EVALUATION OF THE EFFECT OF LABEL PLACEMENT ON DROP ORIENTATION IN THE SMALL PARCEL ENVIRONMENT

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ABSTRACT

EVALUATION OF THE EFFECT OF LABEL PLACEMENT ON DROP ORIENTATION IN THE SMALL PARCEL ENVIRONMENT

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This study investigated the effect of label placement on drop orientation of the overnight delivery system through UPS (United Parcel Services). The five data recorders manufactured by Dallas Instruments (SAVER) were used per shipment. The forty roundtrips were performed to measure drop heights and drop orientations for this study.

The average drop height of the forty roundtrips was 17.75 inches at the 95% occurrence; 52% of the drops occurred on edge, 29% on corner, and 19% on the base. The two different placements of "shipping label" didn't make a significant difference on drop orientation. "This Side Up" arrow markings caused some confusion to workers in loading and sorting in the normal mode of "shipping label"; however, those pictorial markings worked effectively in a non-conventional mode.

Dedicated to Jesus Christ and my parents

ACKNOWLEDGEMENTS

I really thank my major professor, Dr. Paul Sigh, for his sincere guidance and advice through this study. He helped me perform this research from the initial step to the completion at a higher academic level.

I'd like to put special thanks on Dr. Gary Burges who helped me find critical results in this study, and on Dr. Diane Twede for her worthy comments associated with comparisons between past studies and the present in the small parcel distribution environment. All these advice and comments were tremendous assets in my study.

This study was possible due to Eastman Kodak which provided the concern on effect of label placement on drop orientation of package for expensive X-ray films and Lansmont Corporate that rent us 5 environmental data recorders (SAVER).

I really express my deep gratitude to my father, mother, older brother and sister for their spiritual, financial help while having studied in the United States of America.

I believe that Jesus Christ makes it happen to graduate from Michigan State University with great honor from success of this study.

TABLE OF CONTENTS

PAGES

LIST OF TABLES

TABLE PAGES

LIST OF FIGURES

1.0 INTRODUCTION

Generally, all goods manufactured have to be packaged, shipped and delivered through complex distribution networks. The packages suffer various hazards from shock and vibration while moving through these distribution networks. The basic dynamic forces which packages encounter are vibrations, drops, tosses, and kicks. In detail, these kinds of dynamic forces happen during shipment, sorting, handling and storage. The economic loss that occurs from these damages is tremendous and severe. Understanding all distribution systems totally would help make the optimal package that can protect products from these environmental factors economically.

The modes that are generally used to transport goods from one place to another are truck, rail, air, and water. There are many delivery companies that ship packages through their own distinct networks. Overnight delivery services are very customer-oriented because overnight delivery services help businesses meet tight deadlines, conduct business rapidly, and stay in touch over long distances. One of companies to perform overnight delivery services is UPS (UPS, 1998).

In 1907, there was a great need in America for private messenger and delivery services. Few private homes had telephones, so that personal messages had to be carried by hand. Luggage and packages had to be delivered privately, too. The US Postal Service would not begin the parcel post system for another six years. To help meet this need, an enterprising 19-year-old, James E. ("Jim") Casey, borrowed $ 100 from a friend and established the American Messenger Company in Seattle, Washington. With a handful of other teenagers, including his brother George Casey, Jim ran his service from a humble office located under a sidewalk (UPS, 1998).

Growth, ingenuity, and change characterized the decades of the 1920s and 1930s. The company extended operations to Oakland, California, and later to Los Angeles. In 1929, the company opened United Air Express, offering package delivery via airplane to major West Coast cities, and as far inland as El Paso, Texas. Due to the 1929 stock market crash and a failing economy, the air service was discontinued after only eight months. In 1953, UPS resumed air service, offering two-day service to major cities on the east and west coasts. Called UPS Blue Label Air, the service grew, until by 1978 the service was available in every state including Alaska and Hawaii. The demand for air parcel delivery increased in the 1980s, and federal deregulation of the airline industry created new opportunities for UPS. But, deregulation caused change, and UPS abandoned routes altogether. To ensure dependability, UPS began to assemble its own jet cargo fleet. With growing demand for faster service, UPS entered the overnight air delivery business and by 1985, UPS Next Day Air service was available in all-48 states and Puerto Rico. Alaska and Hawaii were added later (UPS, 1998).

Along with shipments moved by ground, UPS handles an average 1.3 million air packages each day, including Next Day and 2nd Day Air packages and documents. To accommodate this volume, UPS uses a system of "air hubs" located around the world. At the main UPS air hub in Louisville, Kentucky, over 60 airplanes land and take off each night. Between 10 p.m. and 2:20 a.m., hundreds of thousands of packages must be unloaded from the aircraft, sorted, and then routed to the appropriate ground or air feeder.

By midnight, the process is well under way, and UPS aircraft begin taking off at the brisk rate of one every two minutes (UPS, 1998).

Would goods that were picked up, sorted, delivered during transit be safe arriving at destinations? How does a packaging engineer design the package that will protect a product in transit? It is necessary that a packaging engineer asked with the above questions turn to understand transportation environments that the products will experience.

Handling of shipping containers, either manually or by mechanical means or assistance, has always been considered to impose the severest loads on cargo. Such operations occur at terminal or transfer points and are a result of physically removing or loading a vehicle or moving it within a transfer or terminal facility. The main hazard from these operations is the impact resulting from dropping, throwing or just plain rough or accidental handling. Intuitively and from experience it is known that the severity of these impacts are affected by such factors as size, weight, and the shape of the shipping unit (Ostrem, 1980).

Currently, some end-user oriented data recorders are available to help measure the actual transportation environment (drop height, impacts in all three axles, vehicle motion, temperature and humidity). The environmental data recorder used for this study is the SAVER manufactured by Lansmont, Monterey, MI. The SAVERs were placed inside the boxes to measure the effect of mechanical and manual handling on boxes through the UPS distribution systems.

2.0 LITERATURE REVIEW

Distribution Environment

From the perspective of the packaging engineer, there are three crucial pieces of information necessary for a good package design. These are knowledge of the distribution environment, knowledge of basic product sensitivity to shock and vibration inputs, and knowledge of the dynamic behavior of available cushion systems (Schueneman, 1987).

Knowledge of the distribution environment is a key element in the overall process of efficient package design. This knowledge has traditionally come from two sources: literature research, and direct observation and measurement (Schueneman, 1987).

Transportation Environment Information Center at Sandia Laboratories, Springfield, VA, tried to collect, analyze, store, and make available descriptions of the environment of transportation expressed in engineering terms. They catalogued the data under two major headings: Normal and Abnormal Environments. Normal environments are those which will be encountered at some intensity during every shipment. They have a high frequency of occurrence, but a relatively low intensity. The abnormal or accident environments, on the other hand, are characterized by higher intensities but at a lower frequency of occurrence. The very high intensities of environment occur very infrequently. Twelve environment categories were reported according to this study (Davidson, 1979).

1. Acceleration/Time*
2. Acoustic Noise
3. Atmospheric Contents
4. Fragmentation *
5. Humidity
6. Precipitation
7. Pressure*
8. Radiation
9. Shock*
10. Temperature*
11. Vibration
12. Wind*

(*: Environments with both normal and abnormal aspects)

Many studies have been performed to evaluate the distribution environment and to develop test protocol for simulation testing which will help the package and product get over the hazards of the real distribution environment.

Ground Transportation

Ostrem (1980) assessed the common carrier shipping environment including the mechanical shipping hazards of shock and vibration associated with the handling and transportation of typical distribution cycles.

Caruso and Silver II (1976) studied the transportation of loose cargo in tractor-trailers to determine how products are damaged in shipment and how they can be better designed to resist this damage. The road test phase of these studies was performed with the following factors: suspension system types, degree of load, rear wheel position, road types, and different drivers. They concluded that certain suspension systems not only prevent shipment damage, but also reduce trailer fatigue and tires wear, and improve road handling. In addition, nearly all of the energy of the trailer bed vibrations concentrates on two fundamental frequency modes and the lower of the two frequency peaks will be influenced by loading on the trailers as long as the load stays in contact with the trailer bed. The energy notch that occurs between 8 and 9 Hz will probably exist for all similar trailers at all load conditions. The frequency regions above 20 Hz also occur for package and product resonance. The random vibration shipping test specification developed for loose cargo in tractor-trailers reflected the worst-case condition (the ride over the rear axle of a lightly- loaded trailer with conventional steel leaf springs, travelling at high speed over interstate highways).

Singh and Antle, et-al (1992) did another study on the shipment of tractor-trailers. The purpose of the study was to compare the levels of lateral and longitudinal vibration to vertical levels in the same truck trailer travelling over the average US highway. The results showed that below 20Hz, lateral and longitudinal vibration levels were generally much lower than vertical levels, but at frequencies above 20 Hz, all three were similar. The more heavily loaded trucks showed higher lateral and longitudinal levels of vibration than the lightly loaded ones.

Besides these studies, many researchers have published some studies related to shock and vibration levels in commercial truck shipments in many forms depending on the end use of the data.

Ship Transportation

Another mode of transportation, such as ship was studied by Laboratoire National d'Essais (LNE) to design a specific testing method to simulate the mechanical hazards encountered in sea transport regardless of sea routes and sea conditions and to put it into practice with specially designed devices. Eight sea routes of major commercial importance had been chosen and among them five zones in which heavy swells are likely to occur. The analysis of parameters that described the environment of the ship and affected the packaging are, respectively, rolling, pitching and slamming. The forces applied to packages at the bottom of a stack are a vertical compression force and a horizontal force applied by the moving stacked packages (Andre and Veaux, 1988).

Air Transportation

In recent years, air transport has become increasingly important to a growing number of manufacturers. The time-factor has become more important, and faster transport together with an efficient materials flow means that stocks are reduced along with storage costs. Further, this development can be traced to the fact that the amount of highly processed products has increased; e.g. sophisticated electronic products with a high value per weight have to reach their customers fast.

Trost (1988) conducted a field study on board a Boeing 747 Combi (freight and passenger) aircraft on the routes Stockholm (Arlanda) via Oslo (Gardermoen) to New York (John F. Kennedy Airport) and return to Stockholm (Arlanda). The study encompassed all phases of the flight, including taxiing, climb, cruise during both calm and turbulent conditions, descent and approach, landing including touchdown and taxiing to apron. The field data were analyzed by conventional frequency analysis and modeling techniques. Besides, he studied the mechanical stresses from the shocks and vibration to which air cargo is exposed during transport and handling at airports. It was found that when products are transported in the airport area, they are exposed to much higher stresses than during actual flight.

Overnight Delivery Distribution Environment

What is there about the nature of the overnight delivery distribution process that makes it distinctly different from common carrier shipment? The primary distinguishing feature of this environment is the large number of manual handling operations as compared to normal delivery or common carrier shipment. In addition to individual packages being dropped, they're also subjected to a higher than normal incidence of impact from other packages flying onto them. Another significant difference in this environment is the exposure to horizontal impacts which occur primarily in the sorting devices built into the facility and the high speed impacts from other packages. Finally, the potential for puncture type of damage appears to be higher in this environment due to random nature of packages as they travel from van to truck to aircraft, through the sorting facility, and back on the aircraft, truck, and van. In all cases, they're handled with other randomly sized packages and thus are rarely stacked in a uniform fashion. Because of the rectangular nature of most packages, it is easy for a flat surface to impact a corner of another package, resulting in puncture of one package or the other (Schuenman, 1987).

At the time when there had been little published about the nature of the overnight delivery distribution environment, the article on overnight delivery was presented in the 1987 Annual Safe Transit Conference by Schuenman (1987). The data recorder used was B&K Model 2503 Bump Recorder that was sent to various destinations randomly selected in the United States (20 roundtrips). He explained that the overnight delivery environment could be described by drop heights. The interesting thing in that study is that trips which registered the fewest number of inputs also showed the highest overall average drop height, and trips which registered a high number of inputs had a relatively low average drop height. The study concluded:

1. Overall the summary of 2,500 inputs showed the average drops height to be approximately 4 inches with 99% of all drops 23 inches or less.

2. The data for the sorting facility showed an average drop height of 3.9 inches, with 99% of all inputs below 15 inches.
3. Overall drop heights experienced in the overnight delivery distribution environment tend to be less severe on average than that typical for common carriers shipments. However, closer analysis of the data shows that because of the larger number of inputs, the overall average of the data tends to be skewed to lower drop heights.
4. At the 99.7% level, the data shows that overnight distribution drop height levels can be more severe than normal common carrier distribution.

In the 1991 Annual Safe Transit Conference, Schueneman (1991) presented the paper- "Package Testing for the Overnight Delivery Distribution Environment"- to help NSTA modify the test procedure. The recommended procedure differs from NSTA Project 1A in that a larger number of impacts are called for, the drop height versus weight ratio is different, a hazard drop is specified, and it allows for the use of random vibration testing in addition or in place of the fixed frequency repetitive bounce test described in Project 1A. An optional compression test is also specified. He considered more testings for other hazards which are known to exist in the overnight distribution environment that might not be properly represented by the proposed Project 3-test procedure. The testings mentioned in his paper were a puncture test, revolving drum test and SMITE test.

Voss (1991) studied the effect of weight and size on the drop height experienced by package handled in the UPS ground transportation environment. DHR (Drop Height Recorder) made by Dallas Instruments were used in different weight and size containers. The study showed the following conclusions:

1. The highest drop observed in the UPS environment for thirty-five roundtrips from Lansing, MI to Monterey, CA was 42.1 inches for the small size package.
2. The size of the package had no significant effect on the drop heights.
3. Lighter weight packages for the smaller size experienced higher drop heights. Weight did not have a significant effect on the medium and larger size package drop heights.
4. 95% of the drops occurred at 30 inches for the small/light package, 24 inches for the small/medium package, 18 inches for the medium/light package, 24 inches for the medium/heavy package, and 18 inches for the large/medium and large/heavy packages.

Cheema (1995) measured the dynamics of the overnight small parcel environment for Federal Express and UPS in the U.S. and developed a test protocol to test packages for the overnight air small parcel environment. Packages were also instrumented with DHRs (Drop Height Recorder). A total of 100 trips were monitored and 2,394 impacts events recorded. The data recorded showed the following results:

1. A package encountered an average of 24 shock events throughout a one way trip consisting of 31% drops, 43.6% kicks, and 25.4% tosses.
2. The highest free-fall drop height measured was 1.97 m (77.8 inches). The maximum kick level was 5.91 m/s (233in./s), and the highest equivalent drop height in a toss was 0.79 m (31.4 inches).
3. 95% of all drops were from less than 0.40m (16 inches), 95% of all kicks were from less than 0.26 m (10.5inches) and 95% of all tosses were from less than 0.26 m (10.5inches) equivalent drop height.

4. The packages received 51.1% of total impacts on edges, 42% on corners, and only 6.9% on the six flat faces.

Based on the above results, the test protocol and sequence were determined using the appropriate assurance levels.

Weigel (1996) measured the shock environment of overnight package delivery services (Federal Express and US Postal Service) for corrugated and plywood containers and studied if handling differences exist between corrugated and plywood containers labeled with and without 'Fragile Labels' for overnight delivery shipments. The recording module used was a Drop Height Recorder model DHR-1 made by Dallas Instruments. He concluded:

1. The average shipment received approximately 38 shock events including 12 drops, 16 impacts, and 10 tosses. The drop heights, of the drops and tosses, ranged from 0.1 inches (threshold level of the recording device) to 83.1 inches. Of these 95% occurred below 21.5 inches and 99.5% were below 48.3 inches. The velocity changes of the impacts measured 95% occurred at less than 149 in/sec and 99.5% at less than 307 in/sec.
2. Corrugated containers averaged almost twice as many shock events, 50 events, as plywood containers, 29 events. The shock events corrugated containers received were also more severe than those of plywood containers.
3. Labeling with a fragile label used did not appear to affect the handling received by the containers tested.

The label on the package is the essential information used to ship the package to the exact destination or to track it through UPS distribution systems in view of efficient package treatment and better customer service. The UPS workers pick up, sort, and deliver the package while checking the label on the package.

The objectives of this study were decided by the Consortium of Distribution Packaging at School of Packaging, MSU as follows.

1. Measure the shock environment of overnight package delivery services (UPS) for different size and weight of packages.
2. Evaluate the effect of label placement on drop orientation in the small parcel environment.

This study was initiated by the Consortium of Distribution Packaging on the recommendation from Eastman Kodak. The interest was to see if the position of a shipping label and use of pictorial markings made a difference on how packages are handled by UPS. This would be then used in modifying tests used to evaluate package that are sensitive in certain orientation such as expensive x-ray films.

3.0 EXPERIMENTAL DESIGN

3.1 PACKAGE TYPES AND TEST INSTRUMENTATION

In this study, three different package weights and two different sizes of boxes were used in combination. For convenience, the boxes used in the experiment were denoted as light/medium (A and B), medium/medium(C and D), and heavy/large (E) depending on weight/size. The detailed configuration is as follows.

Package A and B (light/medium): 18.25 x 12.25 x 10.5 inches (5 lbs)

Package C and D (medium/medium): 18.25 x 12.25 x 10.5 inches (25 lbs)

Package E (heavy/large): 22 x 20 x 20 inches (75lbs)

The data recorders used for this study were SAVERs manufactured by Dallas Instruments (Lansmont Coporate). The SAVER- Shock and Vibration Environment Recorder- is a tool for measuring the transportation/distribution environment, or for any other application which requires the remote and unattended recording of acceleration, drop height, temperature and humidity, and voltages produced by virtually any transducer/electronics system. Data is digitized and stored in memory for later uploading and analysis by a host computer. The SAVER can operate for up to twenty-eight days on an internal set of disposable batteries.

Test packages were composed of four components: a SAVER, a static shielding bag, Polyethylene cushions, and bricks. Cushion materials were used to protect the SAVER. A low drop of the unprotected SAVER onto a hard surface can result in accelerations of several thousand g's, potentially causing inaccuracy, malfunction, or damage. The static shielding bags were used to protect the SAVER from electrostatic discharge during handling (Lansmont, 1995).

The SAVERs were placed into position using Polyethylene cushions in various kinds of thickness on all sides. The units were placed in the geometric center of single wall corrugated boxes. The cushion materials were used to provide a very snug fit for the SAVER which was oriented in the same way for every shipment (Figure1, 2, and 3).

Additional weights were required to match the weight of a container/cushion/SAVER combination with the desired level for Package C and D, and Package E. In those cases, bricks were positioned on the bottom of containers in a symmetric fashion (Figure 2 and 3).

The package orientations were determined by ASTM D-5276 (Figure 4). The label was located at orientation 1 and 5 on the package (Figure 5). In addition, "This Side Up" (arrows pointing along shipping label) on all four sides of the package were used (Figure 5). The combination of label and "This Side up" on each trip was used in the following way.

East Lansing – Monterey, Trip #1: Label on face 1

East Lansing – Monterey, Trip #2: Label on face 1, Arrow Labels on 2, 4, 5 and 6

East Lansing – Monterey, Trip #3: Label on face 5

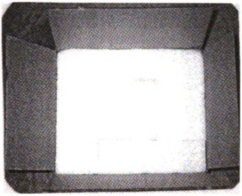
East Lansing – Monterey, Trip #4: Label on face 5, Arrow Labels on 1, 2, 3 and 4

East Lansing – Rochester, Trip #1: Label on face 1

East Lansing – Rochester, Trip #2: Label on face 1, Arrow Labels on 2, 4, 5 and 6

East Lansing – Rochester, Trip #3: Label on face 5

East Lansing – Rochester, Trip #4: Label on face 5, Arrow Labels on 1, 2, 3 and 4



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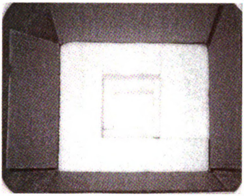

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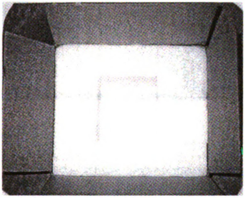

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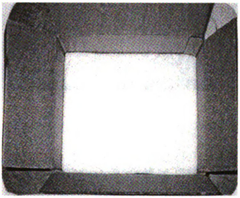
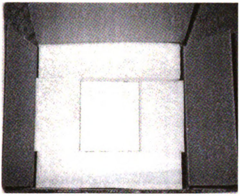


4

Figure 1. Configuration of Package A and B



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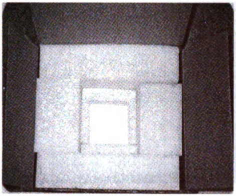

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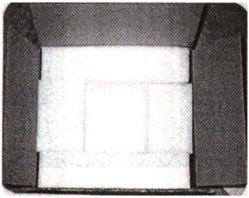

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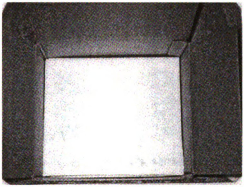

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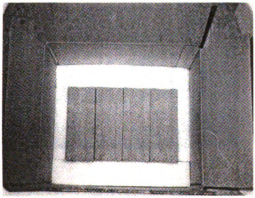

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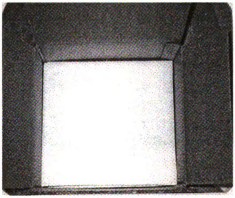

6

Figure 2. Configuration of Package C and D

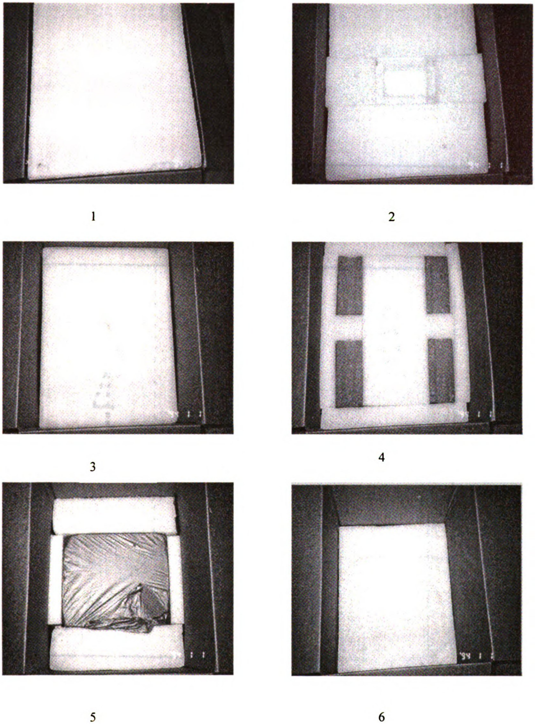

Figure 3. Configuration of Package E

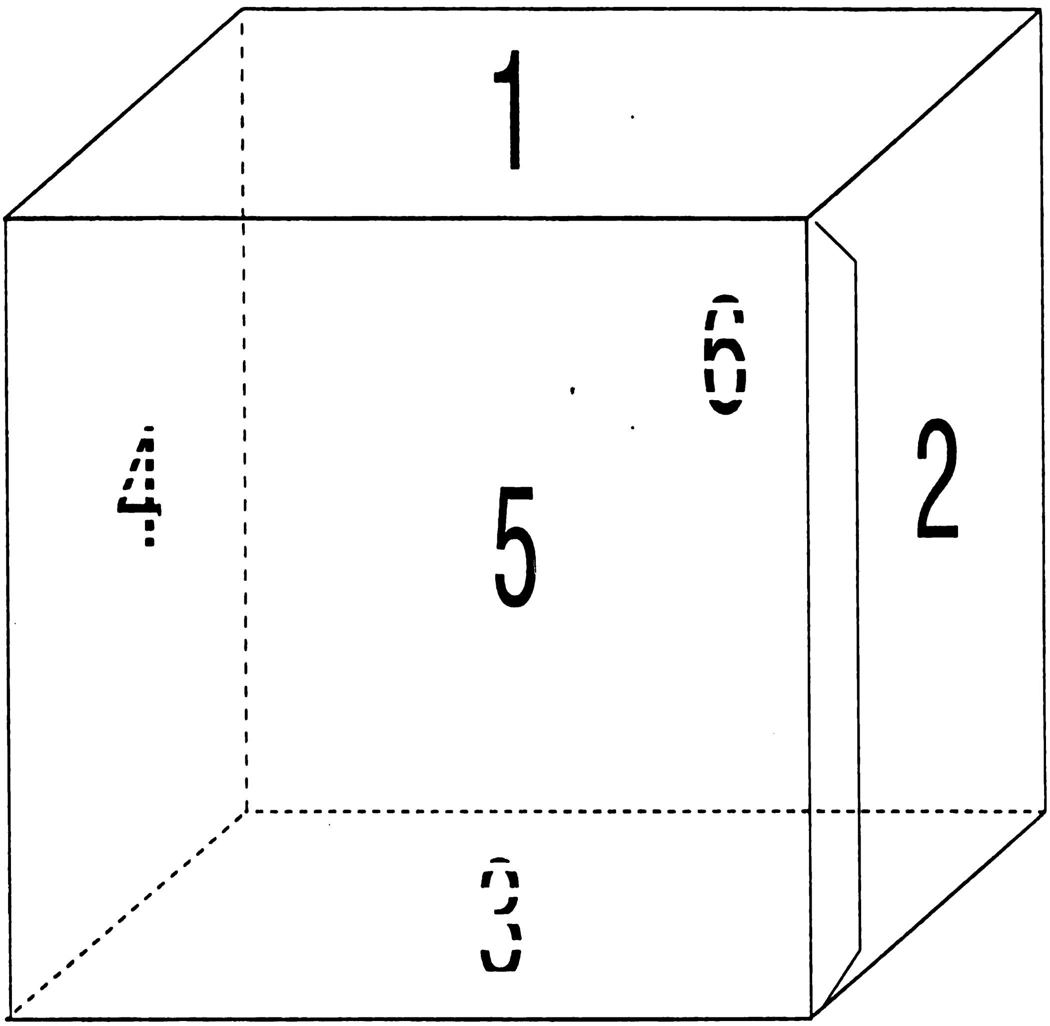

Figure 4. Package Orientations

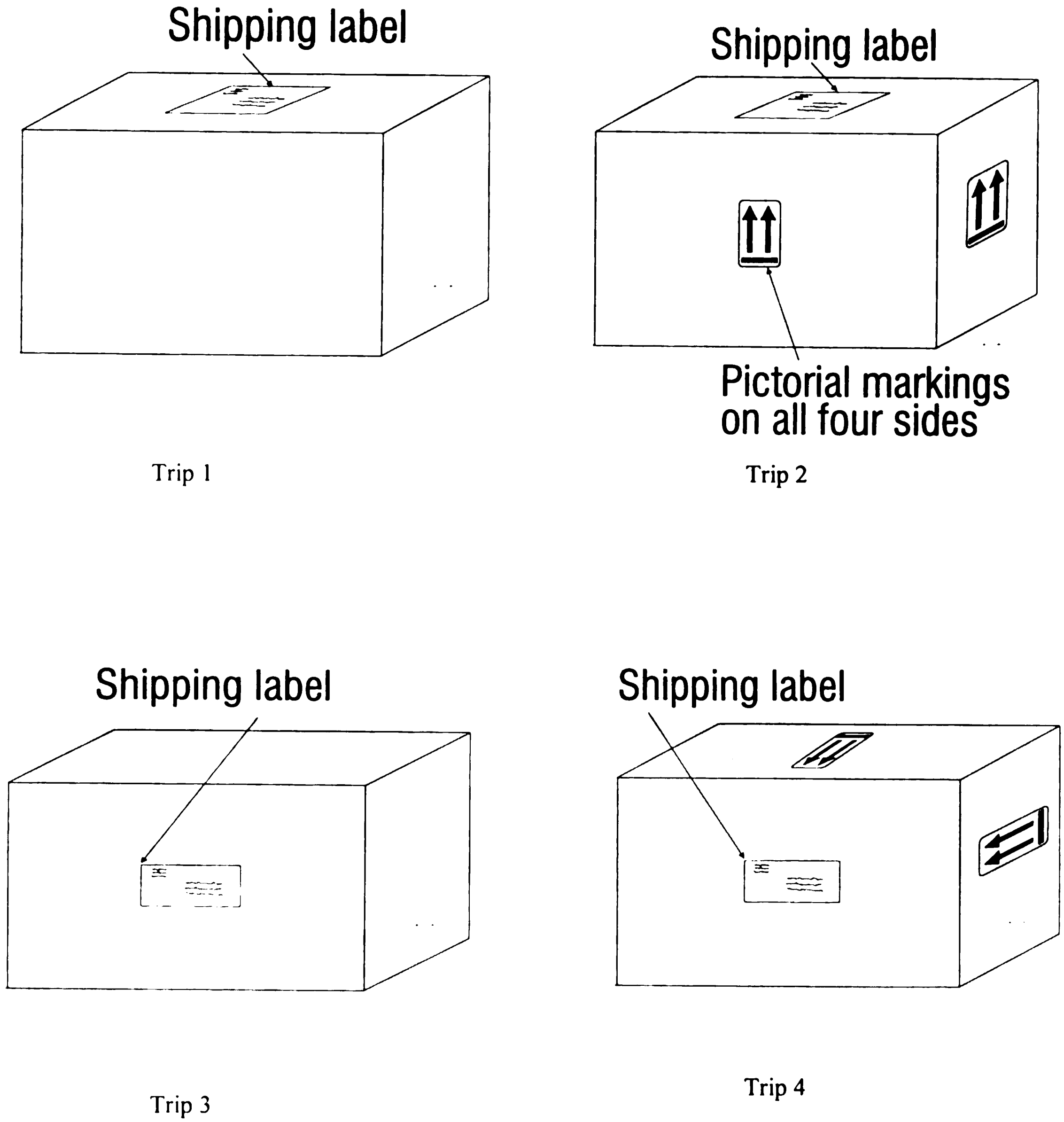

Figure 5. Label Placement on Packages for each trip

3.2 SAVER OPERATION

In one compact unit, SAVER incorporates a triaxial accelerometer, four programmable-gain charge amplifiers, four programmable low-pass filters, two multiplexers, an analog-to-digital converter, a temperature/humidity probe, general-purpose voltage channels, external batteries for longer recording times, and various mounting accessories (Lansmont, 1995).

Instrument setup, communication, and data analysis are accomplished from a host computer, running a Windows™-based program called "SaverWare". This software is used to set up the instrument, retrieve the data, and produce analyzed results. Saver-Ware introduces the concept of software Gateways – application-specific dialogs that automate instrument set-up, and which are linked to appropriate analysis. Gateways permit a casual or infrequent user to successfully take measurements, perform data reduction, and make decisions or design tests based on the results. For advanced users, detailed software controls provide complete freedom and capability to configure the instrument as desired (Lansmont, 1995).

In order to fully understand the operation and application of SAVER, it is helpful to know the basics of system architecture and functions, both hardware and firmware/software (Lansmont, 1995).

Hardware

SAVER contains a signal analog-to-digital (A/D) converter, and its input is connected to two 8-channel multiplexers (MUX's). One multiplexer is assigned to the 8 "dynamic" waveform (rapidly changing signals) channels, and the other is assigned to the 8 "static (slowly-changing signals) channels. Dynamic (waveform) channels 1-4 have built-in charge amplifiers, gain stages, and filters, which allow piezoelectric (charge-type) accelerometers to be connected directly. The standard SAVER incorporates an internal triaxial accelerometer which is connected internally to channels 1 – 3. That leaves channel 4 available for an external accelerometer. The unit may be ordered without the internal accelerometer, in which case all 4 channels (1-4) are available for the direct connection of external piezoelectric accelerometers. Optional dynamic channels 5-8 are straight connections to the multiplexer, and from the output of the multiplexer to the A/D converter. A choice, which must be made at time of order, is that they can either be configured for the direct (D.C.) 0-5 volt input of the A/D, or a de-coupling capacitor and resistor can be installed to change the input to ±2.5 volts A.C. These channels may be configured to measure acceleration or nearly any other parameter, since the transducers and signal conditioning are all external to the SAVER.

Optional accelerometer/cable setups are available for channels 1-4, and optional accelerometer/coupler/cable setups are available for channels 5-8. The latter have battery-powered couples with a 6-day battery life. Other configurations are possible.

Two of the static channels are assigned to the internal temperature/humidity sensor, and two more are assigned to the optional external temperature/humidity sensor. There are a pair of static channels needed for internal circuit voltage measurements, optionally available for any type of measurement; they are the same multiplexer-to-A/D connection as described above. As such, they can be either 0 –5 volts D.C coupled, or +2.5 volts A.C coupled (chosen at time of order).

The microcontroller unit (MCU) is the heart of the SAVER. It controls the basic configuration of the instrument, the A/D and Mux's, the communications port, the real-time clock (for the time- and date-stamping of data, and other timekeeping functions), the internal and external triggering operations, the indicator LED, and the static RAM memory array.

SAVER is powered from four C-size alkaline cells. These are connected in a series-parallel arrangement such that the nominal output voltage from the battery pack is 3 volt D.C. SAVER's LED flashes on initial system power-up to indicate main battery condition. There is also a separate memory back-up battery. The backup battery retains data in memory for typically one year after the main batteries are removed or exhausted.

Firmware/Software

Dynamic (Waveform) and Static Channels

SAVER is a "sampled" data system. That is, it takes periodic readings from its input signals, digitizes the data, and stores it in electronic memory. Readings may be taken as fast as thousands of time per second, or as slowly as only once every 12 hours. Data is taken whenever pre-programmed "trigger" conditions are met – trigger condition may be based on signal levels, combinations of signals, elapsed time intervals, or external events.

SAVER defines two basic types of data, which it treats differently. "Dynamic" data is that which changes rapidly with time; an example would be accelerations due to shock and vibration. In order to characterize dynamic data, many samples must be taken at a rapid rate – so that a waveform, or time signature, of the data may be determined. "Static" data, on the other hand, is ascertained by only one sample per channel (examples would be temperature and humidity, where single readings are sufficient to determine the present values).

When the pre-programmed trigger conditions are met, SAVER typically takes a large number of high-speed samples of the active waveform channels, but only samples each of the active static channels.

Memory Partitioning

SAVER divides its memory into two partitions, and data is stored according to the trigger conditions which caused them to be taken. There is a "Time Triggered" partition and a "Signal Triggered" partition.

The amount of Time Triggered data is easily determined from the total trip length, the programmed time interval, and the number of active channels. Signal Triggered data, however, is not easily controlled. If a threshold is set too low, for example, a large amount of Signal Triggered data may be created very quickly. Without memory partitioning, this data would overrun the Time Triggered data, and the entire measurement project might be degraded or ruined. Memory partitioning eliminated this potential problem; each type of data is confined to its own partition, and cannot corrupt the other partition.

Nearly all of the SAVER's setup parameters – active channels, sampling rate, number of samples, memory mode, etc. may be set differently in the two different memory partitions. This provides enormous flexibility for setting up special measurements and meeting special requirements. The amount of total memory assigned to each partition may be determined by the user.

Memory Modes

The objective of a measurement program is generally to obtain data from the entire trip. Because the amount of data cannot be precisely controlled, however, some allowance must be made for exceeding the capacity of available instrumented memory. SAVER has three different, selectable ways of treating data when the memory partition becomes full. The first, called "Stop when Full", simply ignores any additional data taken. "Wrap & Overwrite when Full" replaces the oldest event with the most recently – taken event. "Max Overwrite Min when Full" replaces an event already in memory with just-taken data, provided the just-taken event is larger. Individual channels may be included or excluded from the "Max" mode calculations, and memory modes may be set differently in the two partitions.

Triggering

SAVER takes data whenever "trigger" conditions are met. Often, this is as simple as when a certain threshold level is exceeded or a certain time interval has elapsed. But, SAVER has the capability of triggering from more complex conditions: individual channels may be included or excluded from the triggering equation; asymmetrical thresholds (different for + and – signals) may be set for each channel; triggering may be set to occur if the data is outside the thresholds or between the thresholds; and single channels or groups of channels may be combined with boolean operations (AND, OR, NOT) for triggering purposes.

Ranges and Filters

Dynamic channels 1- 4 are designed for the measurement of acceleration and as such have charge amplifiers with programmable ranges and filters. Acceleration levels may be selected from 5g full-scale to 200g full-scale, and may be different for different channels. Low-pass filters may be set from 20Hz to 2800Hz, and may be different for different channels. This programmability of ranges and filters means that SAVER can be set to measure a wide variety of signals – shock, vibration, and other dynamic events – without any changes of hardware or basic configuration.

"Gateways"

SaveWare introduces the concept of software "Gateways" – application-specific dialogs which automate instrument setup, and which are linked to appropriate analyses. By entering one of the Gateways (shock, vibration, drop height, etc.), a user can configure the instrument by simply answering three or four questions. Once data is taken and uploaded to a host computer, the Gateway directs a number of automatic analyses specifically tailored to the data type.

A "User Defined" Gateway allows complete access to all of SAVER's setup capabilities, for special measurement situations and advanced or extended applications.

3.3 ZERO-G DROP HEIGHT CALCULATION

SaverWare uses a proprietary algorithm to determine Drop Height and Drop Type. It analyzes the zero-G time to make these determinations. For the zero-G drop height calculation, the free fall time is measured by sensing the change in the recorder from a motionless state (zero-G), into a free fall (1G), and a shock state (several G). Since the time from the onset of the zero-G state of the recorder to the moment of impact is known, the free fall drop height is calculated by following relationship:

$$h_z = \frac{1}{2}gt^2 \text{.....................} (3-1)$$

Where, g = Acceleration due to Gravity = 386.4 in./sec^2

h_z = Free fall drop height in inches

t = Free fall time in seconds

3.4 INTERPRETATION OF DROP HEIGHT ZERO-G DATA

The computer calculation of drop height is not infallible, however, and sometimes the user may wish to override the automatic analysis. To do so requires a general understanding of what the Event Analysis data means and the principles involved.

The Event Analysis data for a Free-fall drop appears as a relatively flat, straight line before the release. When the package (with SAVER inside) begins to fall, the data rises by at least several tenths of a g. The steepness of this rise depends upon the quickness of the release. The data remains essentially at this new level (sloping downward slightly) until impact. The drop time is taken from release to impact, and drop height is calculated from this time.

The Event Analysis data from an Impact – Not a Drop appears as a relatively flat, straight line all the way until impact. There was no release and no drop (the package was stationary and something hit it), so the pre-impact data remains flat.

Event Analysis data for tosses is the most difficult to assess. Tosses may involve both horizontal and vertical motion, tumbling of the package, etc. The data appears as an initial rise during the toss, peaking at the moment the package is released. The package continues to travel upward for some period of time to its maximum height, during which the data resembles that due to a free-fall drop. The time period of the toss and the continued upward motion is subtracted from the apparent fall time to get the actual free-fall time. Drop height is then calculated from this time.

3.5 CHANNEL AND AXIS IDENTIFICATION

The standard SAVER incorporates an internal triaxial accelerometer connected to dynamic (waveform) channels 1, 2, and 3. These channels are also identified as X, Y and Z respectively, with their orientations indicated on the case of the unit (Figure 6).

For shock and drop height analysis, the direction of impact is referenced to "front", "back", etc. of the SAVER. This is based on identifying "front" as the surface with the Host Communication connector, and "top" as the cover with the SAVER logo.

3.6 DATA COLLECTION

The five instrumented packages were shipped between School of packaging, E. Lansing, MI and Eastman Kodak, Rochester, NY, and Lansmont Test Lab., Monterey, CA (Figure 7). The forty roundtrips with different combinations of shipping label and "This Side Up" were done by an UPS overnight delivery system to achieve the objectives of this study discussed before.

The packages with the intended combination of shipping label and "This Side Up" were picked up by an UPS courier from School of Packaging, Michigan State University in East Lansing, MI and loaded in a small delivery vehicle referred to as a "Package Car". The packages were taken to respective operating centers of UPS in the Lansing area where they were consolidated with all the other packages also meant for next day delivery. The consignment of packages was put into air transport containers which were then transported by truck to the regional air facility. The air transport containers were then loaded into the cargo aircraft which serves as the "Feeder". The aircraft then flew to the national Air-Hub with packages and documents headed for various US locations. These air hubs serve as the central sorting facilities for packages from all over the US.

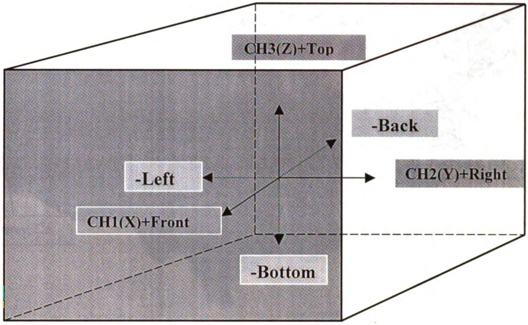

Figure 6. SAVER Tri-axial Orientation

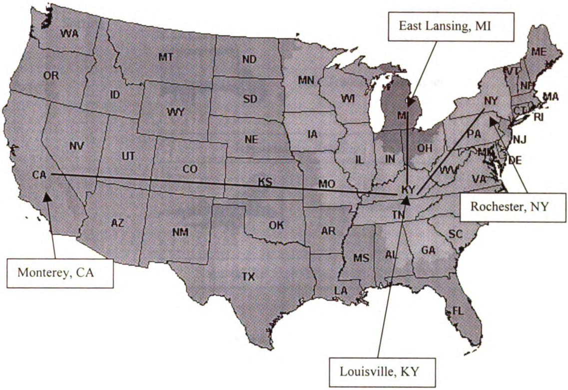

Figure 7. Trip Destinations

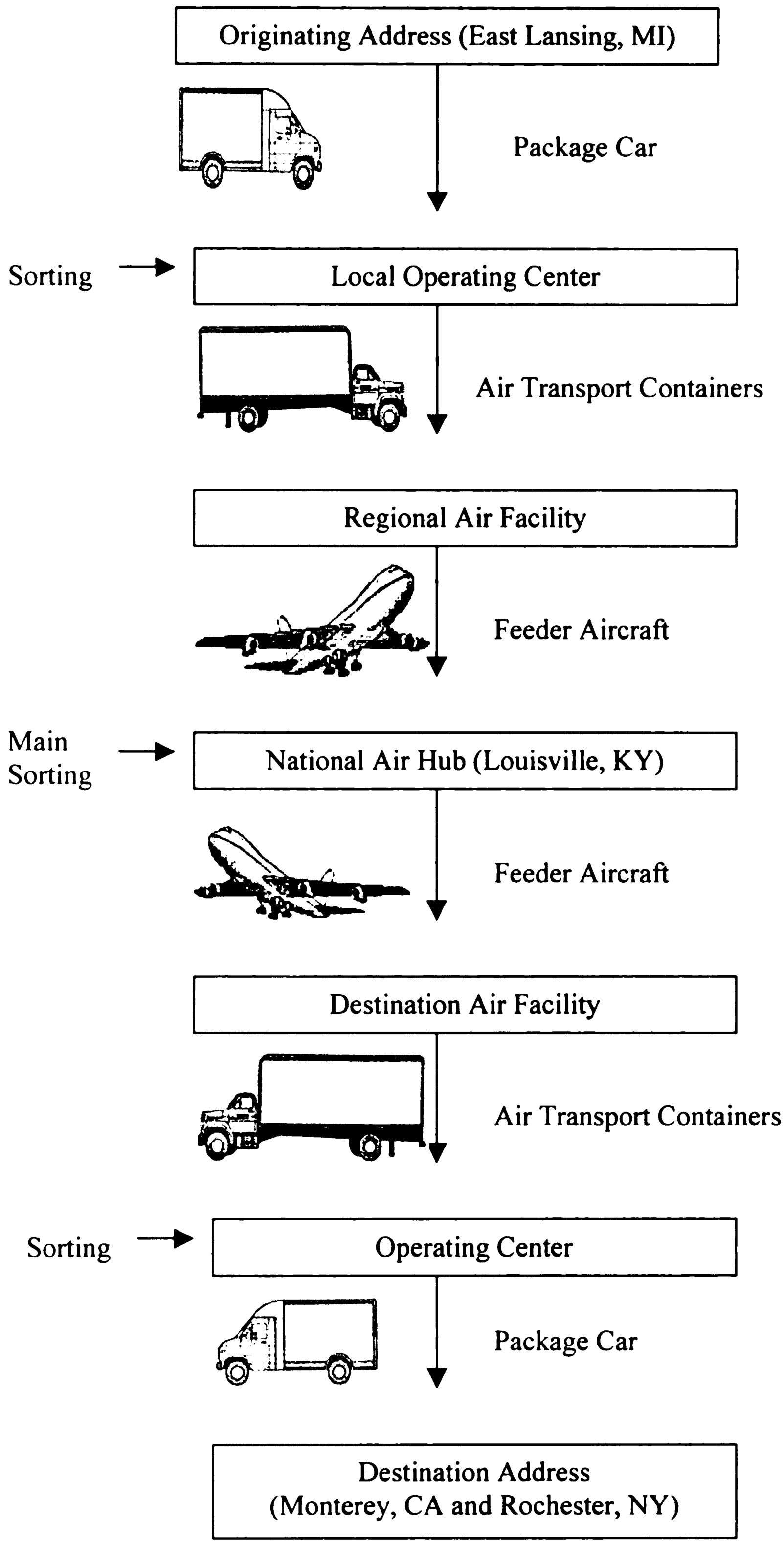

Figure 8. Flow Path of UPS Package Delivery System

The UPS air-hub is located in Louisville, KY, where the arriving aircraft are unloaded. The air containers are unloaded and transferred on rollers to the central sort area. Here, the employees remove the packages from the containers, scan them, and send them on belts to a central sort area, where sophisticated scanners track and check the package destination and size. Packages speed through the hub on a several mile long network of belts and chutes. Diverters, activated by information in the bar code labels activate to kick packages down chutes and onto proper sort belts. The packages are then collected by their destination and any special handling that may be required.

After sorting, the packages are consolidated together with all the other packages bound for the same destination or service area. These are then loaded into containers and onto another "Feeder" aircraft to be delivered to the destination-operating center. The packages, after sorting at the local operating facility, are loaded into "Package Cars" to be delivered to the final destination.

The test packages were then return-shipped to Lansing, the next day, going through the same process. The entire round-trip duration was approximately four days. The data from each SAVER for each round-trip shipment was downloaded into a personal computer for analysis.

4. DATA AND RESULTS

The types of impacts which small parcel packages experience through UPS can be classified as free-fall drops, tosses, and kicks (Voss, 1991). As described in the section of objective, this study was intended to examine dynamic environments of UPS distribution systems in terms of the effect of label placement on drop orientation to package. One type of dynamic impacts, "Kicks" was excluded in this evaluation. The reason is that during kicks the packages are travelling on conveyors with shipping labels facing up for scanners, and all "kicks" are on side faces. Further, only drop heights that are higher than 1 inch were taken into consideration to avoid the effect of bouncing impacts from vibrations on trucks, aircraft, or conveyer belts. In this chapter, drop heights of each different size/weight category are shown. Drop orientations were determined by flat, edge, and corner drops as well as face numbers of a package (1, 2, 3, 4, 5, and 6) shown in Figure 4.

From Table 1, the summary of drop heights in the twenty roundtrips from Lansing, MI to Monterey CA is shown in categories of size and weight of package. Each trip has a different label placement as described in Chapter 3. The drop height at the 95% level of drops is generally used to simulated laboratory testing in industry (Cheema, 1995). Therefore, the drop heights were compared at 95% level. The mean drop heights at the 95% level are 17.8 inches. In the middle size-category, the drop height of middle/medium packages, 16.6 inches, were slightly higher than the middle/light packages, 14.6 inches. The Large/heavy packages were dropped at 22.1 inches while

Table 1. Summary of drop heights by UPS (Roundtrip)
(Lansing, MI ---- Monterey, CA)

Size Category	Weight Category	Box	Trip No.	No.of Drops	Drop Height Percentiles				
					H50	**H75**	**H90**	**H95**	**H100**
Middle	Light	A	1	45	3.03	5.76	10.34	18.5	29.61
			2	32	3.37	5.92	10.89	14.37	18.75
			3	30	2.34	3.83	12.12	14.20	17.27
			4	36	2.3	3.84	8.04	9.35	12.91
		B	1	37	1.98	3.49	10.71	11.41	19.35
			2	44	2.95	5.82	9.23	14.77	26.24
			3	31	3.54	9.30	17.50	22.02	45.73
			4	35	3.66	5.14	9.00	12.02	16.08
Sub-Sum				290	23.17	43.10	87.83	116.6	185.9
Sub-Means				36.25	**2.90**	**5.39**	**10.98**	**14.58**	**23.24**
Middle	Medium	C	1	30	2.38	5.66	7.61	13.57	18.75
			2	21	3.56	5.65	10.4	11.93	32.08
			3	20	3.42	7.54	10.4	13.82	19.35
			4	28	3.22	6.76	11.2	24.82	40.00
		D	1	28	3.76	7.31	12.79	16.61	25.81
			2	26	3.17	6.47	14.42	19.15	22.23
			3	25	3.24	11.1	18.78	19.39	23.06
			4	38	4.32	7.24	12.12	13.47	18.99
Sub-Sum				216	27.07	57.73	97.72	132.8	200.3
Sub-Means				27	**3.38**	**7.2**	**12.22**	**16.60**	**25.03**
Large	Heavy	E	1	13	7.18	16.15	27.68	37.29	49.08
			2	9	3.36	5.26	18.05	23.42	28.79
			3	15	7.78	10.57	13.44	16.14	21.55
			4	22	3.63	7.01	7.98	11.41	13.41
Sub-Sum				59	21.95	38.99	67.15	88.26	112.8
Sub-Means				14.75	**5.49**	**9.75**	**16.79**	**22.06**	**28.20**
Total Sum				565	24.06	46.60	84.23	112.3	166.3
Total Means				26	**3.92**	**7.45**	**13.33**	**17.75**	**25.49**

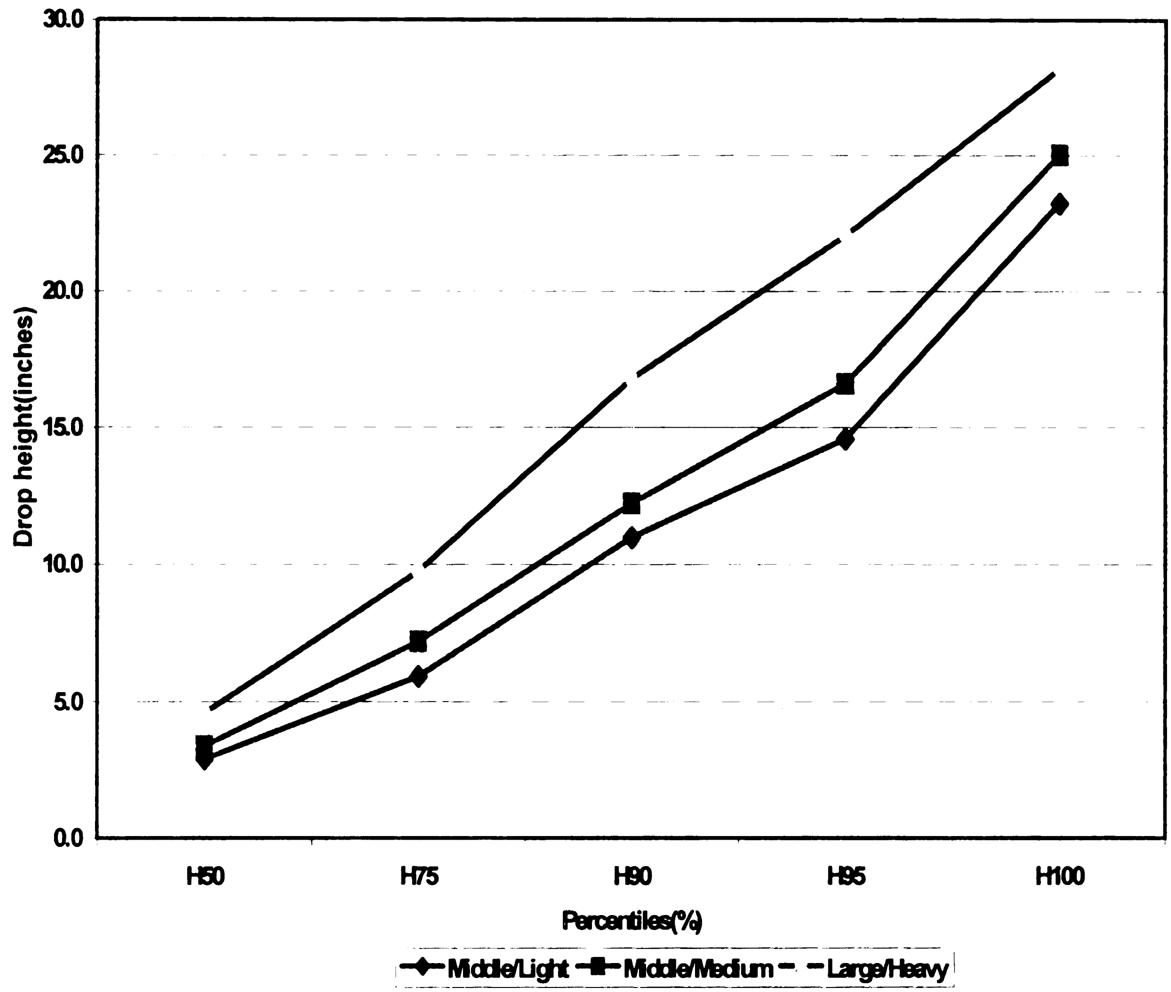

Figure 9. Drop Height vs. Percentiles
(Lansing, MI ---- Monterey, CA)

Table 2. Summary of drop heights by UPS (Roundtrip)
(Lansing, MI ---- Rochester, NY)

Size Category	Weight Category	Box	Trip No.	No. of Drops	Drop Height Percentiles				
					H50	**H75**	**H90**	**H95**	**H100**
Middle	Light	A	1	45	2.40	4.28	10.74	14.53	34.73
			2	39	2.19	3.56	7.16	14.29	19.48
			3	68	2.64	4.43	10.00	13.43	28.56
			4	53	3.08	5.26	14.42	16.37	24.28
		B	1	37	2.28	4.15	5.39	5.45	8.08
			2	46	2.78	5.12	6.82	14.51	19.78
			3	40	2.62	5.36	8.20	9.87	37.92
			4	56	2.53	4.38	7.67	8.97	24.01
Sub-Sum				384	20.52	36.54	70.4	97.42	196.84
Sub-Means				48	**2.56**	**4.57**	**8.08**	**12.18**	**24.60**
Middle	Medium	C	1	51	2.98	4.67	10.35	17.82	41.95
			2	48	2.74	4.95	9.82	17.58	39.38
			3	41	2.99	4.52	16.87	24.83	39.56
			4	56	3.29	5.16	10.02	11.64	38.00
		D	1	59	2.62	4.92	9.82	15.53	23.06
			2	59	3.10	5.04	9.91	18.21	65.33
			3	46	2.92	5.44	12.00	15.43	26.88
			4	45	2.34	4.41	16.48	25.16	29.16
Sub-Sum				405	22.98	39.11	97.27	146.2	303.32
Sub-Means				50.62	**2.87**	**4.89**	**11.91**	**18.28**	**37.92**
Large	Heavy	E	1	26	4.38	10.58	18.82	23.99	37.83
			2	30	3.24	5.36	8.16	15.36	25.11
			3	32	4.01	9.87	17.33	21.64	23.46
			4	31	4.60	8.90	21.10	25.51	29.61
Sub-Sum				119	16.23	34.71	65.50	86.50	116.01
Sub-Means				29.75	**4.06**	**8.68**	**16.38**	**21.62**	**29.00**
Total Sum				302.66	19.11	36.79	77.72	110.0	205.39
Total Means				42.79	**3.16**	**6.05**	**12.12**	**17.36**	**30.51**

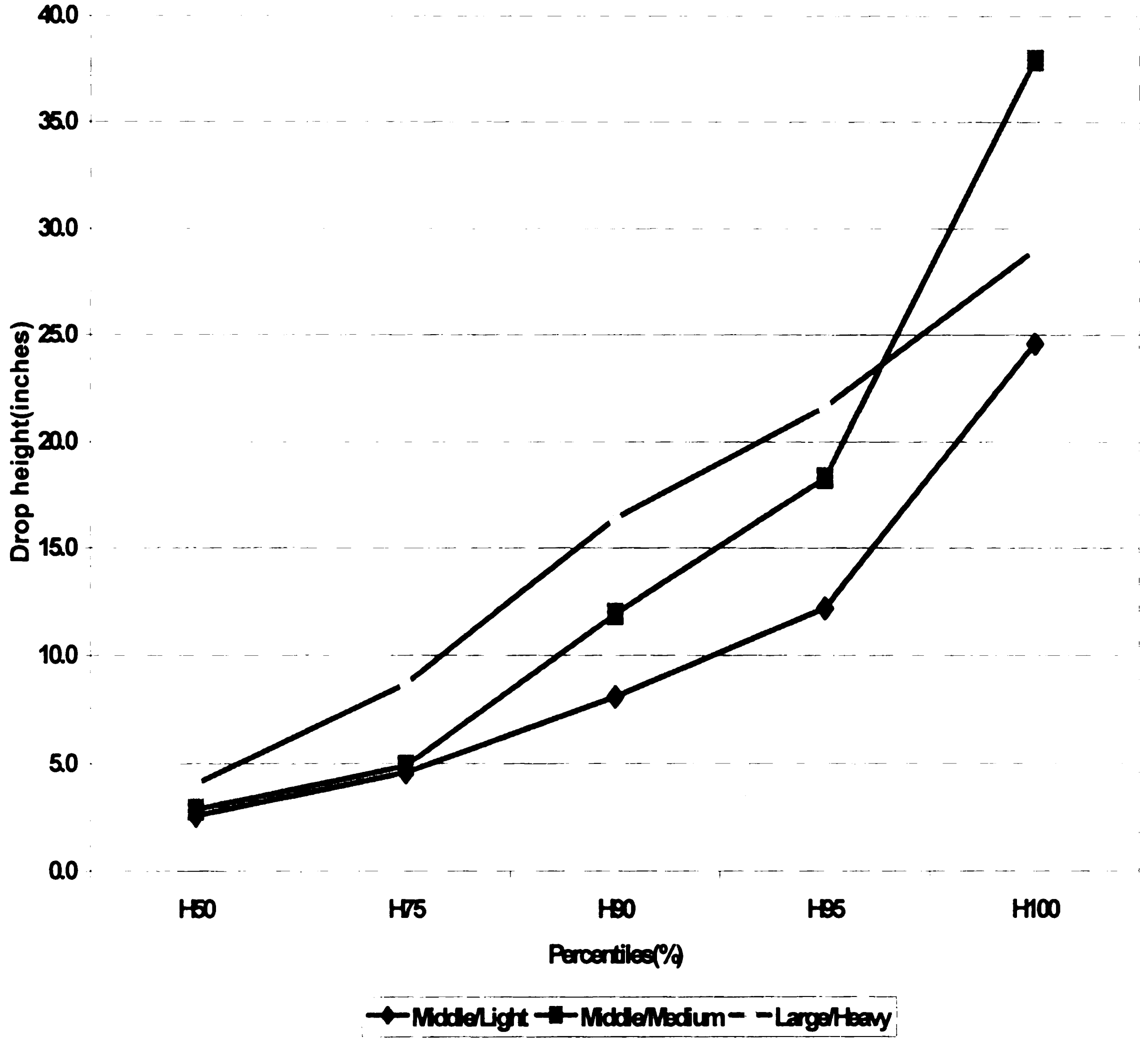

Figure 10. Drop Heights vs. Percentiles (Lansing, MI ---- Rochester, NY)

Table 3. Summary of drop heights by UPS (Roundtrip)
(Both trips)

Size Category	Weight Category	Box	Trip No.	No. of Drops	Drop Height Percentiles				
					H50	**H75**	**H90**	**H95**	**H100**
Middle	Light	A	1	45	2.72	5.02	10.54	16.52	32.17
			2	35.5	2.78	4.74	9.02	14.33	19.12
			3	49	2.49	4.13	11.06	13.82	22.92
			4	44.5	2.69	4.55	11.23	12.94	18.60
		B	1	37	2.13	3.82	8.05	8.43	13.72
			2	45	2.86	5.47	8.02	14.64	23.01
			3	35.5	3.08	7.33	12.85	15.94	41.82
			4	45.5	3.10	4.76	8.34	10.50	20.04
Sub-Sum				337	21.84	39.82	79.12	107.03	191.4
Sub-Means				42.12	**2.73**	**4.98**	**9.89**	**13.38**	**23.92**
Middle	Medium	C	1	40.5	2.68	5.16	8.72	15.70	30.35
			2	34.5	3.15	5.3	10.11	14.76	35.73
			3	30.5	3.20	6.03	13.64	19.32	29.46
			4	42	3.26	5.96	10.61	18.23	39.00
		D	1	43.5	3.19	6.12	11.30	16.07	24.44
			2	42.5	3.14	5.76	12.16	18.68	43.78
			3	35.5	3.08	8.27	15.39	19.41	24.97
			4	41.5	3.33	5.80	14.30	19.32	24.08
Sub-Sum				310.5	25.02	48.42	96.50	139.48	251.8
Sub-Means				38.81	**3.88**	**6.04**	**12.06**	**17.44**	**31.48**
Large	Heavy	E	1	19.5	5.78	13.36	23.25	30.64	43.46
			2	19.5	3.30	5.31	13.10	19.39	26.95
			3	23.5	5.90	10.22	15.38	18.89	22.50
			4	26.5	4.12	7.96	14.54	18.46	21.51
Sub-Sum				75.5	19.09	36.85	66.32	87.38	114.4
Sub-Means				18.88	**4.78**	**9.22**	**16.58**	**21.84**	**28.60**
Total Sum				241	21.98	41.70	80.65	127.14	185.9
Total Means				33.27	**3.80**	**6.75**	**12.84**	**17.55**	**28.00**

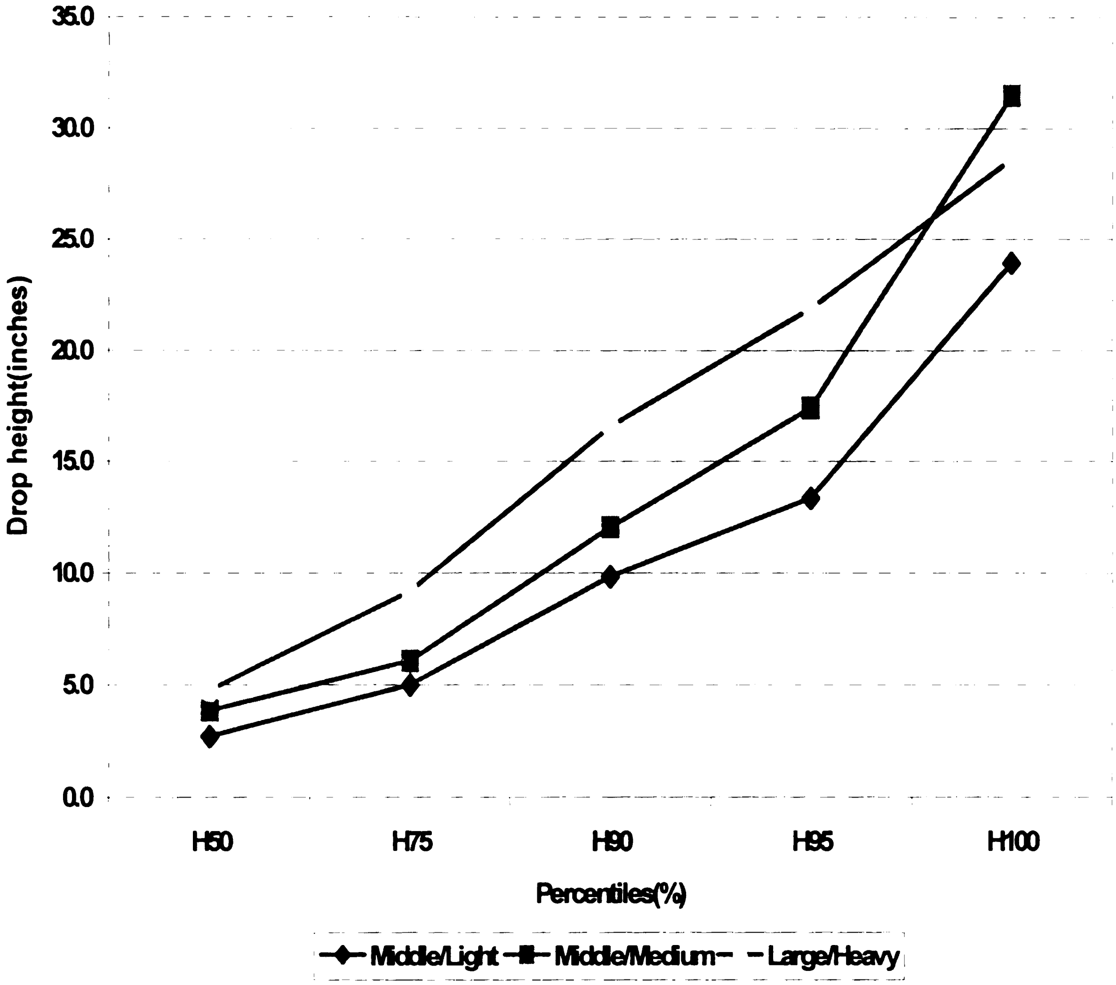

Figure 11. Drop Height vs. Percentiles
(Both trips)

middle/light and middle/medium packages being at 14.6 inches and 16.6 inches, respectively.

Generally in most package drop and impact tests such as ASTM D 4169 and ISTA Project 1A, the drop and impact levels go down as package weight goes up. However, the data from this study shows the contrary.

The reason for this is that as packages become large and heavy they are often lifted to waist height and often dropped from this level, as compared to smaller and lighter packages that are placed on top of other packages.

The mean number of drops per shipment for all categories was 26. The middle/light packages hit the ground 36 times in average per shipment, the middle/medium packages, 27 times, and the large/heavy, 15 times. Figure 9 displays drop height distributions in different size and weight categories at the 50%, 75%, 90%, 95%, and 100% levels.

Table 2 contains the summary of drop heights for the twenty roundtrips from Lansing, MI to Rochester, NY. The mean drop height of the twenty roundtrips was 17.4 inches at the 95% level. The mean drop heights of middle/light, middle/medium, and large/heavy were at the 95% level 12.2 inches, 18.3inches, and 21.6 inches, respectively. The mean number of drops per shipment was 43. The middle/light packages hit the ground 48 times in average per shipment, the middle/medium packages, 51 times, and the large/heavy, 30 times. Figure 10 visualizes mean drop height distributions as Figure 9 does.

Drop heights of all roundtrips were put together in Table 3. The mean drop height of all forty roundtrips at the 95% level was 17.6 inches. The mean drop heights of

Table 4. Drop Orientation Distributions
(Lansing, MI ---- Monterey, CA)

Trip No.	Size Category	Weight Category	Box	Orientation			Totals
				Base	Edge	Corner	
1	Middle	Light	A	13	24	8	45
			B	8	22	7	37
	Middle	Medium	C	4	16	10	30
			D	3	17	8	28
	Large	Heavy	E	1	7	5	13
Sub-Totals				29	86	38	153
% Sub-Totals				**19**	**56**	**25**	100
2	Middle	Light	A	6	19	7	32
			B	14	22	8	44
	Middle	Medium	C	6	6	10	22
			D	5	5	16	26
	Large	Heavy	E	1	1	5	7
Sub-Totals				32	53	46	131
% Sub-Totals				**24**	**41**	**35**	100
3	Middle	Light	A	9	18	3	30
			B	9	14	8	31
	Middle	Medium	C	1	12	7	20
			D	5	13	7	25
	Large	Heavy	E	3	10	2	15
Sub-Totals				27	67	27	121
% Sub-Totals				**22**	**56**	**22**	100
4	Middle	Light	A	14	14	8	36
			B	13	13	9	35
	Middle	Medium	C	8	13	7	28
			D	11	18	9	38
	Large	Heavy	E	8	11	3	22
Sub-Totals				54	69	36	159
% Sub-Totals				**34**	**43**	**23**	100
Totals				142	275	147	564
% Total				**25**	**49**	**26**	100

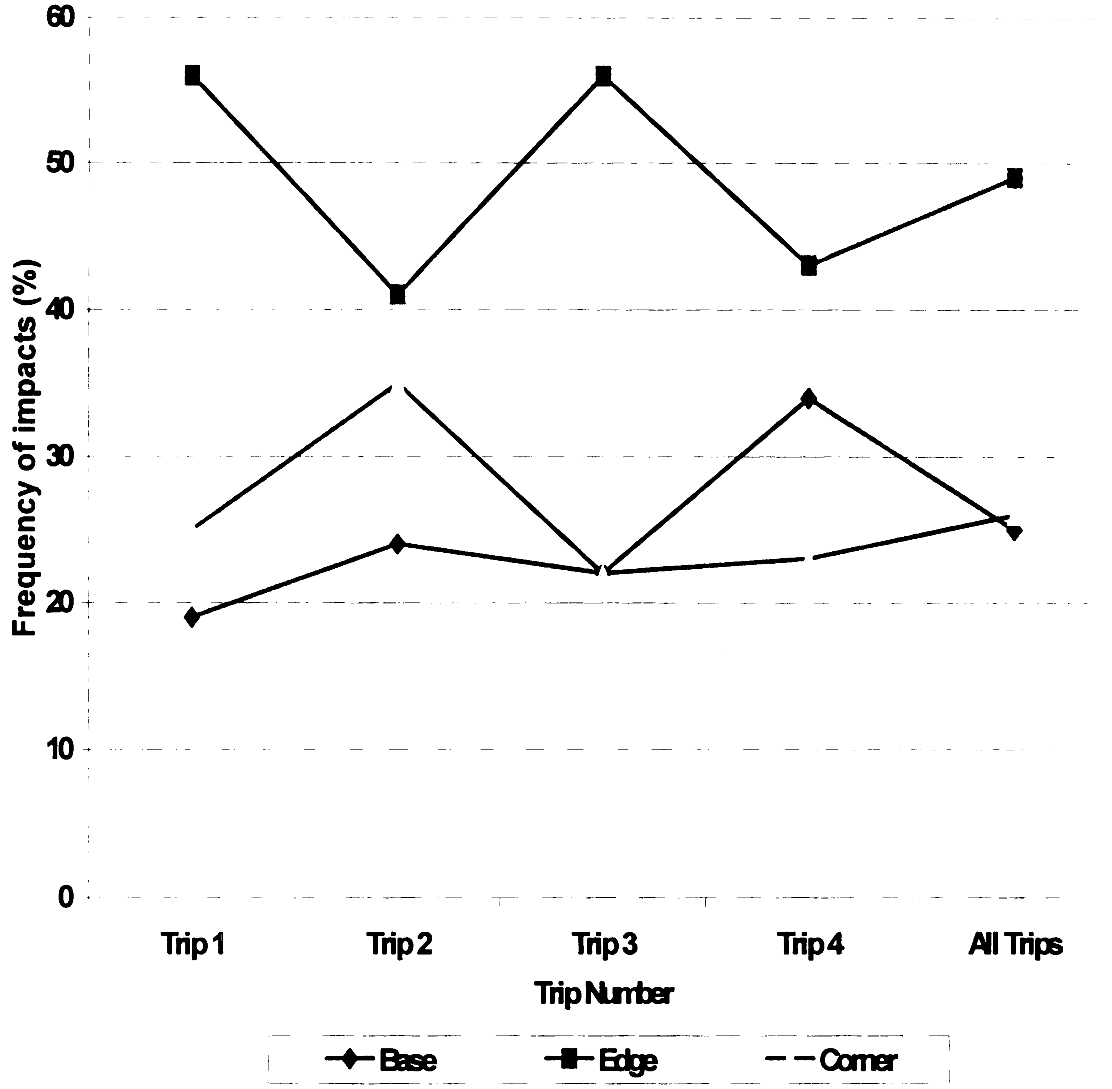

Figure 12. Frequency of Impacts as a Function of Package Orientation (Lansing, MI ---- Monterey, CA)

Table 5. Drop Orientation Distributions
(Lansing, MI ---- Rochester, NY)

Trip No.	Size Category	Weight Category	Box	Orientation Base	Orientation Edge	Orientation Corner	Totals
1	Middle	Light	A	9	22	14	45
			B	3	23	11	37
	Middle	Medium	C	6	22	23	51
			D	4	36	19	59
	Large	Heavy	E	6	11	9	26
Sub-Totals				28	114	76	218
% Sub-Totals				**13**	**52**	**35**	100
2	Middle	Light	A	6	13	20	39
			B	7	26	13	46
	Middle	Medium	C	7	29	12	48
			D	9	31	19	59
	Large	Heavy	E	4	16	10	30
Sub-Totals				33	115	74	222
% Sub-Totals				**15**	**52**	**33**	100
3	Middle	Light	A	7	37	24	68
			B	9	14	17	40
	Middle	Medium	C	4	19	18	41
			D	7	26	13	46
	Large	Heavy	E	6	20	6	32
Sub-Totals				33	116	78	227
% Sub-Totals				**15**	**51**	**34**	100
4	Middle	Light	A	10	29	14	53
			B	4	35	17	56
	Middle	Medium	C	16	26	14	56
			D	8	20	17	45
	Large	Heavy	E	8	14	9	31
Sub-Totals				46	124	71	241
% Sub-Totals				**19**	**51**	**30**	100
Totals				140	469	299	908
% Totals				**15**	**52**	**33**	100

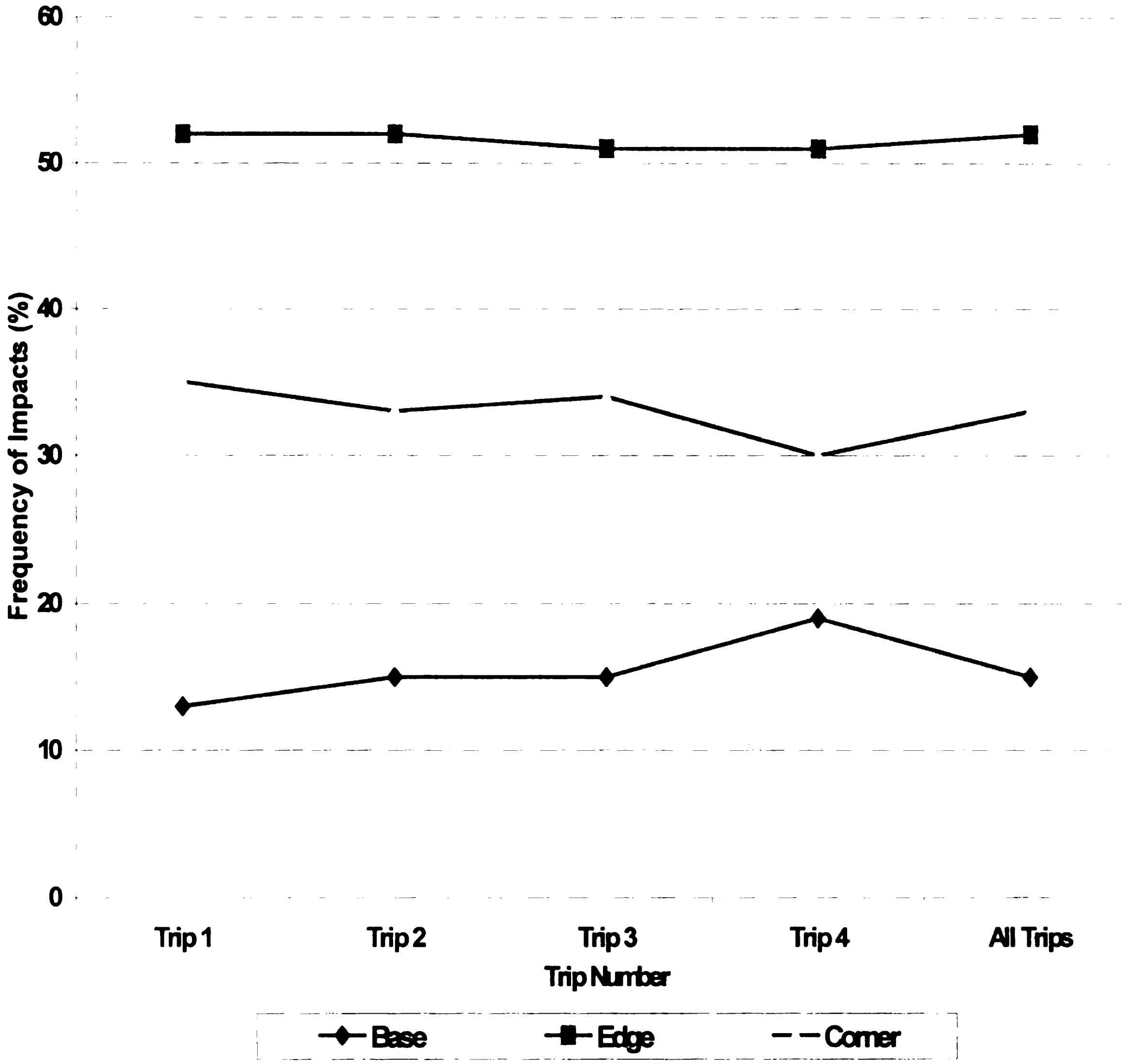

Figure 13. Frequency of Impacts as a Function of Package Orientation (Lansing, MI ---- Rochester, NY)

Table 6. Drop Orientation Distributions
(Both trips)

Trip No.	Size Category	Weight Category	Box	Orientation			Totals
				Base	Edge	Corner	
1	Middle	Light	A	11	23	11	45
			B	5.5	22.5	9	37
	Middle	Medium	C	5	19	16.5	40.5
			D	3.5	26.5	13.5	43.5
	Large	Heavy	E	3.5	9	7	19.5
Sub-Totals				28.5	100	57	185.5
% Sub-Totals				**15**	**54**	**31**	100
2	Middle	Light	A	6	16	13.5	35.5
			B	10.5	24	10.5	45
	Middle	Medium	C	6.5	19.5	8.5	34.5
			D	7	23.5	13	43.5
	Large	Heavy	E	2.5	10.5	6.5	19.5
Sub-Totals				32.5	93.5	52	178
% Sub-Totals				**18**	**53**	**29**	100
3	Middle	Light	A	8	27.5	13.5	49
			B	9	14	12.5	35.5
	Middle	Medium	C	2.5	15.5	12.5	30.5
			D	6	19.5	10	35.5
	Large	Heavy	E	4.5	15	4	23.5
Sub-Totals				30	91.5	52.5	174
% Sub-Totals				**17**	**53**	**30**	100
4	Middle	Light	A	12	21.5	11	44.5
			B	8.5	24	13	45.5
	Middle	Medium	C	12	19.5	10.5	42
			D	9.5	19	13	41.5
	Large	Heavy	E	8	12.5	6	26.5
Sub-Totals				50	96.5	53.5	200
% Sub-Totals				**25**	**48**	**27**	100
Totals				141	381.5	215	737.5
% Totals				**19**	**52**	**29**	100

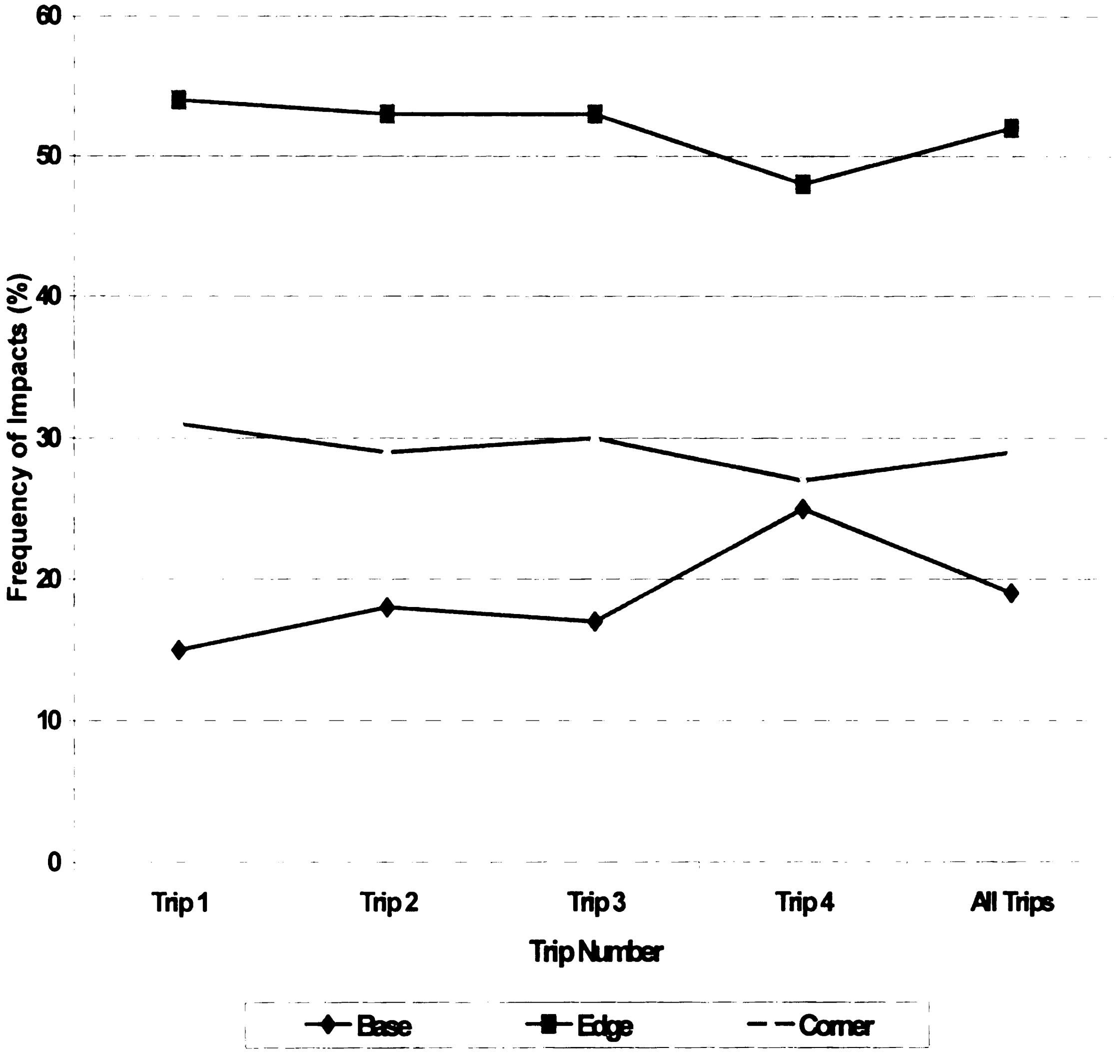

Figure 14. Frequency of Impacts as a Function of Package Orientation (Both trips)

middle/light, middle/medium and large/heavy packages were at the 95% level 13.4 inches, 17.4 inches and 21.8 inches, respectively. The mean number of drops per shipment was 33. The middle/light packages hit the ground 42 times in average per shipment, the middle/medium packages, 39 times, and the large/heavy, 19 times. Figure 3 presents mean drop height distributions of all the forty roundtrips as a function of percentage of drop occurrences.

Table 4, 5 and 6 present data regarding drop orientation during shipment through UPS. 49% of the total drops happened on edges, 26% on corners, and 25% on bases in the twenty roundtrips from Lansing, MI to Monterey, CA. However, trip # 4 had a different outcome that the highest number of drops took place on Edge, second on Base, and third on Corner.

52% of the total drops in the twenty roundtrips from Lansing, MI to Rochester, NY happened on edges, 33% on corners, and then 15% on bases. Each roundtrip had the similar results regarding the percentage of drops.

52% of the total drops in the forty roundtrips from Lansing, MI to Monterey, CA and Rochester, NY occurred on edges, 29% on corners, and 19% on bases. Figure 3, 4 and 5 show how often drops happened on Edge, Corner, and Base by percentage of the total drops in the forty round trips.

Tables 7 and 8 further analyze the data and show the number of times a given face on a package experienced drops. All base, edge, and corner drops were analyzed to find which surface number (s) of a package is (are) engaged in the dynamic event. As the way of putting number on package surface is shown at Figure 4, top of package is number 1:

Table 7. Summary of drop occurrences per surface by UPS (Roundtrip) (Lansing, MI ---- Monterey, CA)

Trip No.	Size Category	Weight Category	Box	Number of Occurrences per Surface					
				1	2	3	4	5	6
1	Middle	Light	A	5	9	27	20	13	11
			B	7	8	23	12	16	7
	Middle	Medium	C	2	11	20	11	14	8
			D	1	11	19	8	13	9
	Large	Heavy	E	0	3	12	5	6	4
Means				3	8.4	20.2	11.2	12.4	7.8
Percentiles				4.8	13.3	**32.1**	17.8	19.7	12.4
2	Middle	Light	A	5	11	6	13	3	27
			B	13	13	13	12	8	23
	Middle	Medium	C	2	6	8	8	7	10
			D	3	8	6	11	7	17
	Large	Heavy	E	0	2	5	4	3	6
Means				4.6	8	7.6	9.6	5.6	16.6
Percentiles				9.2	16	15.2	19.2	11.2	**33.2**
3	Middle	Light	A	2	8	20	9	5	10
			B	8	6	19	10	10	8
	Middle	Medium	C	2	2	17	8	8	9
			D	2	9	14	7	12	8
	Large	Heavy	E	1	4	9	6	3	6
Means				3	5.8	15.8	8	7.6	8.2
Percentiles				6.2	12.0	**32.6**	16.5	15.7	16.9
4	Middle	Light	A	5	5	9	19	2	26
			B	11	12	6	6	4	27
	Middle	Medium	C	2	7	15	11	5	15
			D	6	10	12	16	15	15
	Large	Heavy	E	1	13	7	0	3	15
Means				5	9.4	9.8	10.4	5.8	19.6
Percentiles				8.3	15.7	16.3	17.3	9.7	**32.7**

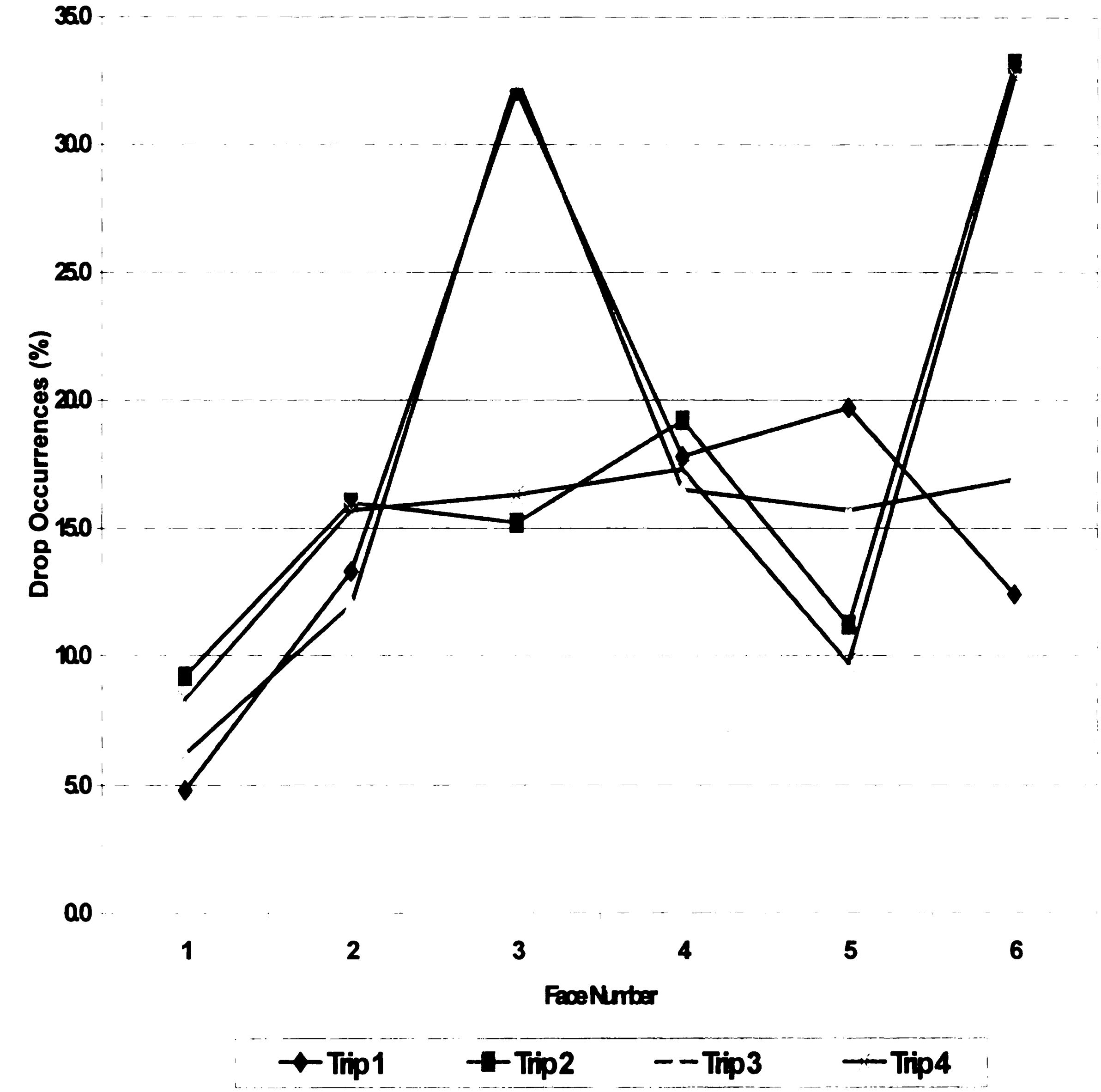

Figure 15. Frequency of Drops as a Function of Package Face Number (Lansing, MI ---- Monterey, CA)

Table 8. Summary of drop occurrences per surface by UPS (Roundtrip) (Lansing, MI ---- Rochester, NY)

Trip No.	Size Category	Weight Category	Box	Number of Occurrences per Surface					
				1	2	3	4	5	6
1	Middle	Light	A	7	15	31	16	10	16
			B	7	14	25	11	16	9
	Middle	Medium	C	0	17	43	22	20	17
			D	3	26	43	22	24	15
	Large	Heavy	E	4	8	15	10	13	5
Means				4.2	16	31.4	16.2	16.6	12.4
Percentiles				4.3	16.5	**32.4**	16.7	17.1	12.8
2	Middle	Light	A	10	13	19	16	13	21
			B	18	13	12	19	16	23
	Middle	Medium	C	4	16	28	16	12	25
			D	1	14	42	25	23	23
	Large	Heavy	E	1	14	18	5	9	19
Means				6.8	14	23.8	16.2	14.6	22.2
Percentiles				7.0	14.3	**24.4**	16.6	15.0	**22.7**
3	Middle	Light	A	19	24	37	25	12	36
			B	7	17	26	12	18	8
	Middle	Medium	C	0	11	35	21	16	13
			D	1	11	33	22	18	13
	Large	Heavy	E	2	13	15	11	10	13
Means				5.8	15.2	29.2	18.2	14.8	16.6
Percentiles				5.8	15.2	**29.3**	18.2	14.8	16.6
4	Middle	Light	A	22	10	12	24	5	37
			B	26	21	15	17	14	32
	Middle	Medium	C	6	26	27	13	12	26
			D	2	16	28	16	13	24
	Large	Heavy	E	4	6	12	13	9	19
Means				12	15.8	18.8	16.6	10.6	27.6
Percentiles				11.8	15.6	18.5	16.4	10.5	**27.2**

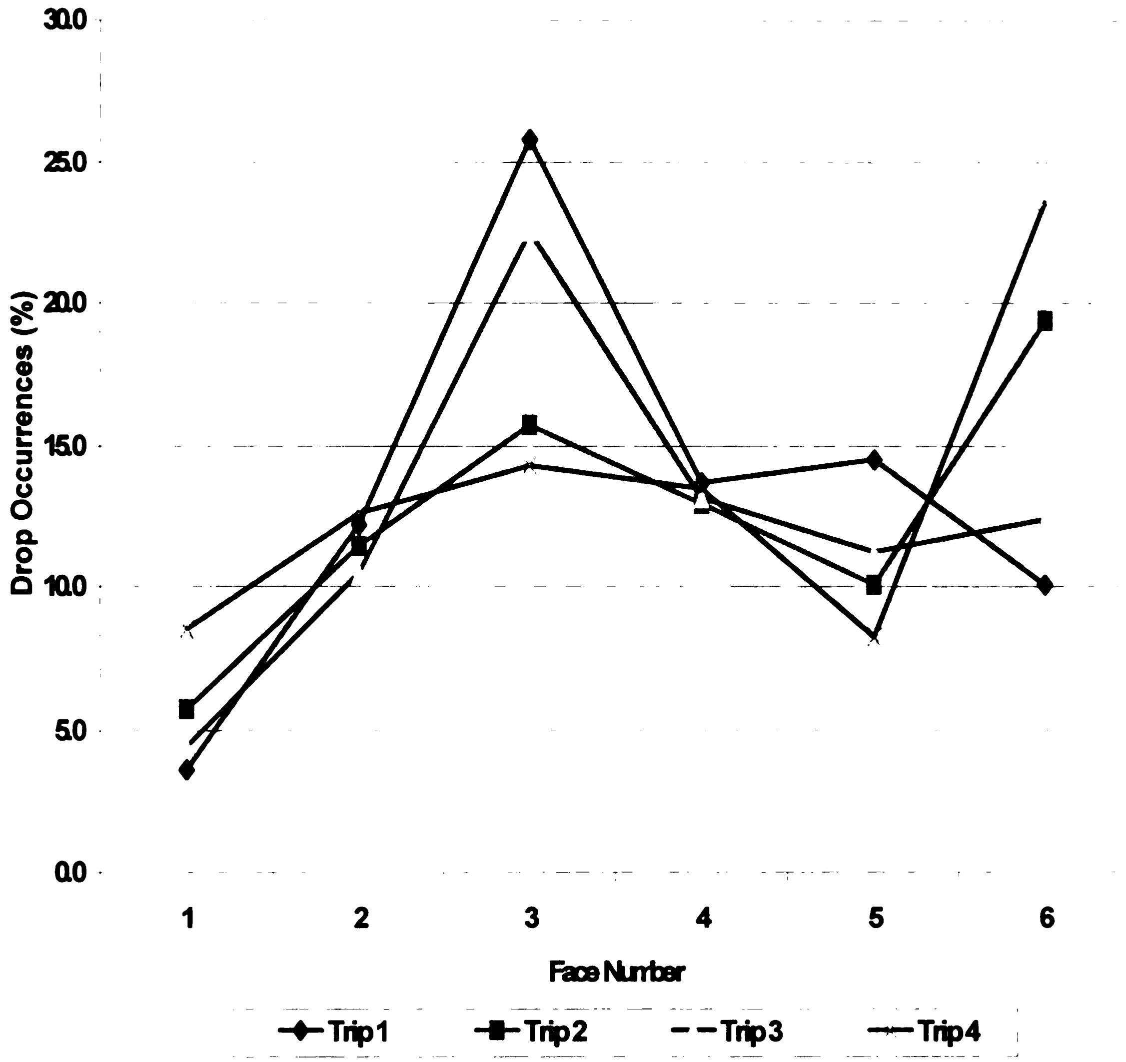

Figure 16. Frequency of Drops as a Function of Package Face Number (Lansing, MI ---- Monterey, CA)

Table 9. Summary of drop occurrences per surface by UPS (Roundtrip) (Both trips)

Trip No.	Size Category	Weight Category	Box	Number of Occurrences per Surface					
				1	2	3	4	5	6
1	Middle	Light	A	6	12	29	18	11.5	13.5
			B	7	11	24	11.5	16	8
	Middle	Medium	C	1	14	31.5	16.5	17	12.5
			D	2	18.5	31	15	18.5	12
	Large	Heavy	E	2	5.5	13.5	7.5	9.5	4.5
Means				3.6	12.2	25.8	13.7	14.5	10.1
Percentiles				4.5	15.3	**32.3**	17.1	18.1	12.6
2	Middle	Light	A	7.5	12	12.5	14.5	8	24
			B	15.5	13	12.5	15.5	12	23
	Middle	Medium	C	3	12	18	12	9.5	17.5
			D	2	12	24	18	15	20
	Large	Heavy	E	0.5	8	11.5	4.5	6	12.5
Means				5.7	11.4	**15.7**	12.9	10.1	**19.4**
Percentiles				7.6	14.7	**21.0**	17.2	13.5	**25.9**
3	Middle	Light	A	10.5	16	28.5	17	8.5	23
			B	7.5	11.5	22.5	11	14	8
	Middle	Medium	C	1	6.5	26	14.5	12	11
			D	1.5	10	23.5	14.5	15	10.5
	Large	Heavy	E	1.5	8.5	12	8.5	6.5	9.5
Means				4.4	10.5	**22.5**	13.1	11.2	12.4
Percentiles				5.9	14.2	**30.4**	17.7	15.1	16.7
4	Middle	Light	A	13.5	7.5	10.5	21.5	3.5	31.5
			B	18.5	16.5	10.5	11.5	9	29.5
	Middle	Medium	C	4	16.5	21	12	8.5	20.5
			D	4	13	20	16	14	19.5
	Large	Heavy	E	2.5	9.5	9.5	6.5	6	17
Means				8.5	12.6	14.2	13.5	8.2	**23.6**
Percentiles				10.5	15.6	17.6	16.7	10.2	**29.3**

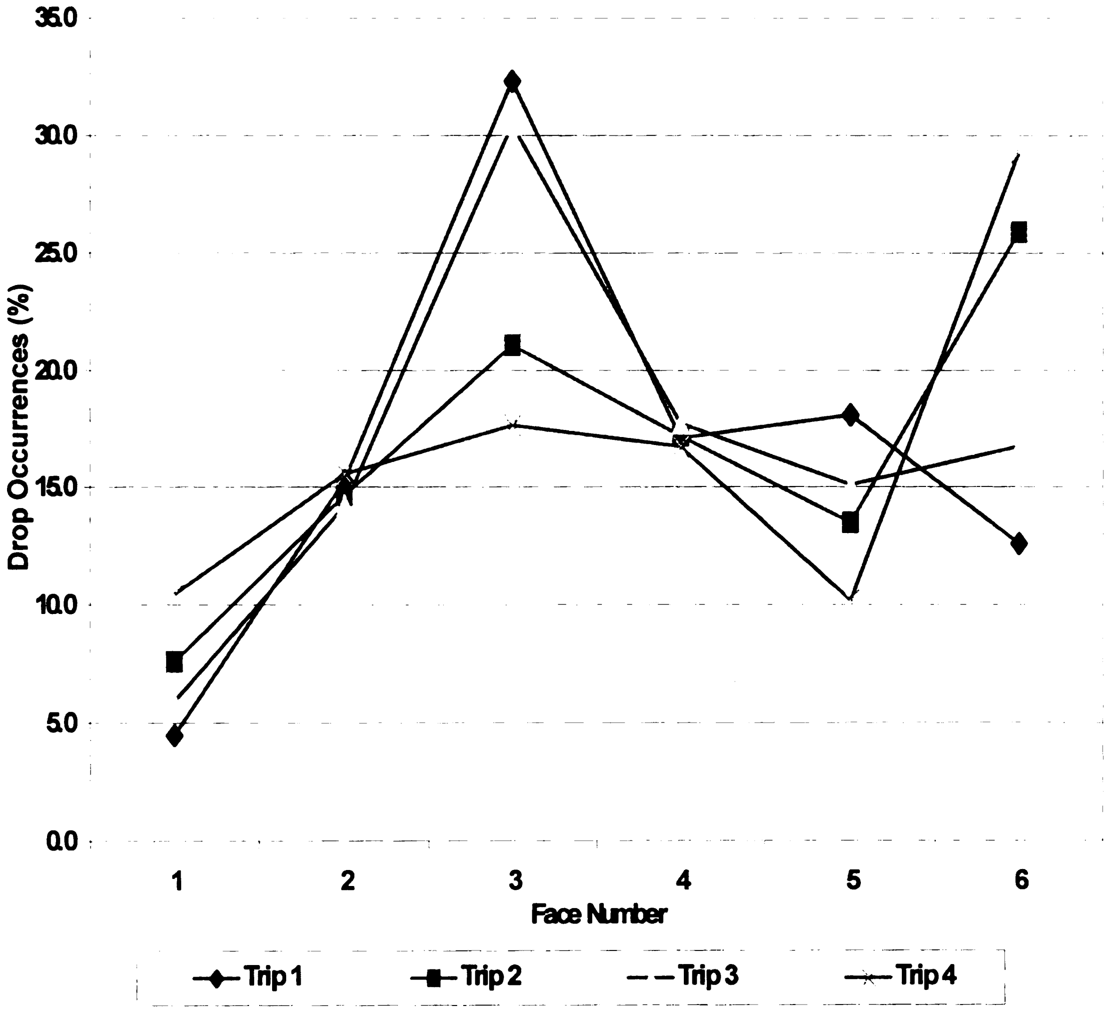

Figure 17. Frequency of Drops as a Function of Package Face Number (Both Trips)

right, number 2: bottom, number 3: left, number 4: front, number 5: back, number 6.

An edge drop would be represented to occur on the two faces adjoining that edge. Similarly a corner impact (right-bottom-front) would be represented on three faces (2-3-5). This data was used to evaluate the effect of shipping label placement on the orientation of impacts. Table 9 provides a summary of drop occurrences per surface for both shipments. Based on this study, for the first shipment (Label on face 1), face 1 is the "top" of the package. Therefore, face 3 (bottom) would be the most likely face to have drops and impacts occur on. This is evident from Table 9, where face 3 has the most number of drop occurrences (25.8 occurrences). However in the small parcel-shipping environment there are also additional impacts on the side faces (2, 4, 5 and 6) during package conveying and sortation at various hubs. This can be seen by the presence of impacts on other surfaces. The top surface (face 1) had the least number of impacts as is observed from Table 9 (3.6 occurrences), and the other side faces (2, 4, 5 and 6) had intermediate number of impact occurrences. For trip # 2, with the use of additional pictorial markings (This Side Up arrow markings), this did not result in more impacts on face 3 as would have been expected. In fact, face 6 had the highest number of impact occurrences, followed by face 3 (bottom), and other side faces. After reviewing this data with representatives of UPS and FedEx, it is evident that some of the pictorial markings can lead to additional confusion for the employees involved with package loading and sorting.

For trip # 3, the shipping label was placed on the front face (5) of the package. This should generate most of the impacts on face 6. This did not occur based on the data in Table 9. Most of the impacts still occurred on face 3 (the expected bottom of a regular slotted container (RSC) style package). This however did improve for package shipments in trip # 4 where additional pictorial markings were used to emphasize the shipping orientation.

5. CONCLUSIONS

The following conclusions were made from this study:

1. The mean drop height of the forty roundtrips was 17.6 inches at the 95% level. For each size and weight category, the mean drop heights of middle/light, middle/medium and large/heavy packages were 13.9 inches, 17.4 inches and 21.8 inches at the 95 % level, respectively. The mean number of drops in the forty roundtrips was 33 per shipment. The middle/light, middle/medium and large/heavy packages experienced 42, 39, and 19 drops per shipment, respectively. Therefore, the larger and heavier packages experienced the higher mean drop height, but less number of drops. The reason is attributed to the fact that large and heavy packages are lifted waist high and then often dropped, as compared to small packages that are placed over other packages.
2. In orientation standpoint, 52% of the drops were on Edge, 29% on Corner, and 19% on Base. A box has 6 faces, 8 corners, and 12 edges or 26 possibilities. Therefore, it is expected to get 12/26 (46%) edge drops, 8/26 (31%) corner drops, and 6/26 (23%) face drops. This is similar to data observed in this thesis.
3. Generally RSC shippers are positioned in their expected top orientation by loading and sortation employees.
4. In most cases the package is positioned with the shipping label in the top orientation during loading or sortation. However to optimize the cube efficiency in a trailer packages may be positioned sideways.

5. Pictorial markings will help if the package shape and shipping label positioning is in a non-conventional mode as was observed in trip # 4.

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APPENDIX

APPENDIX A.

SAVER SETUP SPECIFICATION

Memory Modes: "Max. Overwrite Min. when Full"

Ranges and Files:

Acceleration => 5g – 200g (100g)

Low-pass filter => 20Hz – 2800Hz (780Hz)

Drop Height Recorder:

Maxium Drop Height: 48 inches

Estimated Trip Length: 4 days

Table A1. Advanced Saver Setup:

<table>
<tr><th colspan="2">Signal Triggered Data</th><th colspan="2">Time Triggered data</th></tr>
<tr><td colspan="2">Record time</td><td colspan="2">Record time (No waveform)</td></tr>
<tr><td>Samples/sec: 2,000</td><td>Sample size:2,420</td><td>Sample/sec: 2,000</td><td>Sample size: 50</td></tr>
<tr><td colspan="2">Signal pretrigger %: 92</td><td colspan="2">Wakeup Internal: 4 minutes</td></tr>
<tr><td colspan="2">Signal pretrigger compression: 1 to 1</td><td colspan="2">Time to fill: 4.5 days</td></tr>
<tr><td colspan="2">Record waveform</td><td colspan="2">Record T/H and Static channels</td></tr>
<tr><td colspan="2">Data Analysis Type: Drop height</td><td colspan="2">Data Retention Mode: Temp. and RH</td></tr>
<tr><td colspan="2">Data Retention Mode:
Max Overwrite when full</td><td colspan="2">Data Retention Mode:
Stop when full</td></tr>
<tr><td colspan="2">Memory Allocation: 99%, 284 events</td><td colspan="2">Memory Allocation: 1%, 1611 events</td></tr>
</table>

Table A2. Channel Map:

Channel to sample	1 through 3 (X, Y and Z)
Sample/sec for each channel	2,000
Full scale	100 g's
Filter frequency	780 Hz
Trigger options	Primary Trigger Group
	Outside level: above 5g's or below –5g's

Appendix B.

Table B1a. Trip #1 to Rochester, NY - Box A.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	2.9		X	X			
2	9.31	X	X			X	
3	1.09		X	X			X
4	2.36	X					X
5	1.03			X		X	
6	2.53			X	X		X
7	1.02			X	X		X
8	2.45			X	X		
9	3.17			X	X		
10	5.07		X	X			
11	1.16	X			X		
12	1.36			X	X		X
13	2.11		X	X			
14	2.51		X	X			X
15	1.03			X			
16	1.51				X	X	
17	11.08		X	X			X
18	2.13	X					
19	1.53		X	X			
20	10.4			X			X
21	2.51						X
22	2.09			X	X		X
23	2.19		X	X		X	
24	6.02					X	
25	13.62		X	X			X
26	4.46			X	X		
27	1.19			X			
28	3.44			X	X	X	
29	1.27			X			
30	14.99		X	X			
31	1.27			X			X
32	3.92		X				X
33	2.97	X	X				X
34	2.81	X					
35	2.3	X	X				
36	1.97		X				X

Table B1a. (con'd)

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
37	1.22				X		
38	3.02			X			X
39	1.64			X	X	X	
40	7.16			X	X		
41	25.6			X		X	
42	34.73			X	X	X	
43	8.04			X		X	
44	1.25				X		
45	1.25			X	X		

Table B1b. Trip #1 to Rochester, NY - Box B.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	1.06			X		X	
2	1.41		X	X		X	
3	2.09					X	
4	4.79			X	X	X	
5	3.12		X	X			
6	5.36		X	X			
7	2.13		X	X			
8	2.09			X	X		X
9	1.67		X	X			X
10	1.06		X	X		X	
11	2.21		X			X	
12	4.38			X			
13	1.4					X	
14	5.45	X					X
15	1.31	X					X
16	2.3			X	X		
17	3.37			X	X	X	
18	1.31			X		X	
19	2.25			X	X		
20	2.47		X	X			
21	5.45	X	X				X
22	8.08	X	X				X
23	3.27	X				X	
24	1.56	X				X	
25	4.15			X	X		
26	2.05				X		X
27	3.42		X	X			
28	1.58		X	X			
29	4.15		X	X		X	
30	3.84	X			X		
31	4.67		X	X			
32	3.07				X	X	
33	1.73			X	X	X	
34	1.36			X			X
35	6.58			X	X		X
36	2.17			X		X	
37	4.46			X		X	

Table B1c. Trip #1 to Rochester, NY - Box C.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	1.31			X	X	X	
2	10.35					X	
3	3.09			X	X		
4	5.62			X	X		X
5	3.92			X			X
6	3.29			X		X	
7	5.52			X	X		X
8	7.54			X	X		
9	1.21			X	X		X
10	3.34			X	X		
11	2.15			X	X	X	
12	1.16				X	X	
13	2.42			X	X	X	
14	2.69			X			X
15	2.49		X	X		X	
16	1.27			X	X		X
17	17.97		X				X
18	4.67			X	X	X	
19	2.01			X	X		X
20	1.93			X	X		X
21	4.46			X	X		
22	1.22			X	X		X
23	21.75			X			
24	1.95					X	
25	5.29		X	X			X
26	3.19		X	X			
27	3.39		X	X			
28	10.94		X	X			
29	1.46		X	X		X	
30	1.86			X		X	
31	1.95		X	X		X	
32	1.64		X	X		X	
33	3.37		X	X			
34	3.24		X	X		X	
35	2.07		X	X			
36	3.12		X	X			X
37	2.88			X	X		X
38	2.19			X	X	X	
39	7.54				X		X
40	1.69		X	X		X	

Table B1c. (Con'd)

Impact #	Height(in.)	Orientation					
		1	2	3	4	5	6
41	1.25			X			X
42	2.64		X	X			
43	1.45		X				
44	1.58			X	X	X	
45	3.84				X		
46	41.95		X	X			
47	8.97			X		X	
48	8.6			X	X	X	
49	1.8					X	
50	3.71			X			X
51	17.68			X			X

Table B1d. Trip #1 to Rochester, NY - Box D.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	11.08		X	X			X
2	2.27		X	X			
3	7.38		X	X			
4	1.09				X	X	
5	1.09	X	X			X	
6	5.78			X			X
7	1.87			X			X
8	2.95		X	X		X	
9	1.64			X	X		
10	2.69			X		X	
11	1.25			X	X		X
12	2.01		X	X		X	
13	3.37			X	X	X	
14	2.92		X			X	
15	7.81		X				X
16	3.57			X	X		
17	2.36			X	X		
18	1.38				X	X	
19	4.29				X	X	
20	2.85			X		X	
21	2.99			X	X		X
22	19.48	X	X				X
23	9.61			X			X
24	1.58			X	X		
25	2.45		X	X			
26	2.67			X	X	X	
27	1.13		X	X		X	
28	1.97		X	X		X	
29	1.55		X	X			
30	9.52		X	X			X
31	23.06			X	X	X	
32	4.92			X		X	
33	1.31	X					
34	4.01					X	
35	7.81		X	X			
36	15.53		X			X	
37	2.38		X	X			
38	1.35			X	X		
39	2.01			X	X		
40	1.71		X	X		X	

Table B1d. (Con'd)

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
41	1.24				X		
42	2.6			X	X		X
43	1.16			X	X		
44	2.49			X	X		X
45	10				X	X	
46	2.36			X		X	
47	5.55			X		X	
48	3.63		X				X
49	5.98			X		X	
50	1.03		X	X			
51	1.07		X	X			X
52	2.3		X	X			
53	3.14		X			X	
54	2.47		X				X
55	2.81		X	X			X
56	1.93		X	X			
57	2.64			X	X		
58	16.47				X		
59	9.82			X	X	X	

Table B1e. Trip #1 to Rochester, NY - Box E.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	3.73			X			
2	1.36	X			X	X	
3	1.73	X			X		
4	1.53				X	X	
5	2.38		X	X			
6	6.26		X	X		X	
7	1.69					X	
8	1.36		X	X		X	
9	2.62			X		X	
10	12.12		X	X		X	
11	4.38			X	X		
12	5.45			X			
13	1.22					X	
14	11.08		X	X		X	
15	2.64				X	X	
16	4.09	X	X				X
17	16.14			X	X		X
18	9.06	X					
19	4.49			X	X		
20	24.83		X	X		X	
21	37.83			X		X	
22	10.09		X				X
23	21.49			X	X		
24	1.38				X	X	
25	12.56						X
26	5.82			X	X		X

Table B2a. Trip #2 to Rochester, NY - Box A.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	1.28			X			X
2	3.98	X					X
3	3.07			X	X		X
4	1.84	X	X				X
5	2.19			X			
6	2.42		X	X			X
7	3.84		X	X			X
8	1.62			X	X		
9	2.13						X
10	1.5	X			X		X
11	1.36		X	X		X	
12	2.03				X		X
13	2.19	X			X		X
14	3.92			X	X		X
15	14.29				X		X
16	4.73		X			X	
17	3.29	X			X		
18	19.48						X
19	14.29			X	X		X
20	2.71			X		X	
21	2.97	X	X			X	
22	1.24			X	X	X	
23	3.42		X	X			X
24	2.01	X					
25	7.16			X	X		X
26	1.46				X		X
27	2.38					X	
28	1.12		X	X			X
29	1.18	X				X	
30	1.58	X	X			X	
31	1.89		X				X
32	6.65		X	X		X	
33	8.28		X	X		X	
34	1.53			X	X	X	
35	2.38			X	X	X	
36	1.6				X	X	
37	2.36				X		
38	2.15			X			X
39	1.31	X	X				X

Table B2b. Trip #2 to Rochester, NY - Box B.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	2.25		X	X			X
2	2.9	X					X
3	1.12						X
4	1.33		X				X
5	1.24				X		X
6	1.19				X		X
7	6.76	X				X	
8	1.13	X			X		X
9	3.14	X			X	X	
10	2.15	X			X	X	
11	2.21			X	X		X
12	3.63			X			X
13	2.78				X		X
14	1.28						X
15	2.36			X			X
16	6.47		X				
17	2.71				X	X	
18	3.52	X					X
19	6.79			X	X		
20	13.52	X					X
21	4.64		X				X
22	4.58			X			
23	6.65		X	X		X	
24	4.7	X			X		
25	19.78	X					X
26	17.45			X	X		
27	2.17				X		X
28	6.86		X				X
29	5.78	X			X		
30	1.13	X	X			X	
31	2.34	X	X			X	
32	1.5	X				X	
33	1.4	X			X	X	
34	1.71	X			X		X
35	1.46	X			X	X	
36	2.11	X	X				
37	2.6				X		
38	3.09		X				X
39	3.32		X	X		X	
40	3.57		X				X

Table B2b. (Con'd)

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
41	2.03			X	X	X	
42	6.72			X	X		
43	1.82			X		X	
44	3.87						X
45	12.03	X					
46	5.55		X				X

Table B2c. Trip #2 to Rochester, NY - Box C.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	1.53	X					X
2	1.65		X				X
3	1.58		X	X			
4	3.22			X	X		X
5	3.65						X
6	4.64		X			X	
7	1.06			X	X		X
8	2.42		X				
9	1.28		X	X			
10	2.53		X	X			
11	2.3		X	X			
12	1.28		X	X			X
13	1.5			X	X	X	
14	1.25			X	X		
15	1.21		X				
16	18.45			X	X		X
17	2.38				X	X	
18	2.74						X
19	5.75			X	X		X
20	16.7				X		X
21	2.58	X			X		
22	9.82						X
23	8.6						X
24	1.03				X		X
25	5.95			X	X		
26	4.55			X			X
27	39.38			X	X	X	
28	4.64						X
29	1.99			X		X	
30	1.25		X			X	
31	2.71		X	X			
32	2.38		X	X		X	
33	4.26		X	X		X	
34	2.85			X			X
35	4.95				X		X
36	3.27		X				X
37	1.8		X	X			X
38	1.13			X	X		
39	5.78			X			X
40	3.98			X	X		X

Table B2c. (Con'd)

Impact #	Height(in.)	Orientation					
		1	2	3	4	5	6
41	6.22				X	X	
42	1.65			X		X	
43	22.33		X	X			X
44	3.9			X			X
45	1.19			X		X	
46	3.12			X		X	
47	12.76	X					X
48	8.97	X					X

Table B2d. Trip #2 to Rochester, NY - Box D.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	3.17		X				X
2	3.92				X		X
3	8.81						X
4	2.62			X	X		
5	2.83			X	X		
6	3.04			X	X		X
7	3.6		X	X			
8	1.45			X	X		X
9	2.27			X			X
10	9.56						X
11	1.76						X
12	1.06			X			X
13	6.19			X	X		X
14	1.62			X	X		
15	3.84			X	X		
16	2.85		X	X		X	
17	1.4				X	X	
18	1.03			X	X		X
19	2.21		X	X			X
20	5.01			X	X		
21	4.09					X	
22	2.88			X	X	X	
23	3.98			X	X		
24	2.27			X			X
25	5.04		X	X			X
26	2.19			X		X	
27	2.05			X	X		
28	65.33		X	X		X	
29	2.23			X			X
30	2.11			X	X	X	
31	2.15			X	X	X	
32	5.78			X		X	
33	1.71		X	X		X	
34	8.97				X	X	
35	13.62					X	
36	2.42			X			X
37	8.28			X	X	X	
38	40.7			X		X	
39	24.28	X			X		X
40	18.21		X				

Table B2d. (Con'd)

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
41	4.15					X	
42	3.47			X	X		
43	3.24			X	X		X
44	2.03			X	X		
45	1.25			X	X	X	
46	1.73			X	X	X	
47	3.19		X			X	
48	2.38		X	X			
49	3.02			X			X
50	2.11						X
51	3.42			X		X	
52	2.15		X	X			X
53	5.1		X	X		X	
54	17.68			X		X	
55	2.38		X	X			
56	5.01			X		X	
57	3.5		X				X
58	6.94					X	
59	9.91				X		X

Table B2e. Trip #2 to Rochester, NY - Box E.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	2.49						X
2	4.49				X		X
3	1.36						X
4	3.19			X	X		X
5	6.33			X			X
6	3.14		X	X		X	
7	2.32			X			X
8	6.22			X			X
9	3.24		X	X			X
10	1.41		X	X			
11	1.1		X			X	
12	2.38		X	X			X
13	4.01		X	X			X
14	8.16			X	X		
15	3.98					X	
16	4.17		X	X			X
17	2.9			X			X
18	19.91			X			X
19	10.81		X	X		X	
20	5.49	X	X				X
21	2.71		X			X	
22	2.56		X			X	
23	2.09		X			X	
24	5.23		X			X	
25	2.45			X			X
26	2.88			X			X
27	3.79			X	X	X	
28	5.16		X	X			X
29	25.11						X
30	6.79				X		X

Table B3a. Trip #3 to Rochester, NY - Box A.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	1.74			X	X		X
2	2.03			X			X
3	1.35			X	X		
4	10			X			X
5	1.25		X				X
6	1.73			X			
7	2.9		X	X		X	
8	12.51	X			X	X	
9	5.49	X	X				X
10	1.21	X	X				X
11	6.51			X			X
12	3.9			X	X		
13	4.64		X	X		X	
14	1.55			X	X		
15	1.65	X				X	
16	9.01			X	X		X
17	20.41			X			X
18	14.35				X		X
19	3.52		X	X			
20	1.56		X			X	
21	3.5			X			X
22	11.46			X	X		X
23	1.46		X	X			
24	1.18		X	X			
25	1.89		X	X			
26	2.3		X	X			
27	1.5		X				
28	4.43				X	X	
29	1.87			X		X	
30	3.24		X	X			
31	1.1			X	X		X
32	1.4						X
33	2.27			X			X
34	5.49			X			X
35	12.51				X		
36	2.64	X			X		X
37	2.11	X	X				
38	2.97	X	X			X	
39	2.74	X	X				X
40	1.64	X			X	X	

Table B3a. (Con'd)

Impact #	Height(in.)	Orientation					
		1	2	3	4	5	6
41	1.87	X				X	
42	17.8		X	X			
43	3.52			X		X	
44	6.68			X	X		X
45	3.17	X			X		X
46	4.23				X		X
47	2.78			X	X		X
48	3.47				X		X
49	2.01						X
50	1.35		X	X			X
51	2.51						X
52	4.12						X
53	2.05	X	X				X
54	3.52	X					X
55	1.03	X	X				
56	2.9	X	X				
57	2.17	X	X				X
58	1.5			X	X		
59	1.02			X		X	
60	4.79			X	X		X
61	6.22	X			X		X
62	2.13			X			X
63	28.56			X	X		X
64	8.36	X			X		
65	1.06	X	X				
66	2.17		X	X			
67	3.98			X	X		X
68	1.04			X	X		X

Table B3b. Trip #3 to Rochester, NY - Box B.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	5.26	X			X		
2	6.33			X	X	X	
3	9.87		X	X			X
4	1.74		X	X			
5	1.65		X	X			
6	1.41		X	X			
7	1.13		X	X			X
8	1.41						X
9	1.65			X	X	X	
10	1.89			X	X	X	
11	1.24		X				
12	6.36				X		X
13	1.93				X		
14	2.78			X		X	
15	3.65	X			X		X
16	6.76			X	X		
17	13.36			X	X	X	
18	8.2	X				X	
19	3.22		X	X			
20	37.92		X	X			X
21	1.67			X			
22	8.36	X	X			X	
23	5.36		X	X			
24	3.98		X	X		X	
25	2.4		X	X	X		
26	1.09		X	X		X	
27	1.6			X	X		X
28	3.27		X	X		X	
29	4.55	X					
30	2.62		X	X		X	
31	1.19	X					
32	2.47			X		X	
33	1.1					X	
34	4.7					X	
35	2.25					X	
36	5.36			X			X
37	1.25		X	X			
38	5.72	X				X	
39	3.47		X	X		X	
40	1.71			X	X	X	

Table B3c. Trip #3 to Rochester, NY - Box C.

Impact #	Height(in.)	Orientation 1	2	3	4	5	6
1	5.49		X	X			X
2	3.92			X	X		
3	20.09			X	X		X
4	6.09			X		X	
5	1.6			X			
6	7.77		X	X		X	
7	2.27		X	X		X	
8	2.76			X		X	
9	1.56			X		X	
10	3.84		X	X			
11	4.35					X	
12	4.03		X				X
13	2.23			X	X	X	
14	1.93		X	X			X
15	3.22			X	X	X	
16	3.98			X	X	X	
17	16.87				X		X
18	39.56			X	X	X	
19	4.7			X			X
20	1.07			X	X		X
21	4.61		X	X		X	
22	2.07			X	X		X
23	8.08			X	X		
24	2.36		X	X			
25	33.68					X	
26	2.23		X	X			
27	3.39			X	X		X
28	3.5		X	X			
29	1.51			X	X		
30	2.69			X	X		
31	2.25			X	X		
32	2.25			X	X		X
33	3.76			X	X		X
34	1.4			X	X		
35	1.24		X	X		X	
36	1.18			X			X
37	3.79			X	X		
38	1.25				X		X
39	1.65			X	X	X	
40	2.21			X	X	X	

Table B3c. (Con'd)

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
41	24.83					X	

Table B3d. Trip #3 to Rochester, NY - Box D.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	1.36			X	X		
2	4.61						X
3	7.09		X			X	
4	3.79			X			X
5	4.38			X	X		X
6	1.03			X	X	X	
7	3.34			X	X		
8	1.69			X	X		
9	1.27		X			X	
10	4.55			X	X		
11	2.25				X		
12	1.45			X	X		
13	2.11			X			
14	3.22			X	X	X	
15	2.11			X	X	X	
16	2.6		X				X
17	2.92			X	X	X	
18	1.76			X			
19	5.29			X	X	X	
20	2.21			X			X
21	5.62			X	X	X	
22	3.57			X	X		
23	26.88			X		X	
24	14.35		X	X			
25	2.76			X	X		
26	2.4			X	X		X
27	6.86			X		X	
28	13.41			X			
29	2.6			X	X	X	
30	5.58			X		X	
31	1.45		X	X			
32	1.76		X	X		X	
33	1.28		X			X	
34	2.09			X		X	
35	1.07		X				X
36	1.13			X	X	X	
37	5.1			X		X	
38	2.15			X	X		
39	3.44						X
40	2.88				X		X

Table B3d. (Con'd)

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
41	4.67				X		X
42	26.52						X
43	7.27	X	X				
44	10.04		X	X		X	
45	15.97			X	X		X
46	10.58		X				X

Table B3e. Trip #3 to Rochester, NY - Box E.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	17.74		X	X			
2	4.01			X	X	X	
3	1.78			X	X		
4	2.83		X			X	
5	1.28		X				X
6	2.23		X				
7	5.29		X			X	
8	9.06		X	X		X	
9	1.78			X	X	X	
10	16.53			X	X		X
11	1.15				X	X	
12	7.57	X	X				
13	3.14	X	X				
14	7.96					X	
15	3.81			X			X
16	2.21					X	
17	2.15			X	X		X
18	21.62			X		X	
19	23.46			X	X		
20	2.34						X
21	21.68		X	X			
22	4.2		X	X			
23	1.15				X	X	
24	5.82			X			X
25	4.35			X	X		
26	10.09		X				X
27	3.65			X	X		X
28	14.24		X				X
29	1.51		X				X
30	11.83				X		X
31	2.17						X
32	9.87						X

Table B4a. Trip #4 to Rochester, NY - Box A.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	12.71		X			X	
2	15.64						X
3	3.76	X	X				X
4	1.02	X	X			X	
5	1.43	X					
6	4.03						X
7	1.45	X				X	
8	2.9		X				X
9	21.94	X			X		X
10	6.05				X		X
11	1.28			X	X		
12	1.24		X				X
13	2.34	X					
14	1.43			X	X		X
15	5.2				X		X
16	24.28			X	X		
17	17.1	X					X
18	4.58						X
19	1.35						X
20	1.13			X			X
21	1.24			X	X		X
22	4.09				X		X
23	2.85		X				X
24	5.26				X		X
25	7.96				X		X
26	4.01	X					X
27	4.98	X			X		
28	2.9	X					X
29	3.39	X	X				X
30	2.11	X			X		X
31	1.38			X	X		X
32	2.03			X	X		X
33	1.41	X					X
34	3.12	X					
35	1.19	X			X		
36	2.9	X	X				
37	1.09				X		
38	13.52	X				X	
39	4.82				X		X
40	3.04						X

Table B4a. (Con'd)

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
41	4.46			X	X		X
42	1.69				X		X
43	1.31				X		X
44	9.44	X			X		X
45	4.95	X					X
46	15.31	X			X		X
47	1.71	X				X	
48	7.61	X	X				X
49	2.62						X
50	7.54			X			X
51	1.28			X	X		
52	3.76			X	X		X
53	15.42		X	X			

Table B4b. Trip #4 to Rochester, NY - Box B.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	3.37	X					X
2	2.07	X			X		X
3	7.61			X	X		X
4	2.34	X					X
5	1.07	X			X		
6	1.45	X			X		
7	1.65	X			X		
8	1.8	X			X		
9	2.53	X					X
10	11.08	X	X			X	
11	5.92		X				X
12	4.46						X
13	1.58						X
14	4.38	X					X
15	3.55				X		X
16	1.46						X
17	2.05	X				X	
18	2.17			X	X	X	
19	1.22		X				X
20	3.04			X			X
21	24.01			X	X	X	
22	3.07			X	X		X
23	2.6	X			X		
24	3.34	X	X			X	
25	2.81			X	X		
26	5.85			X			
27	8.97			X			X
28	7.73				X		X
29	4.2		X				X
30	6.76			X	X		X
31	1.46			X		X	
32	6.19		X	X			
33	2.97	X					X
34	1.12		X				X
35	1.91	X					X
36	11.64		X				X
37	1.95			X		X	
38	4.12		X			X	
39	2.05		X			X	
40	1.51	X				X	

Table B4b. (Con'd)

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
41	1.27	X			X	X	
42	1.18	X			X	X	
43	1.1		X			X	
44	5.78	X	X				
45	3.76	X					X
46	1.3	X	X				X
47	1.38	X	X				X
48	1.36		X	X			X
49	2.38	X	X				X
50	1.1		X				X
51	4.26	X				X	
52	1.97		X	X			X
53	8	X			X		X
54	3.47	X	X				X
55	5.07		X	X			
56	1.25		X				X

Table B4c. Trip #4 to Rochester, NY - Box C.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	5.16		X				X
2	3.71		X				X
3	7.96						X
4	13.67						X
5	2.05		X	X			X
6	2.42						X
7	4.17		X	X			
8	2.74		X	X			
9	1.1		X	X		X	
10	4.64		X	X			
11	1.89			X	X	X	
12	1.15		X	X			X
13	1.46			X	X	X	
14	5.16					X	
15	1.84			X	X	X	
16	1.48			X		X	
17	3.29			X			X
18	4.49		X				
19	3.68			X		X	
20	4.95						X
21	2.53			X	X	X	
22	1.21		X	X			
23	2.11		X	X			
24	19.35						X
25	2.9		X	X			
26	5.98		X	X			X
27	2.34						X
28	4.15		X				X
29	3.04		X				
30	4.43		X	X		X	
31	5.49						X
32	10.81						X
33	5.78			X		X	
34	2.71		X				X
35	38						X
36	4.76						X
37	1.18	X	X				X
38	1.06		X				X
39	3.76			X	X		X
40	3.12		X	X			

Table B4c. (Con'd)

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
41	3.07		X	X			
42	1.21		X		X		
43	2.25	X	X				X
44	2.83	X			X		
45	3.22	X			X		
46	1.22	X			X		
47	3.71	X					
48	4.82				X		X
49	1.95				X		
50	1.67		X	X			X
51	11.08			X	X	X	
52	6.36			X		X	
53	11.64		X	X			
54	5.2		X				
55	9.22			X			X
56	7.27				X		X

Table B4d. Trip #4 to Rochester, NY - Box D.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	2.38				X	X	
2	1.74			X		X	
3	11.41			X	X		X
4	2.32						X
5	1.25						X
6	2.74						X
7	1.65			X			X
8	1.71			X	X		X
9	3.14			X	X		
10	2.4			X	X		
11	1.22			X	X		
12	2.27		X	X			
13	2.36				X		
14	2.05		X	X			X
15	1.3		X	X		X	
16	1.02		X	X			X
17	29.16				X		X
18	1.84		X	X		X	
19	25.39			X	X	X	
20	1.74		X	X			
21	21.55		X	X		X	
22	5.68	X					X
23	6.83				X		X
24	1.12		X	X			X
25	4.38			X		X	
26	4.23						X
27	10						X
28	2.09						X
29	1.4		X	X			X
30	1.15						X
31	1.82		X	X			
32	3.14		X	X		X	
33	1.87		X	X			X
34	1.07			X	X	X	
35	5.42		X	X			X
36	4.01			X		X	
37	2.07				X		X
38	6.22				X		X
39	4.43				X		X
40	24.69		X	X			

Table B4d. Trip #4 to Rochester, NY - Box D.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
41	27.68			X			X
42	1.04		X	X		X	
43	3.12	X			X	X	
44	2.36		X			X	
45	1.22			X	X		X

Table B4e. Trip #4 to Rochester, NY - Box E.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	7.05				X		X
2	11.27		X				X
3	1.41						X
4	1.43						X
5	3.52				X		X
6	2.53				X		X
7	8.85	X			X		
8	29.61			X	X	X	
9	2.38			X	X	X	
10	7.42			X	X		X
11	3.12			X			X
12	6.22			X		X	
13	3.32				X		X
14	9.01		X	X			X
15	23.53	X			X	X	
16	1.27						X
17	8.56			X	X	X	
18	2.19	X	X				
19	1.95		X	X		X	
20	7.31			X	X		X
21	1.99		X				X
22	1.12		X				X
23	1.67						X
24	6.51						X
25	5.58						X
26	29.46			X	X	X	
27	3.63	X				X	
28	3.07						X
29	21.1						X
30	16.87			X		X	
31	10.9			X	X		

Table B5a. Trip #1 to Monterey, CA - Box A.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	4.15					X	
2	5.39			X	X		
3	4.17			X			
4	11.41	X	X				X
5	1.6			X		X	
6	1.78					X	
7	4.43	X			X	X	
8	2.9			X	X		
9	1.64			X		X	
10	1.46			X			
11	1.93			X			X
12	4.09			X	X		X
13	1.22	X	X				
14	8.48				X		
15	3.07			X	X		
16	25.88					X	
17	7.57			X	X		
18	1.71			X	X	X	
19	4.23			X	X		
20	3.24	X	X				
21	3.09				X		X
22	2.13			X	X		
23	5.95			X			
24	29.61		X	X			
25	6.19				X	X	
26	12.51			X	X	X	
27	4.38			X	X		X
28	1.09				X		
29	2.23			X			X
30	2.99		X				
31	3.6		X		X		
32	1.4			X			
33	1.84		X	X			
34	1.86				X		X
35	2.27				X		X
36	2.97			X	X		X
37	2.47			X		X	
38	2.53		X				
39	1.19			X			
40	8.48		X	X		X	

Table B5a. (Con'd)

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
41	21.49			X			X
42	9.27				X	X	
43	6.9			X		X	
44	1.16	X					
45	1.69			X			X

Table B5b. Trip #1 to Monterey, CA - Box B.

Impact #	Height(in.)	Orientation 1	2	3	4	5	6
1	3.29			X	X	X	
2	3.22			X	X		X
3	1.6			X		X	
4	1.15			X		X	
5	10.76	X	X			X	
6	2.69						X
7	3.37			X	X	X	
8	1.56			X		X	
9	1.43	X			X	X	
10	1.25			X			
11	5.26				X	X	
12	1.19	X			X		X
13	2.01		X				
14	1.84			X		X	
15	12.03			X			
16	1.93			X			
17	11.41		X	X			
18	5.68			X			
19	2.51			X			
20	1.64		X	X		X	
21	1.62			X	X		
22	1.1	X				X	
23	1.86			X		X	
24	1.95		X			X	
25	1.15			X	X		
26	1.74	X				X	
27	3.52	X			X		
28	1.16			X			X
29	1.73		X	X			
30	5.92				X		X
31	3.24			X			X
32	1.35		X				X
33	19.35			X			
34	3.42	X				X	
35	10.62				X	X	
36	4.98		X	X			
37	2.4			X	X		

Table B5c. Trip #1 to Monterey, CA - Box C.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	1.65					X	
2	2.45			X	X		
3	1.58			X	X	X	
4	1.06		X	X		X	
5	2.21			X	X		X
6	3.87		X	X			
7	2.38	X	X				
8	18.75				X		
9	7.23		X	X			
10	7.61				X		X
11	7.42		X	X		X	
12	6.97		X			X	
13	16.64			X	X		X
14	1.04				X	X	
15	2.4		X	X		X	
16	1.03	X				X	
17	1.15		X	X			
18	2.32		X				X
19	5.75			X	X	X	
20	5.58			X			X
21	1.74			X	X	X	
22	2.56				X	X	
23	2.47			X	X		X
24	2.95					X	
25	10.49			X			
26	1.33			X		X	
27	1.89			X			X
28	1.38		X	X			
29	1.46			X		X	
30	1.43		X	X			X

Table B5d. Trip #1 to Monterey, CA - Box D.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	5.68			X	X		X
2	1.48			X	X		X
3	3.63			X		X	
4	3.79			X	X		
5	3.27			X			X
6	7.31			X	X		X
7	4.15			X	X		X
8	1.02		X				X
9	1.36		X	X			
10	3.76		X	X		X	
11	1.33			X	X		
12	4.92					X	
13	11.74			X		X	
14	25.81		X	X			
15	4.35	X					X
16	7.69			X		X	
17	7.69			X	X		
18	1.41					X	
19	10.13			X	X		X
20	16.53		X			X	
21	4.03		X			X	
22	1.12		X	X			
23	15.97		X	X		X	
24	2.9		X			X	
25	1.24		X			X	
26	1.36					X	
27	2.03			X		X	
28	1.27		X	X			X

Table B5e. Trip #1 to Monterey, CA - Box E.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	2.74		X	X			X
2	5.26			X	X	X	
3	1.33			X		X	
4	18.03		X	X			
5	4.49			X		X	
6	9.87			X	X	X	
7	10.53			X	X	X	
8	4.88						X
9	3.84			X			X
10	49.08		X	X			
11	30.22			X	X		
12	1.22			X			X
13	21.33			X	X	X	

Table B6a. Trip #2 to Monterey, CA - Box A.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	5.85				X		
2	4.29	X			X		X
3	18.09				X		X
4	18.75			X	X	X	
5	3.55				X		X
6	1.28						X
7	1.21				X		X
8	6.19		X				X
9	1.02				X		X
10	1.48				X		X
11	2.32						X
12	1.38		X				X
13	1.58		X				X
14	11.6	X	X				X
15	2.03				X		X
16	12.51						X
17	1.19			X			X
18	3.37			X			
19	2.42		X				X
20	9.48			X	X		X
21	4.15		X				X
22	3.47	X	X			X	
23	5.62	X					X
24	2.53	X	X			X	
25	4.79		X				X
26	3.04						X
27	5.92		X	X			X
28	1.16				X		X
29	1.19		X				X
30	9.39			X			X
31	1.21				X		X
32	8.81				X		X

Table B6b. Trip #2 to Monterey, CA - Box B.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	4.38				X	X	
2	3.52	X					X
3	1.03				X		X
4	3.34						X
5	1.62	X					X
6	1.22		X			X	
7	3.73			X			
8	1.97		X			X	
9	1.21				X		X
10	1.69			X	X		X
11	1.06			X	X		X
12	1.74			X			
13	1.84			X			X
14	1.21			X			
15	3.47				X		X
16	1.46			X			X
17	1.07		X				
18	7.96		X				
19	2.21		X				X
20	5.82	X	X			X	
21	1.04	X					X
22	26.24					X	
23	4.55						X
24	14.77			X	X		
25	6.65			X			X
26	1.62			X			X
27	1.38						X
28	8.72						X
29	2.53	X	X				X
30	4.03	X			X		
31	1.84	X					
32	1.12			X			
33	6.12				X	X	
34	1.15				X		X
35	9.74	X	X				X
36	3.63	X					
37	1.09	X					X
38	11.88	X	X				X
39	8.16	X	X			X	
40	7.01		X	X			

Table B6b. (Con'd)

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
41	5.62		X			X	
42	2.99				X		
43	17.1		X	X			X
44	2.95	X			X		

Table B6c. Trip #2 to Monterey, CA - Box C.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	2.32		X	X			
2	2.58						X
3	5.75						X
4	1.27			X		X	
5	2.49		X	X		X	
6	4.38			X			X
7	2.32					X	
8	4.98	X			X	X	
9	10.4		X	X			X
10	4.29	X					
11	3.47				X		X
12	32.08		X				X
13	11.93			X	X		
14	1.55						X
15	9.61				X	X	
16	3.65		X			X	
17	5.23		X	X			X
18	1.55			X	X	X	
19	1.51				X		X
20	6.43				X		
21	3.47				X		X

Table B6d. Trip #2 to Monterey, CA - Box D.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	1.36						X
2	4.43		X	X			
3	2.74		X	X		X	
4	22.93			X	X		X
5	11.98						X
6	11.08						X
7	1.36				X		X
8	3.17	X					X
9	2.38				X		X
10	2.34		X	X			
11	1.58						X
12	2.9		X	X			X
13	6.4		X				X
14	3.76	X			X	X	
15	19.91				X	X	
16	1.09	X			X	X	
17	11.41				X		X
18	1.1		X				X
19	16.87		X				X
20	1.06					X	
21	1.16				X		X
22	1.27		X				X
23	3.27				X		X
24	4.85				X		X
25	6.54				X	X	
26	3.22			X		X	

Table B6e. Trip #2 to Monterey, CA - Box E.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	2.88					X	
2	5.45				X		X
3	16.98		X	X		X	
4	1.91			X	X		X
5	4.76			X			X
6	28.79				X		X
7	3.71		X	X			X
8	3.02				X		X
9	2.62			X		X	

Table B7a. Trip #3 to Monterey, CA - Box A.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	1.22		X			X	
2	3.04				X		
3	2.85			X			
4	1.74		X	X			
5	1.58		X	X			
6	3.65			X	X		
7	4.01		X	X			X
8	2.34			X			
9	17.27			X		X	
10	2.64			X			
11	5.95			X			
12	12.12			X			X
13	15.09			X			
14	10.04			X	X		
15	7.5	X					X
16	1.18			X	X		
17	1.71				X		X
18	1.45				X		X
19	13.31					X	
20	2.47		X				X
21	2.3			X			X
22	1.95			X	X		
23	1.1		X	X			
24	1.6		X	X			X
25	2.45			X			
26	1.69			X			
27	2.4			X		X	
28	1.65				X		X
29	1.62	X			X		X
30	1.04		X			X	

Table B7b. Trip #3 to Monterey, CA - Box B.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	5.01			X	X		
2	23.6	X			X		X
3	2.45			X	X		
4	1.07			X			
5	1.19		X	X			
6	1.8		X	X			
7	1.97			X	X	X	
8	21.23		X	X			X
9	13.26			X			
10	1.51		X	X			X
11	1.27			X			X
12	7.65			X			
13	7.84			X	X		
14	1.76			X	X		
15	6.02			X	X	X	
16	17.5	X			X	X	
17	6.22	X				X	
18	45.73					X	
19	1.13					X	
20	14.66	X	X			X	
21	2.13			X			
22	1.02			X	X		
23	11.93	X	X				X
24	2.64	X			X		
25	4.82	X					X
26	1.55			X		X	
27	2.42			X			X
28	4.43			X		X	
29	8.6						X
30	2.15					X	
31	10.71	X					

Table B7c. Trip #3 to Monterey, CA - Box C.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	5.1			X			X
2	4.49		X	X			X
3	1.19			X	X		X
4	2.76			X	X		X
5	7.54			X	X	X	
6	3.42			X			
7	8.85			X	X		X
8	19.35				X	X	
9	10.4			X		X	
10	4.17			X		X	
11	8.56			X		X	
12	1.03	X				X	
13	1.46		X	X		X	
14	1.51			X	X		
15	1.73			X			X
16	2.81			X	X		
17	13.82	X			X	X	
18	1.58			X			X
19	3.87			X			X
20	1.78			X			X

Table B7d. Trip #3 to Monterey, CA - Box D.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	1.36		X	X		X	
2	3.73			X		X	
3	2.78				X	X	
4	3.73		X	X		X	
5	3.09			X	X		
6	6.4			X			
7	20.09					X	
8	3.32				X		X
9	18.99			X	X		
10	1.07		X	X			
11	3.17		X				X
12	17.91	X	X				X
13	12.66	X	X				X
14	1.4						X
15	2.19						X
16	2.76			X		X	
17	2.78		X	X			X
18	18.57			X			X
19	6.16			X	X		
20	1.18					X	
21	23.06			X		X	
22	1.35				X	X	
23	2.67		X	X		X	
24	3.98		X	X		X	
25	13.77				X	X	

Table B7e. Trip #3 to Monterey, CA - Box E.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	12.91			X	X		X
2	11.13				X		X
3	2.81				X		
4	10.35				X	X	
5	7.09		X	X			
6	8.48				X		X
7	2.45						X
8	4.64			X			
9	9.39			X	X		
10	2.9			X		X	
11	3.04	X				X	
12	10.04		X	X			
13	13.98		X	X			
14	21.55			X			X
15	1.84		X	X			X

Table B8a. Trip #4 to Monterey, CA - Box A.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	1.38			X			X
2	1.95						X
3	6.09				X		X
4	3.84				X		X
5	2.71				X		
6	1.04				X		X
7	1.67	X	X				X
8	5.82			X	X		X
9	9.52				X		X
10	2.15		X				X
11	3.9				X		
12	3.68		X	X			X
13	7.92						X
14	9.27						X
15	1.1			X	X		X
16	12.91		X	X		X	
17	1.33						X
18	2.56	X			X		
19	1.31			X			X
20	3.34			X	X		X
21	1.28						X
22	3.42				X		X
23	1.65	X			X		X
24	8.28		X	X		X	
25	3.57				X		X
26	2.3				X		X
27	3.52	X					X
28	1.35						X
29	7.16				X		
30	1.13				X		
31	1.4				X		
32	1.16						X
33	3.47	X					X
34	2.17			X			
35	1.06				X		
36	1.06				X		X

Table B8b. Trip #4 to Monterey, CA - Box B.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	5.49				X		X
2	5.13						X
3	8.85	X			X		X
4	1.56		X	X			X
5	5.16	X	X				X
6	1.13	X	X				X
7	1.02	X	X				X
8	3.81						X
9	3.32						X
10	1.5	X	X				
11	11.46	X			X		X
12	9.14						X
13	3.52				X		
14	5.2			X	X		
15	3.39		X	X			X
16	4.49	X	X				X
17	1.78		X				X
18	1.62						X
19	7.57		X			X	
20	4.49	X					X
21	1.67						X
22	2.11	X					X
23	5.1						X
24	3.95						X
25	13.16				X		X
26	1.91			X		X	
27	1.69			X			X
28	1.41		X				X
29	2.83	X					
30	1.31						X
31	1.69			X			X
32	4.29						X
33	5.1		X				X
34	16.08					X	
35	4.17	X	X			X	

Table B8c. Trip #4 to Monterey, CA - Box C.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	6.36			X		X	
2	1.22		X	X			
3	2.64	X			X		X
4	5.62			X	X		
5	2.56			X	X	X	
6	1.25			X	X		X
7	2.09		X	X			
8	3.27						X
9	11.41						X
10	2.9		X	X			X
11	31.53						X
12	2.95	X					X
13	10.81				X		X
14	10.53			X	X		X
15	1.73				X		X
16	2.4		X				X
17	40		X			X	
18	6.76		X	X			
19	3.22			X			
20	1.38			X	X		
21	1.99			X	X		
22	4.46		X	X			X
23	5.55			X		X	
24	1.93						X
25	8.44						X
26	11.13			X	X	X	
27	3.19				X		
28	3.44						X

Table B8d. Trip #4 to Monterey, CA - Box D.

		Orientation					
Impact #	Height(in.)	1	2	3	4	5	6
1	4.06	X			X		
2	8.2					X	
3	5.42		X	X			
4	1.09						X
5	2.09			X		X	
6	4.58		X	X			X
7	2.27			X	X	X	
8	13.47				X		X
9	4.32				X		
10	6.83				X		
11	12.51						X
12	9.48						X
13	1.21	X			X		X
14	4.46		X			X	
15	4.15					X	
16	3.6			X		X	
17	6.09		X			X	
18	6.47		X	X		X	
19	1.04					X	
20	1.56	X				X	
21	1.55					X	
22	1.24			X	X	X	
23	9.69			X	X	X	
24	14.4				X		X
25	11.93	X		X	X		
26	5.49			X		X	
27	18.99		X				X
28	1.62				X		X
29	1.18				X		X
30	1.31				X		X
31	7.65				X		X
32	1.31			X		X	
33	8.32		X				
34	5.95	X	X				
35	1.07	X			X		X
36	6.76			X	X		X
37	4.15		X				X
38	2.17		X				