ERGONOMIC EVALUATION OF VISUAL GUIDANCE AIDS FOR AGRICULTURAL MACHINES

BY

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ABSTRACT

A variety of guidance aids for agricultural machines are available on the market. The visual guidance aid is considered to be the most useful tool for further development. Currently, the main concerns with using the visual guidance aid are the placement of the camera and the driver mental workload caused by the introduction of another monitor into the tractor cab. The objectives for this thesis, therefore, were to determine the optimum placement of a video camera to minimize lateral error and to determine a relationship between lateral error and driver mental workload. To achieve these goals, an experiment was conducted in the field with a visual guidance aid. Two measurements, lateral error and driver subjective scores, were recorded and later analyzed. Based on results of both lateral error and subjective scores, it was concluded that, to achieve a lateral error less than 200 mm, a guidance camera should be placed 1.5 m above the ground and tilted downward at 30°. Furthermore, a camera with a 20° lateral field of view is more appropriate than a camera with a 39° lateral field of view.

To explain the relationship between driver mental workload and lateral error, two concepts, lateral ratio and image velocity were defined based on geometric relationships. Two hypotheses were proposed based on the experimental results. First, it was hypothesized that the driver mental workload would increase as image velocity increased. Second, it was hypothesized that the magnitude of lateral errors would increase as the lateral ratio increased. Because the image velocity is inversely proportional to the lateral ratio, it may be necessary to find a compromise between driver mental workload and the

lateral error. In other words, to achieve a reasonable lateral error, a driver must tolerate a certain workload.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION

As modern agricultural implements become larger, guidance error in field operations becomes a greater concern for farmers. With large implements, it is difficult for a human driver to guide a tractor along a path in the field without producing lateral offset (i.e., guidance error). As early as 1959, Richey stated that "the growing size and complexity of modern field machines has taxed the ability of the operator to accurately guide the tractor and simultaneously watch the action of the machine for proper functioning." Guidance errors are of two types: skipping and overlapping (Hanson 1998). When a portion of the implement passes over the previously-travelled path, this is called "overlapping" guidance error (Fig. 1.1). If the implement leaves a strip between the new path and the previously-travelled path, this is called "skipping" guidance error.

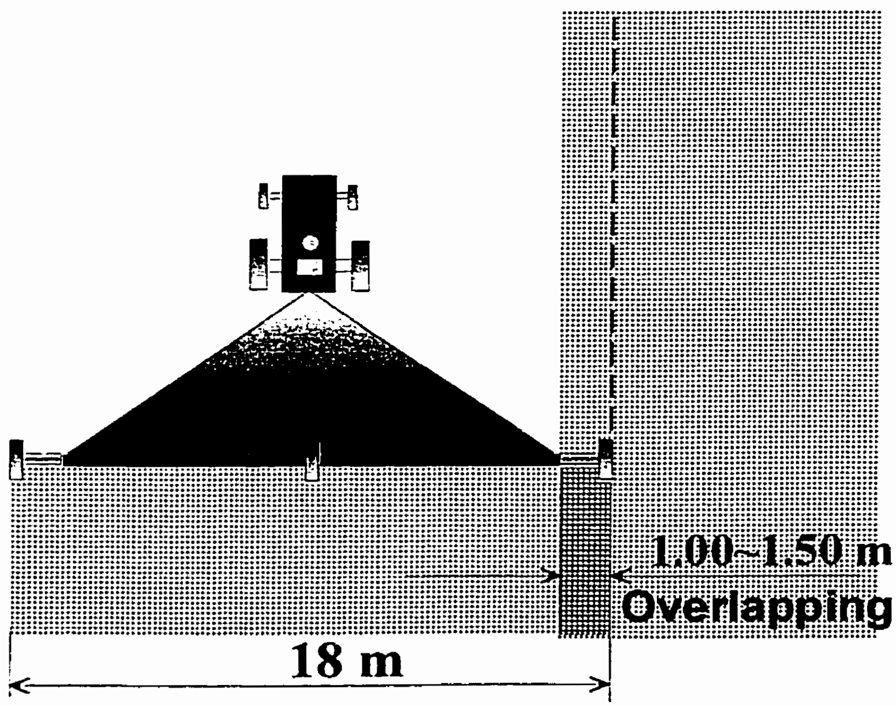

Fig. 1.1 Schematic diagram of an agricultural implement with overlapping operation

Farmers generally consider that double application (overlapping) is better than no application (skipping), although reduced yields can result where the crop receives a double dose of herbicide (Palmer 1989). Lateral overlap has been estimated at 10% of the implement's width (Palmer 1985). Similarly, Palmer and Matheson (1988) estimated that 10% of input resources (seed, fertilizer, chemical, fuel, labour, and equipment wear and tear) were wasted due to overlapping. Hanson (1998) argued that the waste due to overlapping is more likely to be around 7%. Even at 7% overlap, the farmer experiences a significant economic loss. There is incentive, therefore, to further reduce overlap.

The driver's workload during field operation is also a concern. To guide a tractor "precisely" along a path, a driver has to look back to view the implement and look forward to see what lies ahead of the tractor. After continuous steering and rear viewing for a long period of time, the driver readily becomes fatigued (Bartlett 1943), and the fatigue in turn adversely influences the driver's performance (Bottoms 1980). Grovum and Zoerb (1970) said that agricultural field operations are performed using parallel swathing or switchback operation in most cases. This kind of operation is repetitive and can become monotonous for the operator (Stombaugh et al. 1998).

As the functions of modern implements become more complex, the control of these implements becomes more complicated. The tasks for a modern farmer (driver) to accomplish are not only to steer the tractor, but also to concurrently perform other duties, such as monitoring a yield monitor, or varying the rate and depth of seeding. These demands increase the stress on the driver, i.e., the driver workload is increased. With this increase in workload, the driver is likely to become fatigued.

To minimize the guidance error and to alleviate the driver's workload, it is essential to analyze the causes of the guidance error and the driver's workload. Guidance error and driver workload are both caused by a combination of human and environmental factors.

A driver relies on visual information to make guidance decisions. Unfortunately, human visual acuity is finite. Because of limited vision, it is difficult for a driver to obtain visual information from a distance. If a driver is required to make guidance decisions based on distant visual information, the probability of obtaining wrong information and making an incorrect guidance decision increases.

The environmental factors that contribute to guidance error and driver workload are the size of the implement, the complexity of operating the implement, and poor visibility. To improve the working efficiency, implements are becoming larger and more complex. Poor visibility may occur when dust is produced during field operation, when drivers work during bad weather or at night, or when row crops or tillage furrows are viewed as the reference line for the coming operation.

It can be concluded that, compared with environmental factors, human factors are the predominant factors that impact on the guidance error and driver workload. Researchers and engineers, therefore, should consider how to overcome the human physiological limitations when addressing the problem of the guidance error and driver workload.

Many means have been adopted to minimize the guidance error and to reduce the driver workload. Based on the above analysis, all means can be categorized into two types: automated guidance systems and guidance aids.

With an automated guidance system, the driver's physiological limitations are completely overcome because the driver is freed of the driving task. Theoretically, this would reduce both the guidance error and the driver workload. Although many researchers have concentrated on this area since the early 1950's, such an ideal agricultural machine has not yet become commercially available because of limited operating conditions, intolerable errors, or high cost. The general-purpose automatic guidance of agricultural machinery is still in an early stage of development.

With a guidance aid, the driver's physiological limitations are partially overcome. Specifically, a guidance aid is designed to overcome the limitations of the driver's vision. The main purpose of the guidance aid, however, is to minimize the guidance error. The driver's workload still exists and additional workload may occur when the guidance aid is used.

2. LITERATURE REVIEW

2.1 Distinction between a guidance system and a navigation system

Because the terms "navigation" and "guidance" are both used in the literature, it is necessary to clarify the meanings of the two terms. The systems used in transportation (by land, water, and air) and military affairs may be properly called "navigation systems," while the systems used in industry and agriculture may be properly called "guidance systems."

A navigation system is "target-oriented." Its main function is to guide an object to its destination. The precision required for such a system is relatively low. For instance, the precision of a navigation system for an aircraft may be approximately 10 m when the aircraft is flying along its path in the air. Unlike a navigation system, a guidance system is "path-oriented." The main function of a guidance system is to guide an object precisely along a specific path. The precision required for such a system is relatively high. For example, the precision of a guidance system for an agricultural machine may be approximately 100 mm during field operation.

2.2 Automated guidance system (AGS)

2.2.1 History of the AGS in industry

With an automated guidance system (AGS), a vehicle is called an "automatically guided vehicle" (AGV). AGVs were developed to improve the productivity of industry by automating production. In the early stages, the AGV was mainly used in distribution applications in factories (Hammond 1986).

The first AGVs were developed in the United States by Barrett Electronics in the early 1950s (Hammond 1986). The first system was installed in 1954 at Mercury Motor Freight in Columbia, SC. It was a tugger system, following a wire guidance path, with a controller using vacuum tube technology.

Many factors hindered the early growth of the AGV industry at that time. For example, the controllers were bulky and had very limited capabilities. During the 1960s and early 1970s the controllers were first transistorized and then replaced by integrated circuit (IC) technology. This technology made more compact controllers with more computing power possible. But even with this improvement in the electronics on board, it was still very expensive for solving the complex manufacturing and material-handling problems experienced in industry. Thus, during this period, only a few tugger and pallet truck systems were installed in distribution applications.

2.2.2 Definition of an AGS for agricultural machines

There is no standard definition of an AGS for agricultural machines. An AGS for agricultural machines should have the following functional features: (1) compatibility with regular power steering; (2) easy changeover from automated to manual control for turning and centering on the row; (3) no reduction in field speeds compared with manual steering; (4) adaptable to the majority of field operations; and (5) simplicity, ruggedness, and an economic price (Richey 1959; Schoenfisch and Billingsley 1998).

An AGS includes a positioning system, an error detection system, and a correction system (Machardy 1967; Stombaugh et al. 1998). Tillett (1991) and Noguchi et al. (1997) argued that an AGS usually consists of only two components: a control component and a guidance component. Automated guidance of an agricultural machine is achieved by the control component using the information provided by the guidance component.

In this thesis, the guidance component of an AGS for agricultural machines is still called an *AGS*; the control component is called a control system. The focus of the thesis is on the guidance system.

2.2.3 Technologies used in AGSs

2.2.3.1 Leader cables As mentioned previously, leader cables have been used for guidance of vehicles in industry for several decades. Schoenfisch and Billingsley (1998) stated that a wire guidance system involves first burying a wire under the ground, exciting it with an electric current (typically 150 mA and 2 kHz) (Tillett 1991), and then detecting the position of the magnetic field produced using transducers mounted on the moving vehicle. Signals produced by the transducers are used to control the hydraulic steering thereby keeping the tractor on the desired path. Tillett (1991) described different transducers such as a vertical sensing coil, a balanced pair of horizontal coils, and "off wire" guidance.

The main feature of leader cable guidance is that the wire is buried and fixed along a certain path. This feature limits its widespread application in agriculture although its guidance accuracy is adequate (Gerrish and Surbrook 1983; Tillett 1991). The high cost and maintenance (e.g., repairing rodent damage) are the other shortcomings of this technology (Tillett 1991; Schoenfisch and Billingsley 1998). Although some researchers (Schafer and Young 1979; Young et al. 1983) have successfully developed an automatically steered tractor guided by a buried wire (Wilton 1989), there is no commercial product for agriculture currently on the market.

2.2.3.2 Ultrasonic technology Ultrasonic transducers were originally developed for use in automatically focusing cameras. This technology shows considerable potential as a means of providing a non-contact method of controlling the tractor's position (Wilton 1989). Distances ranging from 100 mm to 10 m can be measured by an ultrasonic transducer with an accuracy of 99% (Tillett 1991). The ultrasonic transducer works like an echo sounder. The distance is measured by calculating the time taken for an ultrasonic signal to reach and be reflected back from a target. Although the signal transmitted by the ultrasonic transducer may be reflected back from a number of objects within its field of view, only the nearest is recorded.

Inadequate reflection of an ultrasonic signal from soil led Warner and Monod (1972) to abandon this technology for detecting a plough furrow. Bonicelli and Monod (1987) utilized an ultrasonic transducer to guide their ploughing robot, but its accuracy and reliability are not reported. McMahon et al. (1982) adopted this technology to measure the position of apple tree trunks to guide a harvesting vehicle. Patterson et al. (1985) used two ultrasonic sensors straddling a row of transplants to guide a planter. Schoenfisch and Billingsley (1998) developed an ultrasonic guidance system to determine the position of an agricultural machine in relation to crop rows.

The limitation is that some materials such as plant leaves absorb the ultrasonic signals so that the transducer detects the soil row behind the plant instead of the plant itself (Schoenfisch and Billingsley 1998).

2.2.3.3 Laser Lawson (1985) described a laser guidance system for a tractor. A fixed laser beam is projected in the direction of travel from the headland. To determine displacement from the desired path, a row of detectors mounted on the vehicle is arranged perpendicular to the laser beam. The limitation is that this system can only operate in a field where the line of sight is unbroken (i.e., this system is not suitable for a field with obstructions such as trees or deep valleys). Another laser guidance system developed by Shmulevich et al. (1987) has a similar weakness, although the accuracy (0.15 m) of the system is acceptable.

Zuydam and Sonneveld (1994) developed a field-bound laser guidance system. A laser transmitter positioned at the end of the field is used to emit a laser beam rotating on a vertical plane. A laser receiver is mounted on a vehicle. The center of the laser receiver is over the center of one of the wheel tracks. When the vehicle, together with the implement, drifts away from its desired lateral position, the laser receiver is no longer hit in the center (the deadband) of its receiving window (sensor), and a signal is generated to activate the hydraulic cylinder via an electro-hydraulic valve to move towards the appropriate side. With a properly designed guidance system, an average steering accuracy of ±6 mm was obtained over a trajectory of 250 m. The maximum deviation did not exceed 19 mm. The weakness for this design is that the transmitter must be repositioned for each pass of the implement. This job requires two people to complete.

Laser guidance is most commonly used in drainage machines (Studebaker 1971). A horizontal plane is used to get an accurate depth reference at any position within the sight of the laser source. The limitation of this system is that it provides guidance in only one dimension.

2.2.3.4 Radio Radio techniques are widely used in navigation for aircraft and boats because radio can cover a wide area and requires only a few beacons. Because the accuracy of a radio navigation system is as low as 100 m (Tillett 1991), it is difficult for people to directly use this system to guide agricultural machines. However, researchers still tried to develop guidance systems using this technology.

Palmer and Fischer (1989) developed a guidance system for determining a position of a vehicle using AM radio waves. A pair of active reflectors return signals transmitted by the mobile unit in phase at the reflectors, after compensating for interval circuit delay. The mobile unit compares the phases and determines mutual distances and thus its position. The accuracy of this system was less than 50 mm. An obstacle in the field could be bypassed if its position information was previously programmed. The cost for setting up and running such a system was not mentioned although it was precise enough for guiding an agricultural machine during field operations.

Choi et al. (1990) stated that a small scale radio-navigation system, AGNAV (D & N Micro Products Inc. IA, USA), is used to determine the locations of the tractor front wheels and of the implement. The AGNAV provides position data, in the form of x-y co-ordinates, and can be easily interfaced to a microcomputer. The AGNAV system consists of a computer-transceiver and two repeaters. The computer-transceiver generates and transmits VHF radio signals (154.565-154.605 MHz) to the repeaters, which return the signals to the computer-transceiver. The tractor location relative to the repeater locations is determined. Position measurements with the AGNAV have errors of up to 500 mm. For a guidance system with one AGNAV unit, more than 75% of the absolute errors of a tractor-mounted implement from the desired path are less than 500 mm.

2.2.3.5 Geomagnetic Direction Sensor (GDS) Benson et al. (1998) reported the utilization of a geomagnetic direction sensor (GDS) in the design of an AGS. A compass is a simple magnetometer. The slightly more complicated fluxgate magnetometer uses two oppositely wound coils to detect a magnetic field. Originally developed during the 1930's, the fluxgate magnetometer became important during World War II as a means of detecting submerged submarines (Vacquier et al. 1947). For each direction measured, two solenoids are wound in opposite directions around a high permeability core and connected in series to an alternating current. As the magnetic flux in the core changes, a voltage is induced. When two coils are combined and driven in opposing directions in the absence of an external magnetic field, the induced voltage is cancelled out. In the presence of an external magnetic field parallel to the detector, the flux through the two coils will not be balanced.

Grovum and Zoerb (1970) used a directional gyroscope to provide heading information, noting that magnetic compasses tended to have poor damping qualities. Gyroscopes tend to drift with time (0.3-1.5 degrees per minute) and need to be periodically re-aligned. Noguchi et al. (1997) used a GDS to provide heading information for a tillage robot.

Electrical sources are a potential source of localized disturbances in the electromagnetic field around an object. Two major potential sources of magnetic interference were the tractor heater/air-conditioner fan and a nearby set of high-tension electrical wires (Noguchi et al. 1997). As a result, the tractor air conditioner had a significant effect on the average indicated heading.

2.2.3.6 Global Positioning System (GPS) The global positioning system (GPS) is a space-based triangulation system using satellites and computers to measure positions anywhere on earth. It was originally developed by the US Department of Defense for military purposes in 1978 (Anonymous 1997a). At the beginning of the 1990s, GPS technology became available for civilian purposes. The GPS consists of 24 satellites, constellated in space, which are approximately 20200 km above the earth. The GPS signals are available on any place of the earth, at any given time, and for any climate. Theoretically, to locate a point on the earth, three satellites are required for triangulation. In reality, four satellites are used to pinpoint a location on the earth. To increase measurement accuracy, differential GPS (DGPS) technology is utilized (Anonymous 1997a).

Because of the spatial-positioning features of GPS technology, agricultural engineers and researchers began to adopt this technology to guide agricultural machines when it became available for civilian use (Tillett 1991). Several studies have explored the use of GPS technology for AGSs. Stombaugh et al. (1998) utilized a 5 Hz real-time kinematic GPS for guidance of a tractor. Straight-line tests of vehicle response showed that the lateral position error at 4.5 m/s was within 16 cm (95% confidence). O'Conner et al. (1996) successfully developed a GPS system for guiding a tractor on a prescribed straight row course with headland turns. Four GPS sensors were mounted on the cab and the receiver produced attitude measurements at 10 Hz. The closed-loop heading response was better than 1° and the standard deviation for line tracking was smaller than 2.5 cm. Williams (1999) reported that GPS guidance systems are being used to guide fertilizer spreader, sprayer, and tillage operations.

There are many advantages in using GPS technology to develop AGSs for agricultural machines, however, there are some weaknesses in using this technology. The first is its low accuracy and high cost. Hopefully, this weakness can be overcome with the development of science and technology (Reid 1998). Another main concern with the commercial use of GPS is the control of the satellites by the American government. In a military crisis, the use of the satellites may not be possible (Ellenrieder 1996). In addition, GPS is able to "know" where you are, but GPS is not able to "see" where you are going, i.e., GPS can provide global information, but cannot provide local information.

2.2.3.7 Machine/Computer vision The basic idea of using machine vision to guide agricultural machines is that a video camera can mimic the look-ahead capability of the human operator (Fehr and Gerrish 1995).

Gerrish et al. (1997) described an AGS using machine vision. A control point located in the image was used as a reference to determine the angle to which the front steering wheels should be turned. The control point is the intersection of the target line (the crop row or edge) with a horizontal line in the image corresponding to the look-ahead distance, typically 2.03 m ahead of the front axle. The centerline is a vertical row of pixels in the image. If the control point appears directly over the centerline, no steering correction is required. When the control point "wanders" to the right or left of the centerline, the deviation (measured in pixels) is used to calculate the proper steering response. With a steering gain of 1.0, the front wheels are then aimed directly at the control point's real-world location. For stable automated control, the steering angle deadband was set at 4° (i.e., aiming errors of less than 2° are ignored).

Machine vision technologies have been investigated to guide agricultural machines in various field operations, including weed control (Giles and Slaughter 1997), and row crop cultivation (Reid and Searcy 1988; Fehr and Gerrish 1995; Schoenfisch and Billingsley 1998; Tillett and Hague 1999; Pinto et al. 2000).

Fehr and Gerrish (1995) reported that the major problem with a vision-guided robotic tractor in an actual field setting was the response of the video camera to sunlight. Under direct sunlight the camera's ability to resolve the difference between green corn plants and brown dirt was greatly reduced. The severity of this problem can be reduced by placing optical filters on the camera. Another problem was the camera's slow response to a rapid change in light level, for example, when a cloud passes overhead. Another limitation of using machine vision, which is opposite to GPS technology, is that, machine vision is able to "see" where you are going, but not able to "know" where you are. In other words, machine vision can provide local information, but cannot provide global information.

2.2.3.8 Sensor fusion Benson et al. (1998) addressed the possibility of combining several guidance system technologies to avoid individual limitations. For instance, a Geomagnetic Direction Sensor (GDS) combined with velocity information can supply dead reckoned position information between GPS updates, allowing the user to operate with a slower and less expensive receiver. The average error (<10 mm) for combination of GPS and GDS was less than the accuracy of the GPS (200 mm) (Benson et al. 1998). GDS, therefore, can increase the effectiveness of the other sensors on the vehicle. Another example is that machine vision can provide the heading information relative to field characteristics, but not a global orientation. GPS can provide the global orientation, but not the instantaneous orientation of the vehicle relative to the field. Machine vision and GPS, therefore, would complement each other.

Combining different guidance technologies seems to be an ideal way to develop an AGS. The question is how to properly trade-off the contradictions among these technologies when they provide different guidance information.

2.2.4 Comparison of technologies used in AGSs

Benson et al. (1998) argued that each of the technologies in AGSs has both strengths and limitations. Field-based systems, such as leader cable, are accurate, but their range is limited and they are too expensive to install (Tillett 1991). Satellite-based systems, such as GPS and radio, cannot provide information about the local environment. Machine vision can provide relative local information, but not global information.

Compared with other technologies, however, GPS and machine vision, seem to have the most potential. First, GPS can provide the basic information required by the control component of an AGS, including heading angle and lateral error. Second, because GPS can provide global information, it does not require any prerequisite conditions (e.g., row crops or furrows as reference frames). In other words, it can work for any field conditions for field operations such as tillage, seeding, cultivating, spraying, fertilizing, and harvesting.

Because of its ability to mimic human beings' vision, the machine vision is able to see the local environment (i.e., obstacles) in addition to providing the heading angle and lateral error to the control system. This feature is a critical element of an AGS for agricultural machines.

2.2.5 Limitations of AGSs

Although it seems necessary to develop AGSs as agricultural machines become larger and more complex, there are reasons to proceed with caution. As early as 1959, Richey claimed that automated guidance would not totally remove the operator from the control loop because field conditions are complex and continually changing. Furthermore, Liljedahl and Strait (1962) argued that, although advanced automated control equipment will become available, it will be too expensive to use on a tractor. After several decades of the development of the AGSs, Johnson et al. (1983) and Tillett (1991) drew similar conclusions, even though many new and powerful technologies, such as GPS and machine vision, have emerged during this period of time. In addition, AGSs for agricultural machines have to face the technical problems which are associated with the extensive and unregulated nature of the agricultural environment.

The history of the development of the AGS shows that the most probable short-term solution is to develop guidance aids instead of AGSs. The experiences obtained in developing guidance aids could provide useful guidelines for further development of AGSs.

2.3 Guidance aids

2.3.1 Definition of a guidance aid

Unlike an AGS, a guidance aid is used to aid a human driver to precisely guide his or her agricultural machine during a field operation. Guidance aids such as field markers, flags, stakes, and fence posts, have been used by farmers for decades. As early as the time of seeders drawn by horses, farmers used a guidance aid, the field marker, to guide a seeder to prevent overlapping and skipping in the seeding operation (Fig. 2.1). The limitations for these guidance aids are obvious, such as low efficiency, large error, and limited scope. To meet the requirements of the modern agricultural machines with larger size and higher speed, many new guidance aids such as tramlines, Kleen sight position indicators, foam markers, mechanical markers, GPS lightbars, and visual guidance aids, have been developed and manufactured. Unfortunately, there are few researchers involved in this area of research even though farmers are interested in guidance aids and call for the development of these technologies (Anonymous 1999a). In the following sections, several guidance aids are discussed.

2.3.2 Mechanical marker

A mechanical marker consists of a mechanical arm and a disc. Typically, its length is equal to half of the width of the guided implement. The mechanical arm holds a disc which is used to cut the soil. With the implement going forward, the cut will form a line which should be in the centerline of the tractor when making the next pass. To work properly, the mechanical marker is required to have a low profile, be compact, but still have the capability of reaching out and marking great distances. Mechanical markers are mainly used for guidance of tillage and planting or seeding implements (Fig. 2.2).

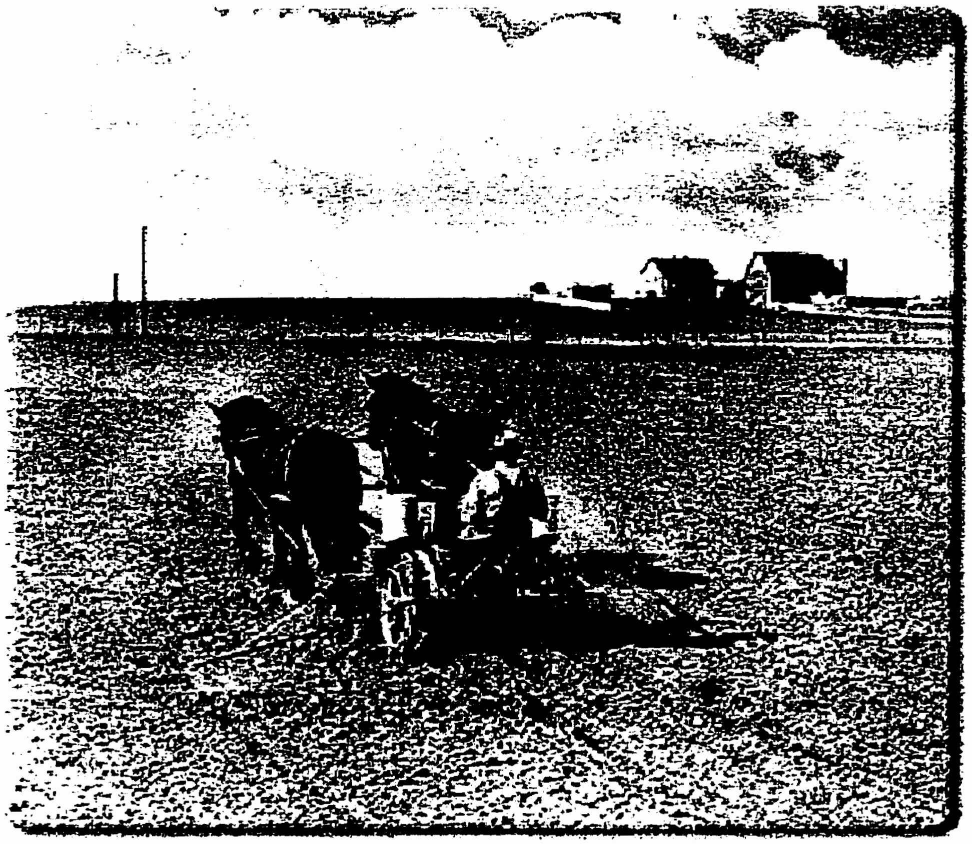

Fig. 2.1 Primitive mechanical marker used to guide a horse-drawn seeder (Anonymous 1999a)

2.3.3 Kleen sight

Kleen sight (Grayson Innovators, Laurier, MB) consists of a moveable pointer which is mounted on either the right or left side of the windshield of an agricultural machine. With the operator in his or her most comfortable sitting position, the pointer is set so that the line of sight past the pointer aligns with the line being followed. As long as the operator keeps his or her sight line passing through the pointer and the predetermined line, such as a crop row or a previous path, the agricultural machine will go parallel to that line.

Fig. 2.2 Modern mechanical marker (Anonymous 1999a).

Kleen sight is probably the cheapest guidance aid on the current market (its cost was less than $30 in January 2000), however, the accuracy of the Kleen sight guidance aid is lower than that of other guidance aids (Anonymous 1999b).

2.3.4 Tramlines

Tramlines are made with tramming units that mount on a seed tube when seeding. As the seeder goes down the field, the tramming units shut off the appropriate seed runs. As the crop matures, the unseeded rows form the tramlines (Fig. 2.3). One prerequisite for making tramlines is that the farmer must have an efficient marking system with his or her seeder. Accurate seeding is essential to making straight tramlines. To use tramlines, farmers have to know the wheel width, tire spacing and boom length of their sprayers, and the length and row spacing of their seeder (Anonymous 1998). One weakness of this technique is that the farmer loses production in the tramlines. Tramlines are suitable for cereal crop and oilseed producers.

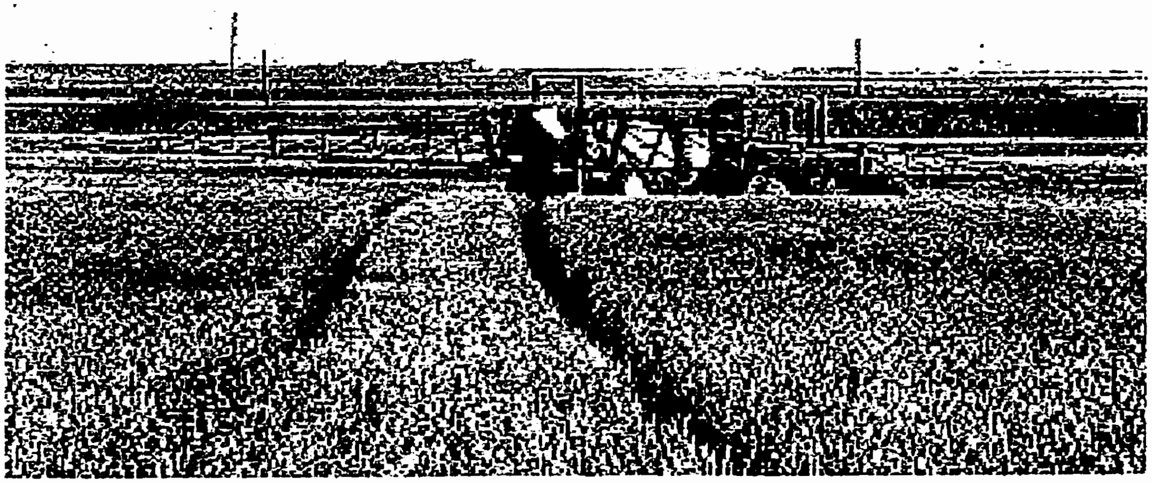

Fig. 2.3 Tramlines formed in a wheat field (Anonymous 1998)

2.3.5 Foam Marker

Foam is generated when air and soap solutions are combined. A low mixing pressure at the tank and a minimal pressure drop at discharge are the essential requirements to produce a thick, dry, stable, and long-lasting foam with small bubbles (Anonymous 1997b). In addition, a boom-mounted chamber system makes it possible to use less soap solution (Anonymous 1997b).

It is essential that the foam markers last long enough and are visible so that the farmer has enough time to complete the next pass. Foam longevity is affected by a wide range of factors such as temperature, wind, humidity, soil moisture, sunlight intensity, rain, proper mix ratio, and method of foam generation. (Anonymous 1997b). Foam can last 2 to 8 h under normal spraying conditions (Anonymous 2000). Foam markers are mainly used for spraying and fertilizing (Fig. 2.4). They could also be used for cultivating and seeding operations.

Fig. 2.4 A foam marker at the end of field sprayer (Anonymous 1997b)

2.3.6 GPS Lightbar

The GPS lightbar, which requires a GPS signal for its activation, is a bar with a series of embedded LEDs that indicate the relative position of an object within a reference frame (Fig. 2.5). The GPS lightbar works very simply. First, a farmer marks the beginning and end of the first swath. Then, when the farmer operates his or her machine on the following swath, the GPS lightbar instantaneously indicates a deviation of the machine based on the programmed width of machine and calculated position. Finally, the farmer steers the agricultural machine based on the deviation indicated by the lightbar. Usually, the GPS lightbar is mounted on the dashboard or ceiling of cabs. The accuracy of this guidance aid is relatively low due to two error sources: GPS receiver error (related to the GPS signal, precision of the GPS receiver) and application error (the difference between the actual position and the calculated position by GPS). The advantage of using the GPS lightbar as a guidance aid is that this system can work under any condition – day or night, dust or fog, wind or rain – allowing farmers to extend hours for chemical spraying, lime and fertilizer application, tilling, and seed bed preparation (Anonymous 1997).

Fig. 2.5 GPS lightbar (Anonymous 1997)

2.3.7 Visual guidance aid

A visual guidance aid usually consists of a camera attached to the end of an implement and a monitor mounted in the cab of an agricultural vehicle. The view seen by the camera and concurrently displayed by the monitor is called "visual information." The line being followed may be called "visual guidance information." It is assumed that, with proper visual guidance information, a driver will be able to precisely guide a tractor during field operations. Because visual guidance aids, such as the CAMTRAK electronic field position indicator (Excel Innovations Ltd., Martensville, SK), recently emerged on the market, little research has been done in this area. The issues related to visual guidance aids will be discussed in detail in the next section.

2.3.8 Advantages of visual guidance aids

As noted previously, the purpose of the guidance aid is to minimize the guidance error by extending the human driver's limited vision. In other words, a guidance aid must be able to provide visual guidance information (local information) to a driver. Mechanical markers and foam markers do provide visual information to the driver, but they do not bring the information into the cab. Rather than forcing a driver to obtain guidance information from the external environment, often far from the driver's seated position, a visual guidance aid brings the guidance information into the cab where it is readily visible to the driver.

2.3.9 Concerns with the use of visual guidance aids

As discussed previously, the visual guidance aid can offer the driver real-time visual guidance information. The quality of the visual information depends on the field of view of the camera and the subsequent placement (height and tilt angle) of the camera. Ultimately, the guidance error will be influenced by the positioning of the camera.

According to Gerrish and Surbrook (1983), the camera should be above and behind the tool, but in line with both the tool and the desired trajectory. Gerrish and Surbrook (1983) further state that the visual information should be displayed with the tool being visible in the middle of the lower edge of the uninverted image.

For an AGS, Fehr and Gerrish (1995) suggested that the camera should look ahead a distance of 1.5 m and provide eight position updates per second. In later work, Gerrish et al. (1997) talk of a look-ahead distance of 2 m ahead of the front axle. Similarly, Slaughter et al. (1997) argued that the tilt angle of the camera should be set so that the field of view includes approximately 2 m of crop row. Contrary to the previous references, Hanson (1998) stated that the field of view of the camera should extend about 10 m ahead of implement so that the recorded video data would have a "forward looking" character.

Reid and Searcy (1988) suggested that the camera be mounted on the front hood of the tractor, parallel to the longitudinal axis, and tilted slightly downward from horizontal 10 to 15°. Gerrish et al. (1997) reported that the camera was aimed forward and downward at 15° below the horizon such that no part of the front of the tractor was in its field of view. When the zoom-angle was properly set, the optical cone angles were 20.2° in the lateral direction and 16.8° in the forward direction. Finally, the installation instructions for the CAMTRAK system state that the guidance camera should be tilted 5 to 10° below the horizon.

The most recent research has focused on camera placement. Tillett and Hague (1999) reported that the camera should be placed approximately 1.25 m above ground and at an angle of 45° to the horizontal. Pinto et al. (2000) indicated that a camera should be placed 0.8 m above ground and tilted at an angle of 15°. Unfortunately, the field of view of the camera was not reported.

The visual information used by an AGS with computer vision may not meet the demands of the human driver. It is speculated that an AGS can function adequately with a limited forward field of view because a computer can perform thousands of calculations per second. The computer, therefore, can respond to rapidly changing conditions. A human driver, on the other hand, will become fatigued if rapid steering adjustments are required. The driver will prefer to look far ahead of the vehicle so that future steering maneuvers can be anticipated. Therefore, it is necessary to investigate the optimal field of view for a human driver using a visual guidance aid.

When using a visual guidance aid, the driver must face another important issue, the mental workload caused by the driver interface (the monitor). With poor quality of visual guidance information or improper display of the information, the driver workload will increase, which in turn, will further increase guidance error. The next section will discuss the related issues.

2.4 Driver mental workload

2.4.1 Definition of mental workload

Several definitions of mental workload have been proposed (Hart 1985; Kantowitz 1985). Most researchers view mental workload as a multidimensional interaction of task and system demands, operator capabilities and effort, subjective performance criteria, and operator training and experience (Eggemeier and O'Donnell 1982). In one sense, mental workload is an expression of the demand that a task places on an individual and the individual's capacity to meet this demand and produce an acceptable level of performance.

The concepts of stress and strain, as used to represent the properties of materials or human physiological responses to physical workload, provide a good analogy for defining mental workload. Task demands and the operating environment determine the level of stress. The impact on the particular individual represents the strain and is reflected in task performance and other measures. Thus, the same level of stress does not result in the same amount of strain for all drivers. The level of mental workload impacts the amount and strategic allocation of resources invested by the operator to achieve an acceptable level of performance (Stokes et al. 1990). Thus, mental workload reflects how "busy" the driver is and how much attention the driving task requires (Schlegel 1993).

2.4.2 Workload assessment

A major implication of the numerous definitions is that no single measurement technique will provide a comprehensive means for the assessment of workload in every situation (Schlegel 1993). Research on the nature of human information processing capacity has generated a variety of proposed workload measures in the following categories: performance and behavioral measures, subjective measures, and physiological or biocybernetic measures.

Performance measures include primary task measures and secondary task measures. Primary task measures quantify overall system performance and describe performance characteristics of the task whose workload is being measured. Increases in the difficulty of the task are expected to increase the level of workload and thereby decrease performance. For example, changes in traffic conditions, driver fatigue, or lane width might be reflected in driver performance measures such as side-to-side weaving (lateral standard deviation), the root mean square (RMS) distance from the lane center, or the rate of steering wheel reversals (Hicks and Wierwille 1979). Problems with these measures include the difficulty of making comparisons across tasks and of identifying what task difficulty really does to workload (Wickens 1990). More importantly, human beings are able to adapt to increased task demands by investing more resources, and thus performance does not always worsen. By the time mental workload is at a level where a performance decline is evident, catastrophic results may occur.

Secondary task measures estimate mental workload by measuring the performance change on an additional well-defined and controlled task performed simultaneously with the primary task. A large performance decrease for the secondary task indicates high resource requirements for the primary task (Brown 1978; Ogden et al. 1979; Knowles 1963). For example, a digit detection task has been used to measure the spare mental capacity of car drivers (Brown and Poulton 1961), to evaluate changes in vehicle handling characteristics (Hoffman and Joubert 1966), and to evaluate the performance of trainee drivers (Brown 1966).

In general, the secondary task is irrelevant or unrelated to the primary task. However, to provide a more realistic situation, researchers have also used embedded secondary tasks which are an integral (though less important) part of the total task (Shingledecker et al. 1980; Hart and Wickens 1990). In essence, the use of instrument panel controls and displays always constitutes an embedded secondary task in comparison with the primary task of stabilization, control, and navigation of the car (Heintz et al. 1982).

Ideally, secondary task performance is inversely proportional to the primary task resource demands. Secondary task may reflect differences in task resource demands, automation, or practice not reflected in primary task performance. They typically provide more information regarding the specific resources demanded by a task. Secondary task techniques possess a high degree of face validity and can be used with different tasks.

As the name implies, behavioral measures reflect the behavior of the operator. An example is the description of eye and head movement behavior while driving (Antin et al. 1988). Behavior measures are often easily quantifiable and may overlap with primary task measures. As an example, the rate of steering wheel reversals may be considered a behavioral measure (MacDonald and Hoffman 1980), but may correlate highly with a performance measure related to lane-keeping ability.

Subjective or self-report measures allow the individual to rate feelings of effort. These measures include the Cooper-Harper scale, Sheridan's dimensional scale, the NASA Task Load Index (Hart and Staveland 1988), the Subjective Workload Assessment Technique (Reid and Nygren 1988), and other multidimensional scaling techniques. Subjective measures are sensitive to total demand without the level of intrusiveness that physiological measures possess. However, they rely on an individual's perception of workload that might be biased by unrelated variables. Overall, subjective ratings of task difficulty represent perhaps the most acceptable measure of workload from the operator's standpoint. Some researchers have argued that these measures come nearest to tapping the essence of mental workload (Sheridan 1980; Johansen 1979). The measures usually do not disrupt primary task performance and are relatively easy to formulate. The only drawback is the uncertainty with which an operator's subjective_rating truly reflects that operator's mental workload (Wickens 1990).

Physiological measures attempt to quantify the physical, electrical, or chemical influence that mental workload has on the body, much the same as one might use heart rate or oxygen consumption as measures of physical workload. These measures include electrodermal (GSR), electrocardiograph (ECG), electroencephalograph (EEG), eye movement (EOG), and analysis of body fluids. Physiological measures are generally less precise than secondary task measures. However, they can provide a relatively continuous record of data over time, and are generally non-disruptive of primary task performance. On the other hand, they impose physical equipment constraints and may be obtrusive in a physical sense. These constraints may influence user acceptance of the measuring devices (Wickens 1990).

2.4.3 Relationship between lateral error and driver mental workload

As discussed in the above section, mental workload can be assessed using the driver's performance measures. For a driver steering a tractor during the field operation, his or her guidance performance may be measured by the lateral error or guidance error. Lateral error, therefore, can be correlated to driver mental workload.

It is expected that increases in the difficulty of the task will lead to increased levels of workload and thereby decreased performance (Schlegel 1993). To minimize the lateral error, researchers are trying to design and develop visual guidance aids. With a guidance aid, a driver mental workload increases because his or her steering task demand increases. As a result, the lateral error may be increased (i.e., decreased performance) because of high driver workload. This possible result is undesirable.

Therefore, it is necessary to consider the relationship of the lateral error to the driver mental workload when a guidance aid is designed.

2.5 Objectives

The objectives of this thesis are:

1. To determine the optimum placement of a video camera to minimize lateral error.
2. To determine a relationship between lateral error and driver mental workload.

3. MATERIALS AND METHODS

3.1 Materials

3.1.1 Guidance aid

The visual guidance aid used in this research was the CAMTRAK Electronic Field Position Indicator, which consists of a color video camera and a dash-mounted display monitor.

The monitor was a TFT, LCD active matrix monitor with a size of 210 mm wide by 130 mm high by 76 mm deep. The size of the display screen was 130 mm wide by 95 mm high. The monitor was mounted to the right of the driver, below eye level, and perpendicular to the driver's sightline (Fig. 3.1). This location resulted in the monitor being approximately 0.6 m from the driver's eyes. The location of the monitor was adjustable to accommodate drivers of varying size.

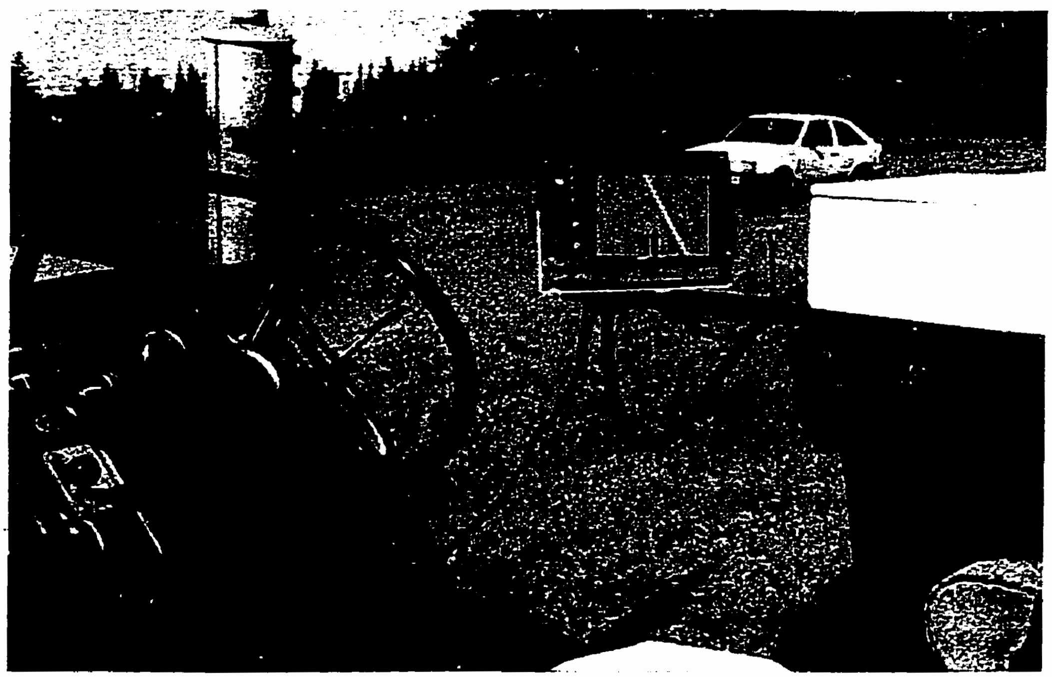

Fig. 3.1 Position of the LCD monitor relative to the driver's position. Note the pointer in the center of the screen.

One modification was made to the CAMTRAK system. A small, black pointer was attached to the exterior surface of the LCD monitor (Fig. 3.1). The pointer was aligned with the centerline of the monitor in the vertical direction and had a length equal to one-third of the height of the monitor.

Two different cameras were used in the research. The field of view of the first camera (Model No. OPSCBC 6, Excel Innovations, Martinsville, SK) (hereafter referred to as the "Narrow FOV" camera), was 15° in the longitudinal direction and 20° in the lateral direction. The field of view of the second camera (Model No. OPSCBC 12, Excel Innovations, Martinsville, SK) (hereafter referred to as the "Wide FOV" camera) was 29° in the longitudinal direction and 39° in the lateral direction. For both cameras, the field of view was fixed.

The experimental procedure required the use of two cameras. The video camera providing the "look-ahead" information was called the "guidance camera," and the video camera used for recording the lateral error was called the "recording camera." Tests were conducted with each camera used as the guidance camera to investigate the effects of field of view on driver performance.

3.1.2 Custom-built pull-type implement

As explained previously, the size of an implement influences the driver's performance (i.e., guidance error). To be a realistic representation of an actual agricultural implement, a width of 18 m was chosen for the custom-built pull-type implement. The pull-type implement (Fig. 3.2) consisted of a frame supported by five wheels (two at each end and one in the center). Added to the main frame of the implement was a vertical frame for supporting the guidance camera, a frame for supporting the recording camera, and a measuring wheel. To accommodate a non-level field surface, a pin joint was added at the middle of the frame to allow rotation in the vertical plane. Steel cables were required to brace the frame in the direction of travel. With cables on both sides of the frame, a stable diamond-shape was formed. To facilitate transportation of the implement in the back of a pick-up truck, the 18 m-long frame consisted of six, 3 m-long pieces joined together by bolts.

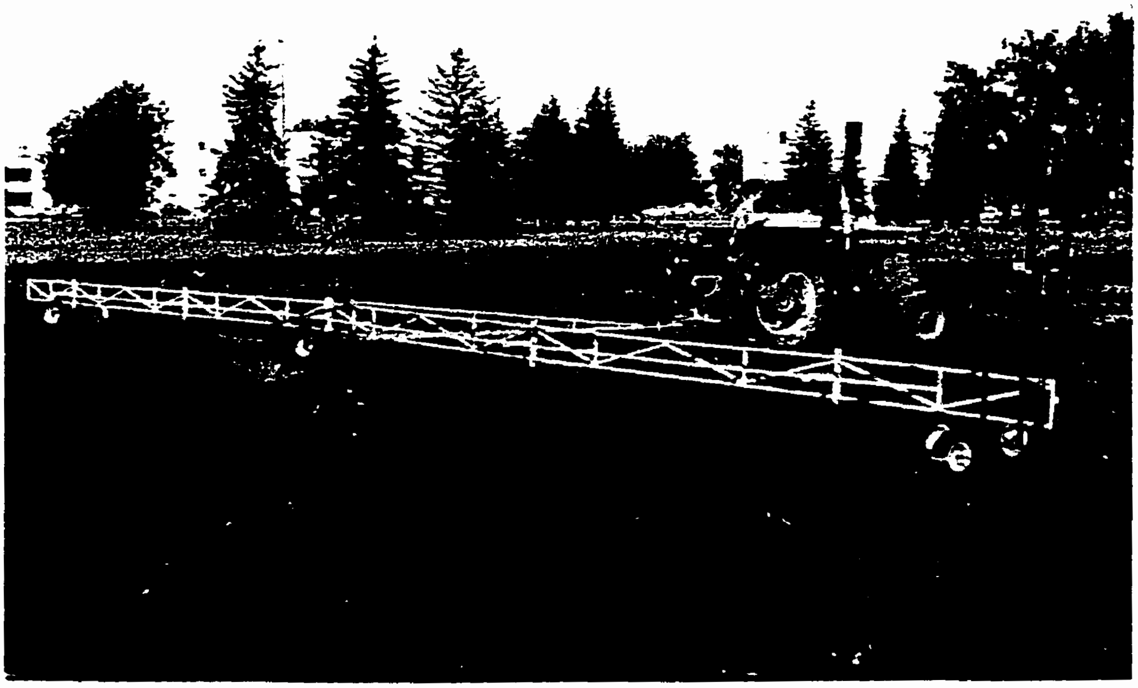

Fig. 3.2 Custom-built pull-type implement with the guidance camera mounted on the right end.

The guidance camera was mounted in a forward-looking direction with both the height and the tilt angle being adjustable (Fig. 3.3). A vertical post with a moveable unit was used to hold the guidance camera. The moveable unit consisted of three parts: a main body, a cylinder, and an angle-measuring device. The main body of the unit was a short piece of steel cylinder welded onto a short piece of square-tubing. The entire main body could slide up and down along the post to adjust the height of the camera. A second cylinder, with a flat base for attaching the guidance camera, fit over the first cylinder and was used to adjust the tilt angle of the guidance camera in the perpendicular plane. A reference pointer, opposite the camera base, was welded onto the second cylinder. The tilt angle of the guidance camera was measured with a "scale board" (i.e., a piece of graph paper indicating angular values taped to an aluminum plate which was attached to the steel cylinder).

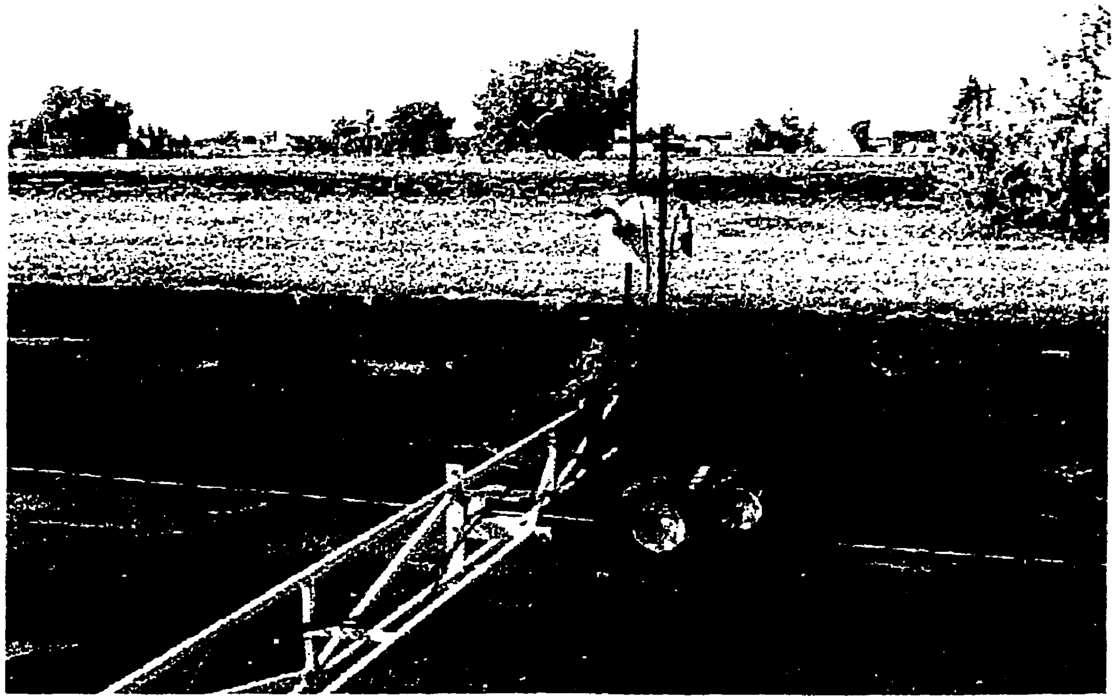

Fig. 3.3 The "guidance camera" (left) mounted in a forward-looking direction and the "recording camera" (right) in a downward-looking direction.

The procedure used to adjust the tilt angle of the guidance camera consisted of four steps. First, a carpenter's level was used to level the guidance camera. Second, the scale board was then rotated to ensure that the reference pointer was aligned with zero on the scale board. After being zeroed, the scale board was tightened in place and was no longer adjusted. Finally, the guidance camera was then rotated to the desired angle.

3.1.3 Data recording system

The data recording system consisted of three parts: a recording camera, a metering wheel, and a video cassette recorder (VCR).

The stand for holding the recording camera consisted of a vertical post (Fig. 3.3) and a horizontal ruler (Fig. 3.4). The vertical post, made of square-tubing, with five holes along the post, was used for holding and adjusting the height of the recording camera. The field of view of the recording camera was set to be perpendicular to the ground. A 600 mm length of survey rod, mounted 200 mm above the ground and 200 mm behind the vertical post, was centered in the field of view of the recording camera (Fig. 3.4).

A metering wheel with a circumference of approximately 1 m was used to measure the travel distance of the implement (Fig. 3.4). The implement frame holding the axle pivoted to allow the metering wheel to follow the contour of the ground. An orange stripe was painted onto the metering wheel. A pointer was used as a reference so that it could be observed when the metering wheel had completed a full revolution. The metering wheel and the reference pointer were visible to the recording camera.

To ensure that all lateral errors were recorded, the field of view of the recording camera was set (by adjusting the height of the camera) to cover the full scale of the ruler (over 600 mm in length), the metering wheel, and the reference pointer for the metering wheel. It was necessary for the centerline of the ruler to be aligned with the vertical centerline of the LCD screen when the recording camera was installed on its own frame. In other words, when the rope was observed to be aligned with the centerline of the ruler, the lateral error was regarded as zero.

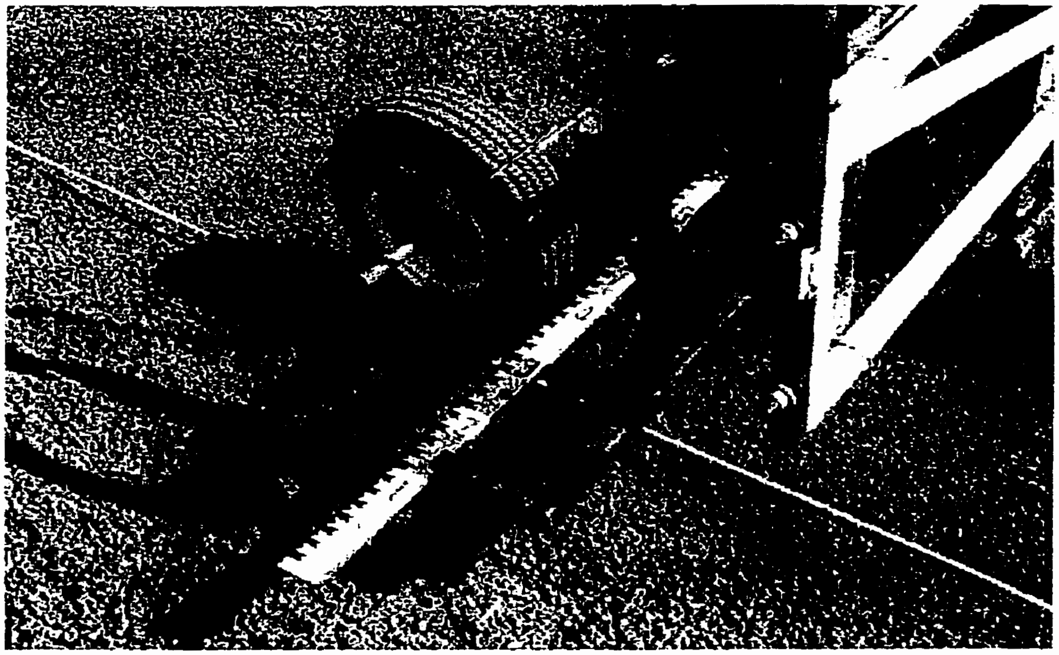

Fig. 3.4 The metering wheel and the survey rod used for measurement of lateral errors

The VCR (model No. VR8419C SAMSUNG) was used to record the signal from the recording camera. A POWER2GO, DC to AC inverter (Model No. L03040, LINKSYSTM) was used to convert the tractor's 12 V DC battery into 120 V AC. The VCR was placed inside a wooden box mounted onto the right rear fender of the tractor. Carpet underlay was used to isolate the VCR from vibration and a piece of furnace filter was used to protect the VCR from dust.

3.1.4 Miscellaneous

A Massey Ferguson 150 tractor, without a cab, was used to pull the custom-built pull-type implement in this research. Yellow, nylon rope (diameter = 10 mm) was used to create an artificial path to follow. For this research, the path was straight and 100 m in length. Testing occurred in a field plot (approximately 350 m long by 100 m wide) belonging to the Faculty of Agricultural and Food Sciences on the University of Manitoba Fort Garry Campus, Winnipeg, MB.

3.1.5 Subject

One driver (subject) was used in this research. The driver was an undergraduate student in the Department of Biosystems Engineering, University of Manitoba. He had some previous experience in driving similar agricultural machines (i.e., an implement pulled by a tractor).

3.2 Experimental Procedure

3.2.1 Equipment calibration

In this experiment, both the field of view of the camera and the tractor velocity required calibration. To calibrate field of view, the camera was set on one edge of a table and was pointed toward a screen (Fig. 3.5). The maximum field of view on the screen and the distance to the screen were measured. Based on the geometric relationship, the field of view of the camera was calculated. The calibration results for the field of view of both the Narrow FOV camera and the Wide FOV camera are shown in Table 3.1.

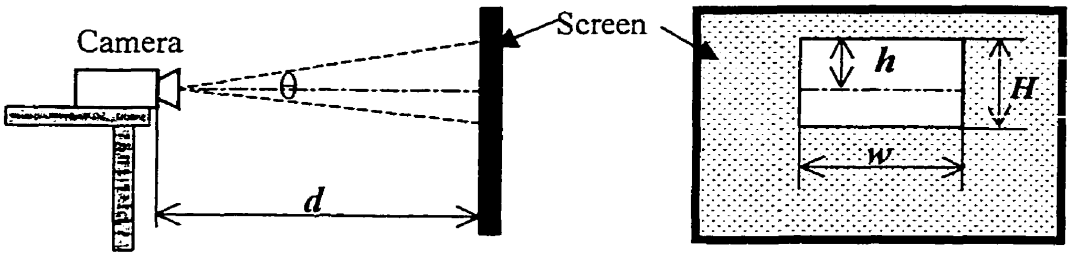

Fig. 3.5 Schematic diagram of the calibration for the field of view of the camera.

Table 3.1 Calibration results for the field of view of both the Narrow FOV camera and the Wide FOV camera.

Camera	*d** (*mm*)	H (*mm*)	*h* (*mm*)	*w* (*mm*)	θ (°)	ϕ (°)	λ
Narrow FOV	2460	655	455	246	15	20	0.31
Wide FOV	2460	1310	920	1750	29.5	39	0.31

* *d* = horizontal distance from camera to screen
H = maximum height
h = height from centerline to bottom
w =maximum width
θ = field of view of camera in longitudinal direction
ϕ = field of view of camera in lateral direction
λ = ratio of the angle from the centerline to the bottom edge of the field of view to the field of view of camera

Tractor velocity was calibrated in the field. The time required for the tractor to travel 100 m was measured. The appropriate gear and engine speed combination was selected to obtain the required velocities (Table 3.2).

3.2.2 Use of the CAMTRAK system

The driver used the CAMTRAK system in the following manner. The driver was asked to guide the pull-type implement along the artificial path (rope), relying only on the guidance information provided by the CAMTRAK system. While driving, if the image of the rope was aligned with the pointer, then the driver would make no steering correction. When the rope was not aligned with the pointer, the driver was required to make a steering correction (either right or left) based on the relative distance between the pointer and the rope or the cross angle between the pointer and the rope. During each trial, the view seen by the recording camera was recorded by the VCR.

Table 3.2 Results of tractor velocity calibration conducted on June 16, 1999.

Gear		Engine speed (rpm)	Desired velocity (km/h)	Distance (m)	Time (s)	Actual velocity	
						m/s	km/h
1	low	1275	6.4	100	57.25	1.75	6.3
2	low	1275	9.6	100	37.88	2.64	9.5
2	high	1275	12.8	100	29.40	3.4	12.2
3	low	1200	16.0	100	21.69	4.6	16.6
3	low	1425	19.2	100	19.09	5.2	18.7

Note: Tractor Model: Massey Ferguson 150

3.2.3 Data acquisition in the lab

The analytical data on the VHS tape were read manually in the laboratory. With the use of a video projector, the video was projected onto a large screen (2 m ×2 m) in a lecture room. As the tape played, a reading was recorded each time the orange stripe on the metering wheel aligned with the reference pointer (i.e., at 1 m intervals). The datum being recorded was the survey rod value that aligned with the yellow rope.

Theoretically, there should have been exactly 100 data points for each trial because the course was 100 m long and the sampling interval was 1 m (i.e., one lateral error was obtained every meter along the course). Typically, there were 102 to105 data points for each trial. There are two possible explanations for this result: 1) the circumference of the measuring wheel was not exactly 1 m in length and 2) the measuring wheel tended to bounce off the ground due to the rough surface.

3.2.4 Measurement of driver's mental workload

Subjective (or self-report) measures were used to measure the driver's mental workload (hereafter referred to as the driver's feeling) in this experiment. Following each experimental trial, the driver gave himself a subjective score and provided written comments. The score, which ranged from 1 to 10, was assigned based on the driver's self-evaluation of the performance during the trial. To keep the scores relatively constant for all trials, the scale was divided into the following five bands: terrible (1-2), bad (3-4), acceptable (5-6), good (7-8), and excellent (9-10). Thus, the driver could give similar scores for those trials for which he had similar feelings. This subjective score, however, did not allow the driver to provide specific information which might help to explain the experimental results.

To provide the necessary additional information, the driver was required to describe his subjective feelings by providing answers to the following questions for each trial:

1. Was this trial easy or difficult?

   The driver could describe main effects of the visual information on his guidance performance, such as the frequency of turning the steering wheel, the difficulties finding the path (rope), and difficulties associated with judging the magnitude of lateral error.

2. Why was the trial easy or difficult?

The driver could explain the possible reasons leading to such a score. Sometimes similar results were caused by different reasons in the experiment. For example, a low score may be given because of bad visual information, the driver's occasional fault, or the rough field. To minimize the experimental error, some "bad data" caused by reasons other than visual information may be ignored.

3. Besides the guidance aid, were there any other problems?

The driver could provide complementary information that a score could not express. For example, the driver may comment on the display location and the screen size. Another typical example was the vibration of the implement. Vibration cannot be ignored because it may influence the driver's feeling.

3.2.5 Experimental trials

The research was designed in two stages. The first stage was exploratory in nature. Six camera tilt angles (15, 30, 45, 60, 75, and 90°, measured down from the horizontal) and four camera heights (0.75, 1.10, 1.50, and 2.00 m) were considered in the first stage. Trials were conducted for each combination of camera tilt angle and camera height at two velocities: 6.4 and 9.6 km/h. Only the Narrow FOV camera was used for guidance in the first stage.

The second stage of the research proceeded following preliminary analysis of the stage one data. Three camera tilt angles (20, 30, and 40°), two camera heights (1.10 and 1.50 m), and three velocities (6.4, 9.6, and 12.8 km/h) were selected for further testing. In addition, both cameras (Narrow FOV and Wide FOV) were tested as guidance cameras. Each combination of four factors was replicated three times. In total, 108 trials (3 angles ×2 heights×3 velocities ×2 field of view of cameras ×3 replicates=108 trials) were conducted in this stage.

Following completion of stage two, additional nine trials were conducted to determine the performance of the driver without using the guidance aid. Three velocities (6.4, 9.6, and 12.8 km/h) were each replicated three times.

4. EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Troubles encountered during the procedures

During this research, many trials had to be repeated because the VCR did not always record the signal from the recording camera. There are two possible reasons: high ambient temperature and excessive vibration. This VCR was a domestic product which was not designed to bear high ambient temperature (over 30°) or excessive vibration. Some trials were repeated several times before useable results were obtained. This problem needs to be addressed before continuing this research.

4.2 Lateral error

4.2.1 First stage

Due to the exploratory nature of the first stage of the research, only a single trial was done for each combination of velocity, camera height, and camera tilt angle. Plots of the lateral errors are shown in Figs 4.1 and 4.2. Positive lateral error occurred when the implement was overlapping and negative lateral error occurred when the implement was skipping. Based on visual inspection of the graphs, the least erratic results occurred when the tilt angle was 15, 30, or 45° at camera heights of 1.1 or 1.5 m. Lateral errors increased sharply when the tilt angle was greater than 45°. A tilt angle of 90° was not tested at a velocity of 9.6 km/h because it was determined to be both unrealistic and unsafe.

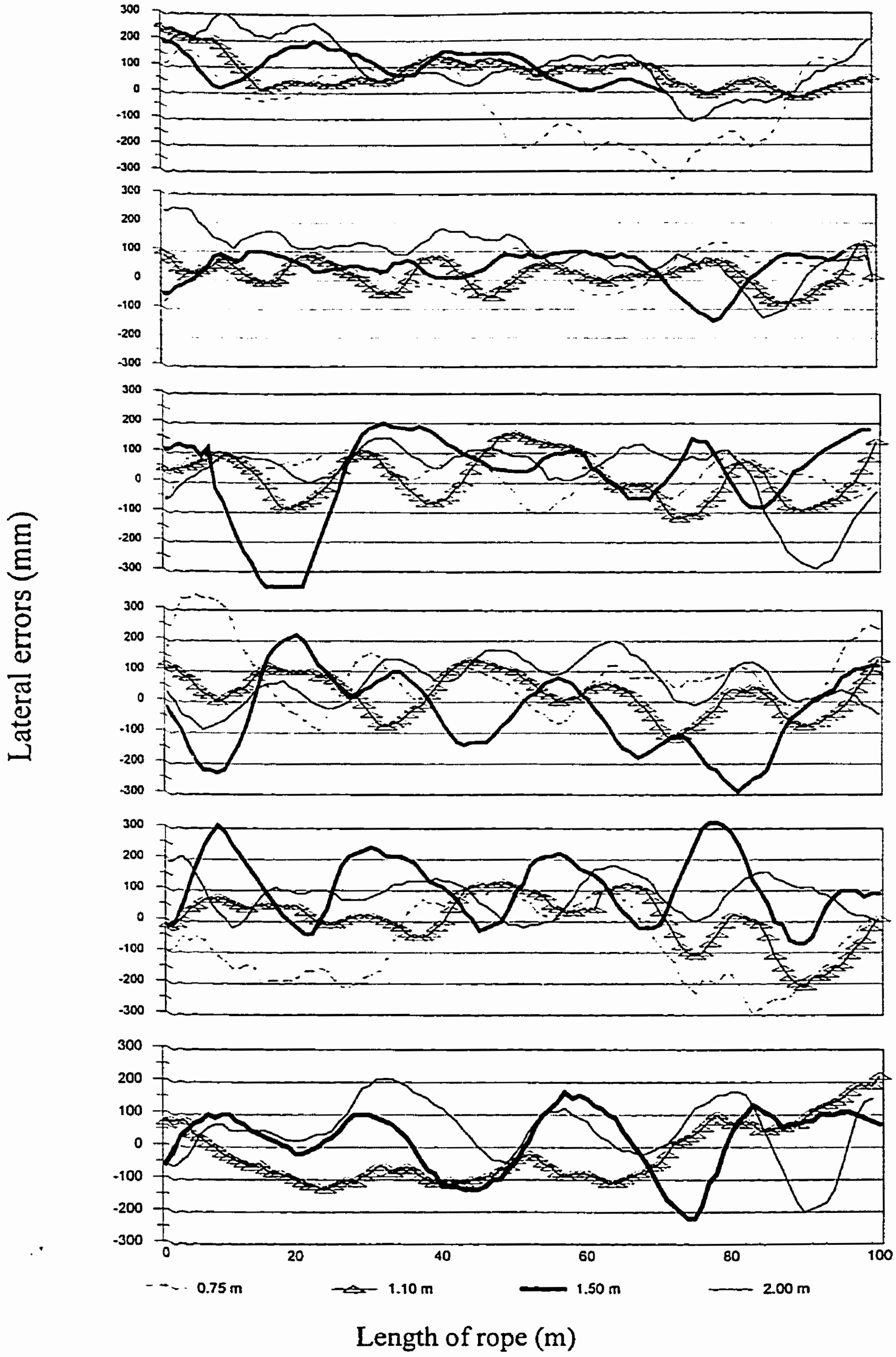

Fig. 4.1 Comparison of lateral errors produced by different combinations of camera tilt angles and heights at a tractor velocity of 6.4 km/h. The graphs represent tilt angles of 15, 30, 45, 60, 75, and 90° from top to bottom, respectively.

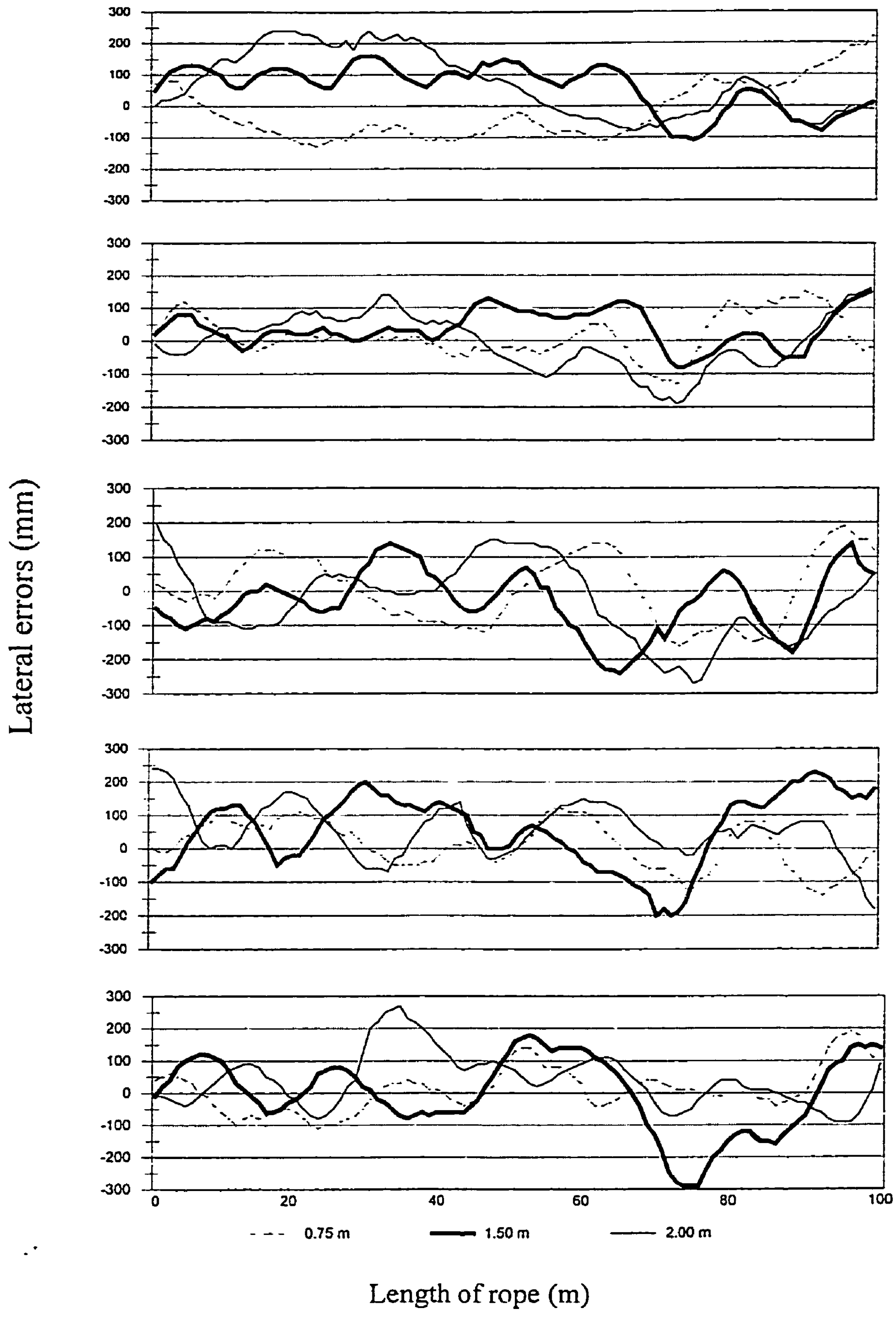

Fig. 4.2 Comparison of lateral errors produced by different combinations of camera tilt angles and heights at a tractor velocity of 9.6 km/h. The graphs represent tilt angles of 15, 30, 45, 60, and 75° from top to bottom, respectively.

Large lateral errors occurred at tilt angles exceeding 45° because the field of view of the camera extended only a short distance ahead of the implement and the driver did not have enough time to react to the visual information. Field of view was also a limiting factor when the camera height was only 0.75 m above the ground. A camera height of 2.0 m was considered unacceptable because excessive vibration of the camera stand caused the image on the monitor to be blurred. This situation made it difficult for the driver to follow the rope.

Based on these observations, additional tests were conducted for camera tilt angles near 30° at heights of 1.1 and 1.5 m.

4.2.2 Second stage

Unlike the first stage of the research which was exploratory in nature, the second stage was subjected to rigorous statistical analysis. For each trial, an average of the absolute value of the 100 readings was calculated. With three replicates, this produced three average lateral errors for each treatment.

Analysis of variance (ANOVA) was used to determine the effects of the camera tilt angle, camera height, tractor velocity, and camera field of view on the lateral error (Table 4.1). The effects of both tilt angle and camera field of view were highly significant (both $p=0.0001$), but the effects of tractor velocity ($p=0.11$) and camera height ($p=0.75$) were not significant. There is no interaction among these four factors, except between the field of view of the camera and the camera height ($p=0.03$).

A multiple comparison of means was also performed (Table 4.2). Analysis showed that a tilt angle of 40° caused significantly different lateral error than caused by tilt angles of either 20 or 30° (Tukey's HSD Test, α=0.05) (Table 4.2). According to Tukey's HSD Test, there is no significant difference in the effects of 20 and 30° tilt angles, but there is a significant difference according to Duncan's Multiple Range Test. Consequently, there is limited proof to suggest that a tilt angle of 30° produces the smallest lateral error.

Table 4.1 A summary of the ANOVA analysis for the effects of the four factors (camera tilt angle, camera height, tractor velocity, and field of view of camera) on the guidance error.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	35	212.97	6.08	3.24	0.0001*
FOV	1	68.32	68.32	36.40	0.0001*
Velocity	2	8.49	4.25	2.26	0.1115
Angle	2	63.00	31.50	16.78	0.0001*
Height	1	0.19	0.19	0.10	0.7529
FOV×Height**	1	8.96	8.96	4.77	0.0322*
Error	72	135.16	1.88		
Corrected Total	107	348.13			

* Effect is significant

** Interactions with no significant effects were not included in the table

An alternative method for determining the optimum value for each parameter is to establish a "band" of acceptable errors. For field-sized, agricultural equipment, lateral errors less than 100 mm are acceptable. Therefore, the percentage of lateral errors (measured at 1 m intervals) greater than 100 mm was calculated for each trial. For a tilt angle of 30°, only 10% of the lateral errors were considered "unacceptable" compared to 15 and 22% for 20 and 40°, respectively (Table 4.2). This analytical procedure also suggests that 30° is the optimum tilt angle.

Statistical analysis showed that there was no significant difference between camera heights of 1.1 and 1.5 m or between tractor velocities of 6.4, 9.6, and 12.8 km/h

(Tukey's HSD Test, α=0.05) (Table 4.2), however, the Narrow FOV camera produced significantly better results than the Wide FOV camera (Tukey's HSD Test, α=0.05) (Table 4.2). Only 11% of the measurements fell outside of the band of acceptable errors for the Narrow FOV camera, but 21% of the measurements fell outside of the band of acceptable errors for the Wide FOV camera (Table 4.2). The experimental results indicate that use of the camera with the narrow FOV produces the smallest lateral errors.

Table 4.2 A summary of the statistical multiple comparison of mean lateral errors for four fixed factors (camera tilt angle, camera height, tractor velocity, and field of view of camera).

Factor	Level	Mean* (mm)	Standard deviation (mm)	Maximum (mm)	Unacceptable offset** (%)
Angle	20	57^{A}	45	250	15
(°)	30	50^{A}	41	280	10
	40	69^{B}	54	280	22
Camera height	1.1	58^{A}	48	280	15
(m)	1.5	59^{A}	47	250	16
Tractor	6.4	57^{A}	45	280	14
velocity	9.6	56^{A}	46	250	14
(km/h)	12.8	62^{A}	51	280	18
Field of view	Narrow	51^{A}	42	280	11
	Wide	67^{B}	51	250	21

* Means with different letters (comparison within each factor) are significantly different (Tukey's HSD Test, α=0.05).
**Percentage of lateral errors greater than 100 mm.

Although there was no significant difference between camera heights of 1.1 and 1.5 m, there was a significant interaction between camera height and camera FOV. According to Fig.4.3, the combination of Narrow FOV camera with a height of 1.5 m produces the smallest absolute lateral error (mean=48.1 mm). This combination, therefore, is most suitable for guidance of agricultural machines.

To summarize, the smallest lateral error resulted when the Narrow FOV camera was placed 1.5 m above ground and tilted downward at 30°. For this combination of factors, the mean absolute lateral error was 43 mm with a standard deviation of 32 mm. The maximum error observed was 160 mm, but only 5% of the measurements were greater than 100 mm.

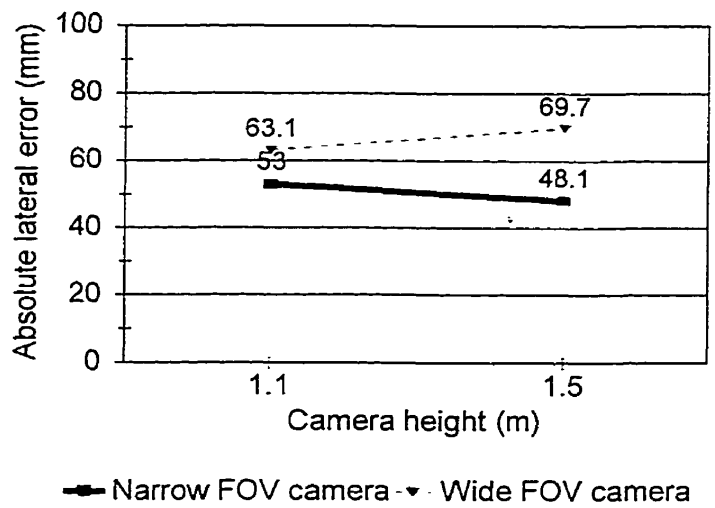

Fig. 4.3 Interaction between FOV and camera height.

4.2.3 Comparison of lateral error with and without using CAMTRAK

Limited testing was done to determine whether the lateral error decreased when the CAMTRAK guidance aid was used compared with trials when no guidance aid was used. Unfortunately, all of the data relates to a single driver. With this data, however, it is evident that the driver's performance decreases when no guidance aid is used (Fig. 4.4). Approximately 40% of the lateral errors exceeded 100 mm compared to 10% when the CAMTRAK guidance aid was used with the Narrow FOV camera.

4.3 Driver's subjective data

4.3.1 Subjective comments

Based on written comments provided by the driver, the following observations can be made. First, the driver preferred to use the Wide FOV camera for guidance because it provided a wider field of view which was more comfortable. Second, the driver's eyes often became fatigued after several hours of watching the display monitor. In some cases, blurring of the image caused by vibration of the implement affected the driver's guidance performance.

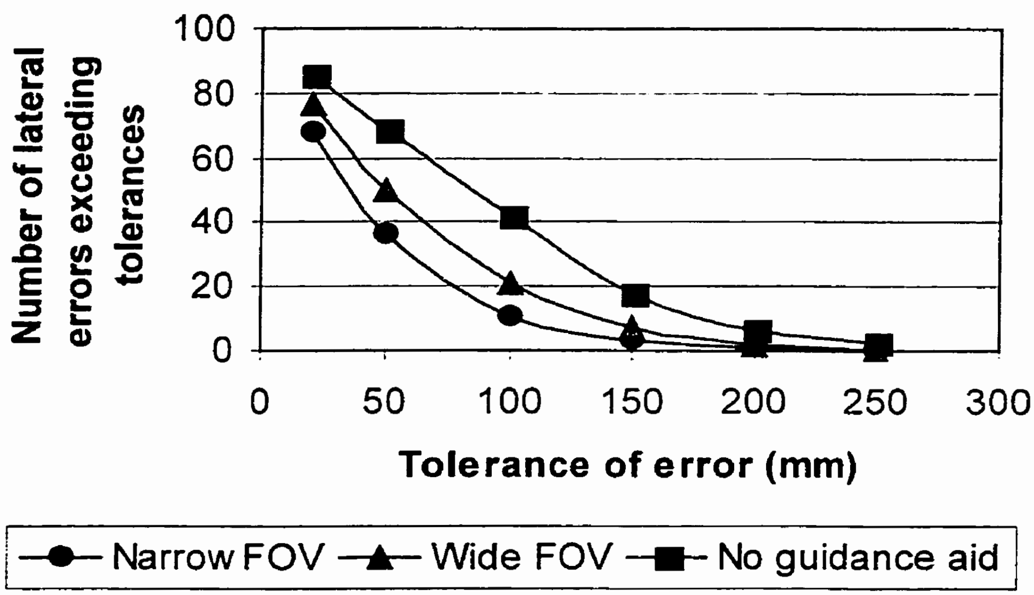

Fig. 4.4 The percentage of lateral errors exceeding tolerances for a driver with and without use of the CAMTRAK guidance aid.

4.3.2 Subjective scores

The subjective scores provided by the driver were analyzed using statistical procedures. For camera tilt angle, the mean subjective score decreased with increasing tilt angle (Table 4.3), however, only subjective scores related to 40° were significantly different (Tukey's HSD Test, α=0.05). With a tilt angle of 40°, the driver's comments tended to be negative such as "hard to find and follow the rope" and "there is not enough time to react to the visual information." For the other tilt angles, the driver's comments were much more positive.

The driver preferred a camera height of 1.5 m over 1.1 m (Table 4.3). Subjective scores were significantly different (Tukey's HSD Test, α=0.05). The results for tractor velocity are not clear. There was a significant difference between subjective scores for 9.6 and 12.8 km/h, but there was no significant difference for each of the other two combinations (Tukey's HSD Test, α=0.05) (Table 4.3). The driver's comments related to vibration of the camera which caused a blurred image on the monitor. Further investigation is required to understand the influence of tractor velocity.

Table 4.3 A summary of multiple comparison of means of subjective scores for four factors (camera tilt angle, camera height, tractor velocity, and field of view of camera).

Factor	Level	Subjective score
Camera tilt angle	20	7.6^{A}
(°)	30	7.2^{A}
	40	5.3^{B}
Camera height	1.10	6.1^{A}
(m)	1.50	7.2^{B}
Tractor velocity	6.4	6.8^{AB}
(km/h)	9.6	6.9^{A}
	12.8	6.3^{B}
Field of view	Narrow	6.9^{A}
	Wide	6.5^{A}

* Means with different letters (comparison within each factor) are significantly different (Tukey's HSD Test, α=0.05).

Finally, the mean subjective score for the Narrow FOV camera was not significantly different than the mean subjective score for the Wide FOV camera (Tukey's

HSD Test, α=0.05) (Table 4.3), but the driver felt more comfortable with the Wide FOV camera based on the nature of the written comments.

4.4 Comparison of analytical and subjective data

There is partial agreement between the analytical and subjective data. Both sets of data concluded that 40° was the worst tilt angle, but only the analytical data distinguished between 20 and 30°. Camera height was not a significant factor based on lateral error, but the driver felt that 1.5 m was significantly better than 1.1 m. At this point, the driver's preference for tractor velocity is unclear, although the analytical data showed no significant difference. Finally, the analytical data showed the Narrow FOV camera to be significantly better than the Wide FOV camera, but the subjective data showed no significant difference.

Based on the lateral errors observed, it can be concluded that a guidance camera should be placed 1.5 m above the ground and tilted downward at 30°. A camera with a 20° lateral FOV is more appropriate than a camera with a 39° lateral FOV. Further study is required to explain why the driver's subjective scores did not always agree with the lateral errors observed.

4.5 Comparison with previous research

Compared with the results (the proper placement of a guidance camera should be placed 1.5 m above ground and tilted downward at 30°) obtained in this research, previous researchers obtained different results for camera placement (the camera tilt angle vary from 5 to 45°, and the camera height vary from 0.8 to 1.25 m), although the field of view of the camera was similar. As speculated previously, it is true that the requirement of camera placement for a human driver is different from that for an AGS. In the terms of camera field of view, this research result agreed with that achieved by Gerrish et al. (1997). A camera with a 20° field of view in the lateral direction is appropriate for guidance of an agricultural machine.

5. THEORETICAL ANALYSIS

5.1 Hypotheses

Based on the experimental results, two hypotheses were proposed and are discussed in the following section.

First, it was hypothesized that the driver mental workload (as measured by subjective self-analysis) would increase as image velocity increased. As the image velocity increased, the driver had less time to react to the visual guidance information. When a driver has less time to make a decision, his or her mental workload increases. Consequently, a driver will not feel confident of his or her performance when the image velocity exceeds his or her endurance.

As discussed previously, the effects of the camera tilt angle, camera height, and camera field of view on the driver's subjective feeling were significant. All three factors can be related to image velocity. Compared with the Narrow FOV camera, the Wide FOV camera produced a relatively slow image velocity. This is the reason why the driver preferred to use the Wide FOV camera. Similarly, the driver's subjective feeling was better with higher camera height than with lower camera height because of the low image velocity.

It was also hypothesized that the magnitude of lateral errors would increase as the lateral ratio (the ratio of the image width to the corresponding ground width covered by the field of view of the camera) increased. With an increase in the lateral ratio, the sensitivity of the driver to the deviation of the rope from the reference point in the display decreased. Consequently, even when the actual deviation did not change, it was harder for the driver to discern the deviation when a large lateral ratio was used. As a result, the guidance error increased.

As addressed in the previous chapter, the effects of camera field of view on the lateral error were significant. Compared with the Narrow FOV camera, the Wide FOV camera had a larger lateral ratio, so that the lateral error was larger. As expected from our experimental results, the lateral ratio does not depend on tractor velocity.

The two hypotheses are correlated with each other. As discussed previously, the mental workload can affect the lateral error, however, the lateral error does not affect the mental workload. For example, a camera tilt angle of 40° produced a small lateral ratio, however, the lateral error increased because the mental workload increased due to the high image velocity. In another example, use of the Wide FOV camera produced a large lateral error, but mental workload did not increase.

These two hypotheses were proposed based on limited experimental results. In the next section, mathematical relationships are derived. Equations for image velocity and lateral ratio are derived based on the geometric relationships between camera tilt angle, camera height, camera field of view, and tractor velocity (Fig. 5.1).

5.2 Mathematical analysis

5.2.1 Calculation of the image velocity

Based on the geometric relationship shown in Fig. 5.1, the image velocity (V_I) is defined as the product of the tractor velocity (v_t) and the ratio of the display height to the ground length (R_l).

$$V_I = R_l \cdot v_t \qquad (1)$$

The display height and tractor velocity can be easily measured. Suppose the camera height (h), the camera tilt angle (α), and the camera field of view in the longitudinal direction (θ) are given, the ground length (d) is equal to:

$$d = h \cdot \{\cot[\alpha - (1-\lambda)\cdot\theta)] - \cot(\alpha + \lambda\cdot\theta)\} \qquad (2)$$

where,

d= the ground length covered by the camera field of view in the longitudinal direction (m)

h= camera height (m)

α= camera tilt angle (°)

λ= ratio of β to θ (Fig. 5.1)

θ= camera field of view in longitudinal direction (°)

The ratio (R_l) of the monitor height (H) to the ground length (d) is equal to:

$$R_l = \frac{H}{d} \qquad (3)$$

By substituting (2) and (3) into (1), we obtain the following expression for the image velocity:

$$V_l = \frac{H \cdot v_t}{h \cdot \{\cot[\alpha - (1-\lambda)\cdot\theta] - \cot(\alpha + \lambda\cdot\theta)\}} \qquad (4)$$

5.2.2 Calculation of the lateral ratio

The lateral ratio (R_w) is defined as the ratio of the image width (W) to the corresponding ground width covered by the field of view of the camera (w).

$$R_w = \frac{W}{w} \tag{5}$$

The ground width (w) covered by the camera field of view in the lateral direction is equal to:

$$w = \frac{2 \cdot h \cdot \tan\left(\frac{\phi}{2}\right)}{\sin(\alpha)} \tag{6}$$

Where,

ϕ= camera field of view in the lateral direction (°)

By substituting (6) into (5), the lateral ratio is

$$R_w = \frac{W \cdot \sin(\alpha)}{2 \cdot h \cdot \tan\left(\phi/2\right)} \tag{7}$$

Where,

R_w = the ratio of the width of the monitor screen to the ground width covered by the camera field of view in the lateral direction (*mm/m*)

W = the width of the monitor screen (*mm*)

Based on equation (7), the lateral ratio depends on the camera tilt angle, the camera height, the field of view in the lateral direction, and the width of the monitor.

5.2.3 Calculation of camera tilt angle, camera height, and camera field of view

Assuming that the two hypotheses are correct, it is necessary for a designer to know how to calculate the required camera tilt angle, camera height, and the camera field of view when designing a visual guidance aid. It can also be assumed that the proper magnitudes of the image velocity and the lateral ratio can be achieved by experiment.

The ground length (d) can be more appropriately described as the "visible" length of ground seen by the camera (Fig. 5.1). From equations (1) and (3), it can be concluded that the visible length is inversely proportional to the image velocity. This implies that the magnitude of image velocity is determined only by the visible length as long as the tractor velocity and the monitor height are both constant.

The invisible length (a) is defined as the ground length from a point directly below the camera to the bottom edge of the camera field of view (Fig. 5.1). Based on the geometric relationship, both the invisible length and the visible length are determined by the camera placement (camera tilt angle and height) and the camera field of view in the longitudinal direction.

The total ground distance ($d+a$) (Fig. 5.1 (b)), can also be expressed as ca where c is a coefficient. The visible length is equal to:

$$d = (c - 1)a \tag{8}$$

When the invisible length, the camera field of view, and the coefficient are given, the required camera height can be calculated using the following equation:

$$h = \sqrt{\frac{-\frac{a^2}{\sin^2(\theta)}\cdot\left[2\cdot c-\left(1+c^2\right)\cdot\cos^2(\theta)\right]\pm\sqrt{\left\{\frac{a^2}{\sin^2(\theta)}\cdot\left[2\cdot c-\left(1+c^2\right)\cos^2(\theta)\right]\right\}^2-4\cdot c^2\cdot a^4}}{2}} \tag{9}$$

(prerequisite: $\theta \le Arc\cos(\frac{2\cdot\sqrt{c}}{1+c})$)

Where,

a = invisible length (m)

c = coefficient between the visible length and invisible length

Based on the above prerequisite, the maximum field of view of a guidance camera in the longitudinal direction can be calculated as follows:

$$\theta \le Arc\cos(\frac{2 \cdot \sqrt{c}}{1+c}) \tag{10}$$

For example, when a value of 2 is assigned to c (i.e., the visible length is equal to the invisible length), θ must be equal to or less than 19.5° based on equation (10). In this experiment, the Narrow FOV camera had a 20° field of view in the longitudinal direction.

When the camera height, ratio of angle, camera field of view in the longitudinal direction, and the coefficient are given, the camera tilt angle can be calculated as follows:

$$\alpha = Arc\tan\frac{h}{c \cdot a} + (1-\lambda)\cdot\theta \tag{11}$$

The camera field of view in the lateral direction can be calculated as follows:

$$\phi = 2 \cdot Arc\tan\left[\frac{w \cdot \sin(\alpha)}{2 \cdot h}\right] \tag{12}$$

5.3 Theoretical verification of the two hypotheses

Using equations (4) and (7), image velocities and lateral ratios were calculated with the values of the four factors used in the experiment. Based on tabulated results (Tables 5.1 and 5.2) both hypotheses are valid.

The velocity of the image for the Narrow FOV camera was more than 20 times greater than that for the Wide FOV camera. The velocity of the image at the camera tilt angle of 40° was more than 5 times greater than that of 20°. This is the reason why the driver mental workload increased when using the Narrow FOV camera with tilt angle of 40°. Because the image velocity ranges from 1 to 421 mm/s (Tables 5.1 and 5.2), future work is necessary to determine the maximum image velocity that can be tolerated by a driver.

With a camera tilt angle of 30° and a camera height of 1.5 m, the lateral ratio for the Wide FOV camera (16.3) was 2 times greater than for the Narrow FOV camera (8.2). In practice, the lateral ratio indicates the driver's ability to distinguish lateral error. For example, with a lateral ratio of 8, a 10 mm offset on the monitor is equal to an 80 mm lateral offset. With a lateral ratio of 16, however, a 10 mm offset on the monitor is equal to 160 mm lateral offset. The higher the lateral ratio, the greater the lateral error will be before it is detected and then corrected by the driver. Based on the experimental results, it is reasonable to choose a lateral ratio of 10 when using a visual guidance system to keep the lateral error within 100 mm.

Table 5.1 Calculated image velocity and lateral ratio for the Narrow FOV camera (15° field of view in the longitudinal direction; 20° field of view in the lateral direction) for each combination of camera tilt angle, camera height, and tractor velocity.

Camera height (m)	Camera tilt angle (°)	Lateral ratio	Tractor velocity (km/h)	Image velocity (mm/s)
1.1	20	8.8	6.4	44
			9.6	66
			12.8	88
	30	6.0	6.4	118
			9.6	176
			12.8	235
	40	4.6	6.4	210
			9.6	315
			12.8	421
1.5	20	11.9	6.4	32
			9.6	48
			12.8	64
	30	8.2	6.4	86
			9.6	129
			12.8	172
	40	6.3	6.4	155
			9.6	232
			12.8	310

Based on the calculated values of the lateral ratio and image velocity, it was discovered that, the lateral ratio is inversely proportional to the image velocity for both the Narrow FOV and the Wide FOV cameras (Figs. 5.2 and 5.3) with the exception of the points related to a camera tilt angle of 30° and 40° at different camera heights. This implies that the driver mental workload is inversely proportional to the lateral error, i.e., driver workload increased as the lateral error decreased. Therefore, it is necessary to find a compromise between driver mental workload and lateral error when using a visual guidance aid. In other words, to achieve a reasonable lateral error, a driver must tolerate a certain workload.

Table 5.2 Calculated image velocity and lateral ratio for the Narrow FOV camera (29° field of view in the longitudinal direction; 39° field of view in the lateral direction) for each combination of camera tilt angle, camera height, and tractor velocity.

Camera height (m)	Camera tilt angle (°)	Lateral ratio	Tractor velocity (km/h)	Image velocity (mm/s)
1.1	20	17.5	6.4	2
			9.6	3
			12.8	4
	30	12.0	6.4	38
			9.6	57
			12.8	76
	40	9.3	6.4	86
			9.6	128
			12.8	171
1.5	20	23.9	6.4	1
			9.6	2
			12.8	3
	30	16.3	6.4	28
			9.6	42
			12.8	55
	40	12.7	6.4	63
			9.6	94
			12.8	126

It was also discovered that, although the lateral ratio (6.3) for the Narrow FOV camera with height of 1.5 m tilted at an angle of 40° is approximately equal to that (6.0) with a height of 1.1 m tilted at an angle of 30° (Fig. 5.2), the corresponding image velocities are significantly different (155 mm/s for the former and 118 mm/s for the latter). The same was observed for the Wide FOV camera. Based on this discovery, there is further proof that the camera tilt angle of 40° is not appropriate for guidance.

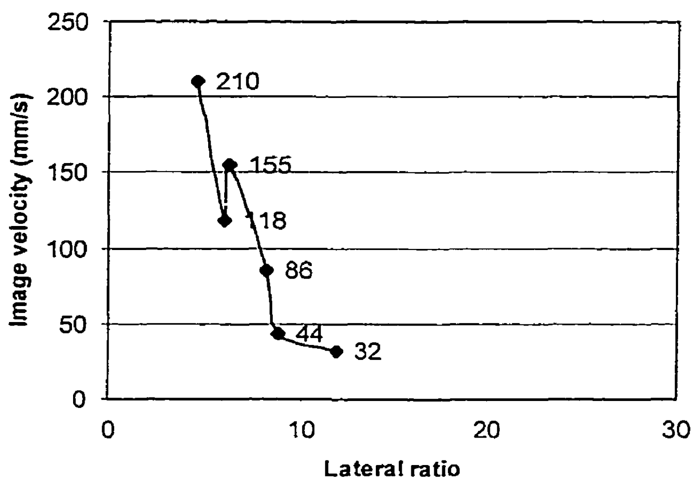

Fig. 5.2 Lateral ratio vs. image velocity for Narrow FOV camera

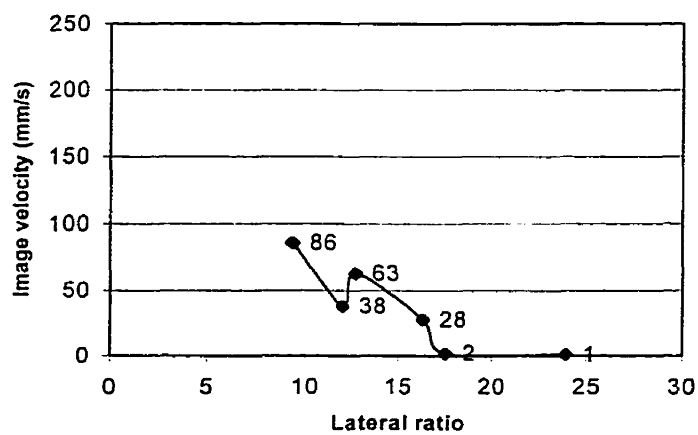

Fig. 5.3 Lateral ratio vs. image velocity for Wide FOV camera

6. CONCLUSIONS

The following conclusions can be drawn from this thesis work:

1. Compared without using guidance aid, a visual guidance aid can minimize the guidance error during field operation, although the driver workload caused by the driver interface requires further study.
2. To achieve a lateral error less than 100 mm, a guidance camera should be placed 1.5 m above the ground and tilted downward at 30°. A camera with a 20° lateral FOV is more appropriate than one with a 39° lateral FOV. This result has been shown to be valid for an assumption that a driver guide an agricultural machine only based on the guidance information provided by the guidance aid and the implement travels on the relatively flat field.
3. Two hypotheses successfully explain the relationship of the driver workload to the lateral error. First, driver mental workload increased as image velocity increased. Second, the magnitude of lateral errors increased as the lateral ratio increased. Because the image velocity is inversely proportional to the lateral ratio, it is necessary to find a compromise between an acceptable level of driver mental workload and an acceptable level of lateral error. In other words, to achieve a reasonable lateral error, a driver must face a certain workload.

7. RECOMMENDATIONS FOR FUTURE WORK

1. To further verify the achieved results based on one driver for both measurements, lateral error and subjective scores, it is necessary to employ more drivers to repeat this experiment.

2. Because the driver mental workload caused by the driver interface is unclear in this work, more work in this area is necessary in order that the visual guidance aid can be available for farmers.

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Appendix A1 Data for stage one

The data was collected in the unit of centimeter for stage one.

Table A1-1 Trial number vs. combination of the three factors (camera tilt angle, camera height, and tractor velocity) with the Narrow FOV camera

Table A1-2 Data for trial no.1 to trial no. 25 in the stage one

Table A1-3 Data for trial no. 26 to trial no. 44 in the stage one.

Note: some data points are missing because of intermittent problems with the VCR

Table A1-1 Trial number vs. combination of the three factors (camera tilt angle, camera height, and tractor velocity) with the Narrow FOV camera

Tractor velocity (km/h)	Camera height (m)	Camera tilt angle (°)	Trial No.
6.4	0.75	15	1
		30	2
		45	3
		60	4
		75	5
		90	6
	1.10	15	25
		30	26
		45	27
		60	28
		75	29
	1.50	15	7
		30	8
		45	9
		60	10
		75	11
		90	12
	2.00	15	19
		30	20
		45	21
		60	22
		75	23
		90	24
9.6	0.75	15	30
		30	31
		45	32
		60	33
		75	34
	1.50	15	35
		30	36
		45	37
		60	38
		75	39
	2.00	15	40
		30	41
		45	42
		60	43
		75	44

Table A1-2 Data for trial 1 to trial 25 in the stage one

T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T19	T20	T21	T22	T23	T24	T25
4.6	2.7	2.9	5.3	2.5	3.5	5.5	3	4.6	3.3	3.3	2.9	5.4	5.9	2.9	3.8	5.4	2.9	6
4.8	3.1	3.3	6.3	2.7	3.3	5.4	3.1	4.7	2.9	3.5	3.3	5.5	6	3.1	3.5	5.5	2.9	5.9
5.1	3.5	4	6.9	3	3.3	5.3	3.3	4.8	2.6	4	3.8	5.7	6	3.4	3.1	5.6	2.9	5.8
5.1	3.7	4.3	6.9	2.9	3.1	5	3.4	4.7	2	4.7	4	5.8	6	3.6	3	5.4	3	5.7
5.1	4	4.4	7	3	2.7	4.8	3.5	4.7	1.6	5.3	4.2	5.5	5.9	3.7	2.8	5	3.2	5.6
4.9	4	4.4	6.9	2.9	2.2	4.4	3.7	4.4	1.3	5.9	4.3	5.8	5.5	3.9	2.6	4.6	3.5	5.5
4.6	3.9	4.5	6.9	2.6	2	4.1	3.9	4.7	1.3	6.3	4.5	5.9	5.3	4	2.7	4.1	3.9	5.5
4.3	3.9	4.4	6.8	2.4	1.9	3.8	4.3	3.3	1.2	6.6	4.4	6.3	5	4.2	2.8	3.8	4.1	5.6
4	3.9	4.3	6.6	2.2	1.8	3.7	4.4	2.9	1.3	6.4	4.5	6.5	4.9	4.4	2.9	3.6	4.2	5.3
3.8	3.8	4.2	6.2	2	1.8	3.8	4.3	2.3	1.7	6	4.5	6.5	4.8	4.4	3.1	3.3	4.2	5
3.5	3.6	4.1	5.5	2	2	3.9	4.2	1.7	2.1	5.7	4.3	6.3	4.6	4.3	3.3	3.4	4	4.7
3.3	3.5	3.9	5.1	2.1	2.1	4	4.2	1.2	2.7		4.2	6	4.9	4.4	3.5	3.6	4	4.4
3.3	3.5	3.9	4.7	2	2.2	4.2	4.5	0.8	3.5	5	4	5.9	5	4.3	3.8	4	4	4.1
3.2	3.4	3.9	4.2	1.5	2.2	4.4	4.5	0.3	4.3		3.9	5.7	5.1	4.3	4	4.3	4	3.8
3.2	3.5	4	4	1.6	2.1	4.6	4.5	0	5		3.8	5.7	5.2	4.3	4.1	4.5	4	3.6
3.3	3.7	4	3.7	1.6	2.2	4.9		0	5.3	4	3.7	5.6	5.2	4.2	4.1	4.6	4	3.7
3.3	3.6	4.1	3.4	1.6	2	5		0	5.5	3.7	3.6	5.8	5.2	4.1	4.2	4.5	3.9	3.8
3.3	3.9	4.2	3.2	1.6	1.8	5.2	4.3	0		3.5	3.5	5.8	5	3.9	4	4.5	3.8	3.9
3.4	4.2	4.1	3.1	1.7	1.8	5.3		0	5.7	3.3	3.3	6	4.7	3.7	3.9	4.4	3.7	4
3.5	4.3	4.2	2.9	1.9	2	5.3		0	5.5	3.1	3.3	6.1	4.6	3.6	3.7	4.4	3.7	3.9
3.8	4.3	4.3	2.7	1.9	1.9	5.3	4		5.1	3.1	3.4	6.1	4.6	3.5	3.5	4.5	3.7	3.9
4	4.4	4.3	2.6	2	1.8	5.5	3.8		4.7	3.5	3.5	6.2	4.6	3.6	3.4	4.5	3.8	3.9
4.2	4.4	4.5	3	1.9	1.8	5.4	3.8		4.5	3.9	3.7	6	4.7	3.7	3.3	4.5	3.9	3.9
4.2	4.2	4.5	3.3	1.6	1.8	5.2				4.7	3.8	5.8	4.6	3.7	3.3	4.4	3.9	3.8
4.2	4.1	4.5	3.8	1.4	1.8	5.2	3.9	3.3	3.9	5.3	4	5.5	4.7	3.9	3.4	4.2	4	3.8
4.5	4	4.6	4.4	1.4	1.8	5.2	3.9	4.1	3.7	5.6	4.3	5.2	4.7	4.1	3.5	4.2	4.3	3.9
4.5	4	4.6	4.8	1.5	1.8	5	4	4.6	3.7	5.7	4.5	4.9	4.7	4.4	3.8	4.2	4.5	4
4.5	3.8	4.5	5	1.7	1.9	5	4	5.1	3.9	5.8	4.5	4.5	4.8	4.7	4.1	4.2	4.9	4.1
4.5	3.6	4.5	5.1	1.8	1.9	4.8	3.9	5.3	4	5.9	4.5	4.2	4.8	4.9	4.4	4.3	5.3	4.1
4.4	3.6	4.3	5	1.9	2	4.7	3.9	5.4	4.2	5.8	4.4	4	4.7	5	4.7	4.4	5.4	4
4.4	3.7	4	4.6	2.3	2.3	4.5	3.8	5.5	4.3	5.6	4.3	3.9	4.7	5	4.9	4.5	5.6	3.9
4.4	3.7	3.9	4.3	2.9	2.4	4.3	3.8	5.4	4.5	5.6	4.2	3.9	4.6	5	4.9	4.7	5.6	4
4.4	3.6	3.7	4.1	3.4	2.4	4.2	4.1		4.5	5.6	4	3.9	4.4	4.8	4.9	4.7	5.6	4.1
4.4	3.4	3.7	3.8	3.8	2.4	4.2	4.1		4.3	5.5	3.8	4	4.4	4.6	4.8	4.8	5.5	4.3
4.4	3.3	3.6	3.6	4	2.4	4.2	4.2	5.3	4.1	5.4	3.5	4.2	4.4	4.4	4.7	4.8	5.4	4.5
4.4	3.3	3.7	3.5	4.2	2.2	4.2	4.1	5.4	3.9	5.1	3.1	4.3	4.6	4.3	4.5	4.8	5.2	4.6
4.6	3.3	3.9	3.6	4.1	2.2	4.5	3.9	5.3	3.6	4.8	2.8	4.3	4.8	4.1	4.4	4.8	5.1	4.7
4.5	3.4	4	3.8	4.1	2.2	4.7	3.7	5.2	3.2	4.7	2.7	4.3	4.9	4	4.2	4.9	5	4.9
4.6	3.3	4.1	4.3	4	2.1	4.9	3.6		2.8	4.6	2.3	4.3	5.2	4	4.2	4.8	4.8	4.9
4.6	3.3	4.5	4.6	4.1	2	5.1	3.6	4.8	2.5	4.4	2.3	4.2	5.3	4.2	4.2	4.8	4.7	4.9
4.4	3.1	4.6	4.7	4.2	2.2	5.1		4.7	2.2	4.2	2.3	4	5.2	4.4	4.3	4.7	4.5	4.8
4.3	3	4.6	4.7	4.3	2.2	5	3.6	4.5	2.1	3.8	2.2	3.9	5.2	4.4	4.5	4.6	4.3	4.7
4	3.1	4.4	4.6	4.5	2.3	5	3.6		2.2	3.6	2.2	3.8	5.2	4.6	4.8	4.4	4	4.6
3.7	3.3	4.3	4.5	4.5	2.3	5	3.7	4.3	2.2	3.2	2.2	3.8	5	4.6	5	4.1	3.8	4.5
3.3	3.6	4.1	4.4	4.4	2.4	5		4.2	2.2	3.3	2.3	3.9	5	4.6	5.2	4	3.5	4.7
2.9	3.9	3.9	4.3	4.6	2.5	5	3.9	4	2.4		2.5	4.1	4.9	4.7	5.2	3.8	3.3	4.8
2.7	4.2	3.7	4.2	4.5	2.6	5	4.1		2.7	3.5	2.5	4.3	4.9	4.6	5.2	3.6	3.1	4.8
2.3	4.4	3.5	4.1	4.5	2.7	5	4.3		2.9	3.9	2.8	4.3	4.9	4.5	5.2	3.4	3.1	4.7
1.5	4.5	3.2	3.8	4.3	2.7	5	4.4	3.9	3.2	4.5	3	4.4	5.1	4.4	5.1	3.4	3	4.6
1.5	4.6	2.8	3.6	4.2	2.8	4.9		3.9	3.5	4.7	3.4	4.4	5	4.4	4.9	3.3	3.3	4.5
1.4	4.6	2.6	3.4	4.1	2.8	4.8	4.3	3.9	3.7	5.3	3.7	4.4	4.9	4.4	4.8	3.4	3.6	4.4

Table A1-2 Cont.

T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T19	T20	T21	T22	T23	T24	T25
1.4	4.5	2.5	3.2	3.8	2.8	4.6	4.4	4	3.8	5.5	4.2	4.4	4.6	4.2	4.6	3.4	4	4.3
1.6	4.4	2.5	3.1	3.7	2.8	4.4	4.3	4.3	4.1	5.6	4.5	4.4	4.4	4	4.5	3.5	4.3	4.1
1.8	4.2	2.6	2.9	3.5	2.7	4.2	4.3	4.4	4.2	5.6	4.7	4.5	4.3	3.6	4.4	3.5	4.5	4.2
2.1	4.1	2.8	2.8	3.6	2.7	4	4.4	4.5	4.3	5.7	4.9	4.7	4.1	3.7	4.4	3.7	4.6	4.3
2.3	3.9	3	2.9	3.7	2.7	3.9		4.5	4.2	5.6	5.2	4.7	4.1	3.6	4.5	4	4.6	4.4
2.3	3.7	3.1	3.2	4	2.8	3.8		4.6	4.1	5.4	5	4.8	4.1	3.6	4.7	4.3	4.7	4.5
2.2	3.4	3.4	3.7	4.1	2.8	3.7	4.5	4.6	3.8	5.2	5.1	4.9	4.3	3.7	4.9	4.7	4.5	4.5
2	3.2	3.5	4	4.3	2.9	3.6	4.5	4.4	3.6	5.1	5	4.9	4.4	3.8	5.1	4.9	4.4	4.4
1.4	3.1	3.5	4.2	4.4	3.1	3.6	4.5	4	3.3	5	4.8	4.8	4.5	4	5.3	5.2	4.3	4.4
1.3	3	3.5	4.4	4.5	3.4	3.6	4.4	3.9	3	4.8	4.7	4.7	4.4	4.1	5.4	5.2	4	4.3
1.5	3	3.5	4.7	4.5	3.6	3.7	4.4	3.6	2.7	4.5	4.5	4.9	4.3	4.3	5.5	5.3	3.8	4.3
1.6	3	3.5	4.7	4.4	3.7	3.8	4.3	3.5	2.3	4.1	4.4	4.8	4.2	4.4	5.5	5.3	3.7	4.5
1.6	3	3.4	4.5	4.2	3.8	3.9	4.3	3.3	2	3.8	4	4.9	4	4.7	5.4	5.2	3.5	4.5
1.5	3.1	3.3	4.3	4	3.9	4	4.4	3	1.9	3.6	3.7	4.9	4	4.7	5.1	5.1	3.4	4.6
1.3	3.2	3.1	4.3	3.6	3.9	4	4.3	3	1.7	3.3	3.4	4.9	4	4.8	5	5	3.4	4.6
1.3	3.3	3	4.3	3.3	3.9	3.9	4.3		1.8	3.3	3.1	4.7	3.9	4.8	4.8	4.9	3.3	4.6
1.2	3.3	2.9	4.3	3	3.8	3.8	4.1	3		3.3	2.7	4.5	3.8	4.6	4.5	4.7	3.3	4.6
1	3.5	2.9	4.2	2.7	3.8		3.9	3.3		3.4	2.3	4.3	3.8	4.5	4.3	4.3	3.4	4.5
0.7	3.6	2.8	4.2	2.4	3.6		3.8	3.5		3.9	1.9	3.8	3.9	4.4	4	4.1	3.5	4.4
0.6	3.8	3	4	2.2	3.5	3.5	3.5	3.8	2.4	4.5	1.7	3.5	4	4.3	3.6	3.9	3.6	4.1
0.2	4	3.1	4	1.6	3.6		3.2	4.1	2.4	5	1.5	3.3	4.2	4.3	3.5	3.8	3.8	3.9
0.4	4.3	3.3	4.2	1.4	3.5		3	4.5	2.3	5.5	1.3	2.8	4.4	4.3	3.5	3.6	4.1	3.8
0.8	4.3	3.5	4.2	1.2	3.4			5	2	6	1.3	2.5	4.3	4.4	3.4	3.5	4.4	3.8
1.2	4.5	3.7	4.2	1.6	3.5		2.6	4.9	1.7	6.5	1.7	2.4	4.2	4.3	3.5	3.6	4.7	3.6
1.3	4.6	4	4.3	1.6	3.5		2.4	4.9	1.4	6.7	2.4	2.5	4	4.3	3.6	3.7	4.8	3.5
1.5	4.7	4.2	4.3	1.5	3.4		2.3		1.3	6.7	2.7	2.6	4.3	4.5	3.8	3.9	4.9	3.4
1.7	4.8	4.3	4.4	1.8	3.5		2.1		1	6.6	3.4	2.9	4.2	4.6	4.1	4.3	5.1	3.5
1.8	4.8	4.5	4.6	1.8	3.5		2.2		0.8	6.4	3.9	3	4	4.6	4.5	4.5	5.1	3.6
2	4.8	4.4	4.7	1.5	3.5		2.5	3.3	0.6	6	4.3	3.1	3.7	4.3	4.7	4.7	5.2	3.7
2	4.5	4.3	4.6	0.9	3.4		2.8	2.9	0.8	5.5	4.5	3.2	3.5	4.1	4.8	4.9	5.2	3.9
1.7	4.4	4.2	4.5	0.5	3.2		3.2	2.7	1	4.8	4.8	3.1	3.2	3.8	4.8	5	5.1	3.9
1.4	4.3	4	4.2	0.7	2.9		3.5	2.7	1.1	4.5		3.2	2.9	3.3	4.7	5.1	4.8	4
1.6	4.1	4	3.9	0.9	2.7		3.7	2.7	1.3	4.1		3.2	2.5	2.5	4.5	5.1	4.3	4
1.7	4.2	4	3.7	1	2.6		3.9	2.9	1.9	3.5	4.4	3.1	2.2	2.1	4.1	4.9	3.8	3.8
2	4.2	3.9	3.5	1	2.3		4.1	3.2	2.5	3.4	4.1	3.2	2.3	1.7	3.8	4.8	3.3	3.6
2.5	4.1	3.8	3.4	1.1	2.3		4.3	3.5	2.9	2.9	4.2	3.3	2.4	1.2	3.6	4.7	2.8	3.5
3.1	4.1	3.8	3.3	1.3	2.3		4.4	3.9	3.1	2.8	4.2	3.5	2.5	1	3.5	4.6	2.3	3.4
3.7	4.1	3.8	3.4	1.4	2.3		4.4	4	3.3	2.8	4.3	3.5	2.9	0.8	3.6	4.6	1.8	3.3
4.3	4.1	3.7	3.5	1.6	2.2		4.4		3.5	3	4.3	3.9	3.3	0.7	3.6	4.6	1.5	3.3
4.6	4	3.7	3.7	1.9	2.1		4.3	4.4	3.6	3.5	4.5	4	3.7	0.6	3.7	4.4	1.6	3.4
4.8	4	3.6	4.1	2.1	1.9		4.3	4.6	3.8	4	4.5	4.3	3.9	0.8	3.7	4.4	1.7	3.5
4.8	3.9	3.4	4.6	2.5	2.1		4.3		3.9	4.3	4.5	4.3	4.1	0.9	3.8	4.2	1.8	3.6
4.8	3.8	3.2	5.1	2.8	2.2		4.2		4.3	4.5	4.6	4.5	4.2	1.3	3.9	4	2.2	3.7
4.7	3.6	3	5.5	3	2.5		4.3		4.4	4.5	4.6	4.6	4.2	1.8	3.8	3.8	2.9	3.8
4.5	3.4	3	5.6	3.2	2.7	3.6	4.5		4.6	4.5	4.5	4.7	4.2	2.3	3.7	3.7	3.7	3.9
4.5	3.3	3.1	5.9	3.5	2.8	3.8		5.3	4.6	4.3	4.4	4.9	4.3	2.6	3.4	3.7	4.5	3.9
4.5	3.3	3.3	6	3.6	3.1			5.3	4.7	4.4	4.3	5.3	4.3	2.9	3.3	3.6	4.9	4
4.5	3.4	3.5	5.9		3.3				4.7	4.4	4.2	5.5	4.4	3.2	3.1	3.5	5	4.1
	3.4		6		3.6				4.6		4	5.5	4.5	3.4	3.1	3.5	5.1	4.4
			5.8		3.8				4.4		3.8	5.7	4.6	3.5	2.9	3.6	5.3	4.5
											3.7	6	4.6	3.5	2.8	4	5.2	4.6
												6.2	4.5	3.6	2.9	4.4	5.2	4.7

Table A1-3 Data for trial 26 to trial 44 in the stage one

T26	T27	T28	T29	T30	T31	T32	T33	T34	T35	T36	T37	T38	T39	T40	T41	T42	T43	T44
4.4	3.9	4.7	3.3	4.2	3.8	3.7	3.5	3.9	4	3.7	3	2.5	3.4	3.5	3.4	5.5	5.9	3.4
4.2	3.9	4.6	3.4	4.3	4	3.6	3.4	4	4.3	3.9	2.8	2.7	3.7	3.7	3.2	5	5.9	3.4
3.9	4	4.4	3.6	4.3	4.4	3.4	3.4	4.1	4.6	4.1	2.7	2.9	3.9	3.7	3.1	4.8	5.8	3.3
3.8	4	4.3	3.9	4.3	4.6	3.3	3.5	4	4.7	4.3	2.5	2.9	4.3	3.8	3.1	4.3	5.6	3.2
3.7	4.1	4	4	3.9	4.7	3.2	3.8	3.9	4.8	4.3	2.4	3.3	4.5	3.9	3.1	4	5.1	3.1
3.8	4.2	3.8	4.2	3.8	4.5	3.3	3.9	3.8	4.8	4.3	2.5	3.7	4.6	4.2	3.2	3.7	4.8	3.2
3.9	4.3	3.7	4.2	3.6	4.4	3.4	4.1	3.5	4.8	4	2.6	4	4.7	4.4	3.4	3.1	4.2	3.4
4	4.5	3.5	4.3	3.5	4.2	3.4	4.2	3.4	4.7	3.9	2.7	4.3	4.7	4.5	3.6	2.7	3.7	3.6
4.3	4.5	3.6	4.2	3.3	4	3.3	4.3	3.1	4.6	3.8	2.6	4.6	4.6	4.8	3.7	2.6	3.5	3.8
4.2	4.4	3.8	4.1	3.2	3.9	3.5	4.5	2.9	4.5	3.7	2.8	4.7	4.5	5	3.9	2.6	3.6	4
4	4.3	3.9	4	3.1	3.7	3.8	4.5	2.7	4.2	3.6	2.9	4.7	4.2	5	3.9	2.6	3.6	4.2
3.8	4.1	4	3.9	3	3.5	4.1	4.3	2.5	4.1	3.4	3.1	4.8	3.8	4.9	3.9	2.5	3.5	4.3
3.6	3.9	4.3	4	2.9	3.4	4.3	4.2	2.7	4.1	3.2	3.4	4.8	3.6	5.1	3.8	2.4	3.8	4.4
3.5	3.7	4.5	4	3	3.3	4.5	4.1	2.8	4.3	3.3	3.5	4.5	3.4	5.3	3.8	2.4	4.2	4.4
3.4	3.4	4.7	4.1	2.8	3.2	4.7	4.1	2.7	4.5	3.5	3.5	4.3	3.2	5.6	3.8	2.5	4.4	4.3
3.4	3	4.6	4	2.7	3.3	4.7	4.2	2.8	4.6	3.7	3.7	3.9	2.9	5.8	3.9	2.5	4.7	4
3.5	2.7	4.5	4	2.7	3.4	4.7	4.1	2.9	4.7	3.8	3.6	3.5	2.9	5.9	4	2.5	4.8	3.9
3.8	2.6	4.5	4	2.6	3.5	4.6	4.4	3	4.7	3.8	3.5	3	3	5.9	4	2.6	5	3.7
4.1	2.7	4.5	4	2.5	3.7	4.5	4.5	3	4.7	3.8	3.4	3.2	3.2	5.9	4.1	2.9	5.2	3.4
4.3	2.8	4.5	3.8	2.4	3.7	4.5	4.5	2.9	4.6	3.7	3.3	3.3	3.3	5.9	4.3	3.1	5.2	3.3
4.3	2.9	4.5	3.6	2.3	3.7	4.5	4.6	2.7	4.5	3.7	3.2	3.3	3.5	5.8	4.4	3.4	5.1	3
4.4	3.1	4.3	3.5	2.3	3.7	4.5	4.5	2.5	4.3	3.7	3	3.6	3.7	5.8	4.3	3.7	5	2.8
4.2	3.3	4.4	3.4	2.2	3.6	4.4	4.4	2.4	4.2	3.8	2.9	3.9	4.1	5.7	4.4	3.9	4.7	2.7
4.1	3.6	4.2	3.4	2.3	3.5	4.1	4.4	2.5	4.1	3.9	2.9	4.3	4.2	5.5	4.2	4	4.5	2.8
4	3.9	4	3.5	2.4	3.6	3.9	4.3	2.5	4.1	3.7	3	4.5	4.3	5.4	4.2	3.9	4.2	3
3.8	4.3	3.8	3.6	2.5	3.5	3.8	4	2.6	4.4	3.7	3	4.7	4.3	5.4	4.1	4	4	3.3
3.7	4.4	3.7	3.7	2.4	3.5	3.8	3.9	2.7	4.7	3.6	3.4	4.9	4.2	5.6	4.1	3.9	3.7	3.7
3.6	4.6	3.4	3.7	2.6	3.5	3.6	4	2.8	5	3.5	3.7	5.2	4	5.3	4.2	3.9	3.4	3.9
3.4	4.5	3.1	3.7	2.7	3.6	3.5	3.8	3	5.1	3.5	4.1	5.4	3.7	5.7	4.2	3.8	3.1	4.7
3.2	4.4	2.8	3.6	2.9	3.6	3.3	3.5	3.3	5.1	3.6	4.3	5.5	3.6	5.9	4.4	3.6	2.9	5.5
3	4.1	2.7	3.5	2.9	3.5	3.2	3.4	3.5	5.1	3.7	4.7	5.3	3.3	5.7	4.6	3.6	2.9	5.7
3.1	3.8	2.8	3.4	2.7	3.6	3	3.3	3.7	5	3.8	4.8	5.1	3.2	5.6	4.9	3.5	2.9	6
3	3.7	2.9	3.3	2.8	3.5	2.8	3.1	3.8	4.8	3.9	4.9	5.1	3	5.7	4.9	3.5	2.8	6.1
3.2	3.4	3.1	3.1	2.9	3.6	2.8	3	3.8	4.6	3.8	4.8	4.9	2.8	5.8	4.7	3.4	3.2	6.2
3.5	3.2	3.3	3	2.8	3.5	2.9	3	3.9	4.4	3.8	4.7	4.8	2.7	5.6	4.4	3.4	3.3	5.8
3.8	3	3.4	3	2.6	3.6	2.8	3	3.8	4.3	3.8	4.6	4.8	2.8	5.7	4.2	3.4	3.7	5.7
4.2	2.8	3.7	3.1	2.5	3.6	2.6	3	3.78	4.2	3.8	4.5	4.7	2.9	5.6	4.1	3.5	4	5.5
4.3	2.8	4	3.3	2.4	3.4	2.6	3.1	3.6	4.1	3.6	4	4.6	2.8	5.4	4	3.5	4.3	5.3
4.3	2.9	4.3	3.5	2.4	3.4	2.6	3.1	3.6	4.3	3.5	3.9	4.8	2.9	5.3	4.1	3.5	4.4	5
4.3	3	4.5	3.9	2.5	3.3	2.6	3.3	3.5	4.5	3.6	3.7	4.9	2.9	5	4	3.7	4.7	4.8
4.1	3.3	4.7	4.2	2.4	3.1	2.5	3.5	3.3	4.6	3.8	3.5	4.8	2.9	4.8	4.1	3.9	4.7	4.6
3.8	3.5	4.8	4.5	2.4	3	2.4	3.6	3.2	4.6	3.9	3.2	4.7	2.9	4.8	4	4	4.8	4.3
3.7	3.9	4.9	4.6	2.5	3.1	2.5	3.6	3.1	4.5	4	3	4.6	2.9	4.7	3.9	4.3	4.9	4.2
3.3	4.2	4.8	4.7	2.5	3	2.4	3.7	3.2	4.4	4.3	2.9	4.5	3.1	4.6	3.8	4.5	4.2	4.3
3	4.5	4.8	4.7	2.6	3.3	2.4	3.6	3.3	4.6	4.6	2.9	4	3.3	4.5	3.7	4.8	3.8	4.4
3	4.7	4.7	4.7	2.6	3.2	2.3	3.5	3.5	4.9	4.7	3	3.9	3.7	4.4	3.5	4.9	3.5	4.4
2.9	5	4.6	4.8	2.8	3.2	2.4	3.2	3.7	4.8	4.8	3.2	3.5	4	4.3	3.3	5	3.2	4.5
3.2	5.1	4.6	4.7	2.9	3.1	2.7	3.1	4.1	4.9	4.7	3.4	3.5	4.4	4.4	3.1	5	3.2	4.4
3.3	5.2	4.5	4.6	3.1	3.3	3	3.2	4.5	5	4.6	3.7	3.5	4.7	4.3	3	4.9	3.3	4.3
3.5	5.1	4.3	4.5	3.2	3.3	3.4	3.3	4.8	4.9	4.5	3.9	3.6	5.1	4.2	2.9	4.9	3.4	4.2
3.7	5	4.2	4.5	3.3	3.2	3.5	3.5	4.9	4.9	4.4	4.1	3.9	5.2	4.1	2.8	4.9	3.5	4

T26	T27	T28	T29	T30	T31	T32	T33	T34	T35	T36	T37	T38	T39	T40	T41	T42	T43	T44
3.9	4.9	4	4.4	3.2	3.3	3.7	3.7	4.9	4.7	4.4	4.2	4.1	5.3	3.9	2.7	4.9	3.8	3.8
4	4.9	3.8	4.3	3	3.2	4	3.9	4.7	4.5	4.4	4	4.2	5.2	3.8	2.6	4.9	4	3.7
4.1	4.8	3.7	4	2.9	3.1	4.1	4.3	4.3	4.4	4.3	3.6	4.1	5	3.6	2.5	4.8	4.2	3.8
4	4.8	3.5	3.9	2.7	3.2	4.2	4.6	4.3	4.3	4.3	3.6	4	4.8	3.5	2.4	4.8	4.4	3.9
4	4.8	3.6	3.8	2.6	3.3	4.3	4.7	4.3	4.2	4.2	3	3.8	4.9	3.4	2.5	4.7	4.6	4.1
3.8	4.7	3.6	3.8	2.7	3.4	4.4	4.7	4.2	4.1	4.2	2.8	3.7	4.9	3.3	2.7	4.5	4.8	4.2
3.8	4.6	3.7	3.9	2.7	3.5	4.6	4.6	4	4.3	4.2	2.5	3.5	4.9	3.2	2.9	4.2	4.8	4.3
3.8	4.5	3.9	3.9	2.7	3.7	4.7	4.6	3.8	4.4	4.3	2.4	3.4	4.9	3.2	3	4.1	4.9	4.4
3.6	4.1	4	3.9	2.6	3.8	4.8	4.6	3.3	4.5	4.3	2	3.1	4.8	3.1	3.3	3.8	5	4.5
3.6	3.8	4.1	4.5	2.5	4	4.9	4.5	3.1	4.7	4.3	1.7	3	4.6	3.1	3.3	3.3	4.9	4.6
3.5	3.6	4.1	4.5	2.4	4	4.9	4.3	3.1	4.8	4.4	1.4	2.8	4.5	3.1	3.2	2.8	4.9	4.6
3.4	3.4	4	4.6	2.4	4	4.9	4	3.2	4.8	4.5	1.2	2.8	4.3	3	3.1	2.7	4.9	4.6
3.6	3.3	3.9	4.7	2.5	3.8	4.8	3.8	3.3	4.7	4.6	1.2	2.8	4.1	2.9	3	2.5	4.8	4.5
3.6	3.5	3.8	4.7	2.6	3.5	4.6	3.6	3.5	4.6	4.7	1.1	2.7	3.8	2.8	2.9	2.4	4.7	4.2
3.7	3.4	3.5	4.6	2.7	3.3	4	3.5	3.6	4.4	4.7	1.3	2.6	3.5	2.8	2.7	2.2	4.5	4
3.7	3.5	3.3	4.5	2.7	2.9	3.7	3.2	3.8	4.1	4.6	1.5	2.4	3.1	2.7	2.3	2.1	4.2	3.8
3.7	3.3	3	4.2	2.9	2.7	3.3	3	3.9	3.7	4.5	1.7	2.3	2.5	2.8	2.1	1.7	4	3.6
3.7	3.1	2.7	3.8	3	2.5	3	2.9	3.9	3.5	4.1	2	2.1	2.2	2.9	2.1	1.5	3.8	3.2
3.6	2.7	2.4	3.5	3.3	2.4	2.5	2.9	3.8	3.1	3.7	2.4	1.5	1.7	2.8	1.8	1.3	3.7	2.9
3.7	2.4	2.3	3.1	3.6	2.3	2.2	2.9	3.7	2.8	3.3	2.1	1.7	1	3	1.7	1.1	3.5	2.8
3.7	2.3	2.4	2.7	3.7	2.3	2	2.7	3.6	2.5	2.9	2.5	1.5	0.7	3.1	1.8	1.2	3.5	2.8
3.9	2.4	2.6	2.5	3.8	2.2	1.9	2.6	3.6	2.5	2.7	2.9	1.6	0.6	3.1	1.6	1.3	3.5	2.9
3.9	2.4	2.7	2.4	3.9	2.5	2	2.3	3.6	2.5	2.7	3.1	1.9	0.6	3.2	1.7	1.1	3.3	3
4	2.5	2.9	2.5	4.1	2.9	2.2	2.3	3.5	2.4	2.8	3.2	2.5	0.6	3.2	2	0.8	3.3	3.3
4.1	2.8	3.1	2.8	4.3	3.3	2.3	2.6	3.5	2.5	2.9	3.4	3	1.1	3.3	2.2	0.9	3.6	3.5
4.1	3	3.3	3.1	4.5	3.9	2.3	2.7	3.4	2.7	3	3.7	3.6	1.5	3.3	2.7	1.3	3.8	3.7
4.2	3.3	3.7	3.4	4.3	4.2	2.4	3	3.4	2.9	3.1	3.9	4	1.7	3.5	2.9	1.7	4	3.9
4.2	3.8	3.9	3.7	4.2	4.4	2.5	3.5	3.5	3.3	3.3	4.1	4.3	2	3.9	3.1	2.1	4	3.9
4.1	4.1	3.9	3.7	4.2	4.7	2.5	3.9	3.5	3.5	3.5	4	4.8	2.2	4	3.2	2.4	4.1	3.9
3.9	4.2	3.8	3.6	4.3	4.6	2.3	4.2	3.5	3.9	3.6	3.8	4.9	2.3	4.3	3.2	2.7	3.8	3.7
3.7	4.2	4	3.5	4.2	4.5	2.1	4.3	3.5	4	3.7	3.5	4.9	2.3	4.4	3.1	2.7	4	3.6
3.5	4	3.9	3.4	4	4.3	2	4.3	3.3	4	3.7	3	4.8	2	4.3	2.9	2.5	4.2	3.6
3.3	3.8	3.7	3	4	4.5	2.1	4.3	3.3	3.9	3.7	2.5	4.7	2	4.1	2.7	2.2	4.1	3.6
3	3.3	3.5	2.4	4.1	4.7	2.3	3.8	3.1	3.7	3.5	2.3	4.9	1.9	4	2.7	2.1	4	3.5
2.8	3	3.1	2	4.1	4.6	2.3	3.6	3.2	3.5	3.2	2	5.1	2.2	3.7	2.7	2	3.9	3.4
2.7	2.7	2.9	1.7	4.2	4.8	2.7	3	3.3	3.3	3	1.9	5.3	2.4	3.3	2.9	1.8	4.1	3.3
2.7	2.6	2.8	1.5	4.2	4.8	3.3	2.8	3.4	3	3	1.7	5.5	2.6	3	3	1.9	4.2	3.2
2.8	2.6	2.7	1.4	4.4	4.8	3.8	2.6	3.5	3	3	2	5.5	2.8	3	3.3	2	4.3	3.2
2.8	2.6	2.8	1.7	4.6	5	4.2	2.3	3.9	2.9	3	2.5	5.7	3.2	2.9	3.5	2.1	4.3	3
2.9	2.7	2.8	1.7	4.7	4.9	4.7	2.2	4.4	2.8	3.5	3	5.8	3.7	2.9	3.7	2.4	4.3	2.9
3.1	2.8	3	1.8	4.8	4.8	4.9	2.1	4.9	2.7	3.7	3.7	5.7	4.2	2.9	3.9	2.7	4.3	2.7
3.3	2.9	3.1	2	4.9	4.7	5.2	2.3	5.2	2.9	4	4.2	5.6	4.4	3.1	4.3	2.9	4	2.6
3.4	3	3.3	2.1	5	4.4	5.3	2.4	5.3	3.1	4.3	4.5	5.3	4.5	3.3	4.4	3	3.5	2.6
3.5	3.3	3.5	2.4	5.2	4.2	5.4	2.6	5.4	3.2	4.5	4.7	5.2	4.9	3.3	4.6	3.2	3.2	2.6
3.8	3.5	3.9	2.7	5.4	3.6	5.2	2.7	5.3	3.3	4.7	4.9	5	5	3.5	4.9	3.3	2.8	2.8
4.3	3.9	4.2	2.9	5.4	3.4	5	2.9	4.9	3.4	4.8	4.3	5.1	4.9	3.5	4.9	3.5	2.6	3.2
4.7	4.3	4.5	3.3	5.4	3.2	5	3.2	4.6	3.5	4.9	4.1	5	5	3.4	5	3.7	2	3.6
4.8	4.9	4.9	3.6	5.7	3.3	4.7	3.4	4.2	3.6	5	4	5.3	4.9	3.4	5.1	4	1.7	4.4
5	5.1	5	3.7	5.6		4.4	3.6	3.8	3.7	4.9	3.6		4.8	3.3	5.2	4.2	1.4	4.8
5	5.3	5	3.9				3.7	3.5	3.6	4.5	3.1			3.4		4.4	1.1	
5.1	5.6	4.9	4.1				3.7	3.5	3.5	4.4				3.4		4.5	0.8	
5.2	5.7	4.9	4.2				3.8		3.3	4.3				3.4				

Appendix A2 Data for stage two

The data was collected in the unit of centimeter for stage two.

Table A2-1 Trial number vs. combination of the four factors (camera tilt angle, camera height, field of view of camera, and tractor velocity)

Table A2-2 Trial number explanation without guidance aid

Table A2-3 Data for trial no. 1 to trial no. 20 in the stage two

Table A2-4 Data for trial no. 21 to trial no. 40 in the stage two

Table A2-5 Data for trial no. 41 to trial no. 60 in the stage two

Table A2-6 Data for trial no. 61 to trial no. 80 in the stage two

Table A2-7 Data for trial no. 81 to trial no. 100 in the stage two

Table A2-8 Data for trial no. 101 to trial no. 117 in the stage two

Table A2-1 Trial number vs. combination of the four factors (camera tilt angle, camera height, field of view of camera, and tractor velocity)

Field of View	Velocity (mph)	Height (m)	Angle (°)	Trial No.		
Narrow	6.4	1.1	20	1	2	3
			30	4	5	6
			40	7	8	9
		1.5	20	10	11	12
			30	13	14	15
			40	16	17	18
	9.6	1.1	20	19	20	21
			30	22	23	24
			40	25	26	27
		1.5	20	28	29	30
			30	31	32	33
			40	34	35	36
	12.8	1.1	20	37	38	39
			30	40	41	42
			40	43	44	45
		1.5	20	46	47	48
			30	49	50	51
			40	52	53	54
Wide	6.4	1.1	20	55	56	57
			30	58	59	60
			40	61	62	63
		1.5	20	64	65	66
			30	67	68	69
			40	70	71	72
	9.6	1.1	20	73	74	75
			30	76	77	78
			40	79	80	81
		1.5	20	82	83	84
			30	85	86	87
			40	88	89	90
	12.8	1.1	20	91	92	93
			30	94	95	96
			40	97	98	99
		1.5	20	100	101	102
			30	103	104	105
			40	106	107	108

Table A2-2 Trial number without using guidance aid

Tractor velocity (km/h)	Trial No.		
6.4	109	110	111
9.6	112	113	114
12.8	115	116	117

Table A2-3 Data for trial 1 to trial 20 in the stage two

t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	t19	t20
3.3	3.4	2.9	3.3	3.3	3.7	3.2	4	4.6	3	3.2	3.3	3.6	3.5	3.3	3.7	3.1	4.8	4.1	4.1
3.3	3.2	2.7	3.1	3.4	3.7	3.3	4.6	4.5	3.1	3.5	3.5	3.8	3.8	3.5	4.1	3.1	4.9	4	4.4
3.2	3.1	2.5	2.8	3.4	3.6	3.5	5.1	4.4	3	3.7	3.8	3.9	4.1	3.7	4.3	3.2	5	3.7	4.6
3.1	2.8	2.3	2.8	3.4	3.5	3.6	5.3	4.3	3.3	3.8	3.9	3.8	4.2	3.9	4.5	3.6	5.1	3.5	4.7
3	2.6	2.2	2.9	3.4	3.4	3.8	5.4	4.2	3.5	3.9	3.9	3.8	4.4	4.2	4.6	3.9	5.1	3.3	4.8
3	2.4	2.1	3.1	3.3	3.3	3.9	5.3	4.1	3.6	3.9	3.8	3.6	4.4	4.3	4.4	4	5.1	2.9	4.6
3.1	2.3	2	3.2	3.1	3.3	3.8	5	4.1	3.6	3.9	3.9	3.4	4.4	4.3	4.2	4.1	5	2.8	4.5
3.1	2.3	1.9	3.2	2.9	3.5	3.8	4.7	4.1	3.7	3.8	3.8	3.1	4.2	4.4	3.9	4.1	5	2.7	4.5
3.1	2.4	1.9	3.2	2.7	3.7	3.9	4.5	4.3	3.8	3.8	3.9	2.8	4	4.4	3.5	4	5	2.5	4.3
3.2	2.5	1.9	3.3	2.6	3.8	4	4.4	4.4	3.7	3.7	3.9	2.6	3.6	4.4	3.1	3.9	5	2.4	4.2
3.2	2.5	1.8	3.5	2.6	3.7	4	4.1	4.5	3.7	3.7	3.8	2.6	3.2	4.5	2.7	3.7	4.9	2.2	4
3.2	2.6	1.9	3.5	2.6	3.5	3.8	3.8	4.5	3.6	3.6	3.5	2.6	2.8	4.5	2.5	3.5	4.9	2.4	3.9
3.1	2.7	2	3.9	2.7	3.4	3.6	3.4	4.3	3.5	3.6	3.5	2.7	2.5	4.4	2.5	3.3	4.9	2.5	3.8
3	2.7	2.2	4.1	2.8	3.2	3.5	3.3	4.1	3.3	3.6	3.4	3	2.2	4.2	2.6	3.4	4.9	2.5	3.6
2.9	2.7	2.4	4.2	2.9	2.9	3.3	3.2	3.8	3.2	3.7	3.3	3.3	2.1	4.2	2.7	3.6	4.6	2.9	3.8
2.9	2.7	2.7	4.2	3	2.8	3.2	3	3.5	3.1	3.7	3.3	3.5	2.2	4.2	2.8	3.7	4.5	3.2	3.8
2.9	2.7	2.8	4.1	3.3	2.8	3.1	2.9	3.2	3	3.7	3.3	3.7	2.4	4.2	3	3.8	4.4	3.6	3.8
2.9	2.7	3	4	3.4	2.9	3	2.7	3.1	3.1	3.8	3.3	3.9	2.6	4.1	3.2	3.8	4.2	3.7	3.7
2.9	2.7	3.1	3.7	3.5	2.9	3.1	2.6	3	3.1	3.8	3.2	4.1	2.9	3.9	3.4	3.7	4	3.8	3.5
2.9	2.7	3.2	3.5	3.6	2.9	3.2	2.5	3.2	3.2	3.8	3.3	4.2	3.2	3.6	3.6	3.6	4	3.8	3.5
2.9	2.6	3.2	3.1	3.7	3.1	3.3	2.4	3.4	3.2	3.8	3.3	4.3	3.3	3.7	3.7	3.5	4	3.8	3.2
2.9	2.5	3.2	2.8	3.8	3.2	3.3	2.6	3.9	3.3	3.8	3.4	4.2	3.4	3.7	3.7	3.5	4	3.8	3.1
3	2.5	3.2	2.5	3.8	3.3	3.2	2.7	4.2	3.3	3.6	3.5	4.2	3.4	3.8	3.6	3.4	3.9	3.8	3
3	2.4	3.2	2	3.6	3.3	3.1	2.8	4.6	3.4	3.5	3.5	4.1	3.5	3.6	3.5	3.4	3.7	3.8	3
3	2.3	3.1	2	3.5	3.4	2.9	3.1	4.9	3.6	3.4	3.6	4	3.6	3.5	3.4	3.4	3.6	3.8	2.8
2.9	2.5	3.1	2.1	3.3	3.4	2.9	3.2	5	3.8	3.3	3.7	4	3.6	3.3	3.4	3.5	3.4	3.8	3
2.9	2.8	3.2	2.2	3.1	3.4	2.8	3.4	4.9	3.8	3.2	3.7	3.9	3.6	3.2	3.3	3.4	3.2	3.8	3
2.9	3	3.2	2.5	3	3.5	2.9	3.4	4.8	3.9	3.3	3.7	3.9	3.6	3.2	3.1	3.2	3.2	3.9	2.9
2.9	3.3	3.4	2.8	2.9	3.4	3.2	3.6	4.6	3.9	3.4	3.6	3.7	3.6	3.2	3	3.2	3.4	4	2.8
3	3.4	3.5	2.9	3	3.3	3.6	3.7	4.1	3.8	3.5	3.6	3.6	3.5	3.3	3	3.2	3.5	4	2.7
3	3.4	3.6	2.9	3.2	3.2	3.9	3.7	3.6	3.8	3.6	3.5	3.4	3.5	3.6	2.9	3.2	3.5	4	2.7
3.1	3.5	3.6	3.1	3.6	3.3	4	3.7	3	3.8	3.6	3.4	3.2	3.5	3.8	3	3.2	3.6	4	2.7
3.1	3.5	3.6	3.2	3.8	3.4	4.1	3.6	2.3	3.8	3.6	3.5	3	3.7	4	3.1	3.4	3.7	3.9	2.8
3.1	3.4	3.6	3.3	4	3.6	4	3.5	1.9	3.8	3.7	3.5	3	3.8	4.1	3.4	3.5	3.8	3.8	2.9
3	3.3	3.4	3.4	3.9	3.7	4	3.5	1.6	3.8	3.7	3.6	3	4.1	4.2	3.6	3.5	3.9	3.7	3.1
2.9	3.2	3.2	3.5	3.9	3.6	3.9	3.5	1.5	3.8	3.8	3.6	3.2	4.3	4.2	3.7	3.6	3.9	3.8	3.3
2.9	3	3	3.6	3.8	3.5	3.7	3.4	1.5	3.6	3.8	3.5	3.4	4.4	4.1	3.7	3.7	3.8	3.8	3.4
2.9	2.8	2.9	3.6	3.8	3.4	3.9	3.4	1.9	3.4	3.8	3.4	3.6	4.5	4	3.8	3.8	3.7	3.7	3.4
3	2.6	2.8	3.8	3.6	3.2	4.1	3.4	2.3	3.2	3.9	3.4	3.8	4.5	3.9	3.8	4	3.6	3.7	3.4
3.1	2.4	2.8	3.9	3.5	3.1	4	3.3	2.9	3.1	4	3.3	3.9	4.4	3.9	3.8	4.1	3.3	3.6	3.4
3.3	2.4	2.9	4.1	3.3	3.2	4	3.1	3.6	3.2	4	3.2	4	4.4	3.9	3.6	4.1	3.2	3.7	3.3
3.6	2.3	3	4.1	3.1	3.4	3.9	2.9	4	3.3	4	3.2	4	4.4	3.8	3.4	4.1	3.2	3.6	3.3
3.8	2.3	3	4	3.1	3.5	3.8	2.7	4.4	3.5	4	3.2	4	4.4	3.8	3.4	4	3.2	3.5	3.3
3.9	2.4	3	4	3.2	3.6	3.6	2.5	4.5	3.9	3.8	3.3	3.9	4.2	3.8	3.3	3.8	3.2	3.5	3.3
3.9	2.5	3	3.9	3.4	3.6	3.4	2.4	4.4	4	3.7	3.3	3.7	4.2	3.9	3.4	3.5	3.1	3.4	3.3
3.8	2.6	3	3.8	3.5	3.6	3.3	2.3	4.3	4.1	3.6	3.4	3.5	4.1	3.9	3.5	3.2	2.9	3.4	3.5
3.6	2.9	3	3.8	3.6	3.5	3.3	2.3	4.2	4.1	3.6	3.4	3.4	3.8	4	3.7	2.9	2.9	3.7	3.6
3.3	3.1	3	3.6	3.6	3.4	3.3	2.3	4.3	4.2	3.5	3.4	3.2	3.5	4.1	3.7	2.6	3	3.9	3.7
3.3	3.4	2.9	3.7	3.5	3.4	3.5	2.5	4.4	4	3.4	3.5	3.2	3.3	4.2	3.7	2.4	3.3	3.9	3.7
3.3	3.6	2.9	3.9	3.6	3.4	3.6	2.8	4.5	4	3.4	3.5	3.3	3.4	4.1	3.7	2.4	3.8	3.8	3.6
3.4	3.7	2.8	3.8	3.7	3.4	3.6	2.9	4.7	4.1	3.4	3.6	3.5	3.6	4.1	3.6	2.6	4.1	3.8	3.6
3.6	3.7	2.7	3.9	3.6	3.3	3.6	3.1	4.8	4.2	3.4	3.7	3.5	4	4	3.5	3.1	4.3	3.8	3.6

t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	t19	t20
3.7	3.6	2.7	4	3.5	3.4	3.8	3.1	4.7	4.4	3.5	3.8	3.7	4.2	3.9	3.3	3.7	4.5	3.7	3.6
3.8	3.5	2.7	4.1	3.3	3.5	3.8	3.2	4.6	4.6	3.5	3.8	4	4.4	3.8	3.1	4.3	4.4	3.6	3.4
3.9	3.4	2.7	4	3.1	3.7	3.8	3.1	4.4	4.6	3.6	3.9	4.2	4.4	3.7	2.9	4.6	4.3	3.6	3.4
4	3.4	2.9	3.9	2.8	3.8	3.8	2.9	4.2	4.7	3.6	3.8	4.2	4.4	3.9	2.6	4.8	4.2	3.6	3.4
3.9	3.3	3.2	3.5	2.6	3.9	3.8	2.8	4	4.7	3.6	3.9	4.1	4.3	4	2.6	4.9	4.1	3.8	3.5
3.7	3.3	3.4	3.3	2.8	4	3.8	2.9	3.9	4.9	3.7	3.8	4.1	4.2	4.1	2.8	4.9	4	4	3.5
3.5	3.2	3.5	3.4	2.9	4	3.8	3	4.1	4.9	3.7	3.9	3.9	4.1	4.3	3.1	4.7	3.8	4	3.4
3.2	3.2	3.6	3.5	3.1	3.8	3.7	3.3	4.4	5	3.5	3.9	3.8	3.8	4.4	3.4	4.5	4	4	3.5
3.2	3.3	3.7	3.7	3.5	3.7	3.6	3.6	4.7	5	3.3	3.9	3.7	3.8	4.5	3.7	4.3	4.1	4.1	3.4
3.2	3.3	3.8	4	3.8	3.6	3.6	3.8	4.9	4.9	3.1	3.8	3.6	3.8	4.6	3.8	4.1	4.1	4	3.2
3.4	3.2	3.9	4.4	3.9	3.5	3.6	4.2	5.1	4.9	2.9	3.9	3.5	3.8	4.7	4	3.9	4.2	4	3.2
3.5	3.2	3.8	4.8	3.8	3.4	3.5	4.2	5.3	4.9	2.9	3.9	3.4	3.9	4.6	4.1	3.8	4.1	3.9	3.1
3.6	3.1	3.8	5.2	3.7	3.4	3.4	4.3	5.3	4.9	2.9	3.9	3.2	3.9	4.7	4.1	3.8	4	4	3.2
3.5	3.1	3.8	5.3	3.6	3.5	3.3	4.5	5.3	4.7	2.9	3.9	3.1	3.8	4.5	4	4	4	4.1	3.3
3.5	3	3.7	5.5	3.4	3.6	3.1	4.6	5.2	4.4	3	3.8	3.1	3.5	4.3	3.7	4.2	4.1	4	3.6
3.4	2.9	3.6	5.8	3.2	3.6	2.9	4.6	5.1	4	3.2	3.7	3.2	3.3	4.1	3.6	4.3	4.1	4.1	3.7
3.3	2.8	3.5	6	3.1	3.6	2.8	4.6	5	3.8	3.4	3.6	3.3	3.1	3.8	3.5	4.3	3.9	4.1	3.9
3.2	2.7	3.3	6.3	3.2	3.7	2.8	4.5	4.9	3.7	3.6	3.5	3.7	2.7	3.7	3.4	4.2	3.8	3.9	3.9
3.1	2.8	3.2	6	3.4	3.7	2.9	4.4	4.8	3.5	3.8	3.5	4.1	2.4	3.6	3.4	4	3.9	3.7	4
3.2	2.8	3.3	5.8	3.7	3.7	3.1	4.1	4.5	3.6	4	3.6	4.1	2.1	3.7	3.6	3.7	4	3.6	3.9
3.2	2.7	3.3	5.5	4.1	3.6	3	4	4.3	3.6	4.1	3.6	4.1	1.9	4	3.8	3.3	4	3.5	3.8
3.3	2.6	3.3	5	4.2	3.6	3.1	3.6	4.1	3.5	4.1	3.7	4	1.9	4.1	4	2.9	4	3.3	3.6
3.3	2.4	3.3	4.4	4.4	3.7	3.1	3.3	3.9	3.4	4.1	3.7	3.7	1.9	4.1	4.1	2.5	4	3.3	3.4
3.3	2.2	3.2	3.8	4.4	3.8	3.2	2.8	3.7	3.4	4	3.7	3.4	1.9	4.1	4.1	2.4	3.7	3.3	3.2
3.2	2	3.1	3.1	4.4	4	3.3	2.5	3.9	3.4	4	3.8	3.4	2.4	4.2	4.1	2.4	3.4	3.3	3.1
3	1.8	2.9	2.7	4.4	4.1	3.5	2.2	4.1	3.4	3.8	3.8	3.3	2.7	4.3	4	2.7	3.1	3.3	3.2
2.7	1.7	2.6	2.7	4.2	4.2	3.7	1.9	4.3	3.5	3.9	3.8	3.3	3	4.1	3.8	3.1	2.9	3.3	3.3
2.4	1.7	2.4	2.8	4	4.2	4	1.9	4.5	3.6	4	3.7	3.4	3.2	4	3.7	3.3	2.8	3.2	3.5
2.2	1.7	2.3	2.8	3.8	4	4.1	1.9	4.5	3.7	4.1	3.7	3.5	3.3	3.7	3.6	3.5	3.1	3.3	3.6
2.1	1.8	2.1	2.7	3.6	3.8	4.1	2.2	4.5	3.7	4.3	3.6	3.6	3.4	3.5	3.4	3.5	3.4	3.2	3.9
2.1	2.1	1.9	2.7	3.4	3.5	4	2.4	4.5	3.7	4.3	3.6	3.5	3.4	3.4	3.4	3.4	3.6	3.1	4
2.2	2.5	1.8	2.6	3.4	3.3	3.7	2.6	4.4	3.7	4.3	3.7	3.5	3.5	3.2	3.4	3.3	3.7	3.1	4.1
2.3	2.7	1.9	2.7	3.4	3	3.5	2.8	4.3	3.7	4.2	3.7	3.4	3.5	3.3	3.5	3	3.7	3.2	4.2
2.6	2.8	1.9	2.7	3.2	2.8	3.2	3	4.2	3.7	4.1	3.7	3.3	3.4	3.6	3.6	2.8	3.8	3.3	4.2
2.9	2.9	2	2.7	3.2	2.8	3	3.2	4.1	3.7	3.8	3.7	3.3	3.3	3.9	3.7	2.8	3.9	3.5	4.2
3.1	2.9	2.3	3	3.1	3	2.7	3.4	4	3.7	3.7	3.8	3.4	3.3	4.1	4	2.8	4	3.6	4.1
3.1	2.9	2.4	3.2	3	3.1	2.5	3.6	4	3.8	3.7	3.7	3.3	3.2	4.2	4.1	3	3.9	3.6	4.2
3.2	2.9	2.5	3.3	2.9	3.3	2.4	3.7	4.1	3.9	3.7	3.6	3.2	3.2	4.2	4.1	3.2	3.7	3.5	4.2
3.2	3	2.7	3.4	2.9	3.5	2.5	3.8	4	4.1	3.8	3.6	3.2	3.2	4.3	4	3.2	3.5	3.4	4.2
3.2	2.9	2.8	3.2	2.9	3.6	2.7	3.7	3.9	4.4	4.2	3.5	3.1	3.2	4.2	3.8	3.2	3.4	3.3	4.2
3.2	2.9	2.9	3	3	3.6	3	3.7	3.7	4.5	4.2	3.4	2.8	3	4.1	3.6	3.1	3.2	3	4.1
3.2	2.9	3.1	2.8	3.2	3.6	3.1	3.5	3.6	4.4	4.2	3.3	2.7	2.9	3.9	3.1	3	3.1	2.7	4
3.1	2.8	3	2.6	3.3	3.5	3.2	3.3	3.5	4.2	4.2	3.3	2.5	2.7	3.7	2.6	2.9	3.2	2.5	3.8
3	2.7	3	2.5	3.4	3.3	3.2	3	3.5	4.1	4	3.2	2.3	2.5	3.5	2.2	2.8	3.7	2.5	3.6
3	2.6	3.1	2.7	3.4	3.2	3.6	2.8	3.5	4	3.8	3.1	2.3	2.4	3.2	1.8	2.7	4.1	2.6	3.5
2.9	2.7	3.1	3	3.4	3	3.7	2.9	3.6	3.9	3.7	3.1	2.7	2.2	3	1.4	2.8	4.4	2.7	3
3	2.9	3.1	3.4	3.5	3	3.8	3.1	3.6	3.8	3.5	3.1	3	2.2	2.6	1.3	2.9	4.8	2.9	2.9
3	3.1	3.2	3.4	3.6	3.1	3.7	3.4	3.7	3.8	3.3	3.1	3.3	2.2	2.3	1.2	3.2	5	3.3	2.8
3.2	3.6	3.4		3.7	3.3	3.6	3.8	3.8	3.9	3.3	3.1	3.6	2.3	2.2	2	3.5	4.9	3.6	2.9
3.5	3.9	3.6		3.8		3.5		3.9	3.9	3.3	3.2		2.4	2.3	2.6	3.7	4.8	3.8	3

Table A2-4 Data for trial 21 to trial 40 in the stage two

t21	t22	t23	t24	t25	t26	t27	t28	t29	t30	t31	t32	t33	t34	t35	t36	t37	t38	t39	t40
2.8	3.2	3.8	2.9	3.6	3.4	3	3.1	3.6	3.1	2.5	3.5	3.1	3.9	2.9	3.4	4	1.5	4	3.7
3.2	3.5	3.6	2.8	3.9	3.4	2.9	3.4	3.7	3.2	2.5	3.2	3	3.5	3	3.5	4.2	1.5	4.1	3.5
3.6	3.7	3.6	2.9	4.2	3.5	2.7	3.6	3.8	3.2	2.5	3	3.1	3.2	3.1	3.6	4.2	1.8	4.1	3.3
4.2	4.1	3.5	3.2	4.3	3.6	2.7	3.6	3.8	3.3	2.5	2.8	3.2	2.9	3.1	3.7	4.2	2.1	4.2	3.2
4.3	4.4	3.2	3.4	4.5	3.6	2.8	3.6	3.8	3.5	2.4	2.9	3.3	2.6	3.2	3.9	4.2	2.5	4.2	3.1
4.5	4.7	3.3	3.5	4.5	3.6	3.1	3.7	3.8	3.5	2.5	2.9	3.4	2.4	3.3	3.9	3.9	2.6	4.1	2.9
4.5	4.9	3.4	3.5	4.4	3.5	3.3	3.8	3.6	3.6	2.7	3.1	3.5	2.2	3.5	3.9	3.7	2.8	4.1	2.7
4.8	5.1	3.5	3.6	4.2	3.4	3.6	3.7	3.6	3.6	2.9	3.4	3.5	2	3.6	3.9	3.6	3.1	4	2.9
4.8	5	3.7	3.7	4.2	3.3	3.8	3.7	3.5	3.7	3.1	3.6	3.5	1.8	3.6	3.8	3.3	3.5	3.8	3
4.8	4.9	3.6	3.8	4	3.1	4.2	3.5	3.3	3.7	3.5	3.7	3.6	1.7	3.6	3.6	3	3.6	3.9	3
4.7	4.9	3.7	3.9	3.9	3.2	4.3	3.4	3.3	3.8	3.8	3.8	3.6	1.8	3.6	3.5	2.8	3.6	3.8	3
4.6	4.6	3.7	3.9	3.7	3.1	4.3	3.3	3.2	3.8	4	3.9	3.6	1.7	3.7	3.4	2.6	3.7	3.8	3.2
4.5	4.4	3.8	4.1	3.6	3.2	4.4	3.1	3.2	3.8	4	3.9	3.5	1.9	3.7	3.3	2.5	3.7	4	3.3
4.4	4.1	3.8	4.1	3.3	3.4	4.4	3.1	3.1	3.8	4	3.9	3.4	1.8	3.7	3.1	2.4	3.7	4.1	3.3
4.4	3.8	3.9	4	3.4	3.7	4.4	3	3.2	3.8	4	3.9	3.4	2	3.7	3.1	2.2	3.6	4.2	3.2
4.3	3.5	4.1	3.8	3.6	4	4.4	3.3	3.3	3.8	4.1	3.8	3.3	2.2	3.8	3.2	2.3	3.6	4.3	3.3
4.3	3.4	4.2	3.8	3.6	4.2	4.3	3.4	3.5	3.8	4	3.7	3.2	2.6	3.8	3.2	2.4	3.5	4.2	3.3
4.2	3.3	4	3.7	3.6	4.3	4.1	3.4	3.6	3.9	4.1	3.5	3.2	2.9	3.8	3.4	2.3	3.4	4.2	3.4
4	3	4	3.7	3.5	4.3	4	3.2	3.6	3.8	3.9	3.4	3.3	3.4	3.8	3.6	2.4	3.4	4	3.3
3.9	3.1	3.9	3.6	3.2	4.3	4	3.1	3.6	3.8	3.8	3.1	3.3	3.7	3.7	3.8	2.5	3.3	3.9	3.2
3.7	3.3	3.6	3.3	3.1	4.3	4.2	3.1	3.6	3.8	3.7	3	3.4	3.9	3.7	4	2.8	3.3	3.8	3.2
3.6	3.4	3.6	3.2	3	4.2	4.2	3.1	3.5	3.8	3.7	2.8	3.4	3.9	3.8	4.1	2.9	3.4	3.8	3.1
3.5	3.5	3.5	3.1	3.1	4.2	4.2	3.2	3.5	3.8	3.6	3	3.4	4.1	3.8	4.1	3	3.4	3.8	3.2
3.6	3.6	3.4	3.1	3	4.1	4.2	3.2	3.5	3.7	3.6	3.2	3.3	4.2	3.9	4.1	3.1	3.4	3.9	3.1
3.6	3.7	3.3	3	3	3.9	4.3	3.2	3.4	3.7	3.6	3.3	3.3	4.1	4	4.1	3.3	3.4	3.9	3.2
3.6	3.6	3.2	2.9	3.3	3.9	4.4	3.1	3.5	3.7	3.6	3.4	3.3	4.2	4	4	3.5	3.3	4	3.3
3.7	3.7	3.2	2.9	3.3	3.9	4.3	3	3.4	3.7	3.5	3.4	3.3	4.3	4	3.8	3.5	3.1	4.2	3.4
3.9	3.7	3	3.1	3.5	3.9	4.4	2.9	3.4	3.7	3.4	3.4	3.5	4.3	4	3.8	3.4	3.1	4.3	3.5
4	3.7	2.8	3.1	3.5	3.9	4.6	2.8	3.2	3.8	3.3	3.4	3.5	4	3.9	3.5	3.4	3.3	4.2	3.6
4	3.7	2.9	3.1	3.7	3.9	4.6	2.8	3.1	3.9	3.2	3.5	3.5	3.9	3.9	3.4	3.3	3.3	4.2	3.7
3.8	3.6	3.1	2.9	3.6	3.9	4.7	2.8	3	3.9	3.1	3.6	3.4	3.8	3.9	3.1	3.3	3.4	4.3	3.7
3.7	3.6	3	3	3.7	3.8	4.6	2.6	3	3.7	2.9	3.6	3.3	3.7	3.8	3	3.2	3.5	4.3	3.6
3.8	3.5	3.1	3.1	3.9	3.6	4.8	2.6	3	3.6	2.9	3.6	3.4	3.6	3.7	2.9	3.2	3.5	4.3	3.5
3.8	3.3	3.1	3.1	3.9	3.5	4.8	2.6	3	3.5	3	3.5	3.3	3.5	3.6	2.7	3.2	3.6	4.1	3.5
3.8	3.5	3.2	3.1	3.8	3.4	4.7	2.5	3	3.4	3	3.4	3.2	3.4	3.6	2.6	3.2	3.7	4	3.6
3.7	3.5	3.2	3.1	3.7	3.2	4.4	2.2	3.1	3.3	3	3.2	3.1	3.2	3.6	2.8	3.3	3.7	3.7	3.6
3.6	3.6	3.3	3	3.5	2.9	4.1	2	3.2	3.1	2.9	2.9	3	3.2	3.5	2.9	3	3.7	3.6	3.6
3.4	3.6	3.3	3	3.3	2.8	3.8	1.9	3.3	3.1	2.8	2.8	2.9	3.3	3.4	3.1	3.1	3.7	3.4	3.6
3.3	3.6	3.3	3	3.4	2.7	3.4	2	3.4	3	2.7	2.7	3	3.4	3.3	3.5	3.2	3.8	3.2	3.7
3.2	3.5	3.4	3	3.5	2.8	3.1	2	3.5	3	2.9	2.6	3	3.6	3.3	3.8	3.4	3.9	3	3.7
2.9	3.5	3.4	3	3.6	2.9	2.7	2.4	3.6	2.9	2.9	2.7	3	3.8	3.1	3.9	3.4	3.8	2.8	3.8
2.9	3.5	3.4	2.9	3.7	3.2	2.5	2.7	3.7	2.9	3	2.9	3	4	3.1	4	3.5	3.7	2.7	3.7
3	3.5	3.3	2.9	3.7	3.4	2.6	2.8	3.8	2.9	3.1	3.1	3	4.2	2.9	4	3.4	3.5	2.7	3.8
3.2	3.4	3.3	2.9	3.8	3.8	2.9	2.9	4	2.9	3.1	3.2	3	4.4	2.9	3.8	3.4	3.5	2.8	3.7
3.4	3.2	3.3	3	3.6	4	3.2	2.8	4.1	2.8	3.1	3.5	3.1	4.4	2.8	3.6	3.3	3.5	3	3.8
3.7	3.1	3.2	3.1	3.5	4.1	3.6	2.7	4.1	2.9	2.9	3.7	3.2	4.5	2.8	3.2	3.3	3.2	3.1	3.6
4	3	3.2	3.3	3.4	4.2	4.2	2.7	4.1	2.9	2.8	3.9	3.4	4.6	2.8	2.9	3.3	3.2	3.3	3.5
4.3	3.2	3.3	3.4	3.1	4.1	4.5	2.7	4.1	2.9	2.6	4	3.4	4.7	2.9	2.6	3.5	3.3	3.5	3.4
4.4	3.3	3.4	3.4	2.8	4	4.7	2.7	4.1	2.8	2.5	4.1	3.6	4.8	3	2.3	3.8	3.2	3.7	3.4

Table A2-4 Cont.

t21	t22	t23	t24	t25	t26	t27	t28	t29	t30	t31	t32	t33	t34	t35	t36	t37	t38	t39	t40
4.4	3.4	3.6	3.4	2.6	3.8	5	2.8	4.1	2.8	2.3	4	3.7	4.8	3.2	2.2	4	3.4	3.7	3.5
4.4	3.7	3.7	3.4	2.6	3.6	5.2	3.1	4.1	2.9	2.2	3.9	3.9	4.9	3.3	2.4	4.3	3.6	3.8	3.6
4.2	3.9	4	3.5	2.8	3.2	5.3	3.4	4.1	3	2	3.8	4.1	4.9	3.6	2.5	4.4	3.7	3.9	3.6
4.1	4	4.2	3.6	3	2.9	5.2	3.6	4	3.2	2	3.6	4.3	5	3.8	2.9	4.4	3.8	4	3.5
4	4	4.2	3.6	3.5	2.4	5	4	4	3.3	2	3.5	4.2	5	4	3.5	4.4	3.9	3.9	3.7
4	4	4.2	3.7	4.1	2.1	5	4.2	3.8	3.6	2	3.4	4.3	5	4.1	4	4.5	4	3.9	3.8
3.9	4	4.2	3.9	4.4	2	4.9	4.3	3.9	4	2	3.3	4.3	5.2	4.1	4.3	4.5	3.9	3.8	3.9
4	3.9	4	4.1	4.7	2.2	4.8	4.4	4	4.3	2.1	3.3	4.3	5.2	4	4.6	4.4	3.9	3.9	3.9
4.2	3.8	3.7	4.3	4.8	2.5	4.6	4.4	4	4.5	2.2	3.3	4.3	5.3	4.1	4.8	4.4	3.7	4.1	4
4.2	3.9	3.6	4.3	4.9	3	4.6	4.5	4.1	4.6	2.4	3.1	4.3	5.3	4.2	5	4.2	3.7	4.1	4.1
4.2	3.8	3.5	4.3	4.7	3	4.5	4.5	4.2	4.7	2.6	3	4.3	5.3	4.4	5	4.2	3.7	4	4.1
4.2	3.8	3.2	4.2	4.6	3.4	4.6	4.4	4.3	4.8	2.8	2.9	4.3	5.2	4.4	5.1	4.2	3.8	3.9	4
4.1	3.6	3.2	4.1	4.6	3.9	4.5	4.4	4.3	4.8	3.1	2.8	4.2	5.1	4.4	5.2	4.2	3.8	3.8	4
4	3.6	3.1	3.8	4.3	4.2	4.2	4.3	4.5	4.7	3.1	2.8	4	5.1	4.2	5.1	4	4	3.8	4
4	3.5	3.1	3.6	4.2	4.5	4.1	4.5	4.5	4.7	3.3	3	3.8	4.9	4.2	5.1	3.9	3.8	3.6	3.8
4	3.4	3.2	3.6	4	4.5	4.1	4.5	4.5	4.7	3.4	3.1	3.8	4.7	4.2	5	3.7	3.7	3.6	3.7
4.1	3.5	3.3	3.7	3.9	4.4	4	4.5	4.6	4.5	3.4	3.4	3.7	4.4	4.2	4.8	3.6	3.5	3.5	3.6
4.1	3.6	3.5	3.7	3.7	4.4	3.9	4.5	4.6	4.2	3.4	3.6	3.6	4.1	4.1	4.7	3.4	3.5	3.5	3.6
4.2	3.8	3.7	3.6	3.5	4.4	3.5	4.5	4.6	4.2	3.3	3.8	3.4	3.7	4.1	4.5	3.4	3.3	3.6	3.8
4.3	4.1	3.9	3.6	3.5	4.2	3.2	4.5	4.6	4	3.2	3.8	3.3	3.5	4	4.2	3.5	3.1	3.5	3.8
4.4	4.3	4	3.6	3.6	4	2.7	4.4	4.6	3.8	3.2	3.8	3.3	3	3.8	4	3.6	3.3	3.5	3.9
4.4	4.5	4	3.6	3.5	3.9	2.4	4.3	4.4	3.7	3.2	3.7	3.2	2.9	3.6	3.6	3.6	3.1	3.4	4
4.4	4.7	4.1	3.6	3.6	3.7	2	4.2	4.3	3.4	3.2	3.6	3.1	2.6	3.3	3.4	3.6	2.9	3.5	4
4.4	4.7	4	3.7	3.8	3.4	1.6	4.1	4.2	3.2	3.3	3.3	3.1	2.3	3	3.2	3.8	2.8	3.5	4
4.2	4.4	3.9	3.6	4.1	3.2	1.3	3.9	4.1	3.2	3.2	3.1	3.1	2.2	2.6	3.2	4	2.8	3.5	3.9
4.1	4.4	3.7	3.5	4.2	3.1	1.4	3.7	4	3.2	3.2	2.9	3.2	2.2	2.3	3.3	4.1	2.6	3.4	3.8
4	4.1	3.6	3.2	4.4	2.7	1.8	3.5	3.8	3.1	3.1	2.6	3.2	2.3	2	3.5	4.1	2.5	3.3	3.8
3.6	4	3.5	3.1	4.5	2.8	2.1	3.3	3.8	3.1	3	2.4	3.2	2.5	1.8	3.8	4	2.3	3.2	3.8
3.7	3.8	3.5	2.8	4.5	3.2	2.4	3.2	3.7	3.2	2.9	2.1	3.2	2.6	1.7	4	4	2.1	3.2	3.8
3.7	3.7	3.3	2.5	4.5	3.5	2.8	3	3.7	3.2	2.9	1.9	3.1	2.8	1.6	4.1	3.9	2	3	3.6
3.6	3.5	3.2	2.3	4.4	3.6	3	2.9	3.6	3.2	2.8	2	3.1	2.9	1.6	4.2	3.9	1.6	3	3.6
3.6	3.5	3.1	2	4.2	3.8	3.1	2.9	3.6	3.1	2.8	2.2	2.9	2.9	1.4	4.1	3.8	1.4	2.9	3.5
3.7	3.4	3.1	1.9	4	3.6	3.1	2.9	3.5	3.1	2.8	2.3	2.9	3	1.4	3.9	3.5	1.2	2.9	3.5
3.7	3.4	3.1	1.9	3.6	3.6	3	2.7	3.4	3.1	2.9	2.5	2.9	2.9	1.6	3.7	3.5	1.1	3	3.5
3.6	3.3	3.2	1.9	3.4	3.4	2.6	2.7	3.4	3.1	2.9	2.8	2.9	2.7	1.7	3.3	3.4	1	3.1	3.5
3.5	3.2	3.4	1.8	3.1	3.1	2.3	2.5	3.4	3.2	3	3	3	2.7	1.9	3	3.5	1	3.1	3.6
3.5	3.3	3.6	2.1	3	2.9	2.1	2.4	3.5	3.3	3.1	3.2	3.1	2.7	2.3	2.7	3.6	1	3.1	3.8
3.4	3.4	3.7	2.3	2.9	2.8	1.8	2.4	3.6	3.3	3.2	3.3	3.2	2.8	2.6	2.5	3.6	1	3	3.8
3.2	3.4	3.6	2.4	3.1	2.9	1.7	2.4	3.7	3.3	3.2	3.3	3.2	2.7	2.9	2.3	3.5	1	3	3.9
3	3.5	3.5	2.5	3.1	2.8	1.6	2.4	3.8	3.3	3.3	3.3	3.2	2.9	3.1	2.1	3.4	1.1	3	3.9
2.9	3.4	3.6	2.4	3.2	2.8	1.7	2.4	3.8	3.3	3.3	3.4	3.2	3	3.2	1.9	3.5	1.2	2.9	3.7
2.9	3.4	3.6	2.1	3.4	3	1.8	2.4	3.7	3.2	3.3	3.5	3.3	3	3.3	2.4	3.4	1.3	3	3.6
2.8	3.5	3.4	1.9	3.6	3.1	1.9	2.6	3.7	3.2	3.2	3.6	3.3	3.1	3.4	2.9	3.3	1.6	3.1	3.2
2.8	3.6	3.4	2	3.7	3	2.2	2.8	3.6	3.1	2.9	3.7	3.3	3.2	3.4	3.2	3.4	1.3	3.3	2.8
2.8	3.6	3.4	1.8	3.7	2.8	2.6	2.8	3.6	3	2.8	3.7	3.4	3.1	3.4	3.5	3.5	1.2	3.3	2.4
2.6	3.8	3.4	1.8	3.6	2.6	2.8	2.7	3.6	2.9	2.6	3.6	3.3	3	3.4	3.5	3.5	1.5	3.3	2.2
2.5	4	3.4	1.7	3.5	2.4	3	2.6	3.6	2.7	2.6	3.5	3.2	2.9	3.4	3.5	3.6	1.5	3.3	1.9
2.4	4	3.2	1.9	3.1	2.3	3	2.5	3.4	2.6	2.6	3.4	3.2	2.7	3.3	3.5	3.5	1.4	3.3	1.6
2.3	3.9	3.1	2.1	3	2.1	3	2.3	3.5	2.5	2.7	3.1	3.1	2.6	3.3	3.4	3.3	1.6	3.3	1.5

Table A2-5 Data for trial 41 to trial 60 in the stage two

t41	t42	t43	t44	t45	t46	t47	t48	t49	t50	t51	t52	t53	t54	t55	t56	t57	t58	t59	t60
3.8	3.4	4.6	3.5	2.7	2.9	2.9	3	4	3.1	3.1	2.4	3.5	2.8	2.6	2.9	3.5	2.5	3	1.5
3.8	3.9	4.5	3.4	2.6	2.7	3.2	3	3.9	3.1	3.1	2.4	3.8	3	2.3	2.9	3.3	2.7	3.1	1.8
3.8	4.2	4.5	3.4	2.9	2.6	3.4	3.1	3.7	3	3.2	2.4	3.7	3.3	2.2	3	3.3	3	3.2	1.9
3.6	4.5	4.5	3.3	3.2	2.6	3.6	3	3.6	3.1	3.3	2.6	3.7	3.5	2.3	3	3.3	3.3	3.2	1.9
3.5	4.6	4.6	3.1	3.4	2.5	3.8	3	3.5	3	3.4	2.7	3.9	3.8	2.3	2.8	3.2	3.4	3.1	2
3.5	4.7	4.5	3.1	3.5	2.5	3.9	3.1	3.4	3.1	3.5	2.7	4.1	4.1	2.4	2.8	3.3	3.5	3	2.1
3.5	4.7	4.3	3.1	3.7	2.5	4	3.1	3.3	3.4	3.5	3	4.2	4.2	2.4	2.8	3.3	3.5	2.8	2.2
3.5	4.6	4.2	3.2	3.8	2.4	4.1	3.2	3.2	3.4	3.5	3.4	4.4	4.4	2.5	2.8	3.4	3.5	2.8	2.6
3.6	4.5	4.1	3.3	3.9	2.4	4.2	3.4	3.3	3.5	3.5	3.6	4.5	4.6	2.5	2.9	3.4	3.4	2.8	2.8
3.4	4.3	4	3.6	3.9	2.5	4.2	3.4	3.5	3.6	3.6	3.9	4.5	4.5	2.6	3.1	3.4	3.2	2.9	3.1
3.2	4.2	3.9	3.9	3.9	2.5	4.2	3.5	3.6	3.7	3.6	4	4.3	4.2	2.7	3.4	3.3	3.2	3.3	3.3
3.2	4	3.9	4.1	3.5	2.4	4.2	3.4	3.6	3.8	3.7	4	4.1	3.9	3	3.6	3.2	3.1	3.4	3.2
3	4.1	3.7	4.2	3.4	2.7	4.1	3.4	3.7	3.7	3.8	4	4	3.8	3.4	3.8	3.2	3.1	3.5	3.1
2.8	4.2	3.6	4.3	3.4	3	4	3.5	3.6	3.7	4	4	4	3.8	3.5	3.9	3.1	3.1	3.6	3
2.9	4.1	3.7	4.3	3.3	3.3	3.9	3.5	3.7	3.7	3.9	4	4	3.6	3.5	3.9	3.1	3	3.6	2.9
2.9	4	3.7	4.3	3.3	3.5	3.9	3.5	3.7	3.8	4	4	4	3.5	3.5	3.9	3.1	3	3.5	2.8
2.9	3.7	3.7	4.3	3.2	3.7	3.7	3.4	3.6	3.9	4	4	4.1	3.2	3.2	3.9	3.1	3	3.4	2.9
2.9	3.7	3.9	4.2	3.1	3.8	3.7	3.4	3.5	3.8	3.9	3.8	4.1	2.7	3	3.7	3.2	2.9	3.4	3
3.2	3.7	3.8	4.1	2.8	3.8	3.5	3.4	3.6	3.8	3.8	3.8	3.9	2.5	2.8	3.6	3.2	3	3.3	3
3.3	3.7	3.9	3.9	2.6	3.9	3.5	3.2	3.6	3.7	3.7	3.7	3.8	2.2	2.5	3.5	3.2	3.1	3.4	2.9
3.4	3.6	3.8	3.8	2.3	4.1	3.4	3.1	3.6	3.6	3.6	3.4	3.7	1.9	2.5	3.4	3	3.2	3.4	2.8
3.5	3.6	3.9	3.7	2.4	4.1	3.3	3.1	3.5	3.4	3.6	3.2	3.8	1.5	2.5	3.3	3	3.4	3.3	2.8
3.5	3.6	3.9	3.6	2.4	4.1	3.2	3.1	3.5	3.3	3.6	3.2	4	1.5	2.6	3.3	2.9	3.4	3.3	2.9
3.5	3.7	3.8	3.6	2.5	4	3.2	3.1	3.4	3.2	3.7	3.3	4.2	1.4	2.8	3.2	2.9	3.5	3.3	3.1
3.6	3.6	3.8	3.7	2.6	4.1	3.2	3.1	3.5	3.2	3.7	3.5	4.2	1.4	3	3.2	3.1	3.4	3.3	3.2
3.5	3.7	3.9	3.7	2.7	4	3.1	3.1	3.4	3.2	3.7	3.5	4.3	1.2	3.1	3.3	3.2	3.4	3.3	3.2
3.4	3.7	3.8	3.7	2.8	4	3.1	3.2	3.5	3.2	3.6	3.6	4.3	1.2	3.1	3.2	3.4	3.3	3.3	3.2
3.4	3.8	3.8	3.7	3	4	3.1	3.4	3.6	3.2	3.6	3.7	4.4	1.4	3.2	3.2	3.6	3.4	3.3	3.2
3.3	3.8	3.6	3.8	2.9	4	3	3.4	3.6	3.1	3.6	3.7	4.5	1.6	3.2	3.2	3.7	3.5	3.5	3.1
3.2	3.7	3.5	3.9	3	4	3	3.5	3.6	3	3.6	3.7	4.4	1.9	3.1	3.1	3.6	3.7	3.7	3
3.2	3.7	3.4	3.8	3	4.1	3	3.5	3.7	3.1	3.4	3.6	4.5	1.9	3.2	2.9	3.7	3.8	3.9	2.9
3.1	3.5	3.4	3.8	3	4.2	3	3.5	3.8	3	3.3	3.7	4.4	2	3.2	2.8	3.7	3.8	4.1	3
3	3.5	3.2	3.8	3.1	4.2	3	3.4	3.7	3.1	3.3	3.8	4.4	1.8	3.1	2.7	3.7	3.9	4.3	3.2
2.9	3.5	3.1	3.9	3.1	4.1	3	3.4	3.7	3.1	3.3	3.8	4.3	1.8	3	2.9	3.7	4	4.3	3.5
2.8	3.4	3	3.7	3	3.9	3	3.6	3.5	3.2	3.3	3.9	4.3	1.7	2.9	3.1	3.8	3.9	4.2	3.9
2.7	3.5	2.9	3.7	2.9	4	3.1	3.7	3.4	3.2	3.3	3.9	4.3	1.7	2.9	3.3	3.9	3.7	4.1	4.3
2.6	3.6	2.9	3.8	2.9	4	3.1	3.7	3.3	3	3.3	4	4.1	1.9	2.9	3.5	4	3.6	3.9	4.5
2.7	3.7	2.9	3.8	2.7	3.9	3.2	3.7	3.1	3	3.3	4.1	3.9	2.2	2.8	3.6	4	3.5	3.8	4.5
2.9	3.8	3	3.7	2.6	3.6	3.3	3.7	3	2.8	3.3	4.2	3.7	2.4	2.8	3.4	4	3.4	3.5	4.5
3.2	3.8	3	3.6	2.7	3.6	3.4	3.7	2.9	2.8	3.2	4.2	3.4	2.6	2.7	3.4	3.9	3.5	3.2	4.4
3.4	3.9	3.4	3.7	2.9	3.7	3.4	3.7	2.7	2.8	3.3	4.2	3.3	2.9	2.6	3.1	3.9	3.6	3.1	4.2
3.6	4	3.5	3.5	3.1	3.7	3.5	3.6	2.7	2.8	3.2	4.2	3.2	3	2.5	2.9	3.9	3.9	3.1	3.9
4	4.1	3.8	3.5	3.2	3.8	3.6	3.6	2.7	2.7	3.2	4	3.1	3.2	2.4	2.8	3.9	4.1	3.2	3.7
4.2	4.2	3.9	3.3	3.4	3.8	3.6	3.6	2.8	2.8	3.1	3.7	2.8	3.3	2.3	2.7	3.9	4.3	3.4	3.5
4.5	4.1	3.8	3	3.7	3.8	3.6	3.5	2.9	2.8	3.1	3.5	2.9	3.4	2.4	2.7	3.9	4.3	3.5	3.3
4.6	4.2	3.8	2.8	3.9	3.8	3.7	3.4	3.1	2.9	3.1	3.4	2.9	3.5	2.5	2.6	4.1	4.3	3.5	3.3
4.7	4.2	3.8	2.8	4.2	3.8	3.8	3.5	3.2	3.1	3.2	3.1	2.8	3.7	2.8	2.5	4.1	4.2	3.3	3.3
4.8	4.2	3.8	2.7	4.4	3.7	4	3.5	3.3	3.2	3.2	2.8	3	3.8	2.9	2.4	4	4	3.1	3.3
4.8	4.3	3.7	2.6	4.6	3.5	4.3	3.6	3.5	3.3	3.4	2.8	3.3	3.8	2.9	2.3	3.9	3.7	3	3.2
4.6	4.2	3.7	2.4	4.6	3.5	4.3	3.5	3.6	3.6	3.5	2.8	3.6	4	2.9	2.3	3.7	3.4	2.8	3.2
4.6	4.2	3.6	2.2	4.6	3.6	4.5	3.4	3.8	3.7	3.6	2.9	3.7	4.1	2.9	2.4	3.4	3.4	2.8	3.1
4.6	4.1	3.7	2.2	4.7	3.6	4.5	3.3	4	3.8	3.8	3.1	3.8	4.2	2.8	2.6	3.2	3.6	2.8	3.1

Table A2-5 Cont.

t41	t42	t43	t44	t45	t46	t47	t48	t49	t50	t51	t52	t53	t54	t55	t56	t57	t58	t59	t60
4.4	4.1	3.6	2.4	4.7	3.7	4.4	3.4	4	3.9	3.9	3.3	3.9	4.3	2.8	3.1	3.1	3.8	3.1	3.3
4.3	4.1	3.8	2.6	4.5	3.8	4.5	3.4	4.1	3.9	4	3.4	4	4.4	3	3.4	3.1	3.9	3.5	3.5
4.3	4.1	4.1	2.9	4.5	3.8	4.5	3.3	4.2	3.9	4	3.7	4.1	4.5	3.3	3.7	3	4	3.7	3.8
4.3	4.2	4.3	3.2	4.2	3.7	4.5	3.3	4.2	3.8	4.1	4.1	4.2	4.7	3.5	3.8	3	4.1	3.9	4.2
4.2	4.3	4.4	3.6	4.1	3.6	4.5	3.3	4.3	3.8	4.1	4.3	4.2	4.7	3.7	4.2	2.9	4.1	4	4.6
4.2	4.5	4.5	4	4.2	3.5	4.5	3.4	4.4	3.8	4.2	4.6	4.1	4.8	3.9	4.3	2.9	4.2	4	4.9
4.2	4.7	4.6	4.6	4.2	3.5	4.5	3.4	4.4	3.8	4.2	4.7	4.3	5	3.9	4.4	3	4.2	3.9	5.2
4.1	4.7	4.6	4.9	4	3.3	4.6	3.5	4.6	3.8	4.2	4.9	4.4	5.1	3.9	4.4	3.2	4.2	3.9	5.5
4.3	4.7	4.6	5.5	3.6	3.3	4.7	3.6	4.8	3.7	4.2	5	4.6	5.1	3.9	4.3	3.5	4.2	3.5	5.7
4.2	4.7	4.7	5.8	3.6	3.2	4.6	3.7	4.9	3.8	4	5	4.6	5	3.8	4.1	3.9	4.2	3.4	5.7
4.1	4.7	4.7	6	3.5	3.2	4.6	3.8	4.9	3.8	3.9	5.1	4.6	5	3.8	3.9	4.2	4.3	3.3	5.5
3.9	4.7	4.1	6.2	3.5	3.2	4.6	3.9	4.7	3.7	3.8	5.2	4.9	4.9	3.7	3.7	4.4	4.2	3.2	5.2
3.7	4.6	4.1	6.3	3.4	3.2	4.4	4	4.7	3.7	3.6	5.2	4.8	5	3.6	3.5	4.5	3.9	3	4.9
3.3	4.5	4.1	6.2	3.4	3	4.5	3.8	4.5	3.6	3.3	5	4.7	4.8	3.5	3.4	4.7	3.6	2.9	4.5
3.1	4.4	4	6.2	3.3	3.1	4.5	3.7	4.4	3.7	3.2	4.7	4.6	4.6	3.7	3.3	4.8	3.2	2.9	4.2
2.9	4.3	3.7	6	3.3	3.2	4.4	3.6	4.3	3.9	3.1	4.5	4.4	4.3	3.7	3.4	4.9	2.7	2.9	4
2.5	4.2	3.3	5.8	3.2	3.3	4.2	3.6	4.2	4.1	3.1	4.3	4.4	4.2	3.7	3.5	5	2.4	3.1	4
2.5	4.2	3.2	5.5	3.2	3.4	4	3.7	4.3	4.2	3.2	4.3	4.2	4.3	3.6	3.5	4.9	2.2	3.5	3.9
2.6	4	3	5.3	3.3	3.2	4	3.6	4.3	4.3	3.2	4.2	4.1	4.2	3.5	3.5	4.9	2.1	3.7	3.8
2.6	4	2.6	4.7	2.8	3.1	3.9	3.5	4.2	4.3	3.1	4	4	3.8	3.5	3.6	4.5	2.1	3.9	3.8
2.6	3.8	2.2	4.5	2.7	3	3.8	3.5	4.3	4.2	3.2	4	3.8	3.4	3.3	3.5	4.2	2.2	3.9	3.7
3.1	3.8	1.9	4.3	2.7	3	3.6	3.4	4.2	4.2	3.3	4	3.6	3.3	3.4	3.6	4	2.3	3.9	3.6
3.5	3.7	1.8	4.1	2.7	2.8	3.5	3.3	4.3	4	3.3	4.1	3.4	3.2	3.4	3.6	3.5	2.4	3.7	3.6
3.7	3.6	1.7	3.9	2.7	2.8	3.3	3.2	4.3	3.8	3.3	4.2	3.2	3.2	3.4	3.8	3.1	2.4	3.6	3.6
4	3.4	1.9	3.9	2.8	3	3.2	3.1	4.2	3.7	3.3	4.3	2.9	3.2	3.3	3.9	2.7	2.4	3.4	3.6
4.1	3.2	2.3	3.8	2.7	3.1	3.1	3	4.3	3.7	3.2	4.2	2.8	3.2	3.2	3.9	2.4	2.5	3.2	3.6
4.1	3.1	2.7	3.8	2.5	3.1	3	3.1	4.2	3.5	3.2	4.3	2.6	3.3	3.1	3.7	2.3	2.6	3	3.6
4	2.9	3.1	3.8	2.3	3	2.6	3	4.1	3.3	3.1	4.4	2.6	3.1	3	3.6	2.1	2.8	2.8	3.6
3.8	2.8	3.5	4	2	3.1	2.6	3.1	4.3	3.2	2.9	4.4	2.7	2.9	2.9	3.3	2	3	2.6	3.7
3.5	2.7	4.1	4.1	1.9	3	2.5	3.2	4.1	3.2	2.8	4.4	2.4	3	2.8	3.2	2	3.2	2.4	3.9
3.3	2.7	4.4	4.2	1.9	3	2.5	3.2	4	3.1	2.8	4.2	2.4	2.9	2.8	3.1	1.9	3.3	2.1	4
3.2	2.8	4.5	4.2	2	3.1	2.6	3.3	3.6	3.1	2.8	4	2.6	2.9	2.8	3.1	1.9	3.5	1.8	4.2
2.9	3.1	4.5	4.3	2.1	3.1	2.5	3.4	3.4	3.2	2.9	4	2.8	3.1	2.9	3.1	1.9	3.6	1.5	4.3
2.9	3.3	4.5	4.4	2.1	3	2.6	3.5	3.3	3.2	3.1	4	3.1	3.2	2.9	3	1.9	3.7	1.5	4.4
2.8	3.6	4.3	4.4	2.1		2.6	3.5	3.2	3.2	3.2	3.9	3.2	3.4	2.9	2.9	2.2	3.7	1.7	4.5
2.6	3.8	4.4	4.4	2.3		2.8	3.4	3.1	3.3	3.2	3.9	3.2	3.5	2.8	2.6	2.4	3.6	2	4.5
2.7	3.8	4.4	4.2	2.1		3	3.3	3.2	3.3	3.2	3.8	3.3	3.5	2.7	2.4	2.7	3.5	2.4	4.5
3	3.9	4.2	3.8	2.4		3.2	3.1	3.1	3.2	3.3	3.7	3.3	3.5	2.6	2.2	2.9	3.3	3.1	4.4
3.3	3.9	4	3.4	2.5		3.3	3	3.1	3.2	3.4	3.5	3.2	3.5	2.7	2.2	3.1	3.2	3.5	4.3
3.3	3.9	3.7	3.3	2.5		3.4	2.8	3	3.1	3.3	3.3	3.2	3.6	2.8	2.3	3.1	3	3.8	4.3
3.3	4	3.1	3.1	2.2		3.6	2.7	2.9	3.3	3.2	3.3	3.1	3.4	2.8	2.7	3.1	2.8	3.9	4
3.4	3.9	2.9	2.9	2.4		3.7	2.8	2.9	3.4	3.2	3.3	3.1	3.3	3.1	3	2.9	2.6	4.1	3.7
3.3	3.7	2.7	2.7	2.6		3.7	2.7	3.1	3.3	3.1	3.2	3.1	3.3	3.2	3.4	2.8	2.4	4.1	3.5
3.2	3.5	2.5	2.6	2.6		3.8	2.7	3.1	3.4	3.1	3.1	3.1	3.3	3.2	3.7	2.5	2.4	4.1	3.3
3	3.3	2.2	2.2	2.7		3.8	2.6	3	3.3	3	3	3.2	3.5	3.2	3.9	2.5	2.6	4	3
3.3	3.3	2	1.8	2.7		3.7	2.7	3	3.2	3	3	2.9	3.5	3	3.9	2.4	2.8	3.9	2.8
2.9	3.1	2.2	1.5	2.6		3.6	2.7	3	3.1	3.1	3.1	3	3.4	2.8	4.1	2.5	3	3.7	3
3	3.1	2.5	1.3	2.6		3.5	2.9	3.2	3.2	3.2	3.2	3.1	3.7	2.7	4.2	2.8	3.3	3.7	3.1
3.3	3.1	2.7	1.1	2.6		3.3	3	3.3	3.2	3.3	3.2	3.2	3.8	2.6	4.2	3	3.6	3.7	3.4
3.5	3.3	2.9	1.2	2.7		3.4	3	3.4	3.2	3.3	3.2	3.2	4.1	2.5	4.2	3.3	3.7	3.7	
	3.5	3.1				3.5	3.2				3.4	3.4	4.2				3.8	3.6	
	3.6																		

Table A2-6 Data for trial 61 to trial 80 in the stage two

t61	t62	t63	t64	t65	t66	t67	t68	t69	t70	t71	t72	t73	t74	t75	t76	t77	t78	t79	t80
2.2	3.2	4.7	3.3	2.7	3	4.1	2.5	2.8	2	3.7	2.4	4.2	4.1	3.3	2.6	4.7	3.3	6	3.4
2.1	3.1	4.6	3.2	2.8	2.8	4	2.3	2.8	1.9	3.6	2.4	4.1	4	3.1	2.5	4.5	3.4	6	3.3
2.1	3	4.4	3.1	2.8	2.6	3.9	2.1	2.8	1.8	3.4	2.3	4.9	4	2.8	2.4	4.3	3.4	6	3.3
2.2	2.8	4.3	2.8	2.8	2.4	3.8	2	2.9	1.9	3.1	2.3	3.7	4.1	2.7	2.4	4	3.5	6	3.3
2.4	2.7	4.1	2.5	2.9	2.2	3.7	1.9	2.9	2	2.9	2.4	3.5	4.3	2.5	2.4	3.6	3.6	5.8	3.3
2.6	2.7	3.9	2.2	3	2	3.5	1.9	2.9	2.2	2.7	2.5	3.4	4.5	2.5	2.4	3.4	3.7	5.3	3.5
2.8	2.7	3.8	1.9	3	1.8	3.4	2	2.9	2.3	2.6	2.7	3.4	4.8	2.5	2.7	3.2	3.6	4.9	3.6
2.9	2.9	3.7	1.8	3	1.8	3.4	2.1	2.8	2.5	2.5	2.9	3.5	4.9	2.6	2.7	3.1	3.5	4.5	3.6
3	3.1	3.6	1.8	2.9	1.8	3.5	2.3	2.7	2.7	2.4	3.1	3.6	5.1	2.6	3	3.3	3.5	4.3	3.7
3.1	3.4	3.4	1.9	2.8	2.1	3.7	2.5	2.6	3	2.2	3.3	3.7	5.1	2.7	3.4	3.5	3.4	4.2	3.8
3.1	3.6	3.3	2	2.7	2.3	3.9	2.7	2.5	3.4	2.2	3.5	3.9	5	2.8	3.6	3.7	3.3	4.3	3.7
3.1	3.8	3.3	2.1	2.6	2.4	4	2.8	2.5	3.6	2.1	3.6	4	4.9	2.9	3.8	3.9	3.3	4.1	3.9
2.9	4	3.3	2.1	2.6	2.5	4	3	2.5	3.8	2.2	3.7	4	4.7	3	3.9	4	3.4	4.2	4.1
3.1	4.2	3.5	2	2.6	2.5	4	3.1	2.6	3.9	2.3	3.7	4	4.4	3.1	3.8	4.1	3.5	3.8	4.1
3.1	4.3	3.7	1.9	2.6	2.4	4	3.3	2.8	3.9	2.4	3.8	4.1	4.2	3.2	3.8	4.2	3.7	3.6	4.1
3.2	4.3	3.8	2	2.7	2.5	4	3.4	2.9	3.7	2.4	3.8	4	4	3.3	3.8	4.2	3.9	3.6	3.8
3.2	4.3	3.9	2.1	2.8	2.6	3.9	3.6	3.1	3.5	2.6	3.8	3.9	3.9	3.4	3.9	4.2	4	3.7	3.7
3.2	4.1	3.9	2.3	2.8	2.7	3.9	3.7	3.2	3.3	2.7	3.7	3.8	4	3.5	3.9	4.2	4.3	3.7	3.5
3.2	3.9	3.9	2.7	2.9	2.8	3.9	3.7	3.2	3	2.7	3.6	3.7	4.1	3.5	3.8	4.1	4.4	3.9	3.3
3.1	3.7	3.7	3	3	2.8	3.8	3.8	3.2	2.8	2.8	3.5	3.5	4	3.4	3.8	3.9	4.5	4	3.2
3	3.6	3.5	3.2	3.1	2.8	3.5	3.7	3.2	2.6	2.7	3.3	3.3	4	3.4	3.8	3.7	4.5	4.1	3.2
2.9	3.6	3.2	3.3	3.2	2.7	3.3	3.6	3.1	2.5	2.7	3.2	3.3	4	3.3	3.9	3.6	4.5	4.4	2.9
2.9	3.7	3	3.3	3.3	2.6	3.1	3.5	3.1	2.5	2.6	3.2	3.1	3.9	3.1	3.9	3.3	4.6	4.4	3
3.1	3.7	2.7	3.3	3.3	2.5	3.1	3.3	3	2.6	2.5	3.1	3	3.9	3	3.9	3.2	4.5	4.3	3
3.4	3.7	2.4	3.3	3.4	2.5	3.1	3.3	2.9	2.7	2.4	3.1	3	4.1	2.9	4	3	4.4	4.3	3.2
3.8	3.7	2.2	3.1	3.4	2.5	3.1	3.2	2.8	2.7	2.3	3.1	3	4.4	2.8	4.1	2.9	4.3	4.3	3.4
4.2	3.5	2	3.3	3.4	2.6	3.3	3.2	2.8	2.8	2.3	3.1	2.9	4.6	2.6	4.2	2.9	4.1	4.2	3.7
4.5	3.3	2.1	2.9	3.4	2.6	3.6	3.2	2.8	2.9	2.3	3.1	2.9	4.7	2.6	4.2	2.9	3.8	4	4
4.7	3.2	2.2	2.9	3.5	2.8	3.7	3.1	2.8	3	2.4	3.3	3	4.7	2.5	4.2	2.9	3.4	3.9	4.4
4.9	3.1	2.3	2.8	3.6	3	3.8	3.1	2.8	3.1	2.4	3.4	3.1	4.6	2.7	4.3	3.2	3	3.6	4.6
4.9	3.1	2.6	2.6	3.8	3.1	3.9	3	2.8	3.3	2.6	3.5	3.2	4.5	2.9	4.2	3.3	2.8	3.4	4.8
4.8	3.1	2.7	2.3	3.9	3.2	3.8	2.9	2.9	3.4	2.7	3.6	3.2	4.3	3	4.3	3.5	2.7	3	5.1
4.5	3.2	2.7	2.1	4	3.2	3.7	2.8	2.9	3.6	2.8	3.6	3.3	4.3	3.1	4.3	3.6	2.6	3	5.4
4.2	3.3	2.6	1.9	4	3	3.8	2.6	2.8	3.7	3	3.5	3.3	4.2	3.1	4.3	3.7	2.7	2.6	5.4
3.7	3.5	2.7	1.7	4	2.8	3.8	2.6	2.7	3.7	3.2	3.5	3.3	4.2	3.2	4.2	3.8	2.8	2.6	5.5
3.2	3.6	2.7	1.8	3.9	2.6	4	2.7	2.6	3.7	3.2	3.5	3.3	4.2	3.2	4	3.9	2.9	2.8	5.6
2.8	3.7	2.8	1.7	3.7	2.4	4.3	2.7	2.5	3.7	3.2	3.5	3.2	4.3	3.2	3.8	4	3	3.2	5.6
2.7	3.8	2.9	2	3.5	2.3	4.5	2.8	2.5	3.6	3.2	3.5	3.3	4.3	3.1	3.6	4.1	3.2	3.7	5.5
2.8	3.8	2.9	2.2	3.2	2.3	4.5	2.7	2.6	3.5	3.2	3.6	3.4	4.3	3	3.5	4.3	3.4	4.3	5.3
2.9	3.7	3	2.3	3	2.4	4.5	2.6	2.7	3.4	3.2	3.6	3.5	4.3	3	3.2	4.3	3.5	4.8	5
3.1	3.6	3	2.4	2.8	2.6	4.3	2.5	2.9	3.4	3.4	3.7	3.7	4.4	3	3	4.3	3.7	5.2	4.7
3.2	3.4	3.1	2.6	2.6	2.6	4.1	2.5	3.2	3.3	3.5	3.7	3.9	4.4	3.2	2.8	4.4	3.9	5.5	4.5
3.2	3.2	3.1	2.8	2.5	2.7	3.8	2.6	3.5	3.1	3.7	3.6	4	4.5	3.3	2.7	4.3	4.2	5.7	4.2
3.1	2.9	3.2	2.9	2.5	2.7	3.6	2.7	3.7	2.9	4.1	3.4	3.9	4.5	3.6	2.7	4.1	4.5	5.8	3.8
3	2.7	3.2	3.2	2.5	2.6	3.5	2.8	3.8	2.7	4.4	3.2	3.8	4.6	3.8	2.8	3.9	4.9	5.8	3.1
2.9	2.6	3.2	3.2	2.5	2.6	3.6	2.9	3.9	2.6	4.6	2.9	3.8	4.6	4.1	2.7	3.8	5	5.8	2.6
2.9	2.6	3.2	3.1	2.4	2.5	3.6	3	3.9	2.6	4.7	2.8	3.7	4.5	4.3	2.6	3.7	5.1	5.5	2.1
2.8	2.7	3.2	3.1	2.3	2.4	3.7	3.2	3.8	2.8	4.8	2.7	3.7	4.5	4.4	2.7	3.5	5.3	5.2	1.6
2.9	2.8	3.1	3	2.1	2.4	3.8	3.3	3.8	3.1	4.6	2.6	3.8	4.4	4.5	2.8	3.4	5.4	5.1	1.5
3	3	3	3	2	2.3	3.8	3.5	3.6	3.2	4.4	2.7	3.9	4.3	4.5	3	3.4	5.4	4.6	1.3
3.2	3.2	2.9	3	2.1	2.4	4	3.7	3.4	3.2	4.1	2.8	4.1	4.1	4.5	3.5	3.5	5.4	4.4	1.4
3.5	3.3	2.8	3.1	2.2	2.5	4.1	3.8	3.2	3.2	3.7	2.9	4.2	3.9	4.5	3.7	3.6	5.3	4	1.4

Table A2-6 Cont.

t61	t62	t63	t64	t65	t66	t67	t68	t69	t70	t71	t72	t73	t74	t75	t76	t77	t78	t79	t80
3.7	3.3	2.7	3.1	2.4	2.7	4.2	4	3.2	3.1	3.4	3.1	4.2	3.7	4.5	4	3.8	5.2	3.7	1.5
3.7	3.4	2.7	3.1	2.7	2.9	4.3	4.2	3.1	3.1	3.1	3.4	4.1	3.6	4.4	4.3	4	5.2	3.7	1.5
3.7	3.4	2.8	3.1	2.9	3.1	4.3	4.4	3.1	3.2	3	3.7	4	3.5	4.3	4.7	4.3	5	3.8	1.5
3.5	3.5	3.1	3.1	3.1	3.2	4.5	4.7	3.1	3.3	2.8	3.8	4	3.6	4.2	4.9	4.5	4.9	3.8	1.5
3.3	3.6	3.4	3.1	3.2	3.3	4.5	4.8	3.1	3.6	2.9	3.9	3.9	3.6	4	5.1	4.5	4.7	4	1.8
2.9	3.7	3.9	3.2	3.3	3.4	4.4	5	3.1	3.9	3	4.1	3.8	3.6	3.9	5.2	4.4	4.5	4.3	1.9
2.6	3.7	4.3	3.3	3.4	3.4	4.3	5.1	3.2	4.3	3.2	4.1	3.7	3.7	3.8	5.4	4.3	4.4	4.6	2.2
2.3	3.7	4.7	3.3	3.3	3.5	4.2	5.1	3.2	4.4	3.4	4.1	3.6	3.8	3.7	5.3	4.1	4.5	4.8	2.6
2.3	3.6	5.3	3.3	3.3	3.5	4.1	5.1	3.2	4.5	3.6	4	3.7	3.8	3.7	5.2	3.9	4.5	5	3
2.4	3.5	5.5	3.4	3.2	3.5	3.9	4.9	3.3	4.6	3.8	3.9	3.4	3.9	3.7	5.1	3.5	4.4	5	3.3
2.7	3.3	5.7	3.4	3.1	3.5	3.9	4.7	3.3	4.5	3.9	3.6	3.1	3.9	3.6	5	3.5	4.2	4.8	3.9
3.2	3.2	5.8	3.4	3	3.5	4	4.4	3.3	4.4	4	3.3	2.9	3.9	3.6	4.8	3.5	4.1	4.5	4.3
3.9	3.1	5.9	3.5	3	3.4	3.9	4.1	3.3	4.2	4.1	3.1	2.8	4	3.6	4.6	3.5	4	4.4	4.5
4.4	3	5.8	3.6	3	3.3	3.8	3.7	3.3	4	4.2	2.9	2.8	4.2	3.5	4.5	3.7	3.7	4.1	4.4
4.7	3.1	5.6	3.6	2.9	3	3.6	3.5	3.2	3.7	4.2	2.6	2.9	4.3	3.4	4.4	3.9	3.5	3.8	4.4
4.8	3	5.4	3.6	2.9	2.9	3.5	3.2	3.2	3.2	4.2	2.3	2.9	4.3	3.4	4.4	4.1	3.3	3.5	4.2
4.9	3	5.1	3.5	2.8	2.7	3.3	3.1	3.1	2.6	3.9	2.2	3	4.4	3.4	4.3	4.1	3.2	3.4	4.2
4.9	2.9	4.7	3.3	2.8	2.6	3.1	3	3	2.2	3.7	2.2	3.1	4.5	3.5	4.3	4.1	3.2	3.4	4.1
4.7	2.7	4.2	3.1	2.8	2.6	2.8	2.7	2.9	1.8	3.3	2.1	3.1	4.5	3.5	4.3	3.9	3.2	3.5	4
4.3	2.6	3.6	3	2.7	2.6	2.5	2.6	2.8	1.6	2.8	2.1	3.2	4.4	3.5	4.3	3.6	3.3	3.7	3.9
3.8	2.6	3.1	2.8	2.6	2.5	2.3	2.5	2.8	1.5	2.2	2.2	3.3	4.3	3.5	4.2	3.4	3.5	4	3.9
3.2	2.7	2.9	2.7	2.5	2.5	2.1	2.6	2.9	1.5	1.8	2.4	3.3	4.1	3.4	4.1	3.2	3.5	4.2	3.8
2.7	2.8	2.8	2.6	2.3	2.4	2	2.8	2.9	1.5	1.4	2.7	3.2	4	3.3	3.9	3.1	3.4	4.4	3.7
2.3	2.9	2.9	2.6	2.1	2.3	2	2.8	3.1	1.5	1.4	3.1	3.2	3.8	3.1	3.7	3.2	3.3	4.4	3.4
2.1	2.9	3	2.6	1.9	2.3	2.1	2.8	3.2	1.5	1.4	3.5	3.2	3.6	2.8	3.5	3.2	3.2	4.3	3.3
2.1	3	3.2	2.8	1.7	2.4	2.3	2.8	3.2	1.5	1.4	3.8	3.2	3.3	2.6	3.6	3.3	3	3.9	3.1
2.4	3.1	3.4	2.8	1.7	2.6	2.6	2.7	3.3	1.6	1.4	4.1	3.3	3.2	2.4	3.6	3.6	2.9	3.6	3
2.9	3.1	3.6	2.8	1.8	2.7	2.8	2.7	3.5	1.8	1.4	4.4	3.4	3	2.2	3.6	3.5	2.9	3.3	3
3.3	3.1	3.8	2.7	1.8	2.6	2.9	2.6	3.5	1.8	1.4	4.7	3.5	2.9	2	3.8	3.2	2.9	2.8	2.9
3.5	2.9	3.9	2.5	2.1	2.5	3	2.5	3.5	1.9	1.4	4.9	3.7	2.8	2	3.9	3	3	2.4	3
3.7	2.7	3.9	2.4	2.3	2.3	3	2.3	3.4	2.1	1.4	5	3.7	2.7	2.1	3.9	2.7	3.2	2.3	3.3
3.9	2.5	3.8	2.2	2.4	2.1	3.1	2.3	3.3	2.3	1.4	5.1	3.6	2.6	2.3	3.9	2.6	3.3	2.1	3.7
3.9	2.4	3.7	2	2.3	1.8	3.2	2.3	2.9	2.4	1.4	5.1	3.6	2.7	2.4	3.8	2.4	3.5	2.3	3.8
3.9	2.3	3.5	1.9	2.2	1.5	3.4	2.5	2.6	2.5	1.6	5	3.6	2.8	2.5	3.6	2.5	3.6	2.5	4
3.8	2.5	3.3	2	2	1.4	3.6	2.7	2.4	2.5	1.9	4.7	3.6	2.9	2.6	3.5	2.6	3.6	2.9	3.8
3.6	2.7	3.1	2.3	1.8	1.4	3.7	3	2.3	2.5	2.2	4.4	3.5	3.1	2.7	3.4	2.8	3.6	3.4	3.7
3.3	2.9	3	2.7	1.6	1.4	3.8	3.3	2.3	2.5	2.5	4	3.5	3.3	2.8	3.3	3	3.6	3.7	3.5
3.1	3.2	2.9	2.9	1.6	1.4	3.7	3.5	2.3	2.5	2.9	3.5	3.5	3.4	2.8	3.2	3.3	3.6	3.8	3.3
3.1	3.4	2.7	3.1	1.7	1.4	3.6	3.7	2.6	2.6	3.1	3	3.5	3.5	2.9	3	3.8	3.7	4	3.1
3.1	3.3	2.5	3.2	1.9	1.4	3.5	3.9	3	2.6	3.1	2.5	3.7	3.5	3.1	3.1	4.2	3.8	4	3
3.2	3.2	2.3	3.2	1.9	1.4	3.2	4.1	3.3	2.8	2.9	2.2	3.8	3.5	3.3	3.2	4.5	3.8	3.8	2.9
3.1	2.9	2	3.1	2	1.7	2.8	4.3	3.6	2.9	2.9	2	4	3.5	3.5	3.2	4.7	3.9	3.5	2.9
3.1	2.6	1.9	3	2	2.3	2.5	4.5	3.7	2.9	2.8	2.1	4.3	3.7	3.7	3.4	4.8	4	3.3	3
3	2.4	1.8	2.7	2	2.5	2.2	4.6	3.8	3	2.7	2.2	4.5	3.8	3.8	3.4	4.8	3.9	3	3.1
2.9	2.5	1.8	2.4	2	2.6	1.9	4.5	3.9	3	2.7	2.5	4.7	3.9	3.9	3.5	4.8	3.7	2.7	3.3
2.9	2.5	1.9	2.3	1.9	2.7	1.7	4.4	3.9	3.2	2.8	2.6	4.8	4	3.9	3.4	4.6	3.5	2.8	3.5
3.1	2.5	1.9	2.2	2	2.8	1.6	4.2	3.9	3.3	2.9	2.8	4.9	4.1	3.9	3.3	4.4	3.2	3.2	3.7
3.3	2.5	2.1	2.3	2.1	3	1.6	4	3.8	3.7	3	3	4.9	4.1	4	3.1	4.3	2.9	3.4	4.1
3.4	2.4	2.4	2.4	2.3	3.1	1.7	3.9	3.7	4.1		3.3	4.8	4.3	4.2	3.1	4.1	2.6	3.5	4.3
3.3	2.6	2.7	2.7	2.7	3.3	1.9	3.8	3.6	4.3		3.7	4.7	4.4	4.4	3.5		2.4	4.5	4.6
3.2	2.8	3.1	2.9	3.1	3.5	2.1	3.9	3.5	4.5				4.4	4.6	3.7		2.2	5.1	4.5
2.9			2.9		3.7	2.3		3.3						4.8	4		2.3		

Table A2-7 Data for trial 81 to trial 100 in the stage two

t81	t82	t83	t84	t85	t86	t87	t88	t89	t90	t91	t92	t93	t94	t95	t96	t97	t98	t99	t100
3.4	5.1	4.9	3.9	3.7	4	4.8	3	4.2	4.1	3.9	3.5	2.6	4.1	4	3.9	2.9	2.4	4.5	2.5
3.4	5.3	4.8	3.7	3.8	3.9	4.9	3	4.5	4.2	4	3.5	2.7	3.9	3.6	3.9	2.9	2.1	4.2	2.5
3.4	5.3	4.9	3.5	3.8	3.9	4.9	3.2	4.8	4.4	3.8	3.3	2.6	3.8	3.4	3.9	3.1	2	3.8	2.3
3.3	5.3	4.8	3.3	3.7	3.7	5	3.3	5	4.8	3.7	3.3	2.5	3.5	3.1	3.8	3.2	2.1	3.5	2.3
3.2	5.2	4.7	3.1	3.6	3.5	5.1	3.4	5.2	5.2	3.7	3.4	2.3	3.3	2.9	3.8	3.6	2	3.4	2.5
3.4	5	4.6	2.7	3.4	3.4	5	3.7	5.3	5.4	3.6	3.5	2.3	3.1	2.9	3.7	3.5	2.1	3.3	2.5
3.7	4.7	4.4	2.6	3.3	3.2	4.8	3.9	5.3	5.5	3.7	3.6	2.1	3.2	2.9	3.6	3.7	2.3	3.1	2.7
3.9	4.4	4.3	2.6	3.3	3.2	4.4	4.2	5.3	5.5	3.8	3.7	2.8	3.3	2.7	3.7	4.1	2.3	3	2.8
4.2	4.2	4.3	2.4	3.2	3	4.1	4.3	5.2	5.5	3.9	4	2.6	3.4	3	4.1	4.5	2.6	2.9	3.2
4.3	4	4.1	2.4	3.3	3	4	4.4	5.1	5.4	3.9	4.3	2.9	3.3	3.1	4	4.6	2.7	3.2	2.8
4.4	3.9	4.1	2.5	3.3	3	3.8	4.5	5	5.2	3.9	4.3	3.2	3.4	3.1	4	5	2.8	2.7	3.2
4.4	3.8	4	2.6	3.3	3.1	3.6	4.6	4.8	4.9	4	4.8	3.4	3.4	3.3	4.1	4.8	2.9	3	3.8
4.3	3.7	3.9	2.8	3.3	3.1	3.4	4.7	4.7	4.5	4	4.9	3.6	3.3	3.5	3.8	4.8	2.7	3	3.9
4.4	3.7	3.8	3	3.2	3.2	3.3	4.8	4.6	4.1	4	4.9	4.1	3.5	3.6	4	4.7	3.2	3	4.1
4.4	3.6	3.7	3	3.2	3.1	3.2	4.8	4.4	3.8	4	4.9	4.3	3.7	3.7	3.9	4.8	3.1	3	4.2
4.3	3.5	3.5	3.2	3.1	3.1	3.1	4.7	4.3	3.7	3.9	4.9	4.4	3.5	3.7	3.6	4.5	3.2	3	4.2
4.2	3.4	3.3	3.1	3	3	3.1	4.5	4.1	3.6	3.7	4.5	4.5	3.4	3.8	3	4	3.3	3.3	4.2
4	3.4	3.2	3.4	3.1	3	3.1	4.4	4.1	3.7	3.5	4.5	4.6	3.4	3.9	2.8	3.9	3.4	3.4	4.3
3.8	3.3	3.1	3.4	3.1	2.9	3.3	4.1	4.1	3.7	3.4	4.6	4.7	3.5	3.9	2.6	3.5	3.6	3.5	4.4
3.6	3.3	3.1	3.3	3	2.8	3.5	3.8	3.9	3.7	3.4	4.2	4.9	3.4	3.8	2.5	3.1	3.7	3.5	4.4
3.5	3.2	3.1	3.2	3.1	2.7	3.7	3.5	3.9	3.6	3.3	4.1	5.2	3.4	3.9	2.7	3	3.8	3.5	4.5
3.4	3.4	3.1	3.2	3.2	2.7	3.8	3.4	4.1	3.5	3.3	4.2	5.1	3.6	3.6	2.7	2.8	4	3.8	4.4
3.2	3.4	3.1	3.2	3.4	2.9	4	3.2	4.2	3.5	3.4	4	5.3	3.8	3.8	3	2.1	3.8	3.9	4.2
3	3.4	3.1	3.2	3.6	3	4	3	4.2	3.8	3.4	4.1	5.2	4	3.8	3	1.9	3.9	4	4.2
2.9	3.6	3	3.5	3.6	3	4	2.9	4.2	3.8	3.2	3.8	5.2	4.1	3.6	3.1	1.5	3.9	4.1	4
2.7	3.6	2.9	3.5	3.7	3.2	4	2.8	4.2	4	3.1	3.9	5.2	4.2	3.7	3.1	1.8	3.7	4.2	4
2.6	3.6	2.8	3.4	3.8	3.4	3.9	2.8	4.1	4.4	3.2	4	5.3	4	3.6	3.2	1.9	3.5	4.3	3.9
2.5	3.5	2.7	3.2	3.8	3.6	3.7	2.9	3.9	4.6	3.1	3.8	5.2	4.1	3.4	3.3	1.9	3.3	4.3	4
2.6	3.2	2.8	3.3	3.8	3.7	3.6	2.9	3.7	4.7	3	3.6	5	4.1	3.3	3.4	2.2	3	4.1	3.7
2.8	3	2.9	3.5	3.9	3.9	3.6	3	3.5	4.8	2.9	3.5	4.9	4.1	3.5	3.3	2.3	2.8	3.5	3.5
2.9	2.6	2.9	3.6	4	4	3.5	3.2	3.5	4.8	3	3.4	4.7	4.1	3.3	3.8	2.6	2.5	3.3	3.5
3	2.4	3	3.7	4	4	3.5	3.4	3.5	4.7	3	3.4	4.4	4.1	3.1	3.8	2.8	2.3	3	3.4
3.2	2.1	3.1	3.8	4	3.9	3.5	3.7	3.6	4.6	3.1	3.3	4.3	4.1	2.9	3.8	3.1	2.3	2.5	3.4
3.3	2.1	3.1	3.8	4	3.8	3.6	3.8	3.8	4.5	3.4	3.2	4.1	4.1	3.1	3.7	3.5	2.5	2.3	3.4
3.4	1.9	3.1	3.8	4	3.7	3.6	4.2	4.1	4.3	3.6	3.3	4	4.1	3.1	3.9	3.8	2.5	2.3	3.4
3.6	2.1	3	3.9	3.8	3.6	3.7	4.5	4.3	4.1	3.7	3.4	3.7	3.9	3.1	4.2	4.2	2.4	2.2	3.4
3.7	2.4	2.8	3.9	3.7	3.7	3.9	4.8	4.3	4	4	3.5	3.5	3.7	3	4.2	4.4	2.5	1.8	3.4
3.7	2.9	2.8	4	3.6	3.8	4	5	4.3	4	4.3	3.6	3.4	3.5	3	4.2	4.7	2.8	2	3.1
3.8	3.2	2.8	4	3.6	3.8	4.1	5.1	4.2	3.9	4.6	3.8	3.3	3.4	3.4	4.4	5.2	3.3	1	3.1
3.9	3.6	2.7	3.9	3.4	4.1	4.1	5.2	4.1	3.7	4.8	3.8	3.4	3.2	3.5	4	5.5	3.4	1.2	3
4	3.8	2.8	3.8	3.4	4.2	4.1	5.2	3.9	3.5	4.9	4.1	3	3.2	3.7	4.3	5.5	3.9	1.5	3.2
4.1	4	3	3.6	3.3	4.4	4	5.2	3.7	3.3	4.9	4.3	3.2	3.1	3.7	4	5.7	4.3	1.9	3.1
4.2	4.3	3.1	3.5	3.4	4.3	4	5.3	3.6	3.2	5	4.5	3.2	3.1	4.1	3.7	5.6	4.8	2.2	3.4
4.3	4.4	3.2	3.2	3.4	4.1	3.9	5.3	3.4	3.2	5.1	4.4	2.9	2.7	4.1	3.7	5.2	4.7	2.5	3.6
4.4	4.5	3.2	3	3.4	4	3.6	5.3	3.3	3.2	5	4.6	2.8	2.9	4.1	3.4	5	5	2.8	3.5
4.4	4.5	3.3	2.7	3.4	3.7	3.4	5.3	3.3	3.2	4.8	4.8	2.8	2.8	4.2	3.1	4.7	5	3.7	3.6
4.5	4.4	3.3	2.7	3.3	3.5	3.2	5.3	3.3	3.3	4.5	4.9	2.9	3.1	4	3.1	4.5	4.7	3.8	3.8
4.6	4.4	3.4	2.6	3.2	3.4	3.1	5.5	3.3	3.5	4.4	4.8	3.1	3.2	4	3	4	4.7	4.2	3.9
4.7	4.2	3.5	2.7	3.1	3.1	3.2	5.6	3.3	3.8	4.3	4.9	3.1	3.4	3.6	3.1	3.9	4.6	4.4	4.2
4.7	4.2	3.6	2.7	3	3	3.4	5.6	3.4	4.1	4.2	4.8	3.1	3.7	3.4	3	3.5	4.4	4.4	4.2
4.6	4	3.8	3	3	3	3.7	5.6	3.3	4.2	4.1	4.9	3.6	3.9	3.2	3.1	3.3	4.4	4.2	4.3
4.5	4	3.9	3.2	3.1	2.9	3.8	5.4	3.2	4.2	4	4.8	4.2	4.3	3.2	3.3	2.9	4.2	4.1	4.4

Table A2-7 Cont.

t81	t82	t83	t84	t85	t86	t87	t88	t89	t90	t91	t92	t93	t94	t95	t96	t97	t98	t99	t100
4.2	3.9	3.9	3.3	3.3	2.9	4.2	5.3	3.2	4.3	3.8	4.4	4.3	4.3	3	3.5	2.9	4	4	4.5
3.7	4	3.8	3.3	3.4	2.9	4.7	5.1	3.1	4.4	3.8	4.4	4.7	4.5	3.1	3	2.7	3.6	3.9	4.4
3.2	4	3.7	3.4	3.7	3	4.9	5	3	4.5	3.8	4.1	5	5	2.9	3.7	3	3.4	3.7	4.6
2.9	4.2	3.7	3.4	3.9	3.2	5.2	4.9	3.1	4.6	3.8	4	5	4.8	3	3.6	3.1	3.3	3.4	4.8
2.7	4.4	3.4	3.4	4.2	3.4	5.2	4.9	3.2	4.7	3.9	3.9	5.1	4.9	2.9	3.8	3.5	3.1	3.3	4.5
2.6	4.5	3.3	3.4	4.2	3.7	5.3	4.7	3.4	4.8	3.9	4.4	5	5.1	3.2	3.8	3.9	3.2	3.1	4.4
2.6	4.6	3.3	3.5	4.2	3.9	5.3	4.5	3.7	4.9	3.8	4.4	4.9	5.1	3.2	3.9	4	2.8	3	4.6
2.8	4.4	3.2	3.4	4.3	4.1	5.1	4.8	4.1	5	3.7	4.6	4.9	4.9	3	3.8	4	3.1	2.8	4.6
3	4.6	3.1	3.4	4.4	4.4	5	4.7	4.5	4.9	3.5	4.4	4.7	5	3.5	3.9	4.4	3.4	2.8	4.6
3.2	4.5	3.2	3.4	4.4	4.4	4.9	4.8	4.8	4.8	3.5	4.5	4.4	5.1	3.5	4.2	4.5	3.4	2.6	4.5
3.3	4.3	3.1	3.3	4.4	4.4	4.8	4.8	5.2	4.7	3.3	4.6	4.2	4.9	3.5	4.1	4.6	3.6	2.5	4.4
3.4	4	2.9	3.3	4.2	4.4	4.7	4.5	5.4	4.3	3.2	4.8	4.1	4.7	3.5	4.2	4.4	3.7	2.7	4.3
3.5	3.9	2.6	3.5	3.9	4.4	4.5	4.3	5.7	4	3	5	4.1	4.5	3.6	4.3	4.4	3.7	2.8	4.2
3.6	3.8	2.4	3.6	3.8	4.4	4.3	4	5.8	3.8	2.7	5.3	4.2	4.7	3.5	4.2	4.1	3.7	3	4.2
3.5	3.6	2.2	3.8	3.7	4.3	4.1	3.8	5.9	3.5	2.4	5.3	3.7	4.7	3.4	4.5	3.4	3.7	3.3	3.7
3.5	3.6	2	4.1	3.6	4.2	3.9	3.7	5.9	3.4	2.3	5.2	3.7	4.7	3.4	4.7	3.1	3.5	3.8	3.8
3.4	3.6	2	4.4	3.5	4.1	3.8	3.6	5.7	3.5	2.3	5.4	3.9	4	3.3	4.7	2.5	3.5	3.8	4.2
3.4	3.7	2.1	4.5	3.5	3.9	3.6	3.5	5.6	3.6	2.4	5.1	3.8	4.1	3.3	4.5	2	3.5	3.9	3.7
3.5	3.7	2.2	4.4	3.6	3.8	3.5	3.5	5.4	3.9	2.2	5.3	3.7	4.3	3.5	4.7	1.4	3.2	4.1	3.8
3.4	3.8	2.4	4.5	3.7	3.4	3.3	3.4	5.2	4.4	2.2	5.2	3.6	4.1	3.3	4.4	1	3	3.9	3.9
3.4	3.9	2.9	4.4	3.9	3.2	3.3	3.4	5	4.4	2.2	5.2	3.4	4.4	3.5	4.1	1	2.8	3.6	3.5
3.3	3.9	3.2	4.2	4.2	3	3.2	3.3	4.9	4.3	2.2	5.1	3.1	4.2	3.5	3.7	1	2.6	3.5	3.5
3.2	3.9	3.3	3.9	4.3	2.7	3.3	3.3	4.8	4.1	2.1	4.7	3.1	3.9	3.2	3.5	1	2.3	3.5	3.3
3	3.9	3.3	3.5	4.3	2.6	3.3	3.1	4.7	3.8	1.9	4.4	2.8	3.6	3.1	3.3	1	1.7	3	3.1
2.8	3.8	3.2	3	4.2	2.6	3.2	2.9	4.7	3.5	1.7	4.4	2.6	3.1	2.9	2.9	1	1.4	2.9	2.6
2.3	3.6	3.1	2.6	4	2.9	3.1	2.6	4.7	3.2	1.7	4.1	2.4	3	2.7	2.8	1.1	1.4	3	2.2
2.1	3.6	2.9	2.2	3.7	3.1	3.1	2.3	4.6	3	1.7	3.9	2.2	2.9	2.3	2.7	1	1.3	2.5	2.1
2	3.5	2.9	2.1	3.5	3.2	3	2.3	4.5	2.7	1.6	3.8	2.2	2.6	2.1	2.4	1.3	1.3	2.4	2
1.7	3.3	2.9	2	3.3	3.4	3.1	2.2	4.5	2.7	1.4	3.4	1.9	2.5	1.9	2.1	1.3	1.5	2.3	1.9
1.6	3.5	2.9	2.1	3	3.6	3.2	2.4	4.5	2.8	1.4	3.6	1.9	2.6	1.8	2.4	1.4	2.2	2.1	1.8
1.6	3.5	2.9	2.1	2.8	3.7	3.4	2.6	4.7	3.2	1.2	3.6	1.8	2.7	1.7	2.5	1.6	2.7	2.4	2
1.6	3.8	3.1	2.1	2.5	3.6	3.5	3	4.7	3.5	1.3	3.4	2	2.8	1.8	2.6	2	2.9	2.8	2.4
1.7	3.9	3.4	2.4	2.4	3.7	3.8	3.3	4.7	3.9	1.4	3.5	2.1	2.8	1.8	3.2	2.4	3.3	2.5	2.5
1.8	4	3.7	2.4	2.3	3.6	4.1	3.8	4.7	4.1	1.5	3.5	2	2.8	1.9	3.2	2.8	3.7	2.8	2.7
1.8	4	3.8	2.4	2.2	3.5	4.1	4.3	4.8	4.2	1.6	3.5	2.1	3	1.7	3.3	3.1	3.8	3	2.7
1.9	4	3.9	2.3	2.2	3.4	4.1	4.4	4.7	4.3	1.8	3.4	2	3	1.7	3.6	3.2	3.9	3	3.1
2.1	3.9	4	2.2	2.1	3.3	3.8	4.7	4.3	4.2	2	3.9	2.1	3.4	1.7	3.9	3.2	4	3.2	3
2.3	3.8	3.9	2.3	2.3	3.2	3.7	4.7	4	4	2.3	4.2	1.9	3.1	2.2	4.4	3.9	4.1	3.2	3.2
2.5	3.7	3.8	2.4	2.5	3.2	3.3	4.7	3.6	3.7	2.4	4.5	1.7	3.3	2.2	4.5	3.9	4	3.2	2.9
2.7	3.5	3.6	2.6	2.4	3.3	3.1	4.6	3.2	3.4	2.7	4.7	1.7	3.5	2	4.8	4.1	4	3.2	3
2.9	3.4	3.4	2.6	2.5	3.4	2.9	4.6	2.7	3	3	4.9	1.8	3.5	2.2	4.7	4.2	3.8	3.1	3
3	3.3	3.2	2.8	2.5	3.5	2.8	4.5	2.3	2.8	3.3	5.2	1.8	3.8	2.2	4.8	3.8	3.8	3	2.8
3.2	3.3	3	3	2.5	3.8	2.8	4.4	2	2.7	3.5	5.1	1.8	3.9	2.2	4.6	3.5	3.6	2.7	2.8
3.3	3.3	2.7	3.2	2.5	4	2.7	4.2	1.9	2.7	3.8	4.6	2	4	2.4	4.4	3.2	3.4	2.6	3
3.6	3.4	2.5	3.2	2.5	4.1	2.9	4.1	2	2.9	4.1	4.8	2	4.1	2.6	4.5	3.4	3.7	2.3	3.2
3.7	3.4	2.4	3.4	2.5	4.1	3	4.1	2.2	3.4	4.3	4.4	2.2	4.2	2.5	4.5	3.5	4	2.5	3.3
3.7	3.5	2.2	3.6	2.6	4.1	3	4.4	2.4	3.9	4.6	4.6	2.4	4.3	2.7	4.2	3.3	3.9	2.5	3.7
3.9	3.6	2.2	4	2.6	4	3.1	4.4	2.8	4.4	4.7	4.7	2.8	4.4	2.8	4.3	3.2	3.8	2.9	4
4.1	3.4	2.2	4.3	2.7	4.1	3.2	4.8	3.3	5		5	3.3	4.8	3.5	4.3	3.2	3.9	3	4.3
4.2	3.4	2.3	4.4	3	4.1		5.3	3.8	5.4		5	3.4	4.7	4	4.1	3.1	4.1	3.2	4.3
4.3	3.2	2.5	4.5	3.4			5.5	4.3			4.4	3.8		4.3	4	3.2	4	3.7	
	3.1	2.6		3.7			5.9	4.7						4.4		3.5		3.7	

Table A2-8 Data for trial 101 to trial 117 in the stage two

t101	t102	t103	t104	t105	t106	t107	t108	t109	t110	t111	t112	t113	t114	t115	t116	t117
5	2.9	5.2	3.9	4.8	4.2	3.1	3.1	3.2	3.2	3.5	2.5	3.2	4.5	2.1	4	3.8
5	2.9	5.1	4.1	4.8	3.8	3.2	3.2	3.4	3.3	3.8	2.4	3	4.6	2.4	4.1	3.8
5	3	4.9	4	4.9	3.5	2.9	2.9	3.4	3.4	4.1	2.2	2.7	4.6	2.8	4.3	3.5
4.8	3	4.9	4	4.8	3.2	3.1	3.1	3.4	3.6	4.5	2	2.6	4.6	2.9	4.4	3.3
4.5	3	4.5	3.8	4.6	2.8	3.6	3.6	3.3	3.7	4.8	2	2.5	4.5	3.2	4.2	3
4.5	3.1	4.4	3.8	4.4	2.4	3.6	3.6	3.2	3.8	4.9	2	2.4	4.5	3.5	4.3	2.9
4.1	3.2	4	3.7	4.5	2.1	4.1	4.1	3.1	3.9	5.2	2.3	2.4	4.4	3.9	4.3	2.5
4	3.6	3.7	3.9	4.6	2	4.7	4.7	3	3.9	5.3	2.4	2.3	4.3	4.3	4.3	2.5
3.5	3.8	3.6	3.8	4.6	2	5.4	5.4	2.8	4	5.2	2.5	2.5	4.2	4.5	4.3	2.4
3.8	4	3.4	3.7	4.4	2	5.7	5.7	2.7	4	4.9	2.8	2.7	4	4.6	4.3	2.3
3.8	4	3.4	3.9	4.3	2.1	5.8	5.8	2.7	4	4.7	3	2.9	3.8	4.8	4	2.4
4	4.3	3.3	4.1	4.2	2.4	6	6	2.6	4	4.5	3.2	3.2	3.7	5	4	2.1
4.1	4.4	3	4.2	4.1	2.5	5.9	5.9	2.6	4.1	4.2	3.4	3.3	3.6	5.2	3.9	2.3
4.2	4.4	3	4.2	4	2.7	5.8	5.8	2.7	4.1	3.9	3.6	3.5	3.4	5.1	3.8	2.1
4.3	4.3	3	4.1	3.6	3.1	5.6	5.6	2.8	4.1	3.6	3.7	3.8	3.4	5	3.7	2.4
4.5	4.3	2.8	4.2	3.7	3.4	5.5	5.5	2.9	4.1	3.3	3.8	4	3.3	5.2	3.7	2.7
4.7	4.4	2.8	4	3.4	3.3	5.5	5.5	2.8	4.1	3.1	3.9	4.1	3.2	5.1	3.7	2.9
4.7	4.3	2.5	3.9	3.2	3.6	5.2	5.2	2.8	4.1	3	4.1	4.3	3.2	5.1	3.7	3.1
4.5	4.1	2.7	3.9	3	4	5.2	5.2	2.7	4.1	2.8	4.3	4.3	3.2	5.1	3.8	3.3
4.5	4.3	2.7	3.9	3.2	3.9	5	5	2.7	4.1	2.7	4.4	4.3	3.3	4.9	3.8	3.4
4.2	4.4	2.8	3.9	3.1	3.7	4.5	4.5	2.5	4.1	2.7	4.5	4.4	3.4	4.7	3.9	3.7
4.1	4.3	3	3.6	3.3	3.9	4.5	4.5	2.5	4.2	2.9	4.6	4.4	3.5	4.6	3.9	3.8
4.2	4.4	3.3	3.8	3.4	3.7	3.9	3.9	2.6	4.2	2.9	4.6	4.5	3.7	4.4	4	4
4.2	4.3	3.4	3.6	3.3	3.4	3.8	3.8	2.8	4.4	3.1	4.8	4.6	3.9	4.3	4.2	4.3
4	4.4	3.7	3.6	3.3	3.5	3.7	3.7	3	4.6	3.3	4.9	4.6	4.1	4	4.3	4.6
4.2	4.5	3.8	3.6	3.3	3.3	3.8	3.8	3.3	4.6	3.4	5	4.6	4.1	3.9	4.4	4.9
4.2	4.5	3.9	3.5	3.4	2.9	3.8	3.8	3.7	4.7	3.5	5.2	4.6	4.3	3.7	4.5	5
4.3	4.6	3.8	3.1	3.5	2.7	4	4	3.9	4.8	3.6	5.3	4.6	4.6	3.5	4.6	5.1
4.3	4.7	3.8	3.1	3.5	2.5	4.2	4.2	4.5	4.7	3.7	5.2	4.6	4.9	3.1	4.7	5.4
4.5	4.5	3.9	3	3.7	2.7	4.1	4.1	4.7	4.7	3.8	5.1	4.5	5.1	2.9	4.8	5.5
4.7	4.5	3.9	2.7	3.8	2.8	4.4	4.4	4.8	4.6	3.9	5	4.2	5.1	2.9	4.6	5.4
4.7	4.3	4	2.7	4	2.7	4.7	4.7	4.9	4.5	4.1	4.8	4.2	5.1	2.8	4.7	5.5
4.9	4.1	4	2.5	4.2	3.2	4.9	4.9	4.9	4.4	4.3	4.3	4.1	4.9	2.8	4.7	5.4
4.7	4	3.9	2.6	4.4	3.2	5.2	5.2	4.9	4.3	4.6	4	4	4.8	3	4.5	5.4
4.6	3.6	3.9	3	4.6	3.4	5.3	5.3	4.9	4	4.8	3.6	3.9	4.6	3.1	4.5	5.2
4.5	3.4	3.9	3.1	4.6	3.5	5.5	5.5	4.8	3.6	4.9	3.2	3.8	4.7	3.5	4.4	5
4.5	3.3	3.9	3.6	4.8	3.5	5.5	5.5	4.5	3.4	4.9	3	3.7	4.6	3.8	4.4	4.9
4.5	3.2	3.9	3.5	4.9	3.5	5.4	5.4	4.1	3.2	4.9	2.9	3.6	4.6	4	4.3	4.8
4.3	3.1	3.9	4.3	5	3.6	5.4	5.4	3.9	3.1	4.9	2.9	3.6	4.7	4.3	4.3	4.6
4.3	2.9	4	4.5	5.2	3.7	5.2	5.2	3.5	3.1	4.7	2.9	3.6	4.7	4.7	4.3	4.3
4.3	2.8	4	4.7	5.2	3.6	4.9	4.9	3.1	3.2	4.5	3	3.7	4.7	4.9	4.3	4.2
4.3	2.6	4.1	4.7	5.2	3.5	4.8	4.8	2.8	3.4	4.4	3.3	3.8	4.8	5.2	4.4	4
4.3	2.6	4.5	5	5.3	3.5	4.5	4.5	2.7	3.6	4.2	3.6	3.9	4.9	5.4	4.4	3.9
4.3	2.6	4.4	5	5.6	3.4	4.4	4.4	2.5	3.9	4	3.9	4.1	4.9	5.6	4.5	3.8
4.5	2.6	4.3	5.1	5.6	3.5	4.1	4.1	2.6	4.2	3.9	3.9	4.2	4.9	5.5	4.5	3.7
4.4	2.6	4.4	5.2	5.7	3.3	3.8	3.8	2.8	4.4	3.7	4.1	4.2	4.9	5.3	4.5	3.6
4.5	2.6	4	5.3	5.3	3.1	3.6	3.6	2.9	4.6	3.5	4.3	4.2	4.7	5.2	4.7	3.5
4.6	2.7	4	5	5.4	3.2	3.5	3.5	3.3	4.8	3.5	4.6	4.1	4.5	5.1	4.7	3.4
4.7	3	3.7	4.9	5	3.2	3.4	3.4	3.6	5	3.4	4.9	3.9	4.4	5	4.6	3.3
5	3.2	3.5	4.9	5	3.2	3.5	3.5	3.9	5	3.4	5.3	3.7	4.1	5	4.5	3.2
4.9	3.6	3.3	4.7	4.9	3.2	3.5	3.5	4.3	5	3.3	5.7	3.6	3.8	5	4.4	3.1
4.6	3.9	3.1	4.6	4.3	3.4	3.6	3.6	4.6	5.1	3.3	6.2	3.4	3.6	4.8	4.3	3

Table A2-8 Cont.

t101	t102	t103	t104	t105	t106	t107	t108	t109	t110	t111	t112	t113	t114	t115	t116	t117
4.5	4.3	2.7	4.3	4.5	3.5	3.8	3.8	5.2	5.1	3.4	6.3	3.4	3.3	4.7	4	2.9
4.2	4.7	2.6	4.3	4.4	3.7	4	4	5.5	5.2	3.4	6.5	3.3	3.1	4.8	3.8	2.7
4.2	4.4	2.1	4.2	4.1	3.8	4.3	4.3	5.7	5.2	3.5	6.5	3.4	3.9	4.7	3.6	2.5
4.2	4.9	2.2	4.1	3.7	4.1	4.6	4.6	5.9	5.2	3.6	6.4	3.5	2.9	4.8	3.3	2.3
4.1	4.8	2.1	4.1	3.4	4.6	4.7	4.7	5.9	5.2	3.7	6.3	3.8	2.9	4.7	3.2	2.2
4	4.7	2.2	3.8	3.3	4.7	4.8	4.8	5.9	5.1	3.9	6.1	4.1	2.9	4.6	3.2	2.2
3.9	4.8	2.3	3.4	3.3	4.5	4.9	4.9	5.9	5	4.1	5.9	4.4	3	4.7	3	2.1
4	5	2.6	3.6	3.6	4.7	5.3	5.3	6	4.8	4.3	5.7	4.6	3.1	4.7	3	2.1
4	5	3	3.7	3.5	4.5	5.2	5.2	5.9	4.7	4.5	5.4	5	3.3	4.7	3.1	2.1
4.1	4.9	3.4	3.8	3.6	4.4	5.4	5.4	5.7	4.6	4.9	5.3	5.8	3.5	4.7	3.3	2.3
4.1	4.6	3.9	3.9	3.4	4.3	5.1	5.1	5.5	4.3	5.1	5.2	5.9	3.7	4.6	3.6	2.6
4	4.5	4.4	4.1	3.1	4.4	4.9	4.9	5.2	4.2	5.3	5.1	6.2	3.9	4.6	4	3
3.9	4.6	4.6	4.3	3.2	4.2	5	5	4.9	4.1	5.4	5	6.4	4.1	4.5	4.4	3.5
3.9	4.5	4.9	4.3	3.2	4.3	5	5	4.5	3.8	5.5	4.9	6.5	4.2	4.2	4.8	4
3.7	4.7	5	4.3	3.2	4.1	5.1	5.1	4.1	3.6	5.6	4.9	6.5	4.4	4	5.1	4.4
3.9	4.8	5.1	4.4	3.5	4.1	5.2	5.2	3.8	3.1	5.7	4.7	6.5	4.5	3.9	5.4	4.8
3.6	4.4	5	4.5	3.5	4.7	5.3	5.3	3.5	2.5	5.7	4.5	6.3	4.4	3.8	5.6	5
3.7	4.5	5	4.9	3.7	5	5.2	5.2	3.5	2	5.7	4.4	6.2	4.8	3.6	5.8	5.4
3.5	4.4	5.2	4.6	4	4.5	5.3	5.3	3.3	1.6	5.7	4.3	5.9	4.9	3.6	5.9	5.7
3.2	4.2	5	5	4.3	4.4	5.2	5.2	3.3	1.3	5.6	4.1	5.4	5.2	3.7	6	5.9
3.1	4	4.8	4.9	4.2	4.3	5	5	3.3	1.1	5.6	3.8	4.9	5.3	3.8	6.1	6.1
2.9	3.7	4.6	4.4	4.6	4.1	4.7	4.7	3.3	1.1	5.6	3.5	4.6	5.4	3.9	6.1	6.2
2.6	3.7	4.2	4.5	4.6	3.6	4.5	4.5	3.1	1.2	5.3	3.2	4.3	5.4	4.2	6	6.2
2.5	3.6	3.5	4.4	4.6	3.4	4.2	4.2	2.9	1.3	4.9	3	3.8	5.4	4.4	5.8	6.2
2.4	3.3	3.4	4.1	4.6	3	4.1	4.1	2.4	1.5	4.6	3	3.3	5.3	4.6	5.3	6.1
2	3.1	3.3	3.8	4.4	2.6	4	4	2.1	1.7	4.3	3	3	5.3	4.8	5	5.8
2	3.6	2.8	3.4	4.4	2.2	3.6	3.6	1.8	1.8	4.1	3	2.8	5.1	4.7	4.5	5.5
2.1	3.8	2.7	3.1	4.3	2.1	3.3	3.3	1.7	2	3.9	3.1	2.7	5.1	4.8	3.8	5.2
2.1	3.9	2.4	2.8	4.1	2	3.3	3.3	1.6	2.2	3.8	3.4	2.7	4.8	4.6	3.4	4.9
2.1	4	2.4	2.6	4.2	2.2	3	3	1.7	2.3	3.8	3.6	2.7	4.6	4.6	3	4.6
2.4	4	2.5	2.3	4.2	2.3	3.4	3.4	1.8	2.3	3.9	3.7	2.8	4.5	4.5	2.7	4.3
2.5	4	2.5	2.4	4	2.5	3.5	3.5	2	2.3	4.1	3.8	2.9	4.5	4.3	2.3	4.2
2.5	4.2	2.5	2.2	3.7	2.8	3.5	3.5	2.2	2.3	4.3	3.9	3	4.4	4	2	3.9
2.7	4	2.6	2.2	3.5	3	3.1	3.1	2.4	2.3	4.5	4.1	3.2	4.5	3.7	1.7	3.7
2.9	3.8	2.8	2.2	3.4	3.2	3.4	3.4	2.5	2.4	4.6	4.3	3.3	4.5	3.3	1.5	3.6
2.7	3.6	2	2.2	3.5	3.9	3.1	3.1	2.7	2.6	4.7	4.5	3.5	4.5	2.9	1.4	3.5
2.2	3.6	3.3	2.3	3.4	3.8	3.2	3.2	2.6	2.8	4.8	4.9	3.6	4.7	2.7	1.4	3.4
2.1	3.1	3.4	2.7	3.2	3.9	3.2	3.2	2.6	3.2	4.9	5.3	3.8	4.8	2.4	1.6	3.3
2.4	2.9	3.7	2.5	3	4.1	3.2	3.2	2.7	3.8	4.9	5.4	3.9	5	2	1.8	3.3
2.2	2.6	3.8	2.5	2.9	4.2	3.3	3.3	2.8	4.4	4.9	5.4	4	5.1	1.8	2	3.3
2.4	2.6	4.2	2.8	2.8	4.1	3.2	3.2	3	4.7	4.8	5.4	4.1	5.1	1.7	2.2	3.5
2.4	2.3	4.3	3	2.6	4	3.4	3.4	3.2	5.1	4.6	5.1	4.3	5.1	1.7	2.3	3.7
2.7	2.3	4.3	3	2.5	3.9	3.4	3.4	3.5	5.2	4.4	4.8	4.6	5.1	1.8	2.5	3.9
2.7	2.5	4.3	3.2	2.5	3.9	3.5	3.5	3.8	5.2	4.3	4.4	4.9	5.1	1.9	2.8	4
3	2.3	4.3	3.1	2.7	3.8	3.5	3.5	4.1	5.1	4		5	5	2.1	3.1	4.3
3.6	2.7	4.3	3.2	2.9	3.7	3.4	3.4	4.3	4.8	3.7		5.3	4.9	2.4	3.4	4.3
3.7	3.1	4.3	3	3	3.9	3.3	3.3	4.5	4.5	3.4		5.5	4.7	2.7	3.8	4.2
4	3.5	4.3	3	3.2	3.6	3.1	3.1	4.6	4.1	3.2		5.7	4.6	3	4.2	4.1
4	4.1	4.3	3.1	3.9	4	2.8	2.8	4.6	3.8	3		5.9	4.4	3.5	4.5	4.1
3.9	4.4	4.4	3.3	4.1	3.6	2.8	2.8	4.6		3		5.9	4.3	3.7	4.6	4
		4.2	3.3	4		3.2	3.2			3		5.8	4.3	4	4.5	4.1
			3.4										4.4	4.3	4.8	4.1

Appendix B Calibration of tractor velocity

Tractor velocity calibration preliminary results with 100 m of travel distance on June 16, 1999

Gear		Engine (rpm)	Time (s)	Velocity	
				(m/s)	(km/h)
1	Low	1000	73.25	1.37	4.93
		1700	43	2.33	8.39
1	High	1200	46.90	2.13	7.67
		1700	32.68	3.06	11.02
2	Low	1225	39.72	2.52	9.06
		1700	28.41	3.52	12.67
2	High	1225	30.63	3.26	11.74
		1700	21.87	4.57	16.45
3	Low	1150	23.49	4.22	15.19
		1800	14.50	6.90	24.84

APPENDIX C Driver subjective scores and feelings for stage two

Trial No.	Driver's comments	Score
1	so slow, it is wiggly feeling, easy to drive, find rope, judge correction, but the precision is low	7
2	I really miss the wide view of the other camera	7
3	same	7
4	first run of the day, and I lost concentration, Driver error	5
5	pretty good precision, difficult to drive, feels very much like 40 degrees, wide camera	6
6	felt ok. It is hard to tell if error is coming from camera, or from me not driving for a week.	7
7	good. I followed the line ok.	8
8	Oscillations are more severe this time.	6
9	finding the line is very hard, following it is not bad	6
10	felt really good following a bit more difficult, finding is super easy, some monitor vibration	9
11	no complaints	9
12	I had a little harder time this time following the line, otherwise, stability was good	8
13	not bad. following the line was pretty easy	8
14	A bit harder to follow the line	7
15	pretty good except for the very end where I lost the rope	7
16	Result good if I use the hood and end of the field to line up the tractor.	7
17	Not to bad. Speed is slow enough that this setting almost works	8
18	following pretty good, finding really bad.	5
19	some vibration, difficult to follow, easy to find	7
20	good, easy to find, ok to follow	9
21	difficult to follow, easy to find	7
22	medium to follow, medium to find	8
23	no complaints	9
24	some error due to first run of the day, hard to find and follow	6
25	with enough practice, this setting good become good	6
26	By the time I see a correction is necessary, the error is huge	6
27	This run was very bad. this is the kind of run which I dislike about 40 degrees	3
28	felt ok, but not great	8
29	even better	8
30	very good, no complaints	9
31	Not perfect but still alright	8
32	I had a slightly harder time this time	7
33	all around good run, no complaints	9
34	harder to find line	6

35	pretty good run I relied a lot on the hood again, using the screen only for small adjustments	8
36	This time I tried using the hood less. Caused some oscillation.	5
37	kind of hard to keep control. I wish the view was a little larger. Example, wide camera with a bigger screen	7
38	Not as good, I had trouble weaving	6
39	a bit better, but still not perfect	7
40	Very good, except I lost control at the end	7
41	very average in all categories, finding, following, vibration, results, etc	7
42	same, but I had a slightly harder time controlling it, also, some driver error	6
43	started out pretty good, but then got worse and worse	5
44	half a second is not enough time to react	2
45	big oscillations, and hard to drive	5
46	easy to find, easy to follow, very good except for right at the end	8
47	very good	8
48	even better	9
49	pretty good. for quite a while I was off to one side	7
50	no complaints except maybe vibration	8
51	same	8
52	lots of medium sized oscillations, and it is very tiring driving this camera setting	5
53	lots of oscillations, hard to get good results.	6
54	Very hard to find rope, I finally got it near the end.	3
55	I was still pretty used to the way the camera behaved when the implement was still bent, which may have increased the error for this run.	6
56	This run felt pretty good, even though I was off the line for a while at the end.	7
57	The first part of this run I didn't do very well, but I thought the middle was pretty good	7
58	It seemed a little more difficult to stay on the line this time	6
59	This run felt pretty good. Not super great, but not bad either.	7
60	This one was not as good. I had a hard time staying on the line.	4
61	oscillations felt fairly severe.	5
62	This run felt ok for the first part, but I had a hard time staying on the rope	6
63	This run was worse again, I had a hard time staying on the rope.	3
64	felt pretty good. I can see enough of the rope ahead of me, which gives me enough time to react. It feels very comfortable	8
65	This one was just as good as the last one	8
66	I had a little more trouble in one spot, but otherwise, this run was just as good as well.	8
67	very good run, all around	9

68	Not too bad. I missed the line for a small section	8
69	I have no complaints. This seems to be a fairly good camera angle	9
70	The driving went not bad, but the camera angle was uncomfortable, because the rope is not on the screen long enough	6
71	I did not have enough advance notice to make corrections	4
72	The oscillations kept building up, getting worse and worse along the entire length of the rope.	7
73	This run felt pretty good. It was easy to follow the line, and easy to find the line	7
74	RED same as above	8
75	This is a good setting for driver comfort, but there is too much camera vibration	8
76	RED Not bad. Maybe a little harder to drive, but better precision. Maybe some extra driver error	7
77	RED same as above	7
78	This time I found it harder to follow the line again	6
79	RED Very hard to follow the line. Stuff only stays on the screen about 1 second	3
80	Precision seems to be a bit better, but it is very hard to drive.	4
81	same as above	5
82	RED felt pretty good. There was a bit too much vibration though	8
83	same	8
84	I really like being able to see the horizon on this one	8
85	OK, no strong opinions either way	8
86	RED same	8
87	RED Pretty good. no complaints, except I wouldn't mind seeing the horizon	8
88	It is harder to follow the line, because there is less time to react	5
89	same	6
90	RED not too hopeless for results, but not very much fun for driving	6
91	Too fast. It felt pretty good except I lost control for a few seconds, just after the midway point. There is too much vibration	6
92	RED loads of vibration, otherwise, easy to drive	8
93	RED would be a easy setting to drive if the camera could be fixed in such a way as to reduce the vibration	7
94	Had a fairly good feel. Precision felt a bit better.	7
95	RED felt a bit too fast for the camera setting. still some vibration	7
96	This setting actually feels pretty good most of the time	7
97	reaction time is virtually zero	3
98	not much better	4
99	RED wild oscillations. I am being rushed too much in my corrections, and therefore, I tend to overcorrect.	4
100	RED Too much vibration to be accurate. Otherwise, driving felt OK but errors could be large	7
101	Still vibrating too much, which makes it hard to drive	7

102	same	7
103	RED I felt I could have driven better, because the camera setting felt ok, but I had a hard time following the rope	6
104	RED This one was more what I would expect. Precision is ok, and driving difficulty is ok	7
105	RED same as above	8
106	RED Some oscillations. There just isn't enough time to react	6
107	RED This result was probably pretty good, even though I found it hard to drive	7
108	RED I find that this angle is too steep. It sometimes gives good results over a 100m track, but I think that it would be much more difficult to use it all day.	6

APPENDIX D C-Code for pre-processing the data

```
/*    C program for calculation of mean, standard deviation, maximum value,   */
/*                and percentage of errors within tolerance                    */

/*****************************************************************/
/*****                                                      *****/
/***** This is a C Program for processing the experiment data being  *****/
/***** done in the summer term of 1999 at the UM            *****/
/*****              (applied to the second stage)           *****/
/*****                                                      *****/
/*****      Using the "3.5*10 cm" as the CRITERION LINE     *****/
/*****        (lateral error=10*(the original data -3.5) cm)  *****/
/*****************************************************************/

#define NL "\n"
#define D2 "%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,"
#define D D2 D2 D2 D2 D2 D2 D2 D2 D2 D2 D2 NL /* 110DATA */
#define A &arra[
#define B ],
#define C B A
#define M A 0 C 1 C 2 C 3 C 4 C 5 C 6 C 7 C 8 C 9 C 10 C 11 C 12 C 13 C 14 C 15
#define N C 16 C 17 C 18 C 19 C 20 C 21 C 22 C 23 C 24 C 25 C 26 C 27 C 28
#define O C 29 C 30 C 31 C 32 C 33 C 34 C 35 C 36 C 37 C 38
#define P C 39 C 40 C 41 C 42 C 43 C 44 C 45 C 46 C 47 C 48 C 49 C 50
#define Q C 51 C 52 C 53 C 54 C 55 C 56 C 57 C 58 C 59 C 60 C 61 C 62
#define R C 63 C 64 C 65 C 66 C 67 C 68 C 69 C 70 C 71 C 72 C 73
#define S C 74 C 75 C 76 C 77 C 78 C 79 C 80 C 81 C 82 C 83 C 84
#define T C 85 C 86 C 87 C 88 C 89 C 90 C 91 C 92 C 93 C 94 C 95 C 96
#define U C 97 C 98 C 99 C 100 C 101 C 102 C 103
#define V C 104 C 105 C 106 C 107 C 108 C 109
#define Z M N O P Q R S T U V
#include "stdio.h"
#include <math.h>
#define NO 300
#define SIZE 330
char str2[10];

main ()
{
        static float arra[SIZE];
        static int b[SIZE];
        int a1,a2,a3,a4,y;
        float u;
        int q,i,j,n,ii,mm=0;
        FILE *fp,*p;
```

```
static char filename[20],str1[10],str3[10],str4[5]={
                    " "             };
printf("How many trials' data do you want to calculate?\n");
printf("Please input:");
scanf("%d\n",&a4);
printf("\n");
for (j=1;j<a4+1;j++)
{
        strcpy(str2,str4);/* initializing str2[]*/
        /*      printf("j=%d\n",j);*/
        strcpy (str1,"test2-");/* note the "strcpy" */
        strcpy (str3,".txt");

        /*              printf("Please input the Trial No.(except");
                                                printf(" the number
13,14,15,16,17,18):");
                                                scanf("%s",str2);
                                    */

        if (j<10)
        {
                q=0;
                char_exchange(q,j);
                /*      printf("str2=%s",str2);*/
        }

        else if (j>=10 && j<100)
        {
                a1=j/10;
                q=0;
                char_exchange(q,a1);/* str2[0]=a1 */
                q=1;
                a2=j-a1*10;
                char_exchange(q,a2);/* str2[1]=a2 */

        }
        else if (j>=100 && j<1000)
        {
                a1=j/100;
                q=0;
                char_exchange(q,a1);/* str2[0]=a1 */
                q=1;
                a2=(j-a1*100)/10;
                char_exchange(q,a2);/* str2[1]=a2 */
                q=2;
                a3=j-a1*100-a2*10;/* note:"10/3=3";"10%3=7" */
```

```
                    char_exchange(q,a3);

                }
                else break;

                /*      strcpy(str2,c);*/
                strcat(str1,str2);
                strcat(str1,str3);
                strcpy(filename,str1);
                if ((fp=fopen (filename,"r"))==NULL)
                {
                        printf("No Such A File Exist!!!\n");
                        printf("Please try to input other trial No.\n");
                        printf("\n\n");
                        return;
                }
                fscanf (fp,D,Z]);

                for (i=0;i<SIZE;i++)
                {
                        if (i>=95 && arra[i]==0) break;
                        u=fabs(10*arra[i]-3.5*10);
                        mm=i+ii*100;
                b[mm]=(int)u;
                        /*printf("arra[%d]=%4.1f\n",i,arra[i]);*/
                        /*printf("b[%d]=%d\n",mm,b[mm]);*/
                }
                ii=ii+1;
                fclose (fp);
        if (j%3==0)
        {print_result(b,str2);
        ii=0;}

                /*printf("j+1=%d\n",j);*/
        }
    }


/*  used for calculating the probability of a certain range  */
/*  of error with a given number of data                     */
/* e--error m--cutoff point                                  */

float chan (b,e,m)
int b[];
int e,m;
{
```

```
        int n,i,sum=0;
        int *p;
        float x,y;
        n=NO-m;
        /*p=&b[m];*/
        for (i=0;i<n;i++,p++)
                if (b[i]<=e && b[i]>=-e) sum=sum+1;
        /* printf("%d\n",sum);*/
        x=1.0*sum/n;
        /* printf("%5.3f\n",x); */
        y=100*x;
        return(y);
}


/*  used for calculating average of the array in the        */
/*  length of (100-2m)                                      */

float aver(b,m)
int b[];
int m;
{
        int i,n,sum=0;
        float x;
        n=NO-m;
        for (i=m;i<n;i++)
                sum=sum+b[i];
        x=1.0*sum/NO;/* orginally NO=100.0*/
        return(x);
}

/*  notice if it is necessary to add decimal in 100 eg.100.0  */
/*  because x belongs to float averable                        */


/*  Used to calculate a standard deviation          */
/*#include "math.h"*/
float std (b,m)
int b[];
int m;
{
        int i,n,k,sum=0;
        float x,y,z,s;
        n=NO-m;
        k=m;
        x=aver(b,k);            /* use of function of average  */
```

```
        for (i=m;i<n;i++)
        {
                y=b[i]-x;
                y=pow(y,2);
                /*sum=sum+(y)*(y);*/
                sum=sum+y;
        }
        z=1.0*sum/(NO-2*m);/*standard deviation*/
        s=sqrt(z);  /* need to check the math library */
        return (s);
}

/*  used for calculating the maximum                        */
/*  values of the array                         */

maxi(b,m)
int b[];
int m;
{
        int i,n,z;
        n=NO-m;
        z=b[m];
        for (i=m;i<n;i++)
                if (z<b[i]) z=b[i];
        return (z);
}

/*  used for calculating the maximum and minimum        */
/*  values of the array                         */
/*

mini(b,m)
int b[];
int m;
{
        int i,n,y;
        n=NO-m;
        y=b[m];
        for (i=m;i<n;i++)
                if (y>b[i]) y=b[i];
        return (y);
}
*/

/* calculating the Coefficient of Variation of lateral error=CV*/
float cvf(b,m)
```

```
int b[];
int m;
{float x,y,z;
 x=aver(b,m);
 y=std(b,m);
 z=1.0*y/x;
 return (z);
}

/* print all the parameters*/
print_result(a,w)
int a[];
int w[10];
{
        static char file[10]={

        "t1"                                        };
        FILE *fp;
        int i;
        float u;
        int f,g,j,b1;
        int mm,max,min;
        float av,sd,ch,cv,q;
        char st1;
        static char st2[4]={
                "No."   },
        st3[5]={
                "AVER"        },
        st4[5]={
                "SD"    };
        static char st5[5]={
                "MAX"         },
        st6[5]={
                "CV"    };
        static char st7[20]={
                "ERROR DISTRIBUTION"  };
        static char st22[7]={
                "LENGTH"    };
        st1=241; /*241 (ASIIC code) standing for the signal + & - */
        printf("%5s",st2);
        printf("%10s",st22);
        printf("%6s",st3);
        printf("%6s%6s%6s",st4,st5,st6);
                g=10;/*g=tolerance of errore e.g.+_10cm*/
                printf("%7c%dcm",st1,g);
        printf("\n");
```

```
        printf("%5s",w);
        f=0;
        b1=NO-2*f;
        printf("%7d(m)",b1);
        av=aver(a,f);
        printf("%6.1f",av);
        sd=std(a,f);
        printf("%6.1f",sd);
        max=maxi(a,f);
        cv=cvf(a,f);
        printf("%6d%6.1f",max,cv);
                /* g=10;*/
                ch=chan (a,g,f);
                printf("%10.1f%%",ch);
        printf("\n\n");

        /* note: fclose(fp) can not be use here!!!  */
        return;
}


char_exchange(i,a)
int i,a;
{
        switch (a)
        {
        case 1:
                str2[i]='1';
                break;
        case 2:
                str2[i]='2';
                break;
        case 3:
                str2[i]='3';
                break;
        case 4:
                str2[i]='4';
                break;
        case 5:
                str2[i]='5';
                break;
        case 6:
                str2[i]='6';
                break;
        case 7:
                str2[i]='7';
```

```
			break;
		case 8:
			str2[i]='8';
			break;
		case 9:
			str2[i]='9';
			break;
		case 0:
			str2[i]='0';
			break;
		}
		return;
}
```

APPENDIX E SAS program for data analysis

Program A for analysis of lateral error

```
Options linesize=72;
Data one;
 Input FOV $ Velocity Height Angle @ ;
 Do Trial=1 to 3;
  Input Average @;
  Output;
 End;
Cards;
Narrow 4 1.1 20 4.3 7.0 6.4
Narrow 4 1.1 30 6.7 3.4 2.4
Narrow 4 1.1 40 3.5 6.5 8.4
Narrow 4 1.5 20 4.5 3.0 2.0
Narrow 4 1.5 30 3.8 5.8 5.2
Narrow 4 1.5 40 4.4 4.6 5.9
Narrow 6 1.1 20 3.8 4.0 5.5
Narrow 6 1.1 30 3.6 2.8 5.8
Narrow 6 1.1 40 4.4 5.2 9.3
Narrow 6 1.5 20 6.8 3.5 4.5
Narrow 6 1.5 30 5.8 3.9 3.3
Narrow 6 1.5 40 8.7 5.4 5.5
Narrow 8 1.1 20 4.0 7.7 4.0
Narrow 8 1.1 30 3.6 4.9 5.2
Narrow 8 1.1 40 6.2 7.6 6.9
Narrow 8 1.5 20 4.9 5.1 2.5
Narrow 8 1.5 30 4.5 3.5 3.1
Narrow 8 1.5 40 5.7 6.0 7.9
Wide 4 1.1 20 5.5 4.6 5.9
Wide 4 1.1 30 4.8 4.4 6.6
Wide 4 1.1 40 6.2 4.7 7.7
Wide 4 1.5 20 7.8 8.5 9.5
Wide 4 1.5 30 5.4 7.3 5.1
Wide 4 1.5 40 7.8 8.8 6.0
Wide 6 1.1 20 3.8 6.6 5.3
Wide 6 1.1 30 6.1 5.0 5.7
Wide 6 1.1 40 8.4 7.5 6.3
Wide 6 1.5 20 5.3 5.7 5.2
Wide 6 1.5 30 4.7 4.3 5.6
Wide 6 1.5 40 9.1 9.2 6.9
Wide 8 1.1 20 7.8 7.9 9.7
Wide 8 1.1 30 5.6 5.4 5.6
Wide 8 1.1 40 10.0 6.9 6.5
Wide 8 1.5 20 6.3 8.4 7.1
Wide 8 1.5 30 7.2 7.1 7.2
Wide 8 1.5 40 5.8 9.4 7.6
Proc GLM data=one;
Class FOV velocity angle height;
Model Average= FOV velocity angle height FOV*velocity FOV*angle FOV*height
velocity*angle velocity*height angle*height
FOV*Velocity*angle FOV*velocity*height FOV*angle*height
velocity*angle*height FOV*velocity*angle*height;
Lsmeans FOV*angle FOV*height/Pdiff Stderr;
Lsmeans FOV*angle*height;
Means Fov Angle Height Velocity/Tuky Duncan Scheffe;
Output out=Two Residual=Rsd Predicted=Pred;
Proc Print Data=Two;
Proc Means Data-Two Var;
 Var Rsd;
Proc Plot Data=Two;
Plot Rsd*Pred Rsd*Angle Rsd*velocity Rsd*Fov Rsd*height;
Quit;
```

Program B for analysis of subjective score

```
Options linesize=72;
Data one;
 Input FOV $ Velocity Height Angle @ ;
 Do Trial=1 to 3;
  Input Average @;
  Output;
 End;
Cards;
Narrow 4 1.1 20 7 7 7
Narrow 4 1.1 30 5 6 7
Narrow 4 1.1 40 8 6 6
Narrow 4 1.5 20 9 9 8
Narrow 4 1.5 30 8 7 7
Narrow 4 1.5 40 7 8 5
Narrow 6 1.1 20 7 9 7
Narrow 6 1.1 30 8 9 6
Narrow 6 1.1 40 6 6 3
Narrow 6 1.5 20 8 8 9
Narrow 6 1.5 30 8 7 9
Narrow 6 1.5 40 6 8 5
Narrow 8 1.1 20 7 6 7
Narrow 8 1.1 30 7 7 6
Narrow 8 1.1 40 5 2 5
Narrow 8 1.5 20 8 8 9
Narrow 8 1.5 30 7 8 8
Narrow 8 1.5 40 5 6 3
Wide 4 1.1 20 6 7 7
Wide 4 1.1 30 6 7 4
Wide 4 1.1 40 5 6 3
Wide 4 1.5 20 8 8 8
Wide 4 1.5 30 9 8 9
Wide 4 1.5 40 6 4 7
Wide 6 1.1 20 7 8 8
Wide 6 1.1 30 7 7 6
Wide 6 1.1 40 3 4 5
Wide 6 1.5 20 8 8 8
Wide 6 1.5 30 8 8 8
Wide 6 1.5 40 5 5 6
Wide 8 1.1 20 6 8 7
Wide 8 1.1 30 7 7 7
Wide 8 1.1 40 3 4 4
Wide 8 1.5 20 7 7 7
Wide 8 1.5 30 6 7 8
Wide 8 1.5 40 6 7 6
Proc GLM data=one;
Class FOV veiocity angle height;
Model Average= FOV velocity angle height FOV*velocity FOV*angle FOV*height
velocity*angle velocity*height angle*height
FOV*Velocity*angle FOV*velocity*height FOV*angle*height
velocity*angle*height
FOV*velocity*angle*height;
Lsmeans FOV*angle FOV*height/Pdiff Stderr;
Lsmeans FOV*angle*height;
Means Fov Angle Height Velocity/Tuky Duncan Scheffe;
Output out=Two Residual=Rsd Predicted=Pred;
Proc Print Data=Two;
Proc Means Data-Two Var;
 Var Rsd;
Proc Plot Data=Two;
Plot Rsd*Pred Rsd*Angle Rsd*velocity Rsd*Fov Rsd*height;
Quit;
```