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Auditory and Light Based Two-Way Effective Sweep Width for Responsive Search Subjects in New Zealand Mountainous Terrain

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Abstract

Search theory is completely dependent upon an accurate assessment of how well a search area was covered by a team or the Probability of Detection (POD). Determining the POD for auditory whistle blasts and a response to sighting lights at night (sound-light line technique) involves a two-way detection problem.

Two experiments were carried out at Nelson Lakes along the Porika Road track in New Zealand. The first experiment was conducted during the day with six subjects and fourteen two-person teams conducting a sound line tactic. The detection index for a search team hearing a shout was 332 meters. The detection index for a subject hearing a whistle was 401 meters. Searchers were able to detect 99% of high-visibility clues (orange gloves) and 52% of low-visibility clues (gray gloves) on the track. The night experiment was conducted at the same location, but with different search subjects placed in different locations. Search teams used a sound-light line tactic in two-person teams. The detection index for a search team hearing a shout was 306 meters. The detection index for a subject hearing a whistle was 395 meters and seeing a light 277 meters. The detection index for a subject detecting either signal was 460 meters.

This is the first report in the land search literature of both elements (searcher and subject) of a two-way detection problem.

Keywords: Detection index, Sweep Width, two-way detection, Probability of Detection, POD, whistle, shout, sound-light line.

Introduction

Koopman (1946, 1980) established search theory and practice with his pioneering work during WWII. Prior to his work there was no published scientific literature on search theory. An essential part of Koopman's work was developing the concept of Effective Sweep Width (ESW)—a single numeric value of detectability for a given sensor to detect a specific search object in a unique environment. The ESW can then be used to calculate the Probability of Detection (POD), a measure of a search team's thoroughness. While determining the POD is critical to search theory it is not the ultimate goal. Instead POD is used to determine the Probability of Success (POS) in conjunction with the Probability of Area (POA). In turn POS is used to determine the Probability of Success Rate (PSR) which can be used to make decisions on the optimal allocation of resources in the field (Charnes and Cooper, 1958). For additional information on the full development of search theory and ESW see Frost (1999a, 1999b, 1999c, & 1999d).

Lateral Range

The method for estimating the ESW uses the concept of a "lateral range curve" introduced by Koopman (1946). Lateral range refers to the perpendicular distance an object is to the left or right of the searcher's track where the track passes the object. Therefore, it represents the distance from the searcher to the object at the Closest Point of Approach (CPA). A lateral range curve is a plot of the probability of detecting the object on a single pass as a function of the object's lateral range (distance) from the searcher's track. **Figure 1** shows a hypothetical relationship between POD on a single pass and an arbitrary scale of distances to the left (negative) and right (positive) of the searcher's track. Negative values are distances to the left of the searcher's track while positive values are distances to the right of the searcher's track. The shape of the lateral range curve is determined through actual field experiments. Twardy (2012) provides a recent discussion on the various shapes a lateral range may take.

Auditory search is also highly dependent on distance. However, it differs from visual search in that it is possible to know the distinct distance for each and every auditory attempt. It is also different in that each auditory signal is discrete. In fact a searcher making a continuous sound would be unable to listen to a response. It is also possible to determine if each auditory attempt of the team (whistle blast) was detected or not detected. This unique feature allows analysis using both the CPA and to determine an alternate detection index from each discrete detection opportunity.

The lateral range method also functionally integrates all of the effects various factors have on the detection process during the experiment. Even in a fairly constant environment many factors may affect detection. Wind or rain may affect hearing at a particular point; one searcher may have better hearing than another; or the object may require several glimpses to register on the consciousness of the searcher, especially if it has a low contrast with its surroundings.

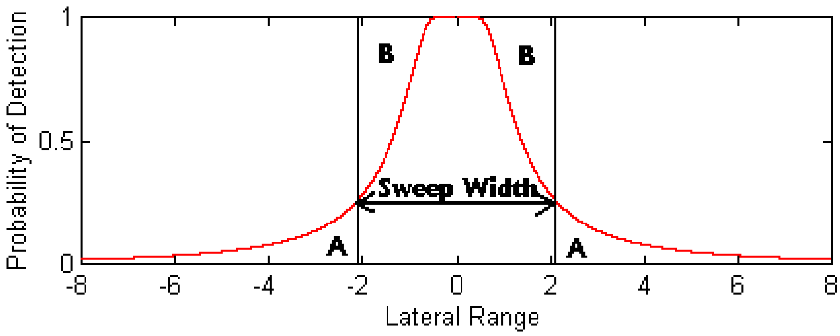

Figure 1 A Lateral Range Curve. The number of missed detections (B) inside the effective sweep width equals the detections (A) that occur outside the sweep width. This is often called the cross-over point. Figure from Frost 1999b.

Detection Index (Effective Sweep Width)

The ESW is one of the central concepts of search theory and its application to SAR. Additional information about ESW may be found in Koopman (1980), Stone (1989), and Frost (1999b).

The ESW may be thought of as the area where the number of objects *missed inside* the swath are equal to the number of objects *detected outside* the swath as shown in **Figure 1**. In more mathematical terms the ESW is also numerically equal to the area under the lateral range curve. Robe & Frost, (2002) previously showed for land search that the cross-over technique based upon finding the point where the number of cumulative detections equals the number of cumulative misses is equalvalent to calculating the area under the curve, and may in fact be superior. The technique has also been used by Koester et al (2004) and Chiacchia & Houlahan (2010) for visual search. An ESW value has not been determined for auditory search.

Probability of Detection (POD)

Successful search planning, whether in an urban, wilderness, or marine environment requires an objective standard for providing an estimate of the Probability of Detection (POD). In each of these settings the variables that describe the searcher, the search object, and the search environment will differ not only in kind but also in their influence on the estimate of the POD. What is constant, however, is that POD estimates should be based on objective measures and observations. Previous research by Koester et al (2004) found experienced searchers were unable to make accurate assessments of POD based upon subjective assessments by either the search planner or the searchers. POD depends upon coverage, which depends on three things:

- The "detection index" or ESW for the combination of search object, search environment, and sensor (e.g., auditory search from the ground) present in a given search situation,
- The amount of effort expended in searching the area, and
- The size of the area where the effort was expended.

The size of the search area requires special comment when the field technique of a sound light line is being used. The tactic places a team of searchers following a linear feature. Since each member of the team follows the same course, increasing the number of team members does not increase the total track line distance. Instead, any advantages of additional team members would be derived from factors such different abilities to hear, differences in types of whistles, differences in listening orientation, differences in attention, and other subtle factors. The size of the search area, since linear in nature, should be defined by how far off the route a POD is desired. This also simplifies the inputs and computation required to determine the POD value.

Previous Related Experiments

Koester et al (2004) reported on five visual experiments conducted in different environments for high, medium and low-visibility search object approximating prone search subjects. Chiacchia & Houlahan (2010) followed up with two additional visual experiments with similar results and using the same methodology.

No previous study used the combination of un-alerted searchers and subjects for auditory search. In addition, no previous studies have reported the POD values for clues placed directly on the track which is a common search tactic. Only two previous SAR experiments involving sound have been conducted. Martin Colwell (1992) conducted field trails to determine both visual and sound Probability of Detection (POD) in British Columbia. More specifically the experiment was conducted in a Pacific West Coast coniferous forest (Marine Temperate ecoregion division). The experimental methodology involved placing dummies in a standing position. The dummies were outfitted with inexpensive, portable, battery powered

AM radios. The radios were tuned to a local "talk" radio stations the volume adjusted to best match a person talking loudly or shouting. Manson (2009) reports that some of the researchers who had placed the subjects were also involved in the detection experiment. Colwell's results are reported as the searcher's POD based upon the spacing. While this allows creation of a lateral range curve and therefore finding the area under the curve (one method to determine an effective sweep width), this value was not calculated at the time. The actual value would be expected to be underestimated since the experiment required the searcher to also make a visual detection of the search subject in order to identify the dummies code number. Manson (2009) conducted research looking at sound in the same environment as Colwell. He looked at the relationship of loudness and range using different whistles. His experiments showed that loudness does not always directly indicate a whistles range, since pitch is also an important factor. The experiment reports an attention-getting range for each source, although this was a subjective value determined by the testers.

To date no experiment has attempted to determine the detection index or effective sweep width value for auditory search that is required to determine an objective POD. In addition, no experiment has ever been conducted to look at the use of light in getting a subject to respond. Finally, no previous experiments have looked at the real-life issue of the two-way nature (lost subject detects searcher shouts and then searchers hear subjects response) of the signal detection in the land environment.

Methodology

The methodology used was similar to visual land based experiments previously described by Koester et al (2004). That methodology was further refined and described by Koester et al (2006). An important tool used to setting up experiments is the Integrated Detection Experiment Assistant (IDEA) which is built using MS Excel. Required inputs include the projected number of search participants, the number of different types of search objects, and the Average Maximum Detection Range (AMDR). The calculator would then determine the total number of targets required, expected length of course, expected time to complete the course, and locations to place search objects (subjects). If the number of targets or course time fell outside the experimental parameters the parameter was flagged by a change in color. In addition to setting up the experiment, IDEA displays the results after inputting raw data. The experimental design calculator was a useful tool for the experiment team but is not a finished product in regards to sound-light experiments. Key differences in the experimental methodology of Koester et al (2004) and the auditory experiments are described.

Determining AMDR

During the site visit an Average Maximum Detection Range (AMDR) was obtained. The AMDR protocol was modified from the visual protocol described by Koester et al (2004) in the following ways. The AMDR was conducted by taking four measurements instead of taking sixteen measurements as specified in Koester et al (2004). The reduction was due to measuring only the extinction point (i.e., point unable to hear the whistle or shout) and reducing the number of legs from eight to four. Since the distances were large a GPS (Garmin 60CSx) was used to obtain coordinates and then measure the actual distances using Google Earth software. Since it was unknown what the difference between voice and whistle might be, both were provided. A total of three people were involved in the AMDR collection. One person stood at a fixed location. Once every two minutes a whistle was blown. Also every two minutes a shout was made. Combined, this meant either a whistle or shout would occur at the same time every minute. This allowed the "searchers" walking away from the sound source to know if the signal heard was valid. The goal is to achieve the maximum distance possible and still hear a valid signal.

Marking the track

In the sound-light experiment a two-way detection is required. The searcher must signal the subject, the subject must detect the signal and respond, and finally the searcher must detect the signal the subject sent. Therefore, it was important to control the exact location that each whistle blast occurred. This was accomplished by precisely marking the track. A one-meter measuring wheel was used to measure the course. Every 100 meters the location was marked (see **Figure two**) and the coordinate entered into a Garmin 60CSx GPS receiver. The location was indicated with an orange traffic cone marked with the appropriate distance and reflective white or red reflective tape. The cone was held in place by a fiberglass rod driven into the ground with a mallet and further enhanced with surveyor's flagging tape.

Figure 2. Cone used to mark every 100 meters along the track.

Prior to the experiment the several forms were created in order to collect data, manage experiment participants, brief participants, and ensure searcher safety.

Visual Glove experiment

The day time experiment also had clues placed on the track. The clues consisted of either high visibility clues or low-visibility clues. The high-visibility clues were white workers gloves painted with day-glo orange dazzle (paint), and the low-visibility clues were the same gloves painted gray. One low-visibility glove was left white, since it was placed on some snow. Locations for placing the gloves on the track were determined by IDEA. Searchers were informed to record any gloves they located.

Participant Recruitment

Participants were recruited mostly from Tasman Search and Rescue, the New Zealand Police, and some additional participants recruited from the Canterbury district. All searchers belonged to a search team or played an active role in search and rescue.

Basic Protocol

The sound-light experiment used search and rescue (SAR) personnel for both search subjects and searchers. The searchers used whistle blasts (day) or a combination of whistle blasts and light (night) to send a signal to the search subjects. Teams used technique taught in the SARINZ Search Methods course and corresponding student reference (Wells et al, 2012). If the search subject detected a signal (either a whistle blast or shining light) they responded by shouting “Hey, it’s Bravo.” Each subject was assigned a unique phonetic alphabet word to shout. The order of the words were randomized

All participants signed in on the participant sign-in sheet and were assigned to a team. Teams were staggered at a 15 minute interval. Each searcher provided basic information on the Searcher Profile form. The form is broken into three sections. Section A collects demographic information on the searcher. Section B collects physical characteristics such as hearing, vision, and height. In addition it collects information on the physical characteristics of the searcher’s whistle and flashlight. Section C is filled in during debriefing and includes collected weather information, estimated PODs, and self-reporting of morale and fatigue.

The search subjects and searchers received separate briefings. The searchers were not aware of how many subjects were placed into the field. Each search team carried equipment needed to safely function in the environment (typical SAR pack) and a copy of the searcher information sheet, task assignment form, detection log, guide to determining Beaufort scale, clip board, pencil/pen plus a backup writing tool, and may have been issued a radio. The team’s departure was tracked on the Team Tracking Log. Actual position reporting, once the team was dispatched was greatly facilitated by the numbered cones. Teams, instead of reporting coordinates, only need to report the closest cone number.

Upon completing the experiment (returning from the field), each team was debriefed and the detection log examined to ensure it was filled in correctly or if any questions existed. The Detection Log form has a tabular representation of the search track. A row exists for each 100 meter cone. Each detection made by the searcher is recorded on the log along with its description, time, wind condition at the time (using the Beaufort scale), and clock bearing relative to 12 o’clock being straight ahead on the track. The time was recorded for every 100 meters (cone location) where the team blew a whistle.

Current weather and changes in the weather conditions are recorded at the command post using a Kestrel 4000. The weather characteristics recorded were precipitation, cloud cover, temperature, visibility, barometric pressure, humidity, and wind speed.

Data Scoring

Data was scored in the same manner as described by Koester et al. (2004). Some differences between a visual experiment and auditory experiment are described. Subject's location were recorded by the subjects using a Garmin GPSMAP 60CSx GPS receiver and recorded on their detection logs. The GPS was setup to New Zealand Grid and the WGS84 map datum. The New Zealand Grid was used so subjects could locate themselves on the gridded map. The grid coordinate was then transformed to a decimal degree format using Franson CoordTrans version 2.3. The decimal degree subject coordinate was plotted using Google Earth. The subject's location was then compared against the previously plotted cone coordinates and the subject placement sheet which was used to place the subject's. If the location, side of the track, and distance matched it was considered a valid subject location. All subjects' had valid locations. It was also noted (using Google Earth elevation features) if the subject was uphill, downhill, or at the same level as the cone location of closest point of approach. All scoring was done by one individual to ensure consistent results. Each search object would be scored as either being detected or missed. Virtual search objects (described in Koester et al. 2004) were not placed onto the Detection Log scoring template and were all scored as misses.

Data Scoring Closest Point of Approach Method

It was possible to score the detection and non-detections using several different techniques. Detecting the search subject involved the team sending out a whistle blast at each cone and then listening for a response. A chart was prepared that showed each subjects point of closest approach or lateral range between the cone and the search subject. Each time would then be scored a "1" if the search team detected the subject's shouts and a "0" if it did not. It was possible to score the sheets rather quickly for this technique.

Data Scoring Each Cone Method

Unlike visual experiment where detections and non-detections can occur anywhere along the track (thus requiring the CPA method) sound experiments send out a discrete signal from a fixed and known location to a subject at a fixed location. Since the coordinates of each cone were recorded along with the subject's it was possible using a GIS system to measure the distance between each cone (site of the searcher's whistle blast) and the subject. The measurement ruler is precise to 0.1 meters and measurements were recorded to the closest meter (see **Figure 3**).

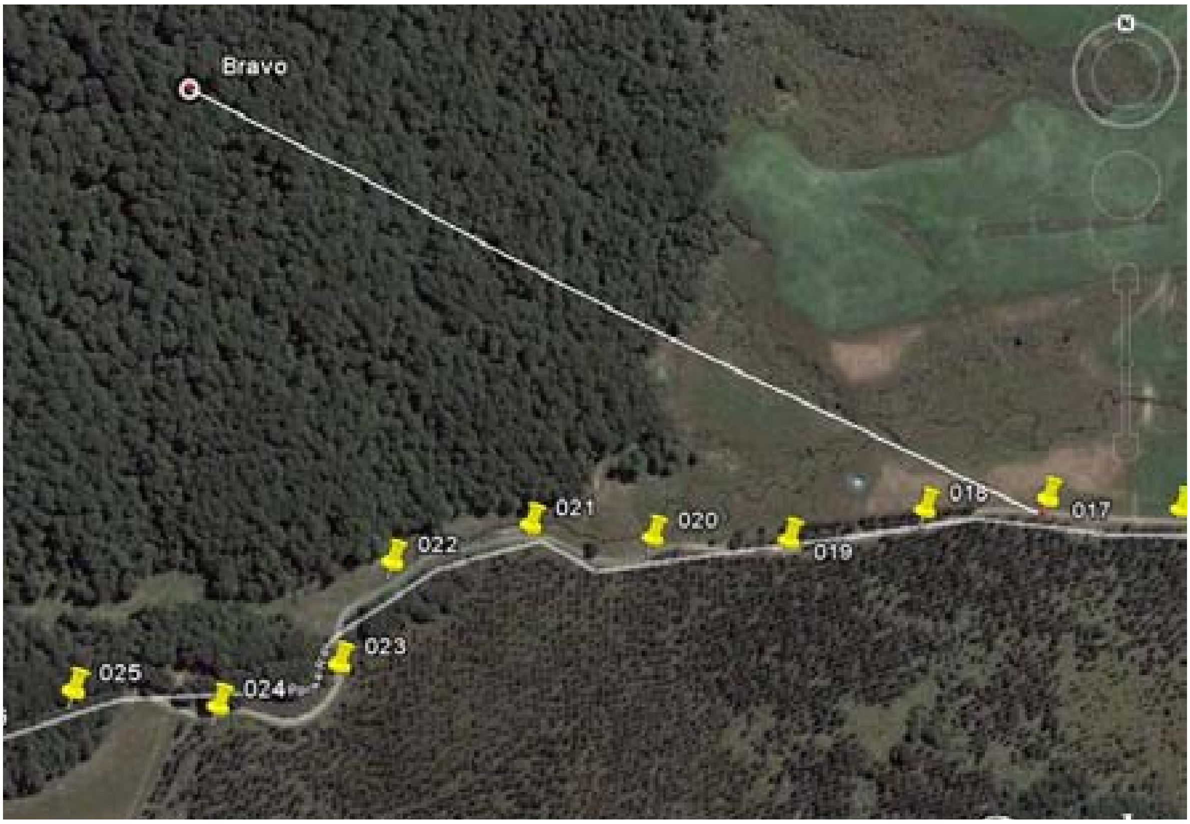

Figure 3 Method used to measure the distance from subject to each cone location

Each cone was then assigned to one particular subject (using midpoint between two subjects). The lateral range from that cone to the assigned subject was made. Then each team's detection or non-detection was scored for each cone. During the day experiment this results in 1327 detection opportunities versus the 115 using the CPA method. The lateral ranges were then placed into bins and the average of the distances within each bin was used to determine the lateral range for each bin.

Data entry was then made into the MS Excel based IDEA Data input Search Object 1 sheet. The clue number, lateral range (or off-track distance), and clue type were entered. Then for each searcher (using their coded searcher number) the "0" and "1" were transcribed from the scoring form into the spreadsheet.

Data Analysis

Using the information provided on the spreadsheet, another worksheet (Data Summary Object #1) automatically calculated the crossing over point of the cumulative detections and cumulative misses after the automatic sort button is clicked. The purpose of the clicking on the sort button is to sort the lateral ranges from smallest to greatest. It is then possible to calculate the detection index.

The first step in scoring was starting with the team detections. If the team heard the subject, then by default the subject had heard the team. The next phase was to determine if the subject had heard the team, even when the team did not hear the response. The trackline distance where most teams had heard the subject was recorded. Then in a separate worksheet the exact time each team reached that particular cone (trackline location) was recorded. Finally, the team's cone time was cross-referenced to the subject's detection log. If the two times matched then the subject scored a detection for that particular team. One team did not record their cone times so it was not possible to score that team.

Results

Description of Venue – Nelson Lakes St. Arnaud

Nelson Lakes National Park (established in 1956) is situated in the north of New Zealand's South Island. This park protects 102,000 hectares of the northern most Southern Alps. The park contains beech forest, craggy mountains, streams and lakes both big and small.

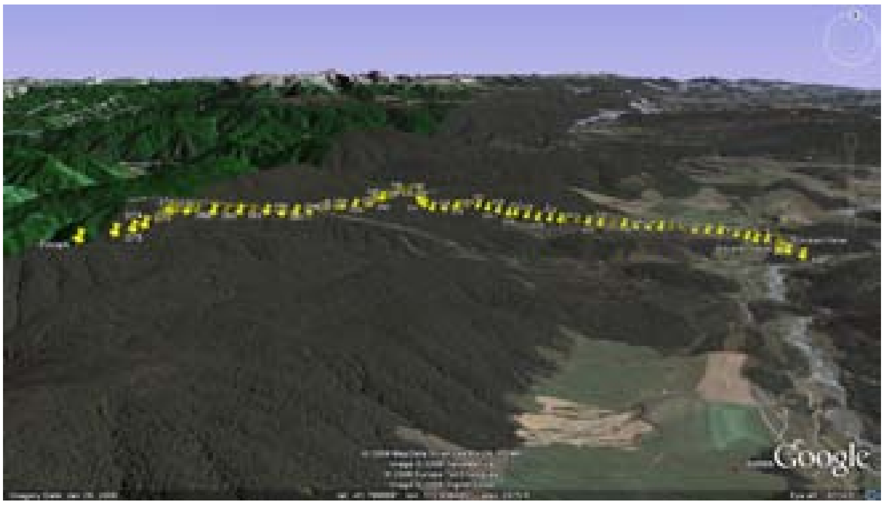

Figure 4 Google Earth view of search track with cone locations plotted

Two separate experiments were carried out at Nelson Lakes on July 18 and into the early hours of July 19, 2009. The first experiment occurred during daylight and looked at the sound line tactic and clues placed on the track. The second experiment occurred after dark. New subjects were placed in different locations. The night time experiment involved both sound and light line tactics. For each experiment the detection index can be determined by using the Closest Point of Approach (CPA) technique or from each cone's position.

Course Characteristics

Table 1 provides the general characteristics of experiment conducted at Nelson Lakes.

	Day	Night
Location	Porkia Road, Nelson Lakes	
Ecoregion	Mountainous Subtropical M230	
Season	Winter	
Length	7.5 km	
Elevation Change	467 – 983 meters	
Layout	Road	
Temperature	10-12 C	1-5 C
Wind Speed	0-10 kph	2-45 kph
Visibility	Unlimited	Unlimited – 200 meters
Cloud Cover	Partly Sunny	Clear – Foggy
Precipitation	None	Rain Moderate
Pressure	943 mb falling	943 mb
Time	11:28 – 17:57	20:36 – 01:34

Table 1 Course general characteristics

Day time Experiment – Team Detection Experiment Results

In several cases it was observed that the subject in fact detected almost all of the teams. However, almost none of the teams detected the subject. This would result in a larger detection index for the subject detecting the teams. This is in fact the actual result. The team's detection index (CPA method) was 332 meters and the subject's detection index was 401 meters.

Day time Experiment – Clue Detection

The clue detection experiment only took place during the day. The original intent was to conduct the clue detection experiment at night. Therefore, the clues were placed (using IDEA to determine the locations) the previous day. A total of 12 orange gloves were placed, 11 gray gloves, and 1 white glove (placed on snow). Out of the 15 teams that turned in a detection log only 12 completed the log in such a way it was possible to score the clues.

The last team (team 14) consisted of one of the officers who had help setup the course. He had specific knowledge about the white glove. Therefore, that particular glove from team 14 was thrown out. The range of POD% for the orange glove was 92% - 100%. The range of POD% for the low-visibility gloves was 25% - 83%. The results are summarized in table 4.

Night time Experiment – Subject Detection Light Experiment Results

In addition to the whistle blast, teams were using sound-light line tactics. Therefore, the subject also had the potential to detect the teams light. Subject's were instructed to only respond to whistle blast, but also to record when they detected light. The technique for scoring was the same method to use to determine which whistle blast matched a particular team. The detection index for subject's detecting light was 277 meters.

Predicted versus actual detections.

As part of the debriefing process, each searcher was asked to give what percentage of the potential targets did they detect? This is similar to a typical debriefing question asked on many searchers in order to obtain a "POD" value. Since the number of search objects were fixed and known, it is possible to determine how accurate the searchers were with their predicted POD versus the actual POD.

Parameter	Average Predicted	Range Predicted	Actual % Detected	Offset
Sound (Day)	29%	0-90%	33%	± 18%
Sound (Night)	38%	5-75%	59%	± 23%
Orange Glove	84%	60-100%	99%	± 21%
Gray Glove	68%	10-100%	53%	± 37%

Table 2 Searcher ability to predict Probability of Detection (POD)

Overall Summary Experiment Results

The table below provides an overall summary of both day and night experiments.

Detection Type	Method	Day Experiment ESW	Night Experiment ESW
Searchers detecting subject shouts	CPA	332 m	306 m
Searchers detecting subject shouts	Cone	276 m	262 m
Subject hearing searchers' whistle	CPA	401 m	395 m
Subject seeing searchers' light	CPA	NA	277 m
Subject detecting searchers (light or sound)	CPA	401 m	460 m

Table 3 Summary of ESW results

The Probability of Detection (POD) for a glove on the actual track during daylight.

	Number	Detection Opportunities	Average POD%	Average POD%
Orange Glove	12	144	99%	99%
Gray Glove	11	132	57%	52%
White Glove	1	11	0%	

Table 4 Summary of detection results for clue on track

Discussion

The experimental methodology was built upon the solid foundation of previous visual experiments to determine land-based detection indexes. The design and methodology of the visual experiments were in turn based upon maritime experiments conducted by the US Coast Guard Research and Development center. Key concepts such as detection opportunities, scoring each detection and non-detection, closest point of approach, looking at and for correction factors, generating lateral range curves, and using the cross-over technique to generate the actual detection index value have all been previously validated by Koester et al (2004).

The fundamental issue with sound and light detection is the two-way nature of the detection. It requires two cooperating elements that wish to find each other. The searcher desires to detect the search subject and the search subject wishes to be found. The search team sends out an initial signal (sound and/or light) and the subject must first detect the signal; recognize it for what it represents, and then respond in some fashion. Based upon conversations with SARINZ instructors it was determined the most common signal generated by search teams is a whistle blast. Then depending upon the subject type and scenario teams will sometimes augment the whistle blast by shouting the subject's name. It was then stated that approximately 90% of the time the response is a shout from the subject. Therefore, from an experimental point of view the ideal "search object" would be one that could recognize a whistle blast and then respond with a human voice. It was felt a human voice would be important since human sensory and processing systems are ideally suited to recognize a human voice across many different frequencies and hidden in background noise (Lewis et al, 2009). It was also felt the reply voice should be a short discrete signal and not a constant noise to aid in the detection of the voice. Therefore, it was decided that by using actual humans as the search subjects a detection index which actually reflects reality most closely would be obtained. More importantly, in the real world subjects don't know when they will hear a shout. The experiment methodology ensured that search subjects were un-alerted. In other words, they did not know when a team would whistle. In return, search teams were also un-alerted, since they had no idea when they would hear a reply. Future experiments should continue to use actual subjects.

While this first auditory two-way land detection experiment resulted in several key findings, the results should be viewed as preliminary and not definitive. The experiment clearly showed it was possible to obtain a detection index for sound and/or light line tactics. Furthermore, the fact that the closest point of approach method (with 115 detection opportunities) and the cone method (with 1327 detection opportunities) provided similar results indicates experiments with approximately 100 detection opportunities can be conducted. This is further bolstered by the fact that the day and night experiments resulted in a team detection index of 332 and 306 meters respectively, a difference of only 8%. The difference for the subjects hearing the whistle was only 1%.

This experiment was the first reported experiment of detection of light in a realistic search environment. Since the experiments took place in a forested area in mountainous terrain, it is expected that distances would be small. In fact, the detection index for a subject detecting the light was 277 meters. It is interesting to note that the detection index for light appeared to be independent of the detection index for sound. In some cases the subject detected the light without detecting the sound. In other cases a subject detected the sound without detecting the light. This means the overall probability of making some type of detection increases. Therefore, the detection index (ESW) for a subject detecting a team increased to 460 meters (when both sound and light were considered. It is important to realize that the detection index is not the maximum range of a possible detection but instead is either the area under the lateral range curve or the distance where the number of missed detections equals the number of detections. Depending upon conditions, it is expected that the detection index for light would be large.

While no previous studies generated a detection index for un-alerted searchers, the maximum ranges provided by other experiments do provide some insight. A previous test of several different whistle types conducted in New Zealand (B Were, personal communication, 2006) showed for the loudest whistle the maximum range was between 300 to 500 meters depending upon the conditions, compared to our results of a detection index of 400 meters for a subject detecting a whistle. After taking into account differences between alerted and un-alerted searchers, different whistle types, and the left/right nature of a detection index, the results are somewhat comparable. The first classic sound study was conducted in Canada (Coldwell, 1989). This study was conducted under more search-like conditions. The study results were reported as a lateral range curve. Using the cross-over technique found in IDEA it is possible to convert a lateral range curve into a detection index. This gives a detection index of 313 meters. The Canadian experiments were conducted in a Pacific West Coast coniferous forest. Manson (2009) also carried out a sound experiment in the Pacific West Coast coniferous forest in a recent study. This study reported both maximum and minimum attention ranges. The minimum attention getting range was a subjective measurement determined by the searcher. Depending upon the whistle type and season this ranged from 200 to 400 meters for alerted searchers. While maximum ranges do not convert to an ESW value the general range is similar.

One important finding of this paper was the observation that in many cases the subject detected the search team without the searchers detecting the subject. The experiment protocol was for a single verbal reply and for the subjects to stay in one place. In reality a missing person would most likely try to move towards the team and shout multiple times. Operationally teams would be well advised to make sure they spend sufficient time listening for a response. Those venturing into the woods are also well advised to carry a whistle and light source.

One challenge of this research was to adapt the specifics of experimental design and analysis for the specifics of sound-light line and sweep. This required direct observation of the techniques being taught and conducted by actual practitioners in the appropriate environment. This was accomplished by conducting and attending field trials, refresher courses, and field demonstrations prior to establishing the methodology. In addition, extensive conversations were conducted with knowledgeable searchers, including and going beyond the SARINZ instructor pool. This allowed for the development of the specific methodology.

The changes in methodology from previous visual methods included; marked cones every 100 meters, a modified AMDR procedure, use of trained searchers as the search subjects, use of un-alerted subjects and searchers, clear difference in signals generated by searcher and subject, creation of detection log, and measuring wind speeds at every detection opportunity. These changes were viewed as successful. In fact, this was the first auditory detection experiment where both the subjects and searchers were not alerted. As a result it was possible to document cases where the subject heard the search team, but the search team did not hear the response.

Previous visual experiments had used data collectors that were not part of the experiment staff. These “volunteer” data collectors often collected more data than needed (making scoring a little bit more difficult) but fortunately seldom left out critical information. This was the case with the sound-light experiments. All of the data collectors were searchers themselves. Almost all of the searchers successfully completed the data collection log. Only one team neglected to record the time at each cone. While the team’s detections were logged, it was impossible to score the team for subject’s hearing the team. This problem could easily be remedied by spot checking the logs early on in the track by a member of the experiment staff. Using searchers as data collectors was a success overall.

As a “pilot” experiment several important factors have been identified that could improve future experiments. Two key variables were not controlled. Searchers were allowed to use whatever whistle and torch (flashlight) they normally used. It was noted anecdotally that the type of whistle and torch did make a significant difference in detections. This is well worth further experimentation. Some other sources of improvement include; conducting experiments in different terrain (such as flat terrain, valley bottom, etc.), conduct experiments in different types of vegetation or times of the year, conduct experiment to quantify potential correction factors (wind, background noise, precipitation, temperature, hearing loss, etc.), better measure participants hearing ability, record AMDR values for auditory, whistle, and torches, update IDEA, issue radios to all subjects and obtain location coordinates immediately, create a subject debriefing form, use synchronized time (available from GPS receivers), use GIS software for measurements versus Google Earth, and have staff spot check detection logs early in the experiment.

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