NSW** and **SSW**) three points located in the front yard of the house (**BADE, BADS,** and **BADW**), one point (**BOHP**) located west of the house in an open field, and five points located in an open field north of the house (**TE05**, **TE10**, **TOWER**, **TS05**, and **TS10**). Trimble 5700 GPS receivers were used to survey these points in static mode. The Edwards main control station **UNO 1997** and **Master North Base 1955** were used as the primary control to position survey points **BADW**, **BOHP**, and **TOWER**, for the local control. A minimum of two one-hour static sessions were observed with a change in the height of the antenna between sessions. Then **BADW**, **BOHP,** and **Tower** were used to position the additional points with a minimum of two ten-minute static sessions with a change in the height of the antenna between sessions, when feasible.

b. Team members: Ken Bennett, Bill Pressley, and Helen Miller.

4. DATA REDUCTION

Static GPS: The data collected through static GPS methods were post processed using Trimble Geomatics Office software Version 1.62 which produced differential vectors. The derived differential vectors were then adjusted using GeoLab 3 three-dimensional least squares adjustment software Version 7.32. Station **UNO 1997** was held fixed in the adjustment and the coordinates for **MASTER NORTH BASE 1955** were used as a quality control check on the published position.

5. GEODETIC DATA

a. The WGS 84 latitude and longitude are in degrees, minutes, and seconds. The WGS 84 ellipsoid heights and EGM 96 orthometric heights are in meters.

STATION NAME	LATITUDE (WGS 84)	LONGITUDE (WGS 84)	ELLIPSOID (WGS 84)	ORTHOMETRIC (EGM 96)
BADE	N34 55 59.11191	W117 57 00.63394	697.979	730.065
BADS	N34 55 59.07423	W117 57 00.68771	698.042	730.129
BADW	N34 55 59.13155	W117 57 00.70109	698.115	730.202
BOHP	N34 56 00.06220	W117 57 05.54533	698.964	731.048
NBW	N34 55 59.47888	W117 57 02.05668	698.925	731.011
NRC	N34 55 59.07326	W117 57 00.96841	698.446	730.534
NSW	N34 55 58.88326	W117 57 01.28018	698.387	730.473
SBW	N34 55 58.87898	W117 57 02.18595	699.290	731.376
SRC	N34 55 58.86949	W117 57 01.02006	698.421	730.508
SSW	N34 55 58.77560	W117 57 01.31082	698.386	730.473
TE05	N34 56 03.18932	W117 56 59.47058	696.881	728.965
TE10	N34 56 03.18963	W117 56 59.27364	696.793	728.877
TOWER	N34 56 03.18867	W117 56 59.66682	696.861	728.945
TS05	N34 56 03.02667	W117 56 59.66665	696.961	729.046
TS10	N34 56 02.86475	W117 56 59.66604	697.033	729.118
WRC	N34 55 58.98766	W117 57 01.70854	697.880	729.966

b. The following azimuths are in arc degrees and minutes and are referenced to true north.

FROM STATION	TO STATION	AZIMUTH	DISTANCE
SRC	NRC	011 48	6.415m
SRC	WRC	281 46	17.858m
SBW	NBW	010 04	18.783m
SSW	NSW	013 11	3.408m

6. STATION DESCRIPTION

BADE The eastern most point of the three points located in the front yard of 52 Blackbird St.

BADS The southern most point of the three points located in the front yard of the house.

BADW The western most point of the three points located in the front yard of the house.

BOHP	The point is located on the backside of the house about 110 meters west in a creosote bush field.
NBW	The point is located in the backyard of the house. It is the point at which the northern part of the block wall and the chain link fence form its axis at ground level.
NRC	The northeast most corner of the garage wall at ground level.
NSW	The northern most end of the north/south block wall on the south side of the house.
SBW	The point is located in the backyard of the house. It is the point at which the southern part of the block wall and the chain link fence form its axis at ground level.
SRC	The southeast most corner of the garage wall at ground level.
SSW	The center point of the north/south and east/west block wall on the south side of the house at ground level.
TE05	A point 5 meters east of the **TOWER** point in the creosote bush field about 132 meters north of the house.
TE10	A point 10 meters east of the **TOWER** point in the creosote bush field about 134 meters north of the house.
TOWER	A point located approximately 130 meters, in a creosote bush field about 131 meters north of the house.
TS05	A point 5 meters south of the **TOWER** point in a creosote bush field about 126 meters north of the house.
TS10	A point 10 meters south of the **TOWER** point in a creosote bush field about 121 meters north of the house.
WRC	The southwest corner of the house at ground level.

7. SURVEY ACCURACIES

a. WGS 84 Geodetic Positions: The survey is accurate to 0.025 meter, SE, relative to local WGS 84 (G1150) Edwards control station **UNO 1997**. The G1150 reference system is the latest NGA realization of WGS 84 that is coincident with the

International Earth Rotation Service's (IERS) Terrestrial Reference Frame 2000 (ITRF00).

b. Orthometric Heights: The accuracy is estimated to be 0.025 meter, SE, relative to the local Earth Gravity Model 1996 (EGM96) from station **UNO 1997.** The orthometric heights given in this publication are representative of mean sea level (MSL). The term mean sea level implies orthometric height. In actuality, these elevations are relative to a vertical datum (EGM96) that approximates mean sea level and are correctly referred to as orthometric heights.

c. True North Azimuths: The azimuths are accurate to within 30 arc minutes.

8. COMMENTS

Prepared by: Kenneth P.D Bennett
Geometric Geodesist

Neal L. Thompson
Chief, Edwards Range
NGA Support Team

Appendix E

Locations and pictures of the changes made to the transducers for the tests on July 18, 2007.

(All dimensions are in inches unless otherwise noted)

Summary of the changes made on July 18th, 2007, see pictures on following pages for new locations. See appendices B and C for original locations.

Channel	Type	Original Location	New Location
65	Accelerometer	Front bedroom wall	Garage door
66	Accelerometer	Front bedroom wall	Garage wall
67	Accelerometer	Front bedroom wall	Front entry door
68	Accelerometer	Front bedroom wall	Front entry door
77	Microphone	Interior front bedroom window near-field	On the eave under roof microphone array
78	Microphone	Front bedroom interior	Interior garage door near-field
91	Microphone	Exterior front bedroom window near-field	On the wall under roof microphone array
100	Microphone	Exterior garage bedroom window near-field	Exterior garage door near-field
109	Microphone	Family room	Interior front entry door near-field

Notes: All other transducers remained mounted in the locations documented in Appendices B and C.
Pictures of these transducers for the July18th, 2007 measurements are included on the following pages.
The front bedroom window was left open 6 inches on the boom tests on July 18th, 2007.

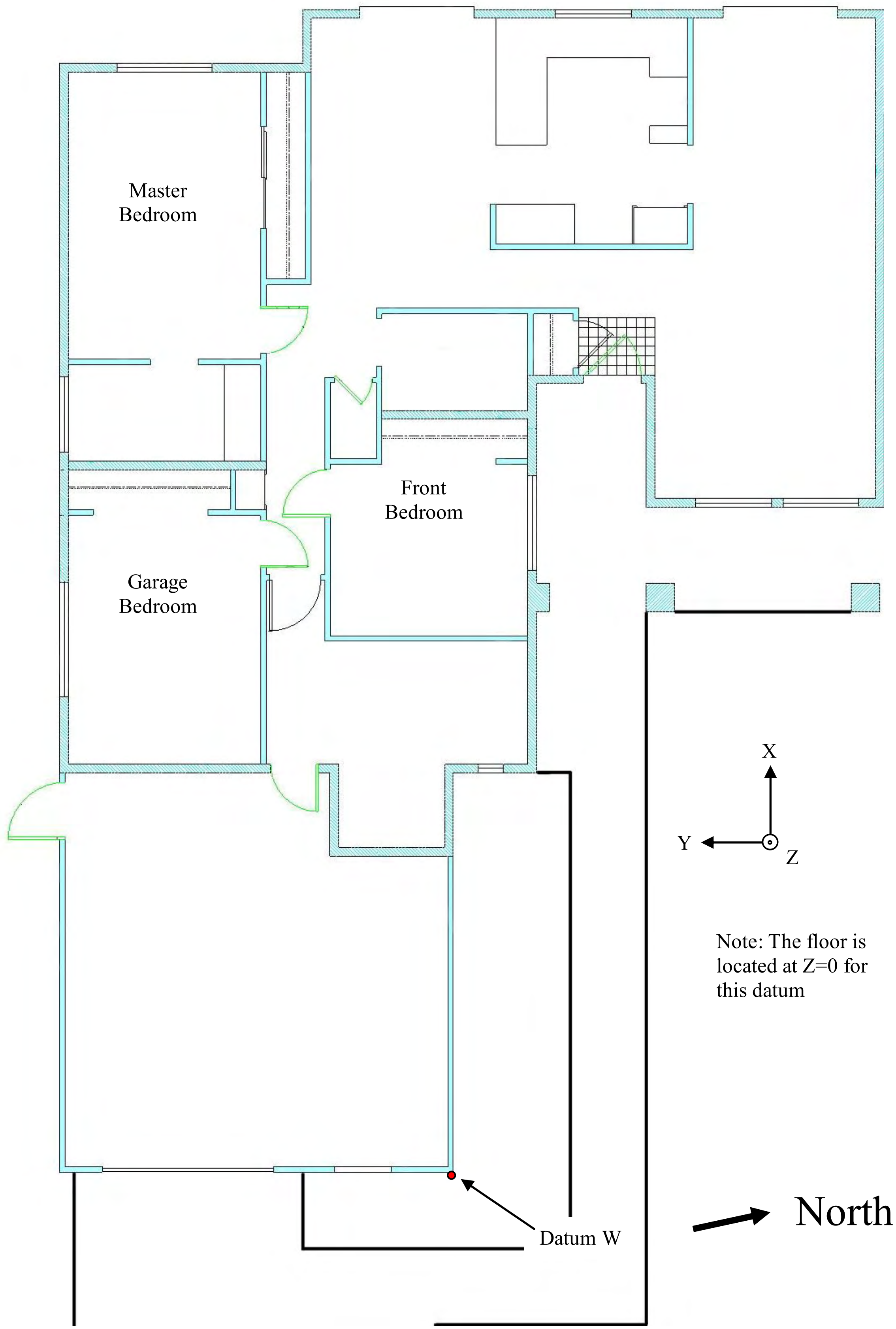
Exterior Transducer Locations

July 2007 Sonic Boom Flight Test

coordinates given in inches from datum W (see next page)

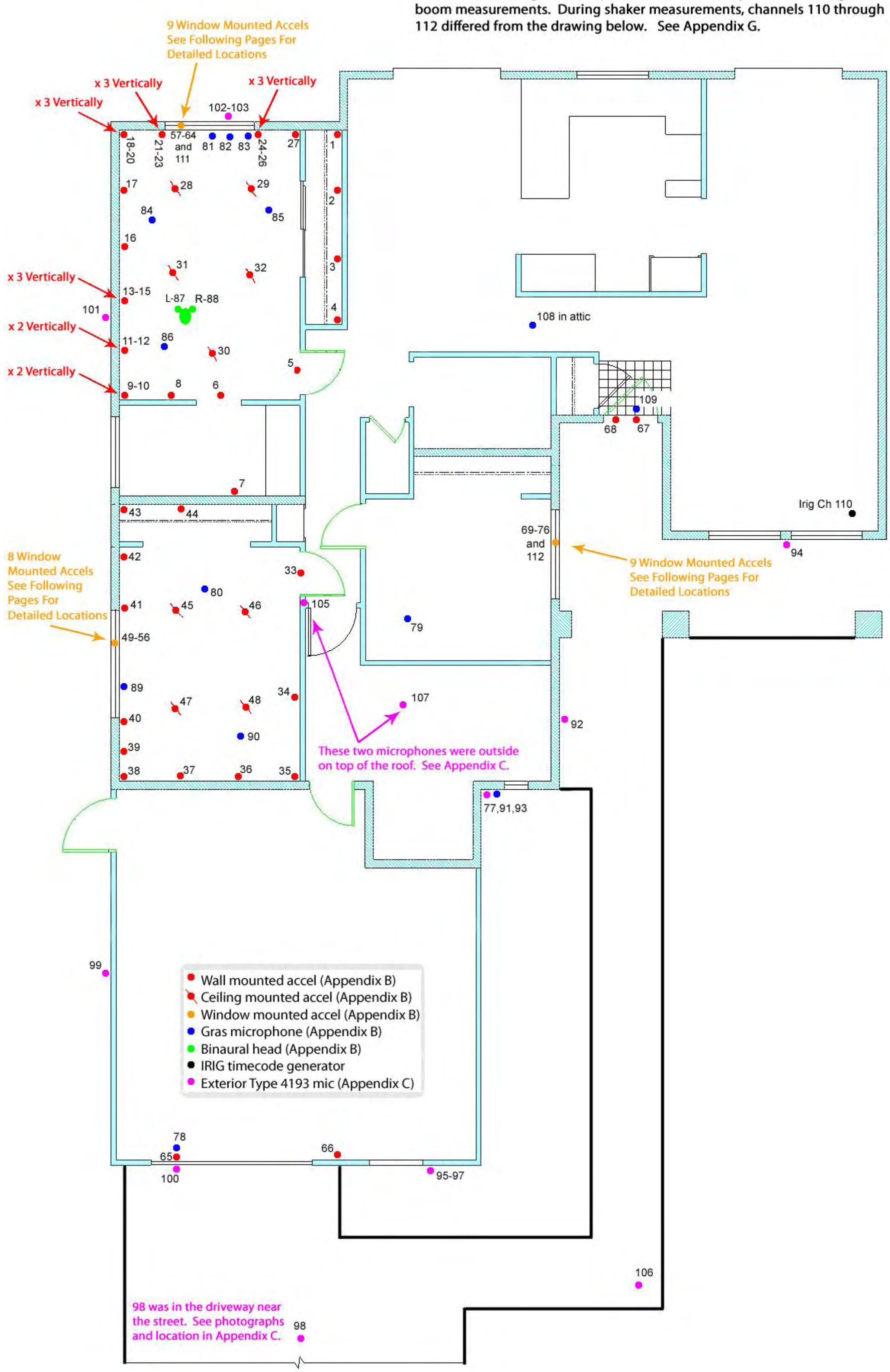
Transducer	Type	X	Y	Z	ORIENT
65	accel	6	202	32	x+
66	accel	6	94	45	x+
67	accel	501	98	46	x-
68	accel	501	84	63.5	x-
77	mic	233	-28	96	
78	mic	8	202	31	
91	mic	251	0	57	
100	mic	2	202	64	
109	mic	504	98	46	

Datum and coordinate system used to define the transducer locations.

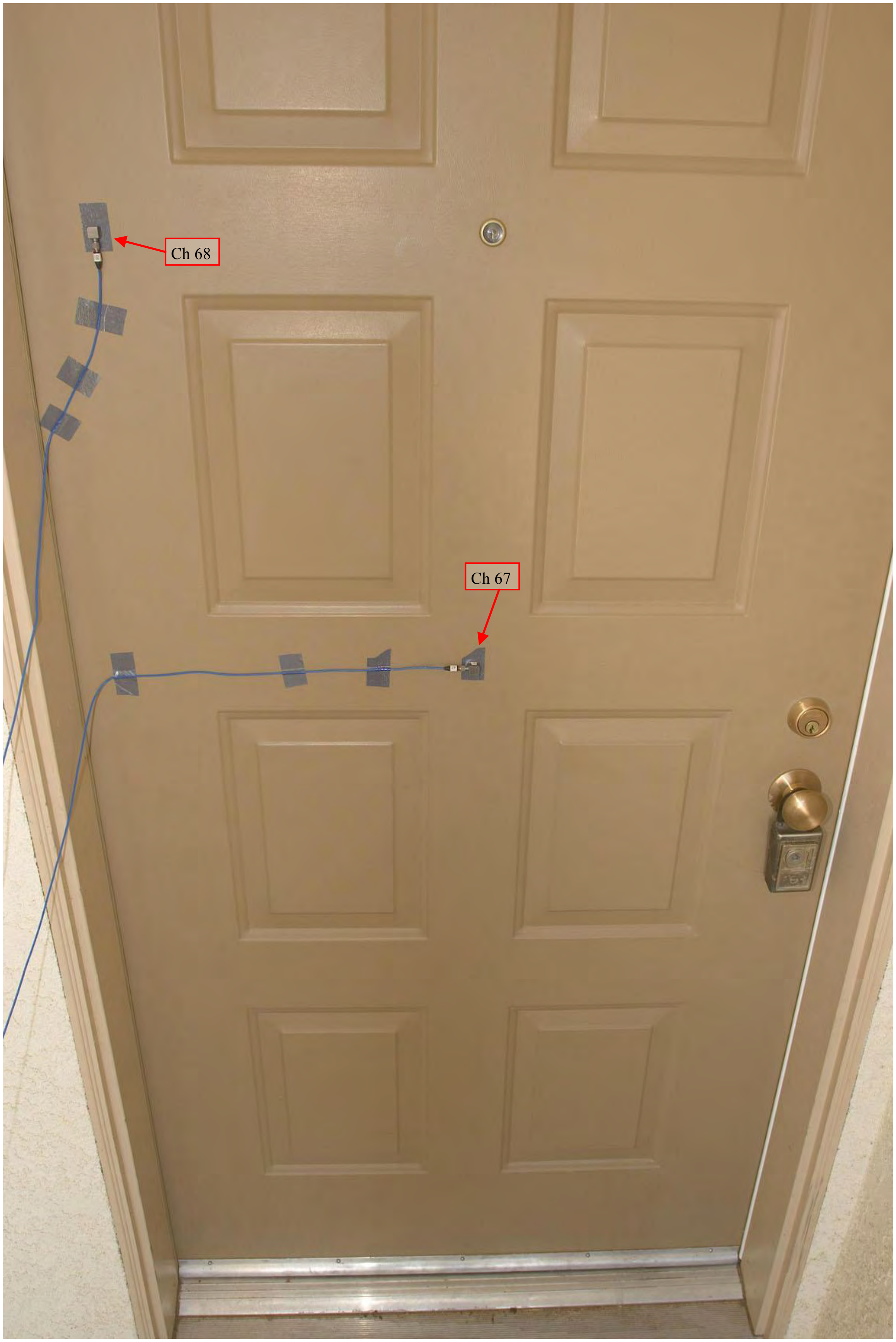


Approximate locations of interior transducers. See tables and pictures for actual locations.

Notes: The drawing below depicts the transducer layout used during boom measurements. During shaker measurements, channels 110 through 112 differed from the drawing below. See Appendix G.



The accelerometers on channels 67 and 68 were removed from the front bedroom and placed on the outside of the front entry door to the house for test on July 18th 2007.



The accelerometers on channels 67 and 68 were removed from the front bedroom and placed on the outside of the front entry door to the house for test on July 18th 2007.

The microphones on channels 77 and 91 were removed from their locations near the front bedroom window and placed on the wall below the roof microphone array for test on July 18th 2007. channels 93, 105 and 107 were left in their nominal locations.

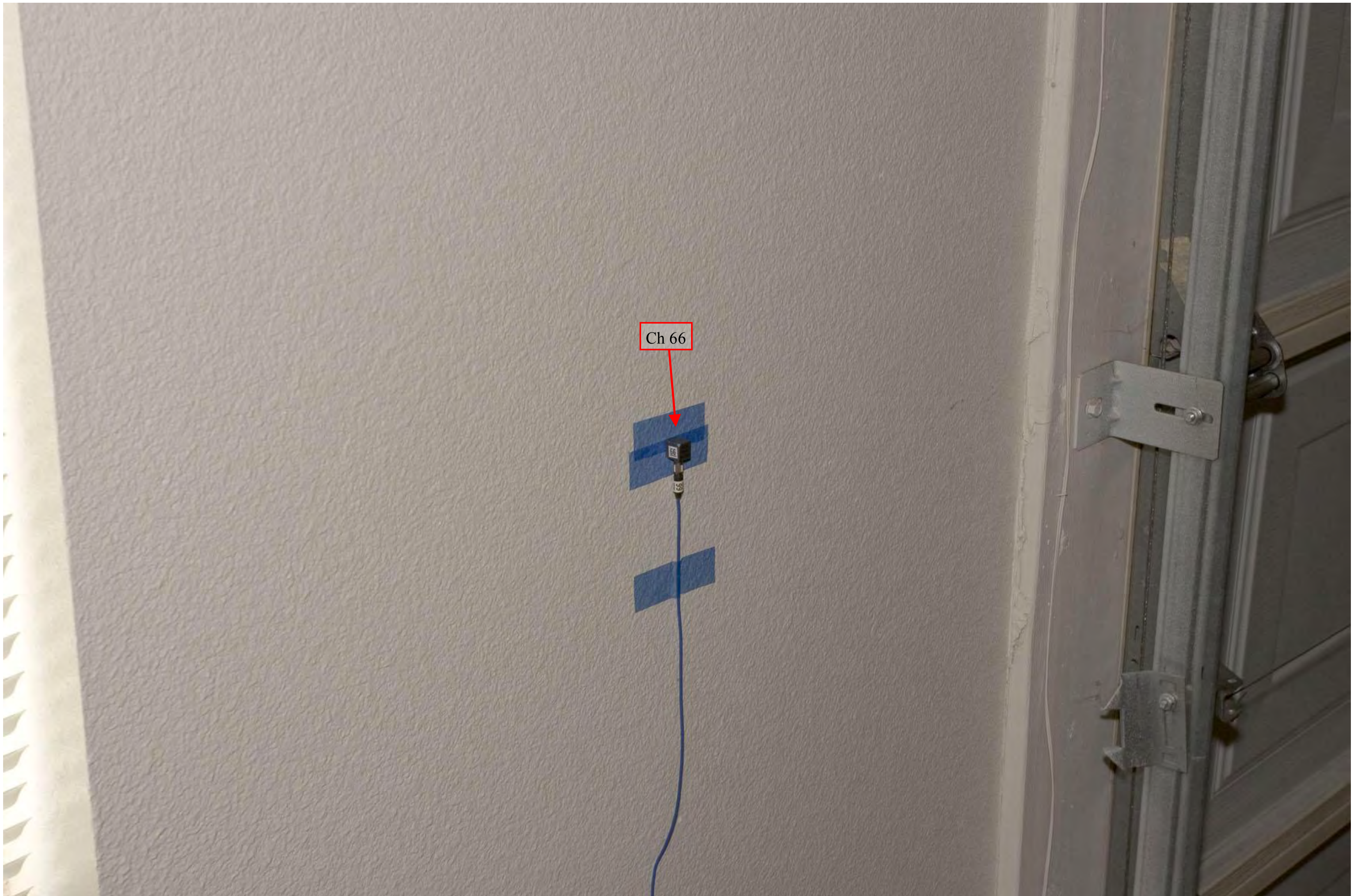
The window for the front bedroom was left cracked open about 6 inches so that the transducer cables could pass to the outside. The window was left open during the boom tests on July 18th, 2007.

The microphone on channel 100 was removed from in front of the garage bedroom window and placed in front of the garage.

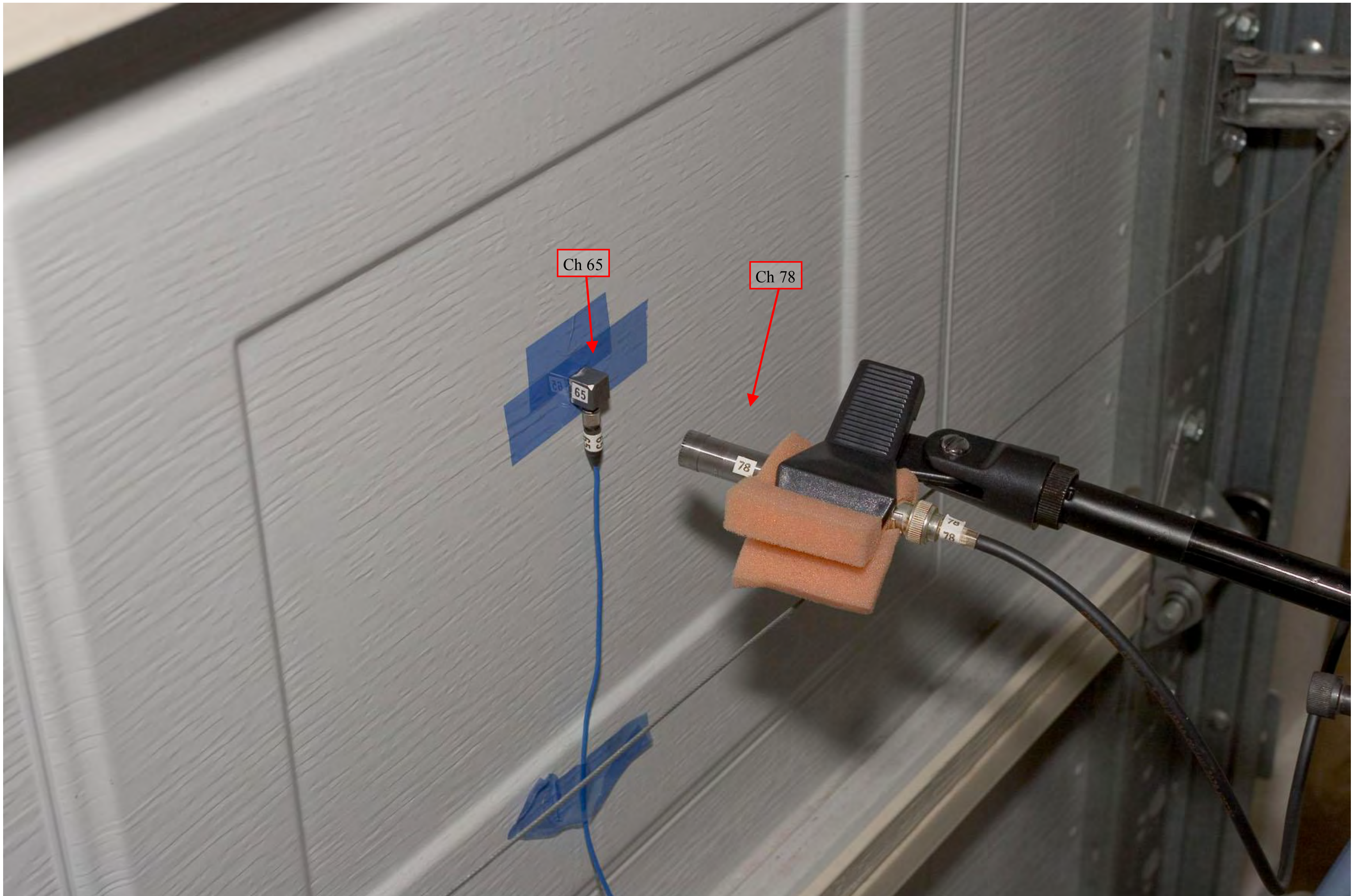
The microphone on channel 100 was removed from in front of the garage bedroom window and placed in front of the garage for test on July 18th 2007. The microphones on channels 95 through 97 are also pictured in their nominal locations.

A close-up of the microphone on channel 100 during tests on July 18th, 2007.

The accelerometers on channels 65 and 66 and the microphone on channel 78 were removed from the front bedroom and placed in the garage for test on July 18th 2007. In addition, some shaker measurements on the garage door were made with the transducers in place in the locations documented in this appendix.



A close-up of the accelerometer on channel 66 during tests on July 18th, 2007.



A close-up of the accelerometer on channel 65 and the microphone on channel 78 during tests on July 18th, 2007.

Appendix F

Transducer and data acquisition equipment specifications.

(These specifications are an abridged version contained on the manufacturers' specification sheets, sheets or information not contained in this appendix may be available upon request)

<u>Pistonphone type 4228</u>

Satisfied standards
IEC 942 (1988) Class 1L (Class 0L with suitable external barometer)
ANSI S1.40-1984

Nominal sound pressure level

	124 dB re 20 mPa –0.2 dB at reference conditions:
Ambient Pressure	1013 hPa
Ambient Temperature	20 C (68 F)
Ambient Humidity	65%RH
Effective Load Volume	1.333 cm^3

Frequency

Nominal	250Hz
Actual	251.2 Hz –0.1%

Individual calibration accuracy

At Reference Conditions	–0.09 dB
At Ambient Reference Conditions	–0.12 dB with specified microphone types
Within Range of Ambient Conditions	
With External Barometer	–0.15 dB — IEC 942 (1988) Class 0L
With Included Barometer	–0.30 dB — IEC 942 (1988) Class 1L

Nominal effective coupler volume
19.733 cm3 (at 250Hz) including Nominal Effective Load Volume 1.333 cm^3

Total harmonic distortion <3%

Ambient conditions

Ranges	
Pressure	650 hPa to 1080 hPa
Temperature	–10 to +50 C (14 to 122 F)
Relative Humidity	5% RH to 95%RH
Required Measurement Accuracy	
Pressure	–0.3% (IEC 942 Class 0L)
	–2.0% (IEC 942 Class 1L)
Temperature	–5 C
Relative Humidity	–15% above 35 C (95 F) (measurement is not necessary below 35 C (95 F))
Ambient Pressure	SPL is proportional to the ambient pressure (correction read from the barometer supplied)
Ambient Temperature	–0.0005 dB/ C (estimated)
Ambient Humidity	–0.0001 dB/%RH at the reference conditions

Accelerometer Calibrator 394C06

Performance	**SI**
Operating Frequency (±1 %)	159.2 Hz
Acceleration Output (±3 %)	1.00 g rms
Velocity Output	9.81 mm/s rms
Displacement Output	9.81 µm rms
Transverse Output	≤3 %
Distortion (0 to 100 grams load)	≤2 %
Distortion (100 to 210 grams load)	≤3 %
Maximum Load	210 gm
Environmental	
Temperature Range (Operating)	-10 to +55 °C

Accelerometer Model 333B32

Performance	**SI**
Sensitivity (±10 %)	10.2 mV/(m/s²)
Measurement Range	±490 m/s² pk
Frequency Range (±5 %)	0.5 to 3000 Hz
Resonant Frequency	≥40 kHz
Phase Response (±5 °)	2 to 3000 Hz
Broadband Resolution (1 to 10 kHz)	0.0015 m/s² rms
Non-Linearity	≤1 %
Transverse Sensitivity	≤5 %
Environmental	
Overload Limit (Shock)	±49000 m/s² pk
Temperature Range (Operating)	-18 to +66 °C
Base Strain Sensitivity	0.1 (m/s²)/με
Electrical	
Excitation Voltage	18 to 30 VDC
Constant Current Excitation	2 to 20 mA
Output Impedance	≤300 ohm
Output Bias Voltage	7 to 12 VDC
Discharge Time Constant	1.0 to 3.0 sec
Spectral Noise (10 Hz)	110 (μm/s²)/√Hz
Spectral Noise (100 Hz)	33 (μm/s²)/√Hz
Spectral Noise (1 kHz)	14 (μm/s²)/√Hz
Physical	
Sensing Element	Ceramic
Sensing Geometry	Shear
Housing Material	Titanium
Sealing	Hermetic
Size (Length x Width)	16.0 mm x 10.2 mm
Weight	4.0 gm
Electrical Connector	10-32 Coaxial Jack
Electrical Connection Position	Side
Mounting	Adhesive

Accelerometer Model 333B42

Performance	**SI**
Sensitivity (±10 %)	51.0 mV/(m/s²)
Measurement Range	±98 m/s² pk
Frequency Range (±5 %)	0.5 to 3000 Hz
Resonant Frequency	≥20 kHz
Phase Response (±5 °)	2 to 3000 Hz
Broadband Resolution (1 to 10 kHz)	0.0005 m/s² rms
Non-Linearity	≤1 %
Transverse Sensitivity	≤5 %
Environmental	
Overload Limit	±49000 m/s² pk
Temperature Range	-18 to +66 °C
Base Strain Sensitivity	0.1 (m/s²)/με
Electrical	
Excitation Voltage	18 to 30 VDC
Constant Current Excitation	2 to 20 mA
Output Impedance	≤200 ohm
Output Bias Voltage	7 to 12 VDC
Discharge Time Constant	1.0 to 2.5 sec
Spectral Noise (10 Hz)	37 (μm/s²)/√Hz
Spectral Noise (100 Hz)	11 (μm/s²)/√Hz
Spectral Noise (1 kHz)	3.9 (μm/s²)/√Hz
Physical	
Sensing Element	Ceramic
Sensing Geometry	Shear
Housing Material	Titanium
Sealing	Hermetic
Size (Length x Width)	17.3 mm x 11.4 mm
Weight	7.5 gm
Electrical Connector	10-32 Coaxial Jack
Electrical Connection Position	Side
Mounting	Adhesive

Accelerometer Model 333B52

Performance	**SI**
Sensitivity (±10 %)	102 mV/(m/s²)
Measurement Range	±49 m/s² pk
Frequency Range (±5 %)	0.5 to 3000 Hz
Resonant Frequency	≥20 kHz
Phase Response (±5 °)	2.5 to 3000 Hz
Broadband Resolution (1 to 10 kHz)	0.0005 m/s² rms
Non-Linearity	≤1 %
Transverse Sensitivity	≤5 %
Environmental	
Overload Limit	±39000 m/s² pk
Temperature Range	-18 to +66 °C
Base Strain Sensitivity	0.1 (m/s²)/με
Electrical	
Excitation Voltage	18 to 30 VDC
Constant Current Excitation	2 to 20 mA
Output Impedance	≤500 ohm
Output Bias Voltage	7 to 12 VDC
Discharge Time Constant	0.7 to 2.0 sec
Spectral Noise (10 Hz)	37 (μm/s²)/√Hz
Spectral Noise (100 Hz)	11 (μm/s²)/√Hz
Spectral Noise (1 kHz)	3.9 (μm/s²)/√Hz
Physical	
Sensing Element	Ceramic
Sensing Geometry	Shear
Housing Material	Titanium
Sealing	Hermetic
Size (Length x Width)	17.3 mm x 11.4 mm
Weight	7.5 gm
Electrical Connector	10-32 Coaxial Jack
Electrical Connection Position	Side
Mounting	Adhesive

Accelerometer Model 2250a-10

Performance	SI
Sensitivity (±10 %)	10 mV/g
Measurement Range	±500 g pk
Frequency Range (±1 dB)	2 to 15000 Hz
Resonant Frequency	≥80 kHz
Phase Response	Unknown
Broadband Resolution	Unknown
Non-Linearity	≤1 %
Transverse Sensitivity	≤5 %
Environmental	
Overload Limit	±2000 g pk
Temperature Range	-55 to +125 °C
Base Strain Sensitivity	0.0004 g/με
Electrical	
Excitation Voltage	18 to 24 VDC
Constant Current Excitation	2 to 10 mA
Output Impedance	≤100 ohm
Output Bias Voltage	8.5 to 11.5 VDC
Discharge Time Constant	3 sec
Spectral Noise (10 Hz)	Unknown
Spectral Noise (100 Hz)	Unknown
Spectral Noise (1 kHz)	Unknown
Physical	
Sensing Element	Ceramic
Sensing Geometry	Shear
Housing Material	Plastic
Sealing	Epoxy Sealed, non-hermetic
Size (Length x Width)	about 7 mm x 4 mm
Weight	0.4 gm
Electrical Connector	1.2 UNM threads
Electrical Connection Position	Side
Mounting	Adhesive

<u>Microphone Model Brüel and Kjær Type 4193</u>

Open-circuit sensitivity (250Hz):
–38 dB –1.5dB re 1 V/Pa, 12.5mV/Pa
–54dB –1.5dB re 1V/Pa, 1.8mV/Pa with UC0211
Polarization voltage (external): 200 V
Frequency response:
Pressure-field response:
0.12 Hz to 7 kHz –1dB
0.07 Hz to 20 kHz –2dB
0.13 Hz to 20 kHz –2 dB with UC 0211
In accordance with ANSI S1.4 – 1983, Type 1 and ANSI S1.12, Type M

Lower limiting frequency (–3 dB)	0.01 Hz to 0.05 Hz (vent exposed to sound)
Pressure equalization vent	Side vented
Diaphragm resonance frequency	23 kHz (90 phase shift)
Capacitance (polarized, 250Hz)	18 pF
Equivalent air volume (101.3 kPa)	8.8mm3
Calibrator load volume (250 Hz)	190mm3
Pistonphone 4228 correction (with DP 0776)	+0.02 dB
Cartridge thermal noise	19.0 dB (A), 21.3 dB (Lin.)
Upper limit of dynamic range (3% dist)	>162 dB SPL
Maximum sound pressure level	171 dB (peak)

Environmental

Operating temperature range –30 to +150 C (–22 to +302 F)
(can be used up to +300 C (572 F), but with a permanent sensitivity change of typically +0.4 dB which stabilises after one hour)

Operating humidity range	0 to 100% RH (without condensation)
Storage temperature	–30 to +70 C (–22 to +158 F)
Temperature coefficient (250 Hz)	–0.002 dB/ C (for the range –10 to +50 C)
Pressure coefficient (250Hz)	–0.005 dB/kPa
Influence of humidity	>1000 years/dB at 20 C (68 F) <0.001 dB/100%RH
Vibration sensitivity (<1000 Hz)	65.5 dB equivalent SPL for 1 m/s2 axial acceleration
Magnetic field sensitivity	16 dB SPL for 80 A/m, 50 Hz field
Estimated long-term stability	>100 hours/dB at 150 C (302 F)

Physical

Dimensions

Diameter	13.2 mm (0.52 inches) (with grid) 12.7 mm (0.50 inches) (without grid)
Height	13.5 mm (0.53 inches) (with grid) 12.6 mm (0.50 inches) (without grid) 27.6 mm (1.09 inches) (with UC 0211 and grid) 26.7 mm (1.05 inches) (with UC 0211, no grid)

Thread for preamplifier mounting 11.7 mm – 60UNS

<u>Microphone Model Gras 40AE</u>

Open-circuit sensitivity (250Hz):
  50 mV/Pa
  IEC 1094-4 designation WS2F
Polarization voltage (external): 0V, prepolarized
Frequency response:
  Pressure-field response:
    5 Hz to 10 kHz –1dB
    3.15 Hz to 20 kHz –2dB

Lower limiting frequency (–3 dB)	3.15 Hz
Pressure equalization vent	Side vented
Diaphragm resonance frequency	Unknown
Capacitance (polarized, 250Hz)	17 pF
Equivalent air volume (101.3 kPa)	Unknown
Calibrator load volume (250 Hz)	Unknown
Pistonphone 4228 correction (with DP 0776)	Unknown
Cartridge thermal noise	14.5 dB (A)
Upper limit of dynamic range (3% dist)	148 dB SPL
Maximum sound pressure level	148 dB (peak)

Environmental

Operating temperature range	–40 to +120 C
Operating humidity range	0 to 100% RH (without condensation)
Storage temperature	Unknown
Temperature coefficient (250 Hz)	–0.01 dB/ C
Pressure coefficient (250Hz)	–0.007 dB/kPa
Influence of humidity	<0.1 dB (0-100%RH)
Vibration sensitivity (<1000 Hz)	63 dB equivalent SPL for 1 m/s^2 axial acceleration
Magnetic field sensitivity	Unknown
Estimated long-term stability	Unknown

Physical

Dimensions

Diameter	13.2 mm (with grid)	
	12.7 mm (without grid)	
Height	16.2 mm (with grid)	
	15.3 mm (without grid)	
Thread for preamplifier mounting		11.7 mm – 60UNS

<u>Microphone Model Gras 40AQ</u>

Open-circuit sensitivity (250Hz):
    50 mV/Pa
    IEC 1094-4 designation WS2F
Polarization voltage (external): 0V, prepolarized
Frequency response:
    Pressure-field response:
        12.5 Hz to 8 kHz –1dB
        3.15 Hz to 12.5 kHz –2dB

Lower limiting frequency (–3 dB)	3.15 Hz
Pressure equalization vent	Rear vented
Diaphragm resonance frequency	14 kHz
Capacitance (polarized, 250Hz)	20 pF
Equivalent air volume (101.3 kPa)	50 mm^3
Calibrator load volume (250 Hz)	Unknown
Pistonphone 4228 correction (with DP 0776)	Unknown
Cartridge thermal noise	16 dB (A)
Upper limit of dynamic range (3% dist)	148 dB SPL
Maximum sound pressure level	148 dB (peak)

Environmental

Operating temperature range	–40 to +120 C
Operating humidity range	0 to 100% RH (without condensation)
Storage temperature	Unknown
Temperature coefficient (250 Hz)	–0.01 dB/ C
Pressure coefficient (250Hz)	–0.008 dB/kPa
Influence of humidity	<0.1 dB (0-100%RH)
Vibration sensitivity (<1000 Hz)	65 dB equivalent SPL for 1 m/s^2 axial acceleration
Magnetic field sensitivity	Unknown
Estimated long-term stability	Unknown

Physical

Dimensions

Diameter	13.2 mm (with grid)	
	12.7 mm (without grid)	
Height	16.2 mm (with grid)	
	15.3 mm (without grid)	
Thread for preamplifier mounting		11.7 mm – 60UNS

<u>National Instruments 4472B Data Acquisition Boards</u>

Channel Characteristics

Number of channels	8, simultaneously sampled
Input configuration	Unbalanced differential
Resolution	24 bits, nominal
Type of ADC	Delta-sigma
Oversampling, for sample rate (ƒs)	
1.0 kS/s ≤ ƒs ≤ 51.2 kS/s	128 times ƒs
51.2 kS/s < ƒs ≤ 102.4 kS/s	64 times ƒs
Sample rates (ƒs)	1.0 to 102.4 kS/s
190.7 µS/s increments for ƒs > 51.2 kS/s	
95.36 µS/s increments for ƒs ≤ 51.2 kS/s	
Frequency accuracy	±25 ppm
Input signal range	±10 V peak
FIFO buffer size	1,024 samples
Data transfers	DMA

Transfer Characteristics

Offset (residual DC	±3 mV, max
Gain (amplitude accuracy	±0.1 dB, max, ƒin = 1 kHz

Amplifier Characteristics

Input impedance (ground referenced)	
Positive input	1 MΩ in parallel with 60 pF
Negative input (shield)	50 Ω in parallel with 0.02 µF
Flatness (relative to 1 kHz)	±0.1 dB, DC to 0.4535 ƒs, max, DC-coupled
-3 dB bandwidth	0.4863 ƒs
Input coupling	AC or DC, software-selectable
AC Coupling -3 dB cutoff frequency	0.5 Hz
Overvoltage protection	
Positive input	±42.4 V
Positive inputs protected	CH<0..7>
Negative input (shield)	Not protected, rated at ±2.5 V
Common mode rejection ratio (CMRR)	
ƒin < 1 kHz	>60 dB, minimum

National Instruments 4472B Data Acquisition Boards (Concluded)

Dynamic Characteristics

Alias-free bandwidth (passband)	DC (0 Hz) to 0.4535 ƒs
Stop band	0.5465 ƒs
Alias rejection	110 dB
Spurious-free dynamic range	130 dB, 1.0 kS/s ≤ ƒs ≤ 51.2 kS/s, 118 dB, 51.2 kS/s < ƒs ≤ 102.4 kS/s THD For ƒin = 1kHz

Crosstalk1 (channel separation) for ƒin = 0 to 51.2 kHz

Between channels 0 and 1, 2 and 3, 4 and 5, or 6 and 7	
Shorted input	<-90 dB
1 k½ load	<-80 dB
Other channel combinations	
Shorted input	<-100 dB
1 k½ load	<-90 dB

Phase linearity	<±0.5 deg
Interchannel phase mismatch	<ƒin (in kHz) x 0.018 deg + 0.082 deg
Interchannel gain mismatch	±0.1 dB
Filter delay through ADC	38.8 sample periods

Appendix G

Indoor reverberation time estimates.

Test 1
Front Bedroom

OTO	EDT	T20	T30
50	0.76	0.99	1.15
63	0.75	0.68	0.66
80	0.65	0.64	0.64
100	0.75	0.68	0.68
125	0.66	0.64	0.65
160	0.34	0.44	0.44
200	0.51	0.51	0.54
250	0.49	0.58	0.62
315	0.48	0.49	0.45
400	0.51	0.48	999
500	0.4	0.39	0.45
630	0.33	0.34	0.34
800	0.33	0.38	0.4
1000	0.31	0.43	999
1250	0.37	0.44	0.45
1600	0.39	0.44	0.46
2000	0.32	0.4	0.4
2500	0.34	0.47	999
3150	0.35	0.45	0.45
4000	0.37	0.5	0.53
5000	0.35	0.41	0.42

Test 2
Front Bedroom

OTO	EDT	T20	T30
50	**0.44**	**0.51**	0.73
63	**0.38**	0.51	0.62
80	0.67	0.6	0.59
100	0.72	0.67	0.66
125	0.47	0.63	0.65
160	0.32	0.46	0.46
200	0.75	0.6	0.57
250	0.49	0.52	0.49
315	0.44	0.51	0.49
400	0.3	0.47	0.41
500	0.36	0.4	0.36
630	0.3	0.4	0.4
800	0.36	0.36	0.37
1000	0.38	0.51	0.54
1250	0.32	0.42	0.44
1600	0.39	0.4	0.49
2000	0.32	0.42	0.47
2500	0.37	0.39	0.4
3150	0.34	0.47	0.52
4000	0.33	0.44	0.48
5000	0.31	0.42	0.41

Test 3
Front Bedroom

OTO	EDT	T20	T30
50	**0.65**	0.87	1.13
63	**0.37**	**0.45**	**0.52**
80	0.84	0.63	0.71
100	0.74	0.7	0.69
125	0.56	0.64	0.66
160	0.36	0.37	0.39
200	0.51	0.46	0.61
250	0.47	0.49	0.48
315	0.35	0.49	0.49
400	0.45	0.31	0.45
500	0.41	0.37	0.42
630	0.37	0.37	0.36
800	0.36	0.37	0.38
1000	0.42	0.44	0.43
1250	0.33	0.45	999
1600	0.36	0.42	0.43
2000	0.42	0.37	0.38
2500	0.32	0.43	0.47
3150	0.34	0.5	0.51
4000	0.37	0.47	0.49
5000	0.37	0.44	0.44

Bolded and underlined values indicate reverberation estimates that were indicated by the sound level meter to be of poor quality. This indication is a result of four possible errors: the T(30) differs from the EDT by more than 20%, one of the results is too short to be reliable, the background noise during the measurement may have affected the results, or the background noise prior to the burst was too high.

Test 1
Master Bedroom

OTO	EDT	T20	T30
50	**<u>0.64</u>**	**<u>0.48</u>**	**<u>0.41</u>**
63	0.89	0.6	0.57
80	**<u>0.36</u>**	0.51	0.48
100	0.54	0.53	0.52
125	0.38	0.73	0.7
160	0.48	0.51	0.57
200	0.72	0.64	0.63
250	0.71	0.85	0.85
315	0.56	0.66	0.68
400	0.62	0.7	999
500	0.44	0.49	0.51
630	0.43	0.41	0.46
800	0.49	0.53	999
1000	0.46	0.47	0.46
1250	0.43	0.45	0.5
1600	0.46	0.47	999
2000	0.35	0.45	999
2500	0.38	0.42	0.47
3150	0.38	0.51	0.54
4000	0.41	0.51	0.57
5000	0.36	0.47	0.51

Test 2
Master Bedroom

OTO	EDT	T20	T30
50	**<u>0.66</u>**	**<u>0.48</u>**	**<u>0.42</u>**
63	0.92	0.62	0.59
80	**<u>0.37</u>**	0.52	0.48
100	0.51	0.52	0.52
125	0.37	0.73	999
160	0.49	0.51	0.55
200	0.74	0.64	0.64
250	0.72	0.86	0.85
315	0.56	0.65	0.68
400	0.62	0.7	999
500	0.44	0.5	0.52
630	0.44	0.41	0.46
800	0.49	0.54	999
1000	0.44	0.5	999
1250	0.44	0.45	0.52
1600	0.46	0.44	0.49
2000	0.35	0.42	0.43
2500	0.39	0.43	0.5
3150	0.39	0.5	0.55
4000	0.41	0.47	0.49
5000	0.37	0.45	0.48

Bolded and underlined values indicate reverberation estimates that were indicated by the sound level meter to be of poor quality. This indication is a result of four possible errors: the T(30) differs from the EDT by more than 20%, one of the results is too short to be reliable, the background noise during the measurement may have affected the results, or the background noise prior to the burst was too high.

Test 1
Garage Bedroom

OTO	EDT	T20	T30
50	**0.041**	**0.48**	**0.72**
63	0.76	0.66	0.68
80	0.45	0.43	0.57
100	0.59	0.72	999
125	0.45	0.52	0.54
160	0.49	0.51	0.48
200	0.52	0.63	0.62
250	0.64	0.54	0.55
315	0.57	0.5	0.47
400	0.49	0.42	0.46
500	0.37	0.47	0.48
630	0.38	0.37	0.36
800	0.43	0.42	999
1000	0.42	0.56	999
1250	0.33	0.42	999
1600	0.37	0.5	0.5
2000	0.35	0.4	0.41
2500	0.44	0.5	0.56
3150	0.38	0.48	0.49
4000	0.37	0.45	0.45
5000	0.39	0.44	0.45

Test 2
Garage Bedroom

OTO	EDT	T20	T30
50	**0.39**	**0.32**	**0.37**
63	0.78	0.62	0.7
80	0.54	0.61	0.63
100	0.35	0.73	999
125	0.51	0.54	0.52
160	0.44	0.49	0.45
200	0.64	0.77	0.82
250	0.81	0.56	0.63
315	0.55	0.42	0.45
400	0.61	0.37	0.37
500	0.43	0.41	0.42
630	0.5	0.51	0.59
800	0.45	0.48	999
1000	0.54	0.98	999
1250	0.38	0.48	999
1600	0.35	0.5	0.54
2000	0.38	0.52	0.55
2500	0.43	0.52	0.5
3150	0.48	0.51	0.52
4000	0.45	0.49	0.49
5000	0.43	0.45	0.46

Bolded and underlined values indicate reverberation estimates that were indicated by the sound level meter to be of poor quality. This indication is a result of four possible errors: the T(30) differs from the EDT by more than 20%, one of the results is too short to be reliable, the background noise during the measurement may have affected the results, or the background noise prior to the burst was too high.

Test 1
Attic

OTO	EDT	T20	T30
50	**0.49**	**0.63**	**0.52**
63	**0.37**	**0.58**	**0.55**
80	**0.27**	**0.4**	**0.31**
100	**0.23**	**0.24**	**0.19**
125	**0.19**	**0.14**	**0.12**
160	**0.15**	**0.11**	**0.12**
200	**0.14**	**0.11**	**0.11**
250	**0.13**	**0.14**	0.17
315	**0.12**	**0.13**	0.15
400	**0.11**	0.16	0.17
500	**0.1**	0.18	0.15
630	**0.1**	**0.12**	**0.1**
800	**0.1**	**0.1**	**0.09**
1000	**0.09**	**0.08**	**0.08**
1250	**0.11**	**0.08**	**0.08**
1600	**0.1**	**0.09**	**0.08**
2000	**0.1**	**0.1**	**0.09**
2500	**0.11**	**0.11**	**0.1**
3150	**0.1**	**0.1**	**0.1**
4000	**0.09**	**0.12**	**0.09**
5000	**0.09**	**0.13**	**0.1**

Test 2
Attic

OTO	EDT	T20	T30
50	**0.49**	**0.7**	**0.55**
63	**0.34**	**0.45**	**0.36**
80	**0.3**	**0.35**	**0.31**
100	**0.24**	**0.24**	**0.24**
125	**0.19**	**0.15**	**0.14**
160	**0.16**	**0.1**	**0.11**
200	**0.16**	**0.11**	**0.12**
250	0.21	**0.14**	0.17
315	0.16	**0.12**	**0.12**
400	**0.13**	0.18	0.17
500	**0.12**	0.18	0.19
630	0.15	0.15	0.15
800	**0.12**	**0.1**	0.1
1000	**0.12**	**0.09**	0.09
1250	**0.11**	**0.09**	0.09
1600	**0.12**	**0.09**	0.09
2000	**0.12**	**0.09**	0.09
2500	**0.1**	**0.11**	0.1
3150	**0.13**	**0.11**	0.12
4000	**0.11**	**0.12**	0.13
5000	**0.11**	**0**	0.14

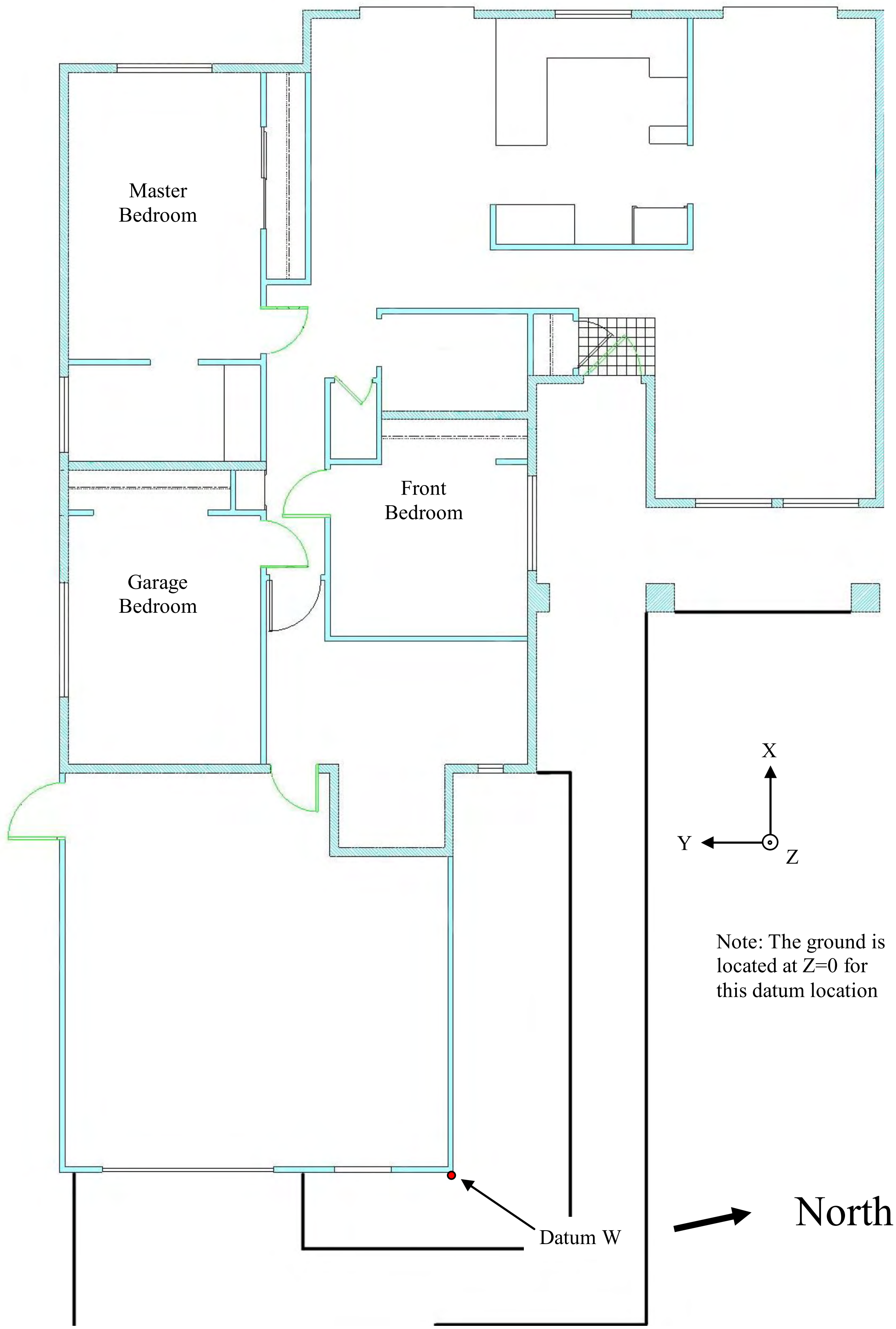
Bolded and underlined values indicate reverberation estimates that were indicated by the sound level meter to be of poor quality. This indication is a result of four possible errors: the T(30) differs from the EDT by more than 20%, one of the results is too short to be reliable, the background noise during the measurement may have affected the results, or the background noise prior to the burst was too high.

Appendix H

Locations of the acoustic impulse excitations on July 18th 2007.

(All dimensions are in inches unless otherwise noted)

The datum and coordinate system used to locate the outdoor acoustic impulses.



Exterior Acoustic Impulse Locations

July 2007 Sonic Boom Flight Test

coordinates given in inches from datum W in sketch unless otherwise noted

Location	Type	DATUM	X	Y	Z
1	bag pop	W	0	-262	0
2	bag pop	W	-240	-262	0
3	bag pop	W	-391	-150	0
4	bag pop	W	-634	145	0
5	bag pop	W	-474	471	0

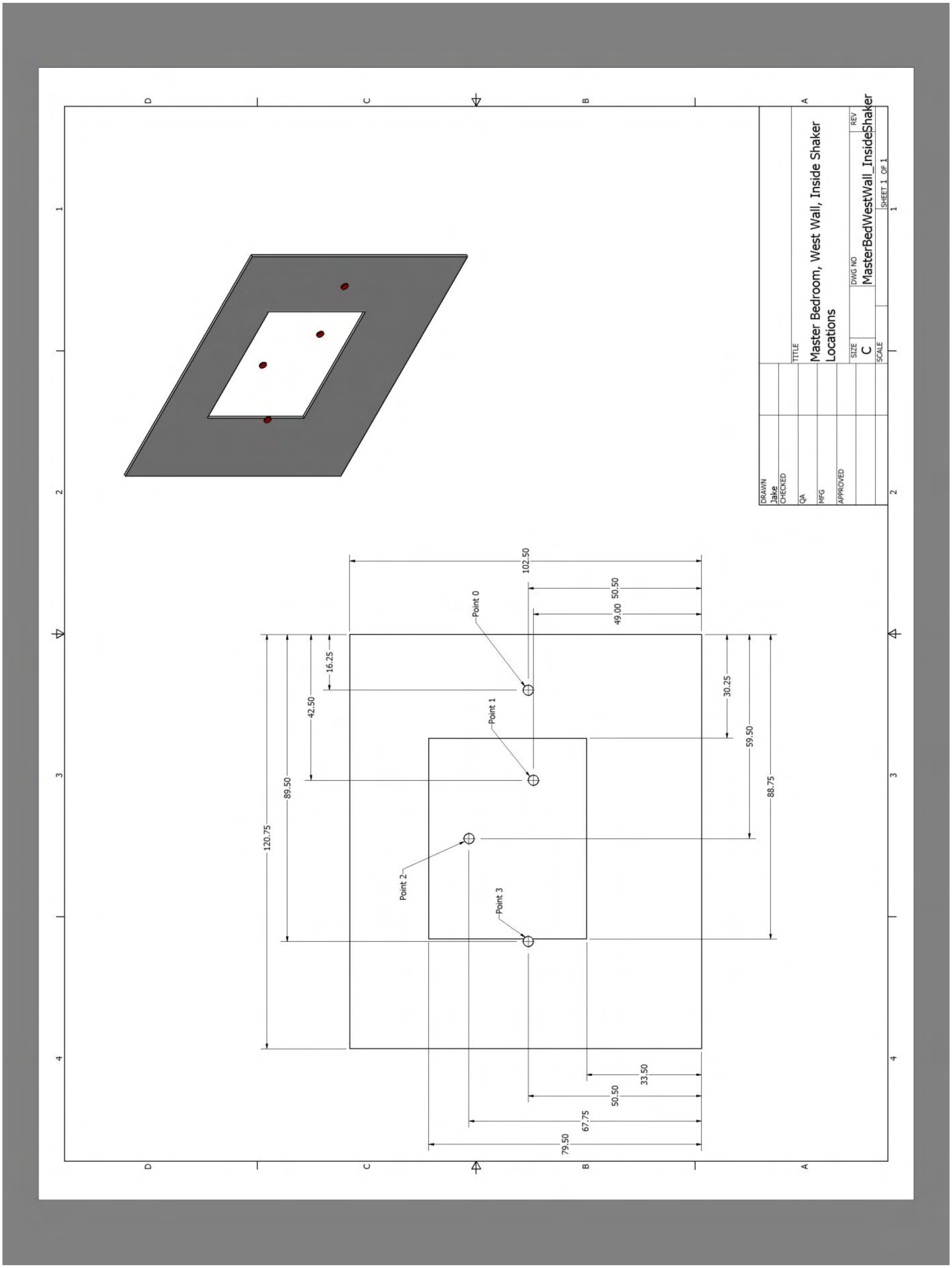
Appendix I

Shaker excitation locations.

Date Stamps for Shaker Response Measurements of the Walls	Location	Excitation Location	Fs (Hz)	Ensemble Length (Samples)	Number Of Channels In Raw Data Files	Size of One Raw Data File (bytes)	Excitation Signal Description	Additional Notes
7_15_2007 11_23_06 AM	Bad data			16384	112	7340040		None
7_16_2007 12_26_25 PM	Garage Bed, South Wall	11 (Appendix I)	12800	32768	112	14680072	White noise (2 to 2kHz)	Glue mount
7_16_2007 1_24_29 PM	Garage Bed, South Wall	12 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Glue mount
7_16_2007 2_58_54 PM	Garage Bed, South Wall	13 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Glue mount
7_16_2007 3_40_15 PM	Garage Bed, East Wall	14 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Glue mount
7_17_2007 2_09_12 PM	Garage Bed, East Wall	14 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount
7_17_2007 2_25_47 PM	Garage Bed, South Wall	8 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, on stud, master bed door was open for test
7_17_2007 2_35_26 PM	Garage Bed, South Wall	9 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, on drywall, master bed door was open for test
7_17_2007 2_56_30 PM	Master Bed, South Wall	7 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, drywall, microphones 101-104 were off
7_17_2007 3_08_07 PM	Master Bed, South Wall	7 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, drywall
7_17_2007 3_26_40 PM	Master Bed, South Wall	6 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, stud
7_17_2007 3_31_52 PM	Master Bed, South Wall	5 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), higher amplitude	Wax mount, stud
7_17_2007 4_38_25 PM	Master Bed, South Wall	4 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, stud, lots of wind noise on outside microphones
7_18_2007 6_26_53 AM	Master Bed, South Wall	5 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, spoke during meas, outside mics on, car dove past
7_18_2007 1_33_12 PM	Not in notes, possibly master bed, west wall	Possibly 0 (App. I)		16384	112	7340040		None
7_18_2007 1_41_48 PM	Master Bed, West Wall	3 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount
7_18_2007 1_53_01 PM	Master Bed, South Wall	4 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, dog was barking next door
7_18_2007 1_56_55 PM	Master Bed, South Wall	4 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, aircraft overhead
7_18_2007 2_22_38 PM	Master Bed, Ceiling	See Photos App. I	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 9_06_42 AM	Master Bed, South Wall, Outside	18 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, large table on impedance head
7_19_2007 9_19_35 AM	Master Bed, South Wall, Outside	19 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, large table on impedance head
7_19_2007 9_31_53 AM	Master Bed, South Wall, Outside	20 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, large table on impedance head
7_19_2007 10_00_46 AM	Master Bed, South Wall, Outside	21 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, large table on impedance head
7_19_2007 10_05_41 AM	Master Bed, South Wall, Outside	21 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, large table on impedance head

Date Stamps for Shaker Response Measurements of the Windows	Location	Excitation Location	Fs (Hz)	Ensemble Length (Samples)	Number Of Channels In Raw Data Files	Size of One Raw Data File (bytes)	Excitation Signal Description	Additional Notes
7_15_2007 3_23_14 PM	Front Bed, Window Frame	17 (Appendix I)	6400	16384	112	7340040	White noise	Glue mount
7_15_2007 3_29_03 PM	Front Bed, Window Frame	17 (Appendix I)	6400	16384	112	7340040	White noise	Glue mount
7_15_2007 4_38_57 PM	Front Bed, Window Pane	16 (Appendix I)	6400	16384	112	7340040	White noise	Glue mount
7_15_2007 4_59_54 PM	Front Bed, Window Pane	16 (Appendix I)	6400	16384	112	7340040	18.5 Hz tone, low amplitude	Glue mount
7_15_2007 5_03_31 PM	Front Bed, Window Pane	16 (Appendix I)	6400	16384	112	7340040	18.5 Hz tone, high amplitude	Glue mount
7_15_2007 5_11_34 PM	Front Bed, Window Pane	16 (Appendix I)	6400	16384	112	7340040	77.75 Hz tone, high amplitude	Glue mount
7_15_2007 5_13_28 PM	Front Bed, Window Pane	16 (Appendix I)	6400	16384	112	7340040	77.75 Hz tone, low amplitude	Glue mount
7_15_2007 5_59_48 PM	Unknown, not in notes	Unknown		16384	112	7340040		None
7_15_2007 6_16_13 PM	Garage Bed, Window Pane	10 (Appendix I)	6400	16384	112	7340040	White noise, high amplitude	Shaker not clamped to wood support, glue mount
7_15_2007 6_21_49 PM	Garage Bed, Window Pane	10 (Appendix I)	6400	16384	112	7340040	White noise, low amplitude	Shaker not clamped to wood support, glue mount
7_16_2007 10_02_33 AM	Garage Bed, Window Pane	10 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), low amplitude	Glue mount
7_16_2007 10_11_59 AM	Garage Bed, Window Pane	10 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), high amplitude	Glue mount
7_16_2007 10_42_50 AM	Garage Bed, Window Pane	10 (Appendix I)	12800	32768	112	14680072	Amplitude swept sine	Glue mount
7_18_2007 10_03_02 AM	Master Bed, Window Pane	1 (Appendix I)	12800	16384	112	7340040	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount
7_18_2007 10_04_26 AM	Master Bed, Window Pane	1 (Appendix I)	12800	16384	112	7340040	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount
7_18_2007 2_09_47 PM	Master Bed, Window Frame	2 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), low amplitude	Wax mount, hand held shaker
7_18_2007 2_12_39 PM	Master Bed, Window Frame	2 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), high amplitude	Wax mount, hand held shaker
7_18_2007 8_51_57 AM	Master Bed, Window Pane	1 (Appendix I)	3200	16384	112	7340040	White noise (2 to 2kHz), low amplitude	Wax mount
7_18_2007 8_56_44 AM	Master Bed, Window Pane	1 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), low amplitude	Wax mount
7_18_2007 9_13_02 AM	Master Bed, Window Pane	1 (Appendix I)	12800	16384	112	7340040	White noise (2 to 2kHz), mid amplitude	Wax mount
7_18_2007 9_23_46 AM	Master Bed, Window Pane	1 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), mid amplitude	Wax mount
7_18_2007 9_34_17 AM	Master Bed, Window Pane	1 (Appendix I)	12800	16384	112	7340040	White noise (2 to 2kHz), high amplitude	Wax mount
7_18_2007 9_35_40 AM	Master Bed, Window Pane	1 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz), high amplitude	Wax mount
7_19_2007 11_02_53 AM	Front Bed, Outside Window Surface	23 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_06_26 AM	Front Bed, Outside Window Surface	24 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker, noise contamination
7_19_2007 11_09_07 AM	Front Bed, Outside Window Surface	24 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_11_59 AM	Front Bed, Outside Window Surface	25 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_15_23 AM	Front Bed, Outside Window Surface	26 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_18_57 AM	Front Bed, Outside Window Surface	27 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_19_2007 11_23_45 AM	Front Bed, Outside Window Surface	23 (Appendix I)	6400	16384	112	7340040	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount, hand held shaker, amplitude sweep log profile
7_19_2007 11_25_19 AM	Front Bed, Outside Window Surface	23 (Appendix I)	6400	16384	112	7340040	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount, hand held shaker, amplitude sweep log profile
7_19_2007 11_28_16 AM	Front Bed, Outside Window Surface	23 (Appendix I)	6400	16384	112	7340040	Amplitude swept sine at 18.5 Hz (1st mode)	Wax mount, hand held shaker, amplitude sweep linear profile

Date Stamps for Shaker Response Measurements of the Doors	Location	Excitation Location	Fs (Hz)	Ensemble Length (Samples)	Number Of Channels In Raw Data Files	Size of One Raw Data File (bytes)	Excitation Signal Description	Additional Notes
7_18_2007 2_01_57 PM	Master Bed, Entry Door	See Photos App. I	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount, hand held shaker
7_18_2007 2_31_00 PM	Front Entry Door, Inside Surface	No Photographs	6400	16384	112	7340040	White noise (2 to 2kHz), low amplitude	Wax mount, hand held shaker
7_18_2007 2_32_46 PM	Front Entry Door, Inside Surface	No Photographs	6400	16384	112	7340040	White noise (2 to 2kHz), high amplitude	Wax mount, hand held shaker
7_18_2007 2_39_43 PM	Front Entry Door, Outside Surface	No Photographs	6400	16384	112	7340040	White noise (2 to 2kHz), high amplitude	Wax mount, hand held shaker
7_19_2007 10_30_04 AM	Garage Door	22 (Appendix I)	6400	16384	112	7340040	White noise (2 to 2kHz)	Wax mount
7_19_2007 10_42_50 AM	Garage Door	22 (Appendix I)	6400	16384	112	7340040	Amplitude swept sine at 40 Hz	Wax mount
7_19_2007 10_44_44 AM	Garage Door	22 (Appendix I)	6400	16384	112	7340040	Amplitude swept sine at 40 Hz	Wax mount
7_19_2007 10_49_11 AM	Garage Door	22 (Appendix I)	6400	16384	112	7340040	Amplitude swept sine at 29 Hz	Wax mount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DRAWN
Jake
CHECKED
QA
MFG
APPROVED
TITLE
SIZE
C
DWG NO
MasterBedWestWall_InsideShaker
REV
SCALE
SHEET 1 OF 1
Point 0
Point 1
Point 2
Point 3
102.50
50.50
49.00
16.25
42.50
89.50
120.75
30.25
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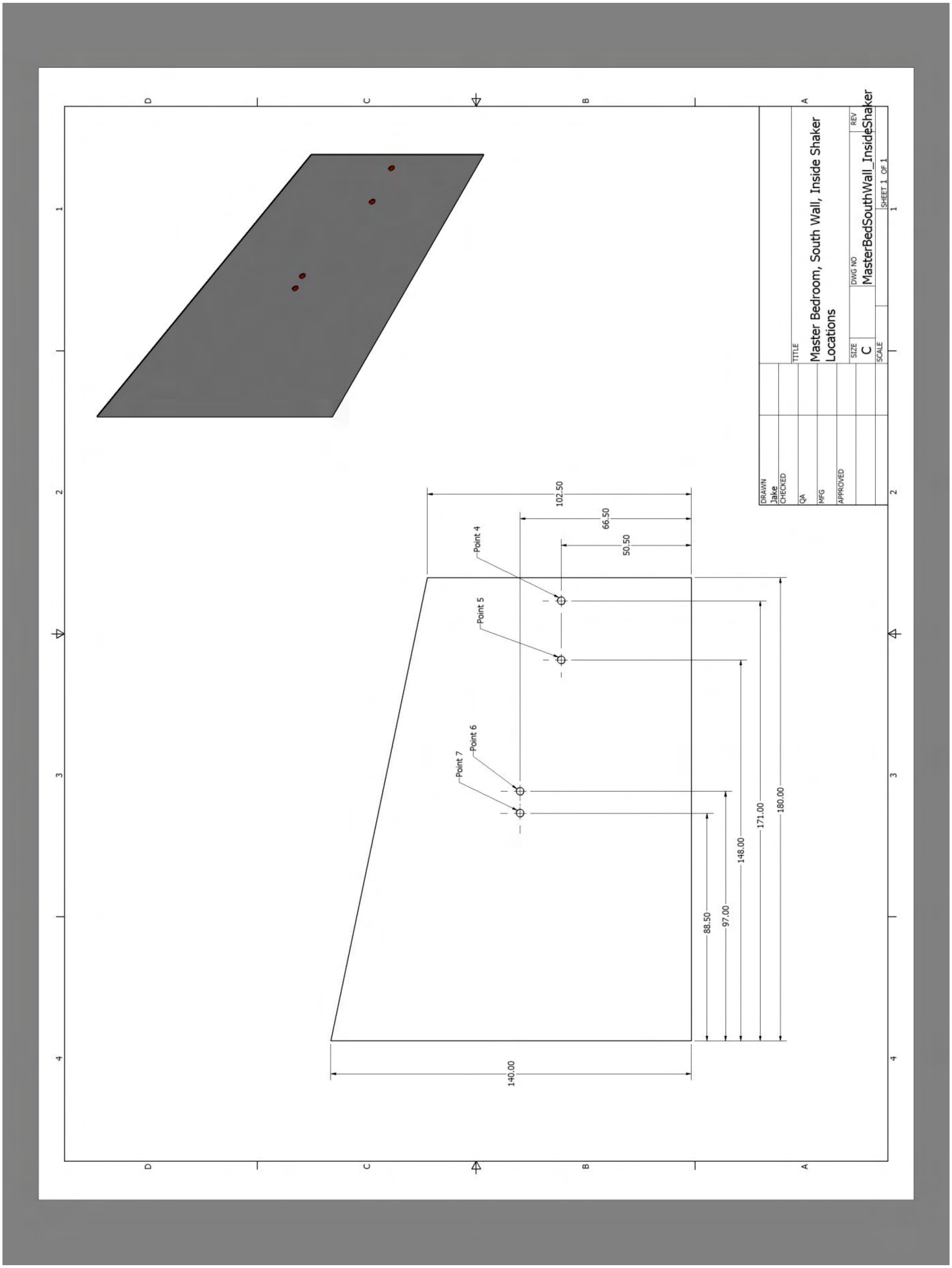
33.50
50.50
67.75
79.50



Master Bedroom, South Wall, Inside Shaker Locations
TITLE
DRAWN
Jake
CHECKED
QA
MFG
APPROVED
SIZE
C
DWG NO
MasterBedSouthWall_InsideShaker
REV
SCALE
SHEET 1 OF 1
Point 4
Point 5
Point 6
Point 7
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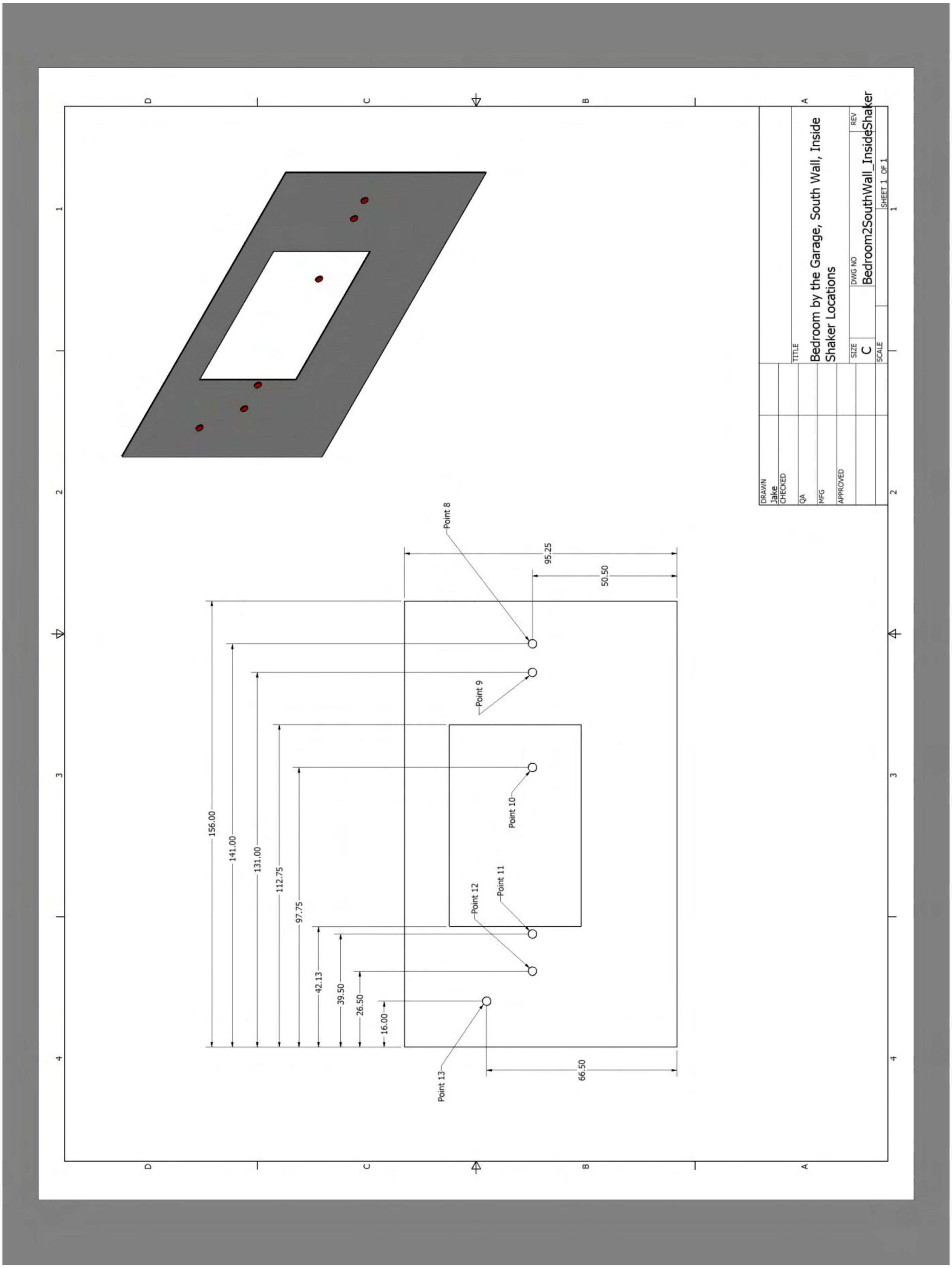
66.50
50.50
180.00
171.00
148.00
97.00
88.50
140.00



Bedroom by the Garage, South Wall, Inside Shaker Locations
DRAWN
Jake
CHECKED
QA
MFG
APPROVED
TITLE
SIZE
C
DWG NO
Bedroom2SouthWall_InsideShaker
REV
SCALE
SHEET 1 OF 1
Point 8
Point 9
Point 10
Point 11
Point 12
Point 13
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156.00
141.00
131.00
112.75
97.75
42.13
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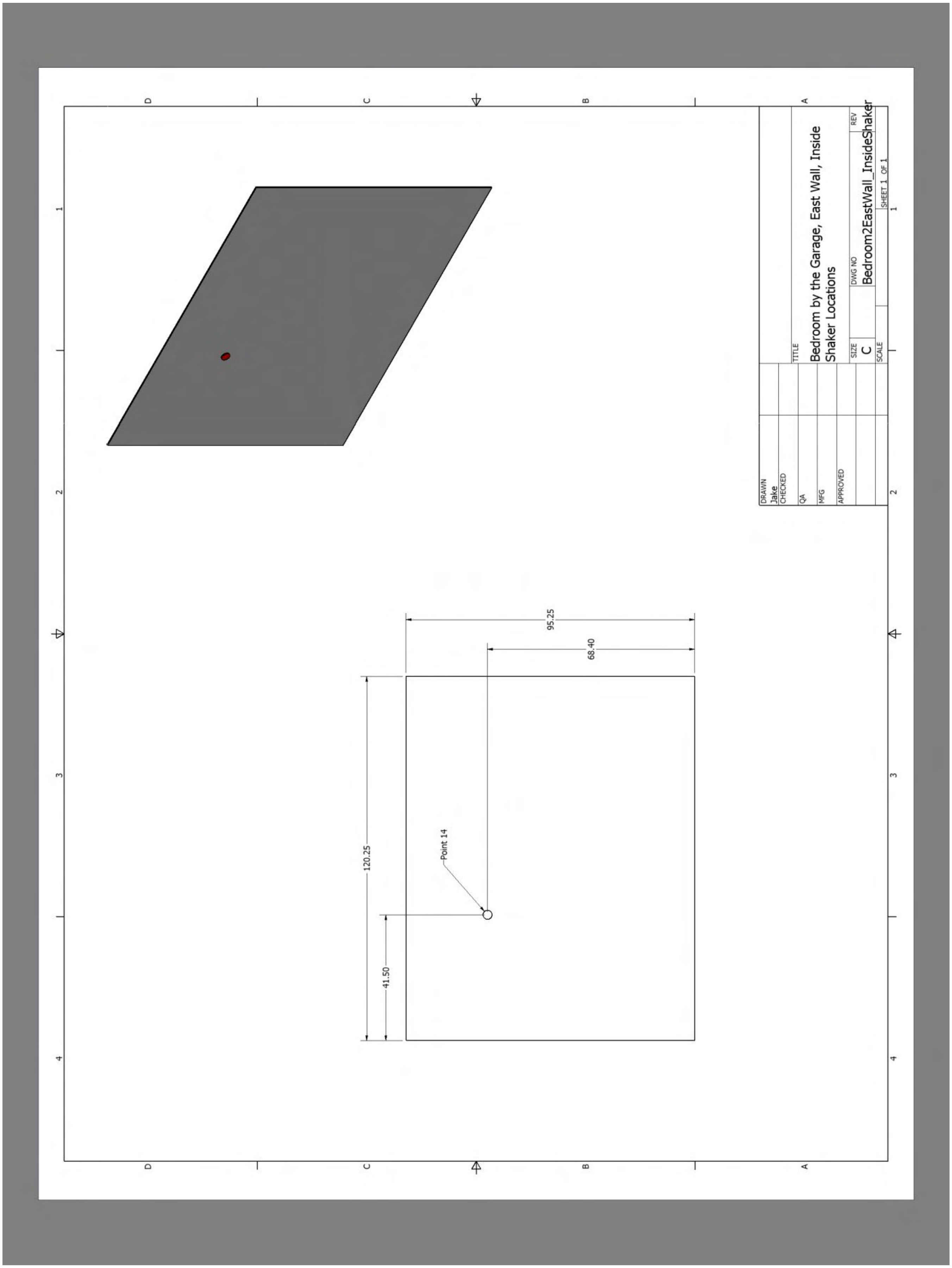
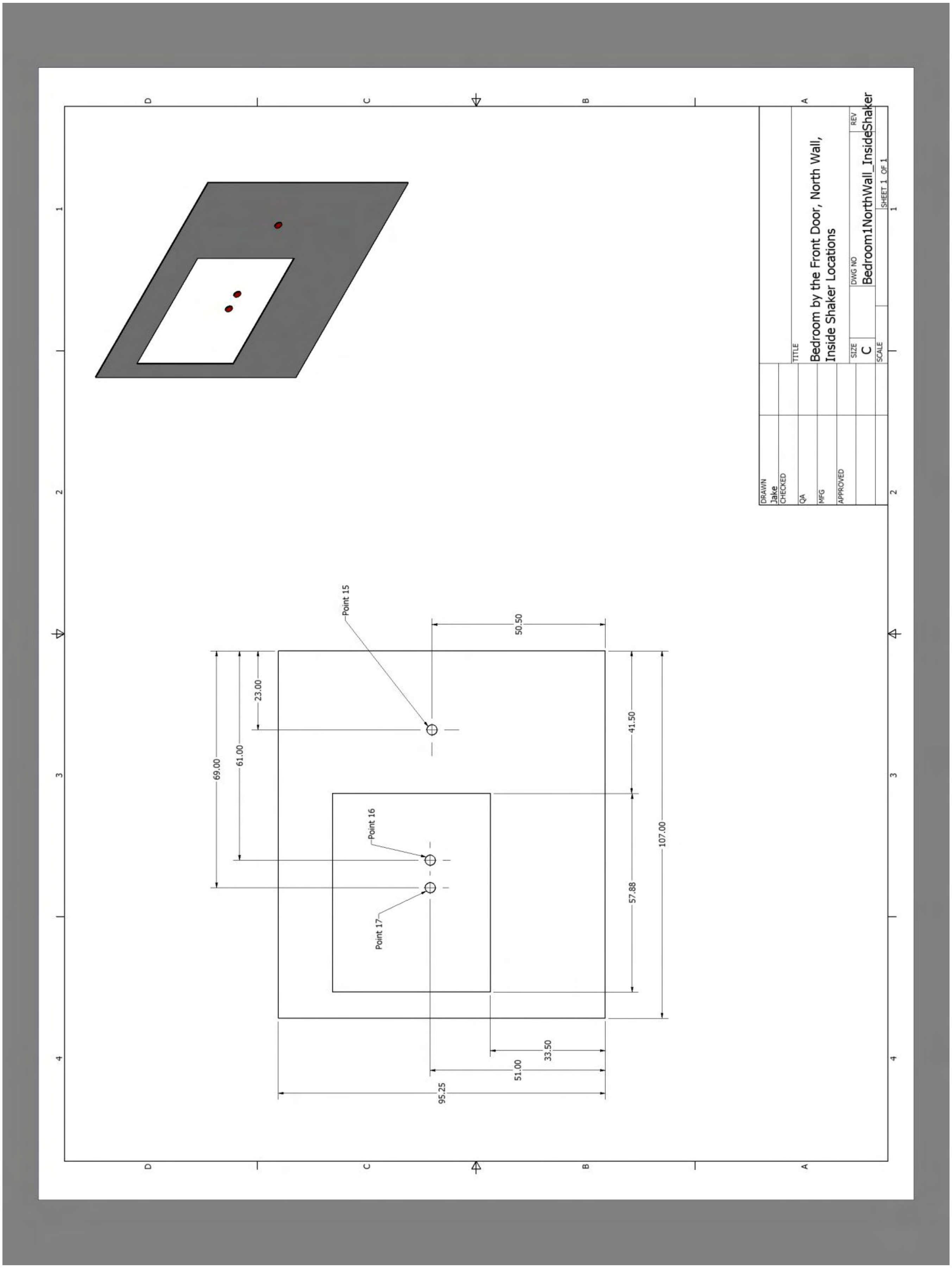
26.50
16.00
66.50


Bedroom by the Garage, East Wall, Inside Shaker Locations
TITLE
DRAWN
Jake
CHECKED
QA
MFG
APPROVED
SIZE
C
DWG NO
Bedroom2EastWall_InsideShaker
REV
SCALE
SHEET 1 OF 1
95.25
68.40
120.25
41.50
Point 14


DRAWN
Jake
CHECKED
QA
MFG
APPROVED
TITLE
Bedroom by the Front Door, North Wall,
Inside Shaker Locations
SIZE
C
DWG NO
Bedroom1NorthWall_InsideShaker
REV
SCALE
SHEET 1 OF 1
Point 15
Point 16
Point 17
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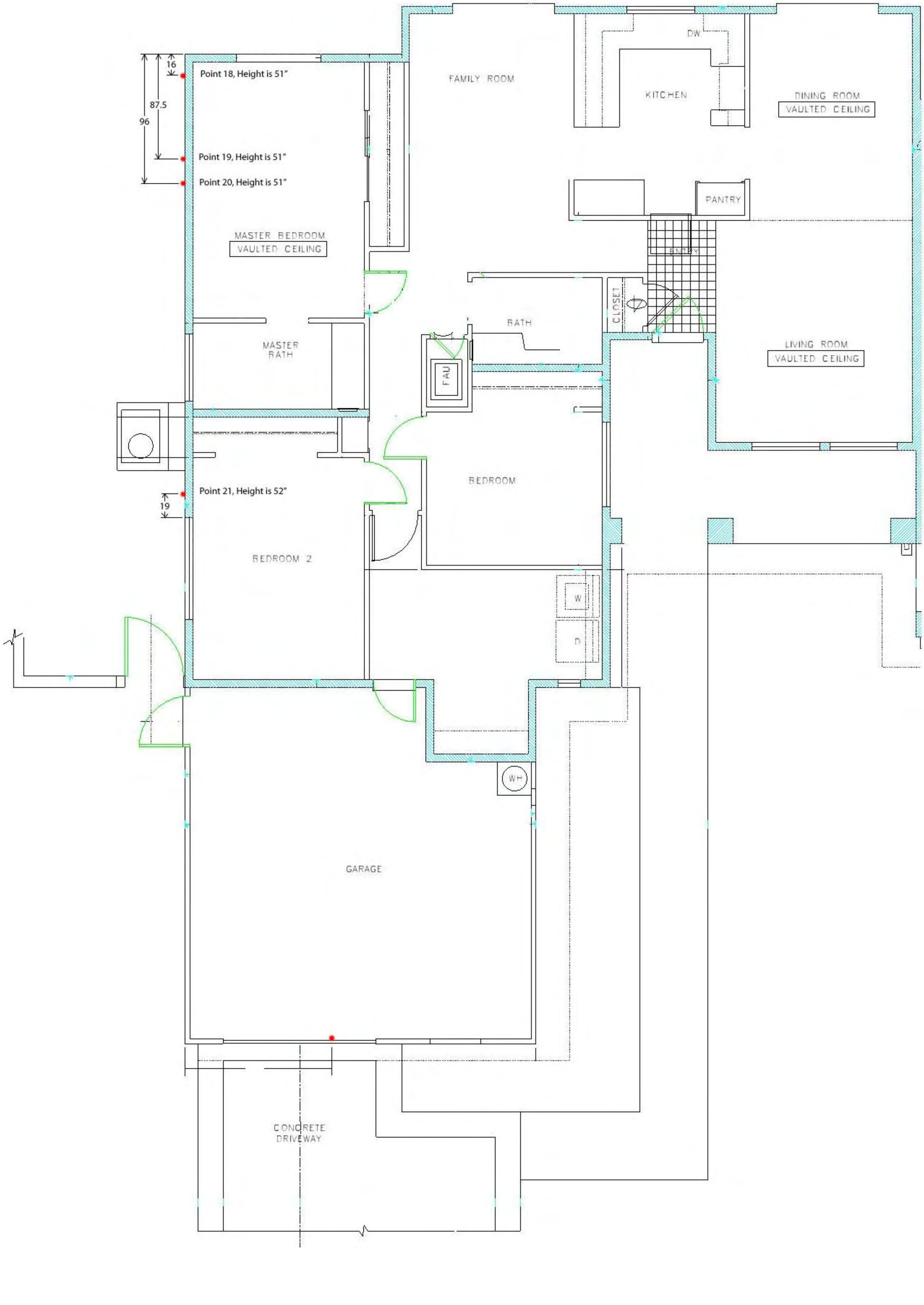
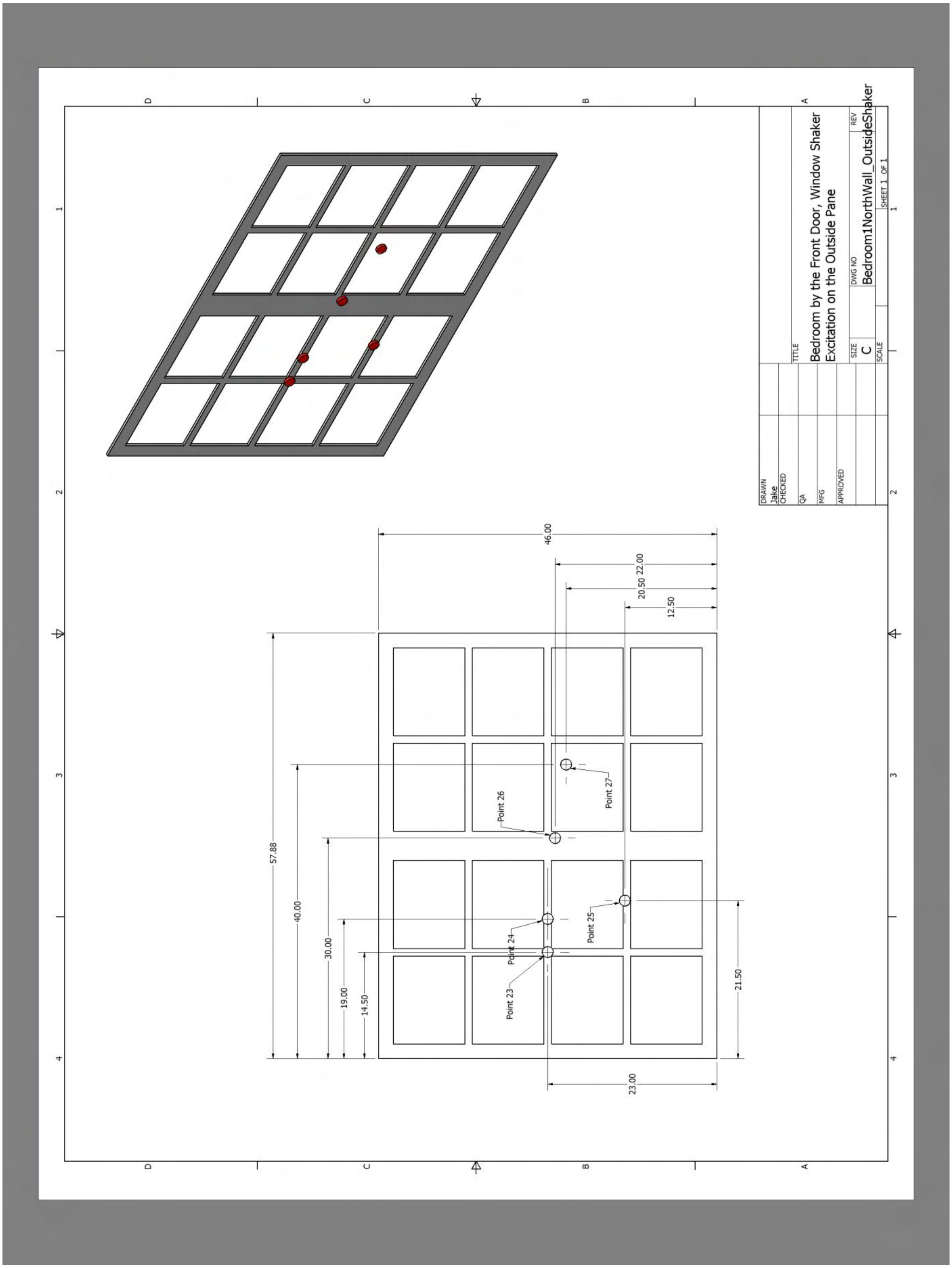
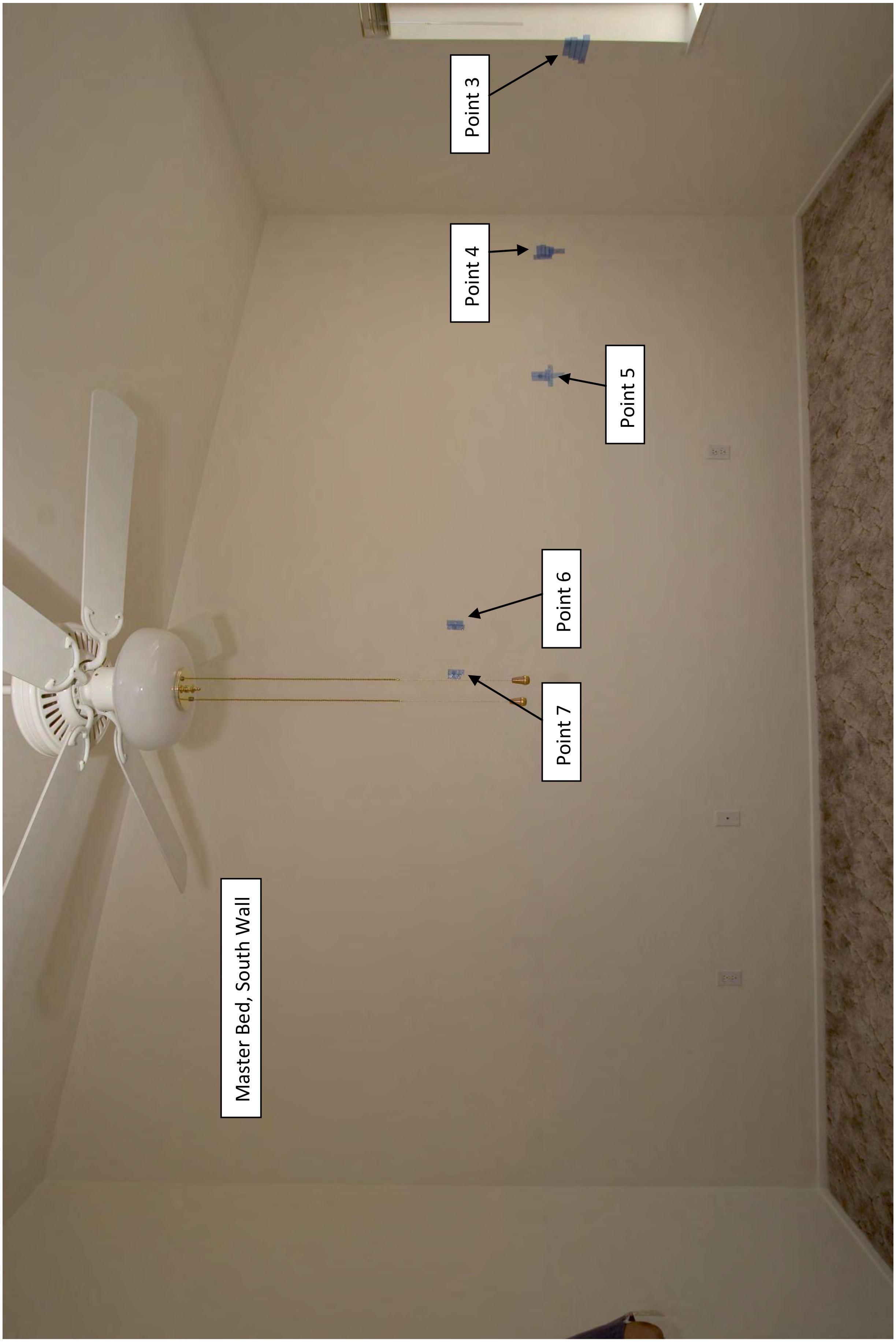
61.00
69.00
41.50
107.00
57.88
33.50
51.00
95.25


16
87.5
96
Point 18, Height is 51"
Point 19, Height is 51"
Point 20, Height is 51"
Point 21, Height is 52"
19
FAMILY ROOM
KITCHEN
DW
DINING ROOM
VAULTED CEILING
PANTRY
ENTRY
CLOSET
BATH
MASTER BEDROOM
VAULTED CEILING
MASTER BATH
LIVING ROOM
VAULTED CEILING
FAU
BEDROOM
BEDROOM 2
W
D
WH
GARAGE
CONCRETE DRIVEWAY

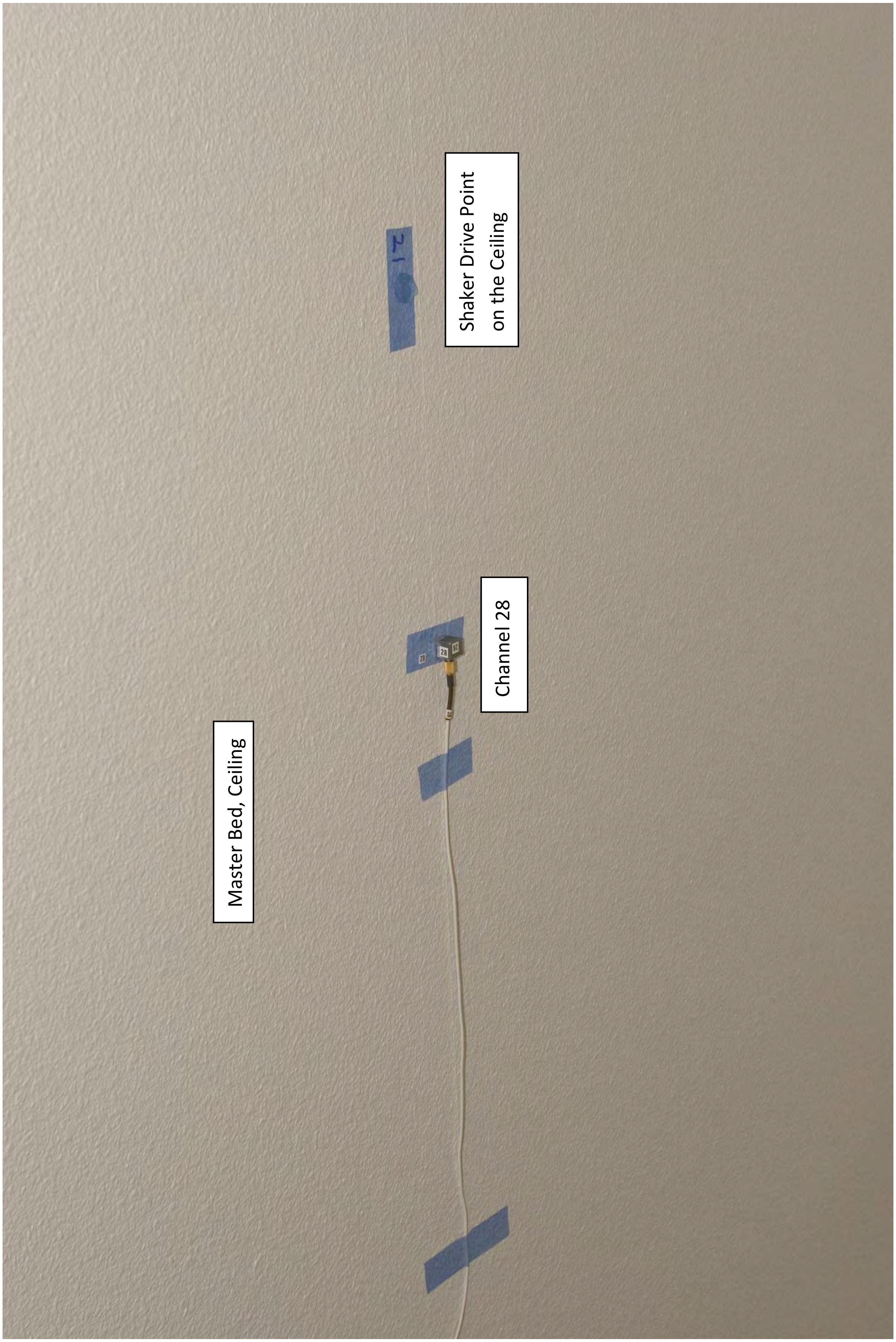

Bedroom by the Front Door, Window Shaker
Excitation on the Outside Pane
DRAWN
Jake
CHECKED
QA
MFG
APPROVED
TITLE
SIZE
C
DWG NO
Bedroom1NorthWall_OutsideShaker
REV
SCALE
SHEET 1 OF 1
Point 23
Point 24
Point 25
Point 26
Point 27
46.00
22.00
20.50
12.50
57.88
40.00
30.00
19.00
14.50
21.50
23.00

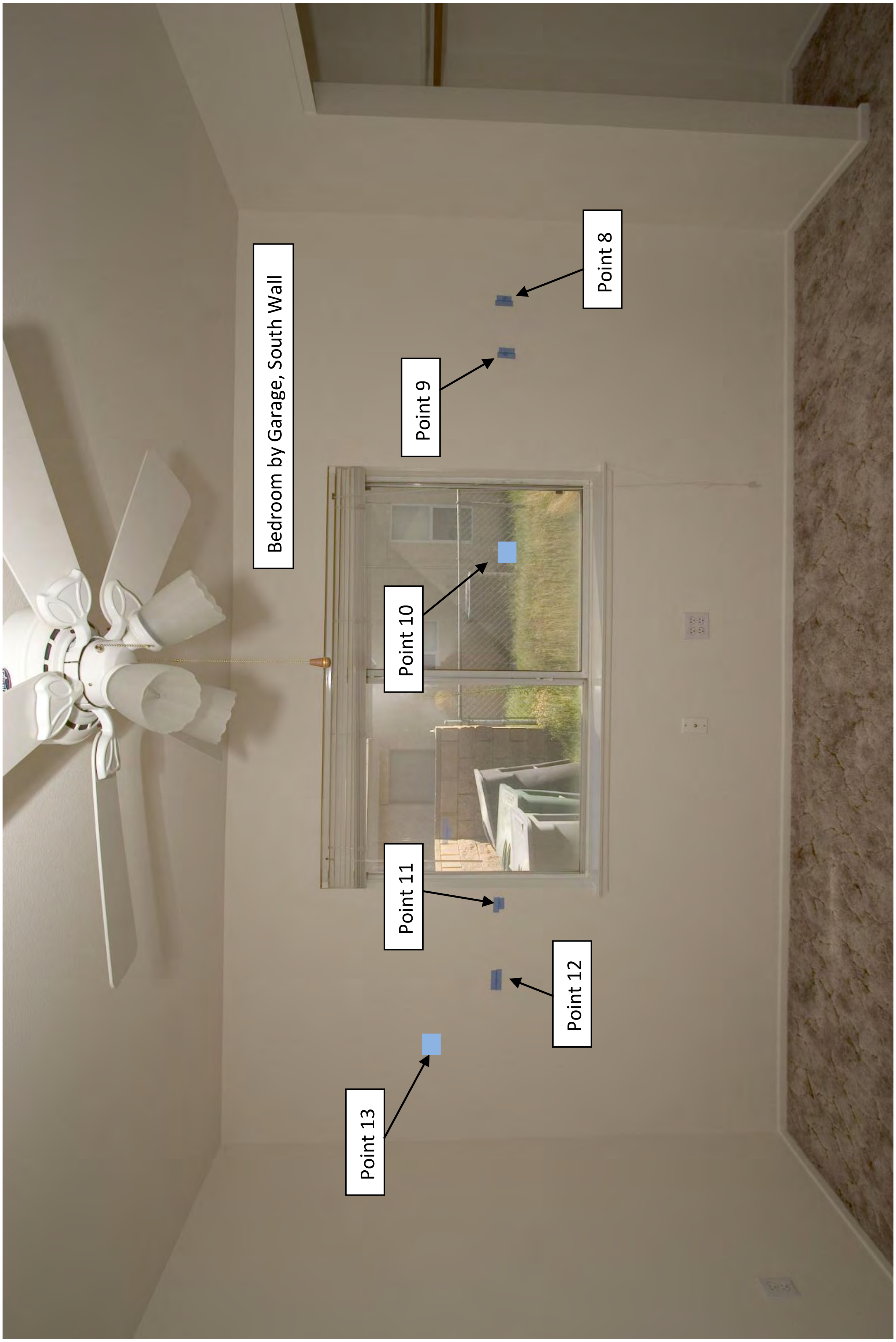

Master Bed, North Wall
Drive Point on the Master Bed Door
Point 0


Master Bed, West Wall
Point 0
Point 1
Point 2
Point 3
Point 4
Point 5

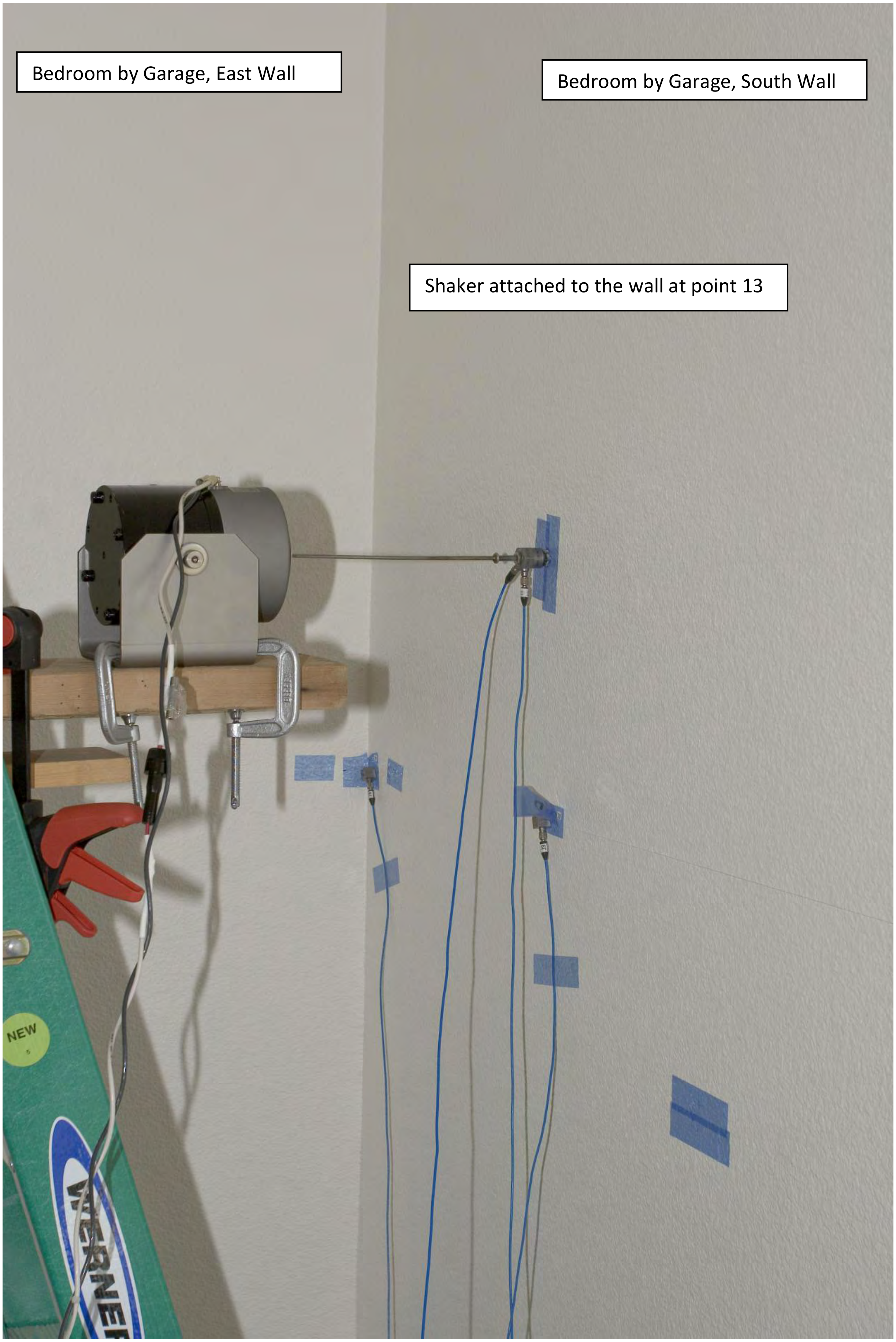

Point 3
Point 4
Point 5
Point 6
Point 7
Master Bed, South Wall

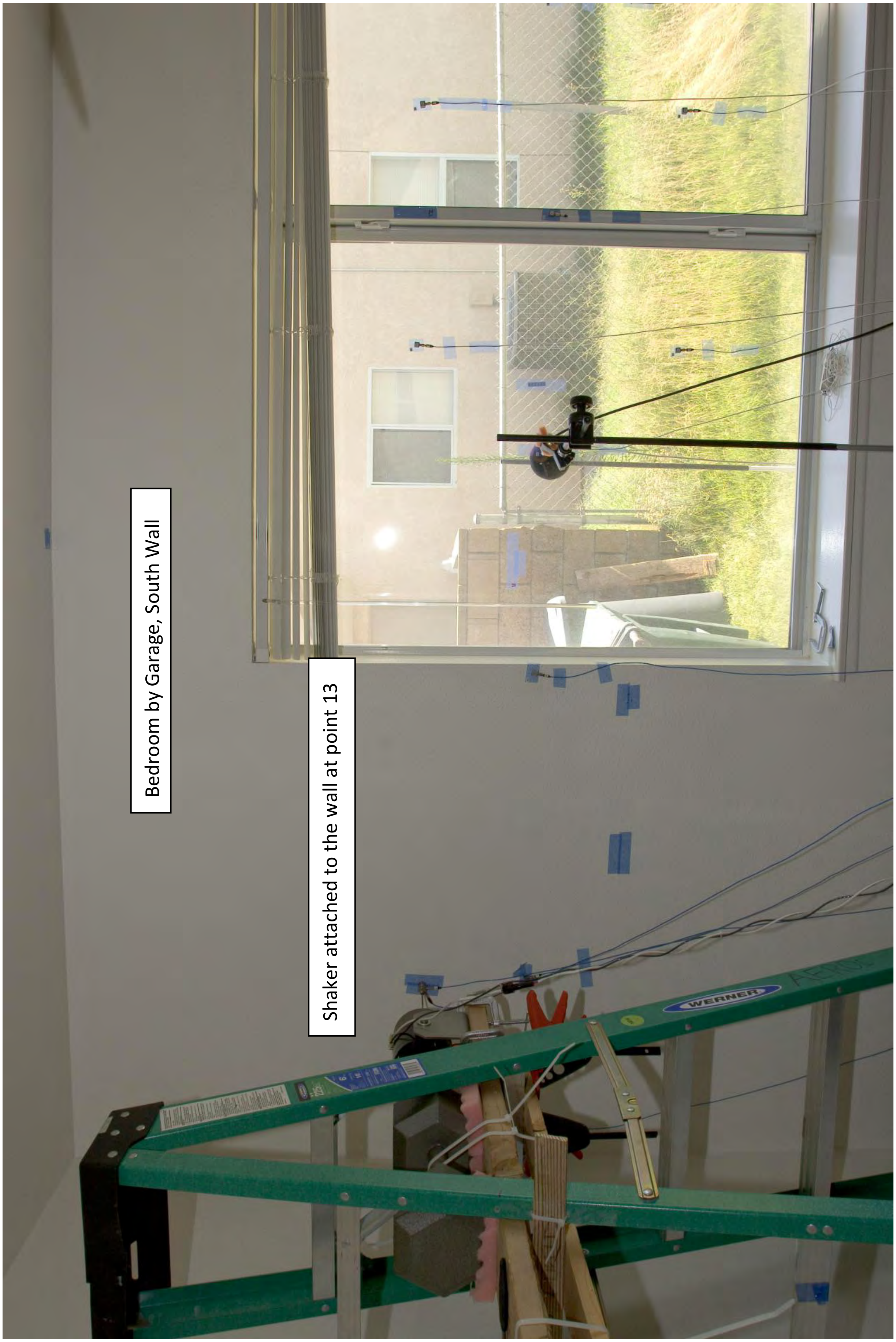

Shaker Drive Point
on the Ceiling
Channel 28
Master Bed, South Wall
Master Bed, Ceiling
Master Bed, East Wall


Shaker Drive Point
on the Ceiling
Channel 28
Master Bed, Ceiling

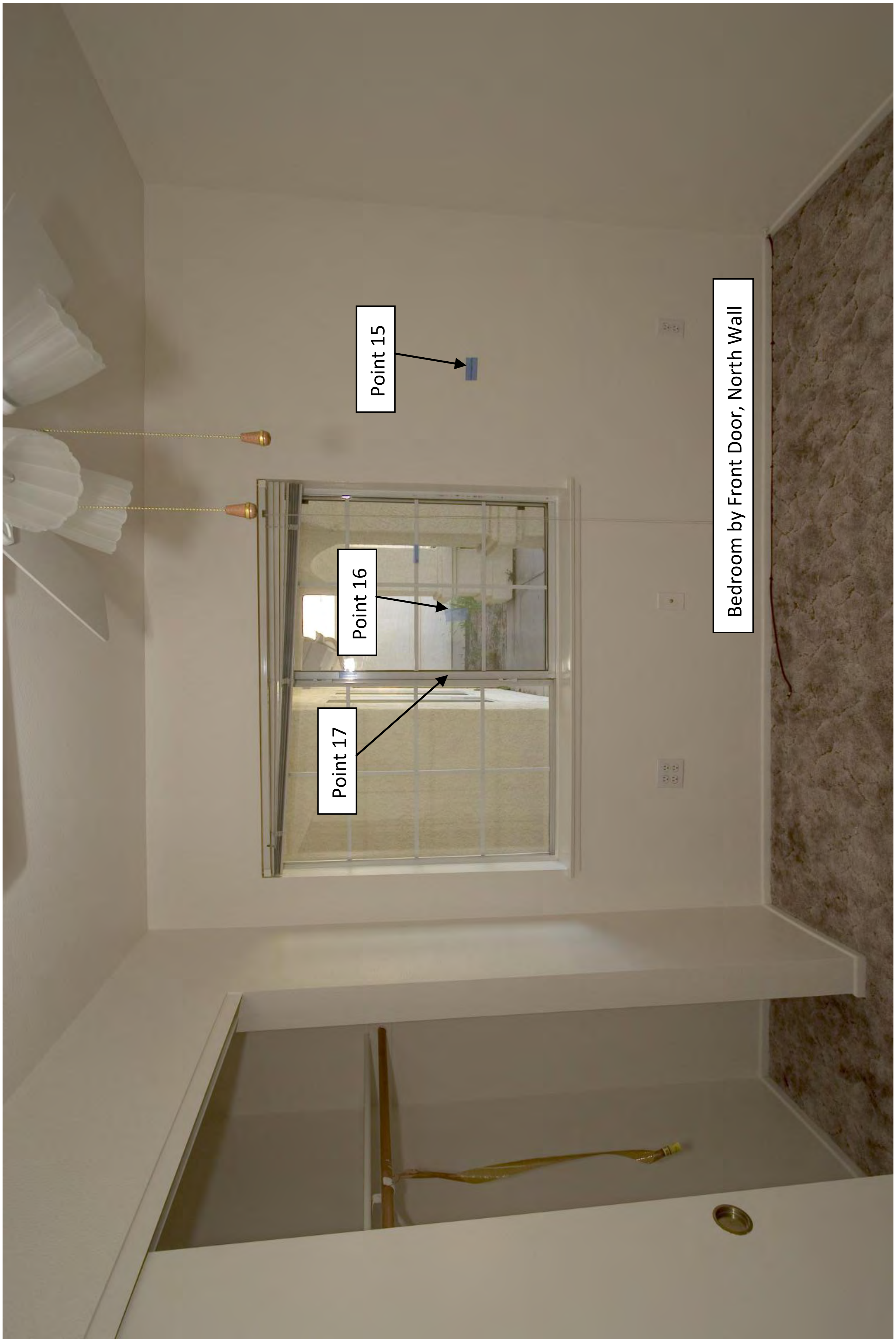

Bedroom by Garage, South Wall
Point 8
Point 9
Point 10
Point 11
Point 12
Point 13


Shaker attached to the window at point 10


Bedroom by Garage, East Wall
Bedroom by Garage, South Wall
Shaker attached to the wall at point 13
NEW


Bedroom by Garage, South Wall
Shaker attached to the wall at point 13


Point 14
Bedroom by Garage, East Wall


Point 15
Point 16
Point 17
Bedroom by Front Door, North Wall


Point 16
Point 17

Shaker attached to the outside of the house at point 21

Shaker attached to the outside of the house at point 21

Shaker attached to the garage door at point 22

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14. ABSTRACT
During the month of July 2007, a series of structural response measurements were made on a house on Edwards Air Force Base (EAFB) property that was exposed to sonic booms of various amplitudes. The purpose of this report is to document the measurements that were made, the structure on which they were made, the conditions under which they were made, the sensors and other hardware that were used, and the data that were collected. To that end, Chapter 2 documents the house, its location, the physical layout of the house, the surrounding area, and summarizes the transducers placed in and around the house. Chapter 3 details the sensors and other hardware that were placed in the house during the experiment. In addition, day-to-day variations of hardware configurations and transducer calibrations are documented in Chapter 3. Chapter 4 documents the boom generation process, flight conditions, and ambient weather conditions during the test days. Chapter 5 includes information about sub-experiments that were performed to characterize the vibro-acoustic response of the structure, the acoustic environment inside the house, and the acoustic environment outside the house. Chapter 6 documents the data format and presents examples of reduced data that were collected during the test days.

15. SUBJECT TERMS
Sonic boom; Structural vibration; Building response; House response

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