



HEAD **IMPACT** TELEMETRY SYSTEM

User Guide

Please review this document thoroughly prior to using the HIT System™.

| *PRELIMINARY COPY*

P/N 02-81011 v 2.2

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FCC Compliance Regulatory Statements

These FCC statements apply to **SIDELINE RECEIVER** and **MxENCODER**:

Compliance Statement (Part 15.19)

The SIDELINE RECEIVER and MxENCODER devices comply with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. These devices may not cause harmful interference, and
2. These devices must accept any interference received, including interference that may cause undesired operation.

Warning (Part 15.21)

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

SIDELINE RECEIVER

RF Exposure (OET Bulletin 65)

To comply with FCC's RF exposure limits for general population / uncontrolled exposure, the antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

MxENCODER

This device and its antenna has shown compliance with FCC's SAR limits for general population / uncontrolled exposure for a portable device. The maximum listed SAR level is 1.27 W/kg (head). The antenna used for this device must not be co-located or operating in conjunction with any other antenna or transmitter.

Industry Canada Statement

The term "IC" before the certification/registration number only signifies that the Industry Canada technical specifications were met.

SIDELINE RECEIVER

Section 5.5 of RSS-210

This device has been designed to operate with an antenna having a maximum gain of 5 dBi using an omni directional antenna. Antenna having a higher gain is strictly prohibited per regulations of Industry Canada. The required antenna impedance is 50 ohms.

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Section 5.11 of RSS-210

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that required for successful communication.

MxENCODER

Section 14 of RSS-210

The installer of this radio equipment must ensure that the antenna is located or pointed such that it does not emit RF field in excess of Health Canada limits for the general population. Consult Safety Code 6, obtainable from Health Canada's website: www.hc-sc.gc.ca/rpb.

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Patents - This product covered by US Patent 6,826,509, other patents pending.

INTRODUCTION

Trainers, coaches and officials of contact sports have long sought to protect players from head injury. But, in hard-hitting sports like football, what can be done? The best equipment, coaching and enforcement of the rules cannot completely protect against mild brain trauma and concussion. Potential injury-producing impacts can go unnoticed and the resulting physiological damage may even be cumulative. Groundbreaking technology developed by Simbex and supported by the National Institutes of Health could change all that. The system is called the Head Impact Telemetry System™ (HIT System™) and is the first device to continuously monitor, analyze and record a player's on-field head impact experience, and which is practical enough to be used in all game and practice situations.

The HIT System not only monitors and records the impact history for all players simultaneously, but also can signal the sidelines staff to the occurrence of an impact that conforms to a Suspect Impact Profile™. The system monitors standard impact measures, such as maximum g's, Head Impact Criteria (HIC), and Gadd Severity Index (GSI), or customized metrics based on any of the following components:

- Impact location
- Impact magnitude
- Impact duration
- Linear and angular acceleration components
- And the exact times,

of single or multiple impacts for improved player protection from serious injury.

About Simbex –

“Simply Better Exercise”

The Head Impact Telemetry System has been developed and patented by Simbex. Simbex has been researching, testing and creating products that benefit active people since its inception. Simbex is a research and product development company, specializing in biomechanical feedback systems, with research awards from the National Institutes of Health and the National Science Foundation. Our goal is to bring to market

the most innovative products and timely solutions for “active life improvement” in the areas of prosthetics, rehabilitation, and injury prevention.

It is our sincere hope that Simbex, our research / development partners and this technology will combine to make contact sports safer for all players.

For more information, please visit us on the web @ www.simbex.com.

The Basics

Please read this User’s Guide completely before set-up and use of the HIT System. If you need assistance with your first use of the system, please call Simbex Technical Support at the number listed in the CONTACT INFORMATION section.

The HIT System™ is comprised of four main systems: the MXEncoders, the Sideline Receiver, the Alert Pager, and the Computer. The Sideline Receiver, Alert Pager, and Computer are all stored within a protective Field Case. The MX Encoders are installed inside Riddell VSR-4 and Revolution football helmets, measure impacts as they occur on the field, and transmit impact data to the Sideline Receiver. The Sideline Receiver manages impact information recorded by the MXEncoders and relays it to the Computer, where the data is processed, analyzed, and stored. When impacts matching user selectable Suspect Impact Profiles (SIP’s) are received, the Alert Pager System sends a signal to the Alert Beeper, signaling sideline staff that a SIP has occurred.



Figure 1: The HIT System™ (Alert Pager not shown)

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When the HIT System™ is initially received, the MXEncoders must be installed in helmets and all system batteries must be charged. Once these two steps are complete, the HIT System™ is ready to be setup out on the field and begin recording impacts.

INITIAL SETUP

Field Case

The HIT System™ is supplied within a protective field case, designed to make the HIT System™ easy to use on and off the field, provide convenient storage for all system components, and protect HIT System™ electronics from adverse weather conditions. Upon opening the field case, the laptop computer, the Sideline Receiver, and the Sideline Receiver Stand are visible. The Alert Pager is stored in a compartment beneath the computer. Access to this compartment is gained by removing the panel underneath the computer, although this is not necessary during normal use conditions.

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The field case is factory configured with internal power outlets and data transfer connections (Figure 2). Power is provided to the case via an external plug (power entry module); when the case has been connected to a 120V source the Alert Pager and power supply for the computer are automatically energized. Spare 5A fuses for the field case power entry module may be found in the bottom of the field case. The case also has an external data port used to relay information from the Sideline Receiver to the computer.

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A Sideline Receiver antenna mast is included in the Field Case. The antenna mast mounts directly to the left side of the field case by inserting the antenna base into the notched key holes. The antenna is mounted onto the Sideline Receiver by inserting the antenna base into the Sideline Receiver antenna jack. For optimal range, the mid-shaft of the Sideline Receiver antenna should be mounted 5 feet from the ground.

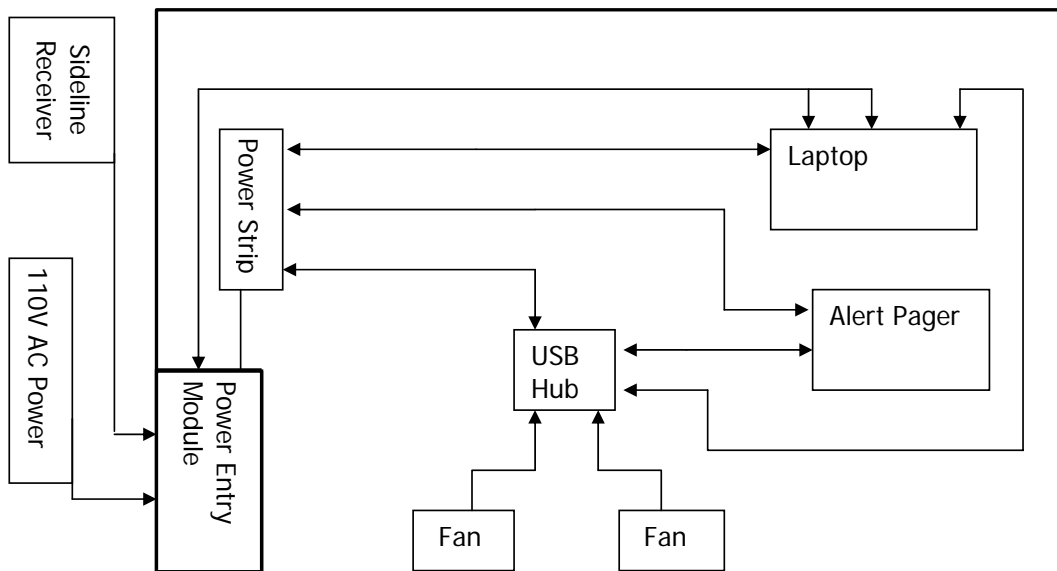
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The computer is supplied installed inside the field case; the computer and its power are connected to the internal power strip of the field case. Connecting the field case to external power will initiate charging of the computer batteries. **Allow 8 hours** to completely **charge the computer batteries before first use** of the HIT System. If the laptop has been subsequently removed from the field case, it will be necessary to ensure the computer is connected to its power supply.

Figure 2: Field Case Wiring Diagram



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Battery Charger Case

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The HIT System™ **MXEncoder** is powered by **rechargeable batteries**, which must receive a **complete charge prior to first use**. It is also recommended that all batteries receive a full charge prior to each subsequent use. Charging of the batteries may be accomplished by:

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1. **Connect MXEncoder batteries** to the chargers located in the charger case, and position the batteries in the cutout next to each charger. Up to 4 batteries may be connected to each charger. Depending on configuration, each charger case may charge up to 24 batteries.
2. Once all connections have been made, **connect the charger case with external power**.
3. **Confirm** that batteries are charging; **red LED indicators** on each charger will **light** when the charger is operating. (It is necessary to lift the chargers on one side of the case from their nest to confirm LED status.)
4. Allow 8 hours to charge fully.



Figure 3: Charger Case

Important:

1. **Connect all batteries** to be charged **at the beginning of the charge cycle**. The chargers operate on a timed 8-hour cycle; the cycle begins when the first battery is connected to a charger that has power, or when a charger that has batteries connected is plugged into external power. The charger first drains the batteries fully, then charges them fully each cycle. Batteries that are connected to the charger mid-way through the charge cycle **will not** receive a full charge.
2. **Do not close** the charger case **lid while charging**.

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3. The battery-type selector switch on the chargers has been disabled; the **charger may only** be used to **charge NiMH-type batteries** that are supplied with the HIT System.

MXEncoder Installation

The MXEncoders (P/N 02-23000) are designed specifically to fit Riddell model VSR-4 size Large helmets. To ensure player safety and proper measurement performance, please consult with Simbex prior to using the MXEncoder in other helmet applications.

To install MXEncoders in each helmet:

1. **Remove** the thin layer of **padding (G)** from between the Top Pad (A & B) and the Temple Pads (H).
2. **Separate** the two large **Velcro strips** which are **attached to the back of the MXEncoder**. Remove the adhesive backings from the loop side and **adhere to inside of the helmet** where pads (G) were just removed.
3. Flip the Forehead Pad (D) up and out of the helmet.
4. Detach Temple Pads (H) and lift up. **Install MXEncoder**, one side at a time, and **position to be symmetrical** about the centerline of the helmet. Replace the Temple Pads (H).
5. Replace the Forehead Pad (D).



Figure 3: Pad Diagram for Riddell VSR-4 Helmet



Figure 4: Helmet w/ Forehead Pad removed, Velcro



Figure 6: Completed MX Encoder Installation

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PRE-GAME SETUP

Configuration and setup of the HIT System is easily completed in about 10 minutes prior to the beginning of play each day. Setup may be completed by accomplishing the following steps:

HIT System Setup

1. Remove the Sideline Receiver and Sideline Receiver Stand from the Field Case.
2. Unlock the clamps on the Sideline Receiver Stand, fully extend the telescoping stand legs, and lock the clamps in place.
3. Slide the keyhole plate on the bottom of the Sideline Receiver Stand over the posts on the left side of the Field Case and lock in place.
4. Screw the Sideline Receiver onto top of Sideline Receiver Stand. **Adjust height** so that the **base of Sideline Unit** is approximately **5 feet above the ground**.
5. Connect the Sideline Receiver Cable to the Data Port on the **outside** of the Field Case.
6. Connect the Field Case to a 120V source.



Important: The HIT System Computer and Sideline Receiver will operate for ~3 hours on the computer battery if fully charged. The **Alert Pager will not operate unless** the field case is **connected to a 120V source** on the field. For best results, it is recommended to have a 120V source connected to the HIT System at all times during use.

Software Initialization

1. Turn on the computer by pressing the power button located centrally above the keyboard.
2. Login to the HITS User Profile: Click on HIT System → (Leave the Password field blank) → Enter.
3. Run the HITS™ Software by clicking on the HITS™ Software icon either on the desktop or in the Start → Programs → Head Impact Telemetry System.



4. When the HITS™ Software loads, the ON light (green LED) on the bottom of the Sideline Receiver begins to blink, indicating that the system is functioning.

Important: For best results, the Sideline Receiver and Software should be setup and run first, which will allow verification that MXEncoder communication with the Sideline Receiver has been properly established as the MXEncoders are brought online. Connecting the batteries to the MXEncoders effectively turns them on; each time they are turned on they must receive configuration instruction from the Sideline Receiver. MXEncoders are properly configured and communicating with the Sideline Receiver when the Player Circles turn from red to green upon initial startup. Once this occurs, the players are ready to measure and record impacts to the onboard memory. During a practice or game, MXEncoders may periodically lose communication with the Sideline Receiver. Once communication is reestablished with the Sideline Receiver, all available impacts are downloaded to the computer and saved. In the unlikely event that communication is not re-established, up to 100 impacts will be stored onboard the MXEncoder. These impact data will be stored until they are successfully downloaded to the Sideline Receiver; data integrity will be preserved if power is lost to the MXEncoder (i.e. battery change).

MXEncoder Battery Pack Installation

The MXEncoder Battery Packs need to be installed into the helmets prior to each use.

1. Hold open the MX Encoder Velcro straps and **place battery pack** in the gap **between straps** with the Velcro patch facing towards you.
2. the MX Encoder. **Position the connector between the battery pack and the helmet pads.**
3. **Close Velcro straps** over the battery pack and connector **to secure** in place.



Figure 7: Battery Pack Installed



Important: **Low MX Encoder battery power** is indicated in the software when the corresponding **player circle turns** from green to **yellow**. The **MX Encoders will continue to function normally for 1-2 hours** in this condition; the player circle will turn red when battery power is lost. Any impact data recorded but not yet downloaded when power is lost will be preserved until power is regained and data can be downloaded.

Once these simple steps have been taken, the HIT System™ is ready to record impacts. Put on the helmets and play ball. The HITS System™ will keep a detailed record of each impact recorded.

SOFTWARE GUIDE

While the HITS™ Software is running, it is continuously downloading, processing, and saving all available impacts from configured MXEncoders. The software has two operational modes, Real-Time Mode and History Mode. Real-Time Mode displays the most current impact information on the field as it is received, while History Mode allows the user to review the daily impact history for any single player.

Layout

The HITS™ Software loads in Real-Time Mode and brings up the main control window, shown in Figure 8 below.

The player list shows numbers that correspond to the specific hardware identification numbers of the MX Encoders in each helmet. This list may be customized (i.e. to show numbers corresponding to the actual player number) by editing the **team.ini** file, found in **C:/Program Files/Simbex HITS**. The format of the team.ini file is as follows:

```
[TEAM NAME]
PlayerNum HWUnit
1,301
18,318
17,317
23,323
24,324
```

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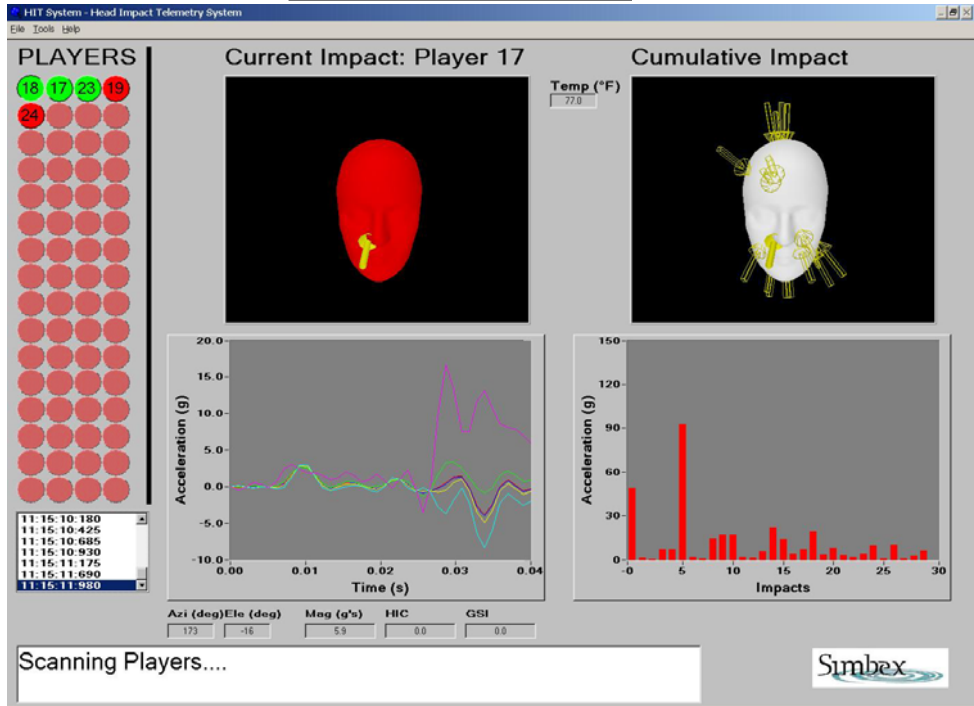
The name inside the brackets may be edited; this is the team name that appears in exported data files. The first number of the two number string is the number that will appear in the player circle; these numbers must be unique, are limited to two digits in length, and numbers 1-9 must be expressed as "1", as opposed to "01". The second number is the hardware address of the MX encoder corresponding to that player, and should not be changed. Under no circumstances should any other .ini files be edited as this may cause a serious system malfunction.

Figure 8: HITS™ Software – Real-Time Mode

Command Menu –
 Access functional commands: Export, Exit, Configure Team (not currently available), Frequency Auto-Set, Frequency Manual Set, Help Contents and About

Current Impact – An arrow points to the location on the head where the last impact was received. In Real-Time Mode, the last impact received is shown. In History Mode, the impact highlighted from the Past Hits List is shown. Below the head is a plot of the acceleration magnitude of each individual sensor in color; cumulative CG acceleration is shown in black.

Cumulative Impact – Arrows point to the location on the head of each the impact received. In Real-Time Mode, every hit from that day is shown. In History Mode, all of the impacts from that day of the highlighted player are shown. Below the head is a bar graph with the maximum CG acceleration of each impact.



Player List – Each numbered circle represents a player. When the circle is green, there is clear communication with that player. When the circle is red, that communication is not established. In the event of no communication, MX Encoders will continue to collect data (up to 120 impacts).

Status Bar – Displays messages regarding the current status of the application.

Temperature – Displays the temperature inside the helmet of the last impact received.

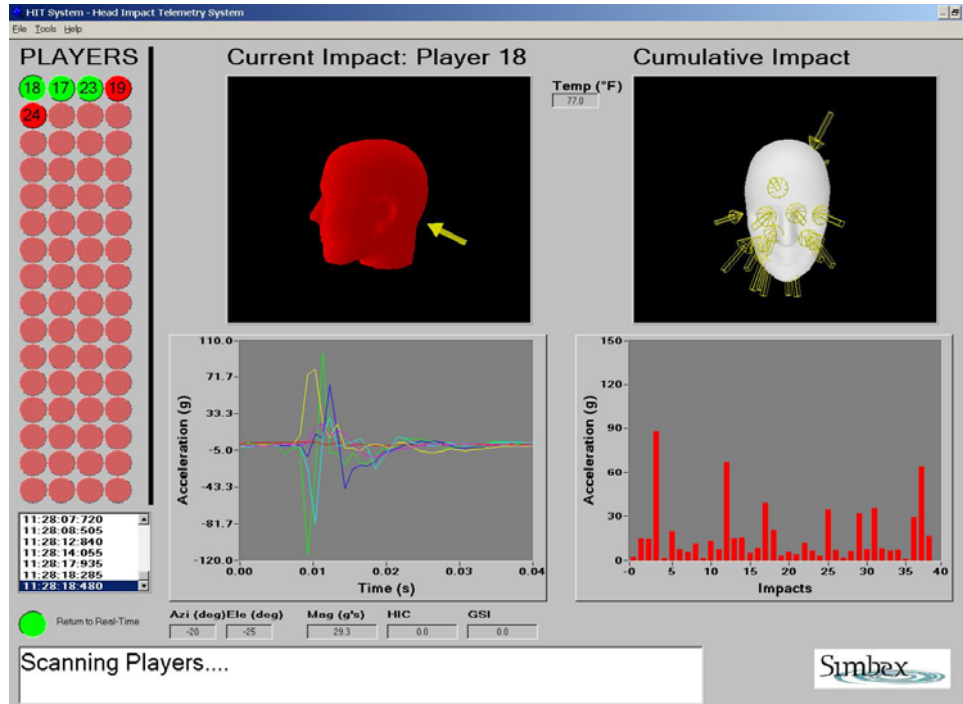
Past Hits List – A list of all of the impacts received by the highlighted player that day. Each hit is labeled with the time of occurrence. (HH:MM:SS:mSec)

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Figure 9: HITS™ Software History Mode

To enter **History Mode** click on **any player circle** from the **player list**. If impact data are available for that day, the Past Hits List is filled with the timestamp corresponding to each impact. Double clicking on any timestamp will display the data for that impact. In History Mode, MXEncoder data are still downloaded, processed, and saved in the background. Click the **Return to Real-Time** button to return to real time mode

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Software Use

Once the software is up and running, it will continuously record all impacts. The most recent impact will show in the Last Impact window with an arrow pointer to the location on the head where the impact was received. The green button corresponding to the player who received the impact will appear depressed, indicating that this player was the recipient of the impact displayed on the screen. The headforms in both display windows can be manipulated using the mouse and keyboard:

- **Left-click & drag** to **rotate** the headform about its CG
- **Shift-Left-click & drag** to **translate** the headform in any direction
- **Ctrl-Left-click & drag** to **Zoom-In** or **Zoom-Out**

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All of the current day's impacts are displayed in the Cumulative Impact window, with a bar chart below displaying the magnitude of each. These data are associated with the Current Impact player number. To examine a specific impact that an individual player has experienced, click on the player's circle in the Player List to enter History Mode. All of that player's impacts for the day will be shown in the Cumulative Impacts window. In addition, a list of the impacts labeled with the time (HH:MM:SS:mSec) at which the impact occurred will be displayed in the Past Impacts List window. Double click on a specific impact in the Past Impacts List window to examine the details of that impact. To return to Real-Time Mode, click on the "Return to Real-Time" button.

The Alarm Pager alerts the sideline staff if an impact or temperature event exceeds a pre-defined threshold. Impact and temperature thresholds can be modified in the **Beeper.ini** file – these thresholds will be applied to all MXEncoders. Alert messages received by the pager have a simple format of "Player xx: Message type Event Value" where Message type will either be Impact **Thres**, **Temp Thres**, or **Crit Temp** and Event Value is the value associated with the alarm. Crit Temp is the temperature of the MXEncoder that is 3 deg above the standard Temp Thres. Use **Test Event Beeper** under the Tools menu item on the menu bar to test the Alarm Transmitter and Pager. Once executed, a simple message (Player 0: FALSE ALARM 0.0) should be received by the Alarm Pager within 5 secs.

The **Impact Qualification** menu option is used to activate/deactivate a neural-network based algorithm to determine whether impacts are valid or invalid. The impact qualification only takes place on data that is being sent to the Alert Pager to minimize the occurrence of false impacts. The algorithm was developed using data collected by Virginia Tech during the 2003 season. As more data are collected and analyzed, the algorithm will get better. There may be times throughout the season where we may need to upgrade the algorithm to provide a better service to our users.

In the unlikely event of wireless communication failure, impact data are still recorded onboard the MXEncoder and can be retrieved later in an environment with "cleaner" air.

The data are stored on the MXEncoder in non-volatile memory and won't be erased until instructed to by the HITS Software.

Communication between the MXEncoder and Sideline Receiver is sensitive to environmental noise (i.e. other devices operating in the ISM band). The communication link between the MXEncoder and Sideline Receiver is designed to be frequency agile, automatically switching between various frequencies to avoid any interference. The HIT System operates in the FCC unlicensed ISM band (902-928 MHz). Typical range is expected to be ≤ 150 yards.

Data Analysis

A detailed CG (Center of Gravity) time series for any single impact may be exported to an ASCII text file for further data analysis:

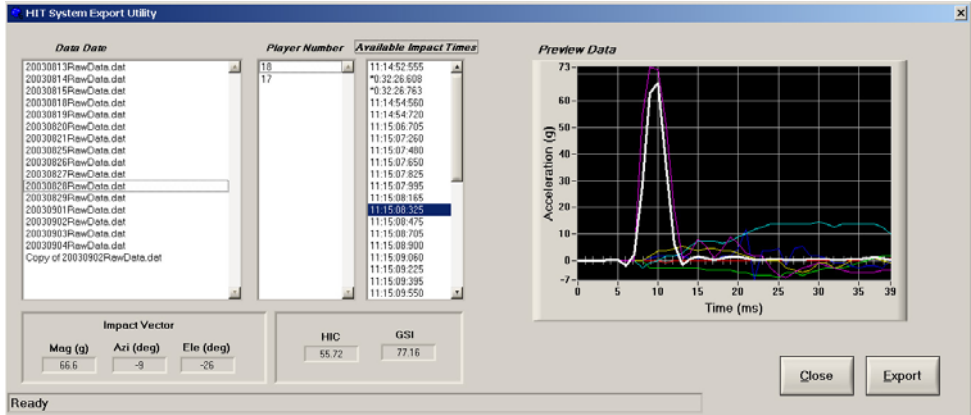
1. Select the Export command under the File Menu. This will bring up an Export dialog box (Figure 10).
2. Select the date on which the impact occurred, the player number and the impact ID number (which is the time the impact occurred). Once the specific impact is highlighted, a graph of the raw data will appear. A few moments later the processed CG time series will appear in the graph window as a thick white line. The impact vector (magnitude, azimuth, and elevation direction) are detailed in the Impact Vector text boxes. Head Impact Criterion (HIC) and Gadd Severity Index (GSI) metrics will also be illustrated. Note that these metrics are calculated using Simbex chosen metric parameters; only the CG time series is exported to the data file. The exported CG time series data should be used with the user's preferred algorithms to calculate metric measures.
3. Once the desired impact has been chosen, press the Export button, which will bring up a Save As dialog box.

NOTE: Qualification of impact data is not supported in this feature and may be included in future releases. All impact data are currently available.

4. Save the file in the desired location. The exported ASCII data file will contain a header with impact information (date, time, player number, impact vector, and

CG time series). This file is tab delimited and can be easily read into commonly used analysis programs.

Figure 10: Export Dialog Box



POST-GAME BREAKDOWN

When practice session or the game is over, breakdown and storage of the HIT System is easily and quickly accomplished by completing the following steps:

1. Exit the HITS™ Software by clicking on the Exit command in the File menu.
2. Shut down the laptop computer.
3. Disconnect the Field Case from 120V source and store cord in the space behind the computer.
4. Unplug the Sideline Receiver Cable from the Field Case and unscrew the Sideline Receiver from the Sideline Receiver Stand.
5. Collapse the Sideline Receiver Stand and return to the Field Case.
6. Return the Sideline Receiver to the Field Case.
7. Bring the Field Case inside and using the extension cord, plug it into a wall outlet. Ensure that the computer charging light is on, then close and lock the Field Case.
8. Remove all of the batteries from the helmets and connect them to the chargers within the Charger Case. Follow instructions for battery charging above.

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MAINTENANCE

Periodically impact data will need to be downloaded to the Simbex Network, and updates to the HITS™ Software may be released. The Simbex Technical Support team will perform these services by remotely accessing the Laptop Computer. In order to do this, the Laptop Computer will need to be connected to the World Wide Web and its IP address will need to be supplied to Simbex Technical Support.

TROUBLESHOOTING

∇ HITS™ Software will not load.

- Corrective Action:
 - Call Simbex Technical Support.

∇ HITS™ Software “Does not detect a Sideline Unit.”

- Corrective Actions:
 - Check that all of the serial cable connections are firmly connected.
 - Close the software and restart it.
 - If that fails to work, the batteries in the sideline unit may be dead. Try recharging the Sideline Unit.
 - If the HITS™ Software still “Does not detect a Sideline Unit,” call Simbex Technical Support.

∇ HITS™ Software does not recognize a specific Helmet Unit.

- Corrective Actions:
 - Unplug the helmet battery. Wait 5 seconds. Plug battery back in.
 - If that fails to work, call Simbex Technical Support.

∇ Battery or antenna cables come loose.

- Corrective Actions:
 - Contact Simbex Technical Support for replacement parts.

Contact Information

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