

Preliminary Design Review

Team RCA
October 15, 2012



RCA (Real-Time Concussion Analyzer)



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Concussion Detection in High School Football



- Current concussion detection
 - Train coaches to recognize symptoms

- Players may hide or not experience symptoms right away

How significant is the problem?

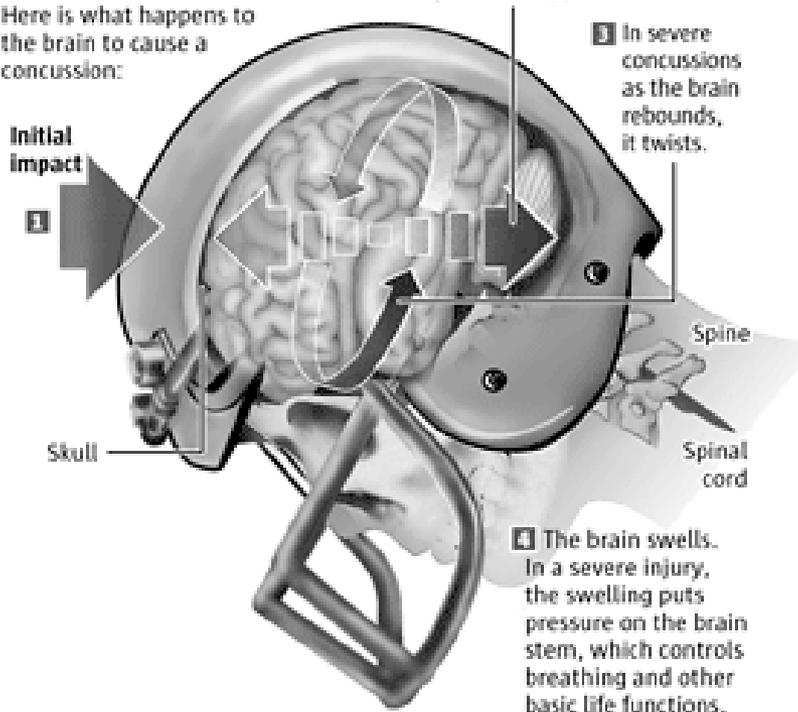
- 1.6 – 3.8 million sports-related concussions in the United states every year
 - Have reached “epidemic level”

- Not only professionals
 - Young people ages 15 – 24 years
 - Second leading cause of TBI (Traumatic Brain Injury)

Context: Effect on Individuals

Anatomy of a concussion

Here is what happens to the brain to cause a concussion:



Sources: Dr. Jay Rosenberg of Kaiser Permanente Medical Care Neurology; American Academy of Neurology; The Human Body

MARK NOWLIN / THE SEATTLE TIMES

■ Post Concussion Syndrome

- Problems concentrating, irritability, sensitivity to light...

■ If gone undiagnosed

- One hit away from traumatic brain injury
- Multiple impacts add up

Context: Effect on Groups

- Affects team sports and the way they're played
- "Tough guy attitude"
 - Creates a culture
- Subjective decision making

Requirements Analysis: Specifications

- Real-Time continuous impact measurements
- Player specific adaptability
- Equipment weight increase less than 5%
- Effective range 150 m
- Responds in under two seconds
- Robust
 - Interference
 - Durable

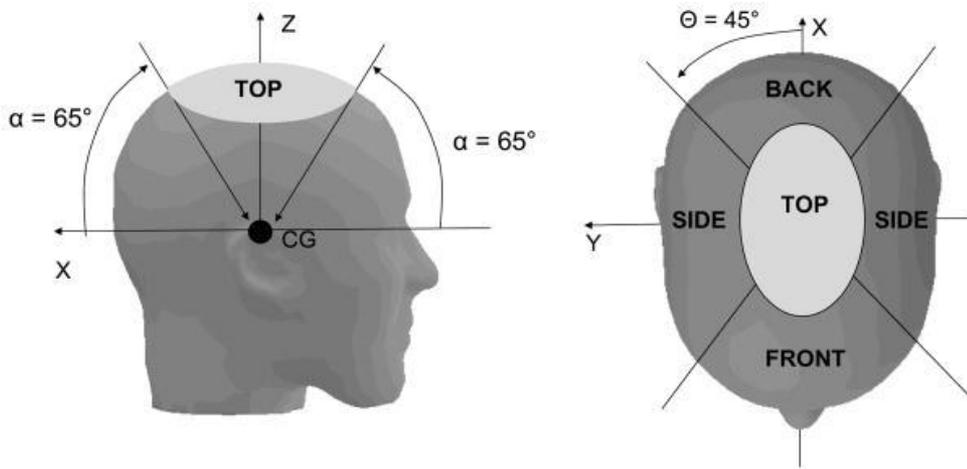
Requirements Analysis: Inputs and Outputs

- Input
 - Impact data

- Output
 - Likelihood of concussion
 - Access to archived impact data

Design Alternatives

- HITS – Head Impact Telemetry System †
 - Six accelerometers
 - Frequency, location, and magnitude
 - Sideline response system
 - Linear acceleration

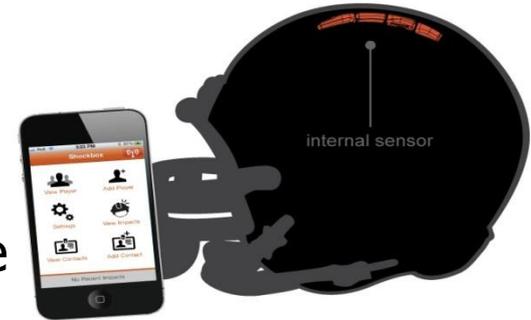


†Measuring Head Kinematics in Football: Correlation Between the Head Impact Telemetry System and Hybrid III Headform. Beckwith, Jonathan, Jeffrey Chu, and Richard Greenwald. October 13th 2011

Design Alternatives

■ ShockBox

- *Impakt Protective*
- Commercial use for football/hockey
- Secured with high adhesive bonding tape
- Wireless transmission
- Threshold of 50 g set by app



■ HEADS

- *BAE Systems*
- Military use
- Suspended beneath the crown of the helmet
- Wireless/USB transmission
- Processing done by computer at base

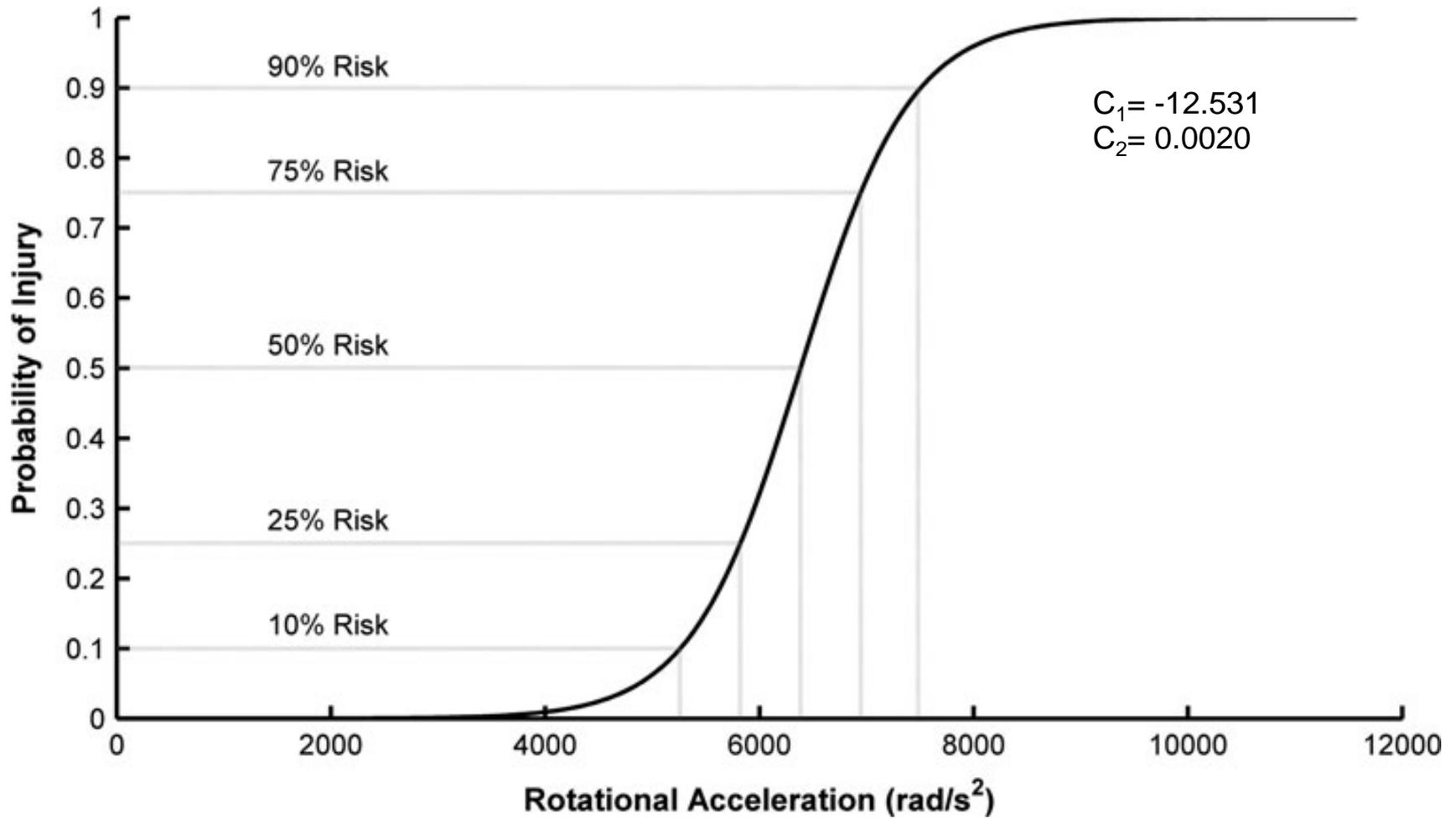


From Impact to Probability

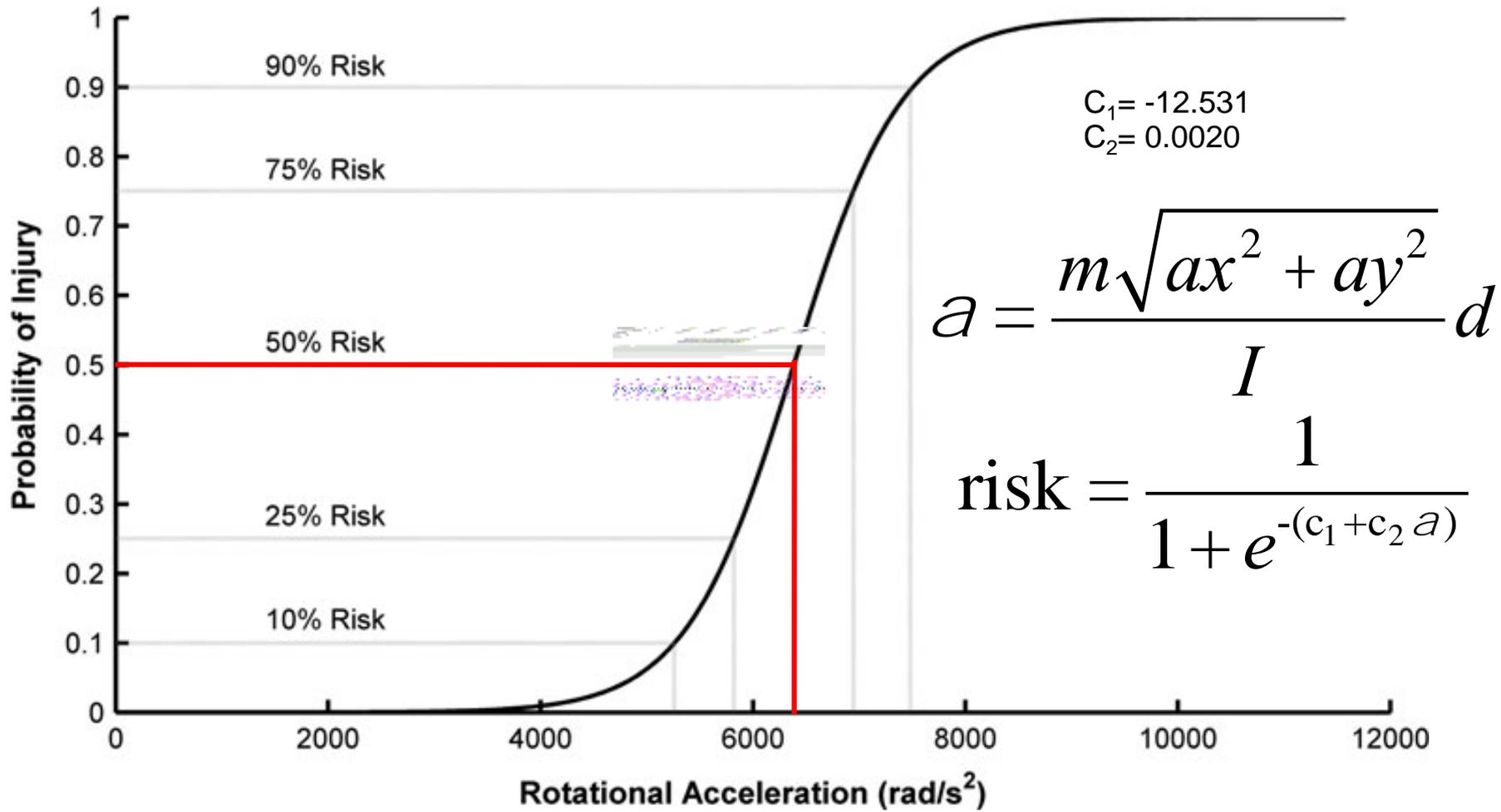
- "Rotational Head Kinematics in Football Impacts: An Injury Risk Function for Concussion"
 - S. Rowson *et al.* *Annals of Biomedical Engineering*, Vol. 40, No. 1, January 2012
- Rotational acceleration is important

$$\text{risk} = \frac{1}{1 + e^{-(c_1 + c_2 a)}}$$

Risk Function



Risk Function



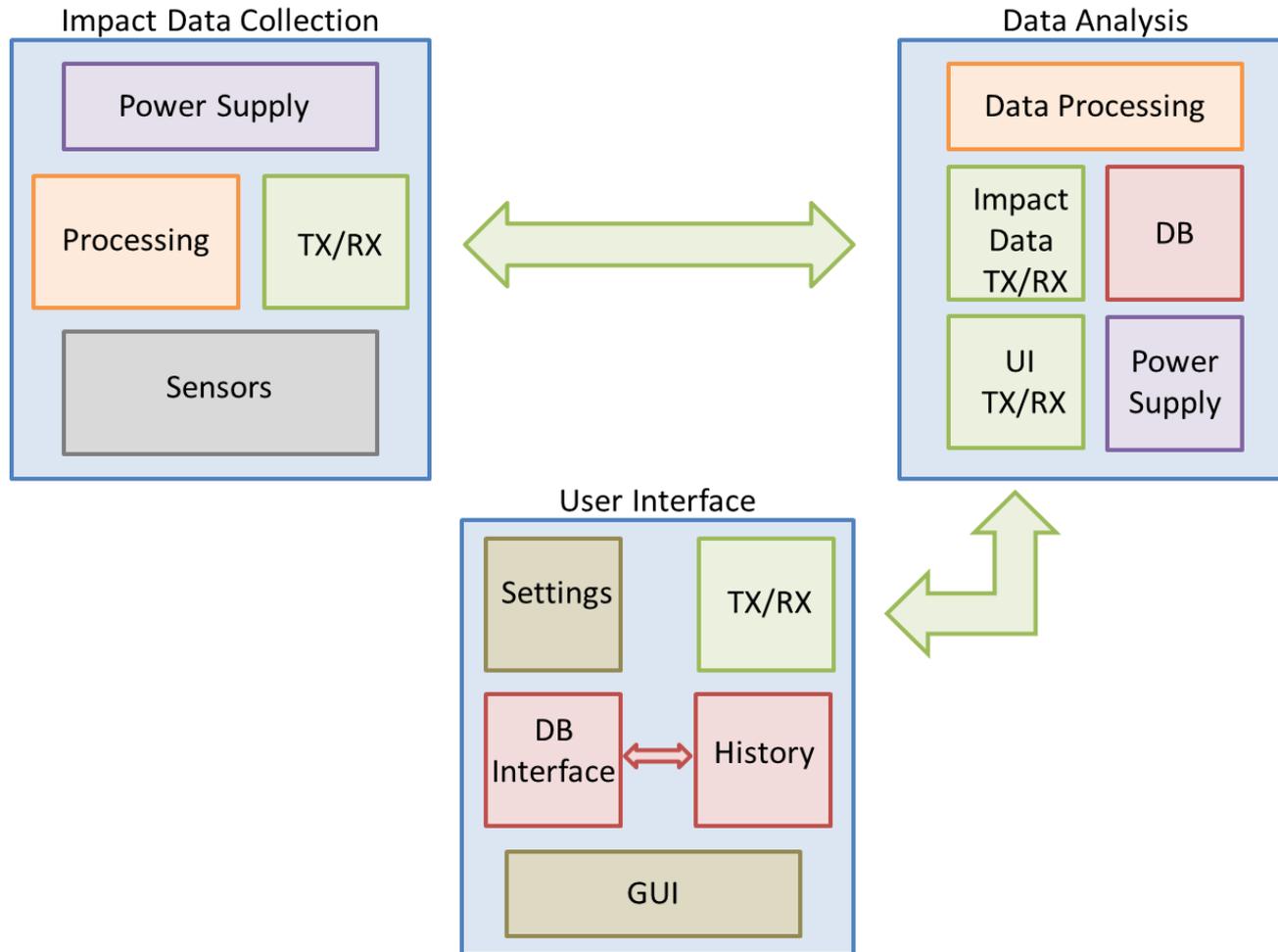
Our Solution: RCA

- Array of sensors in helmet padding
 - Continuous measurements
 - Variable impact thresholds
 - Wireless transmit on threshold trigger
- Base station
 - Database: Impact data & medical history
 - Concussion algorithm
 - Wireless transmit to UI & triggered helmet
- UI
 - Android device
 - Easy to interpret results within two seconds of impact

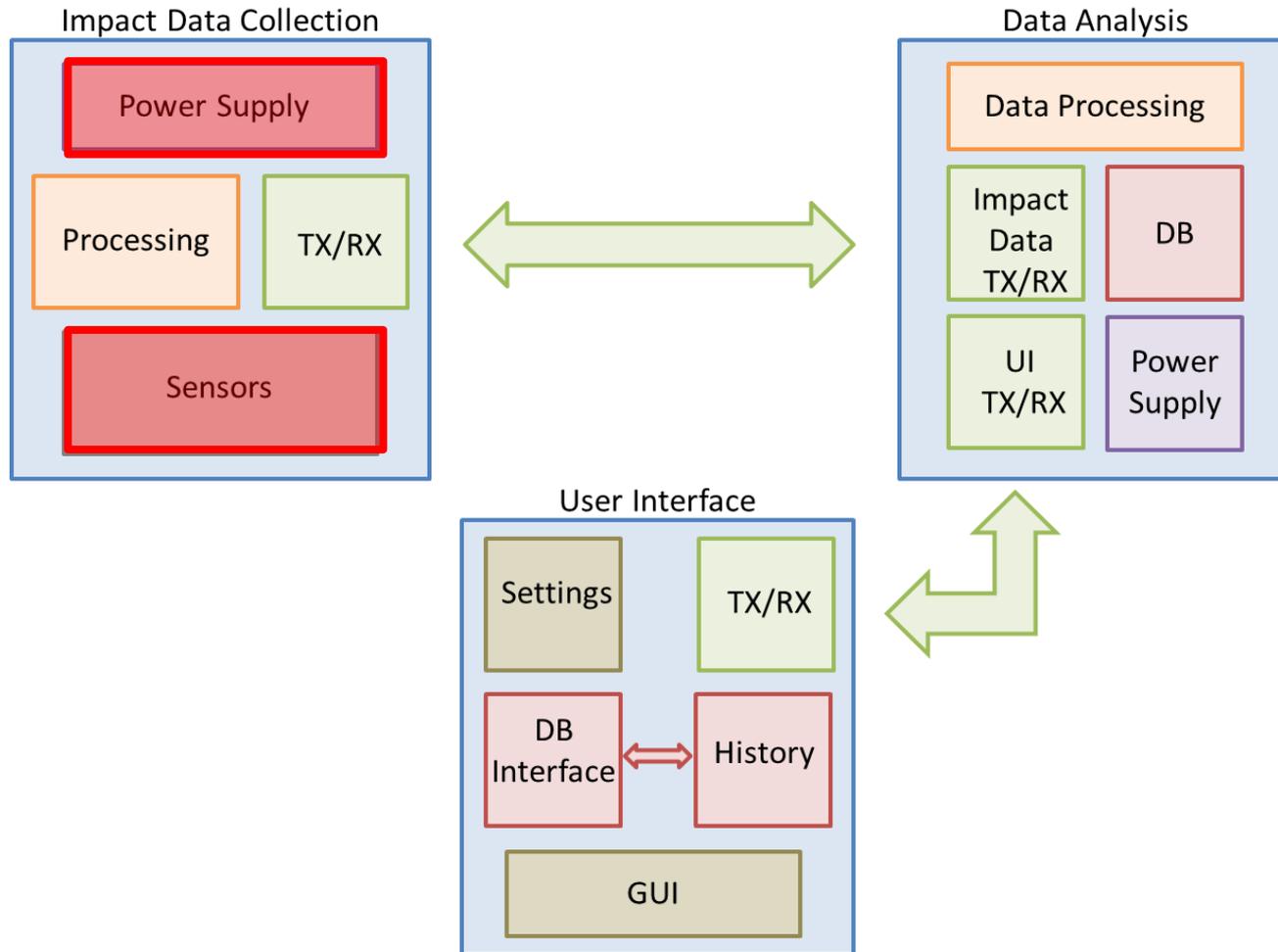
Our Solution: RCA

- Array of **sensors** in helmet padding
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Our Solution: Block Diagram



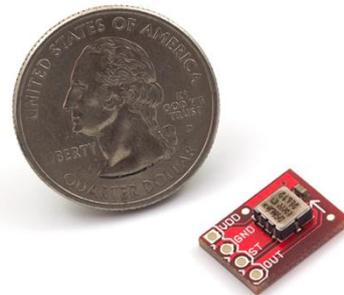
Sensor Network



Sensors

■ Requirements

- Accurate
- Response time under 100 ms
- Low power
- Lightweight and secured safely
 - Players should not notice sensors



■ Implementation

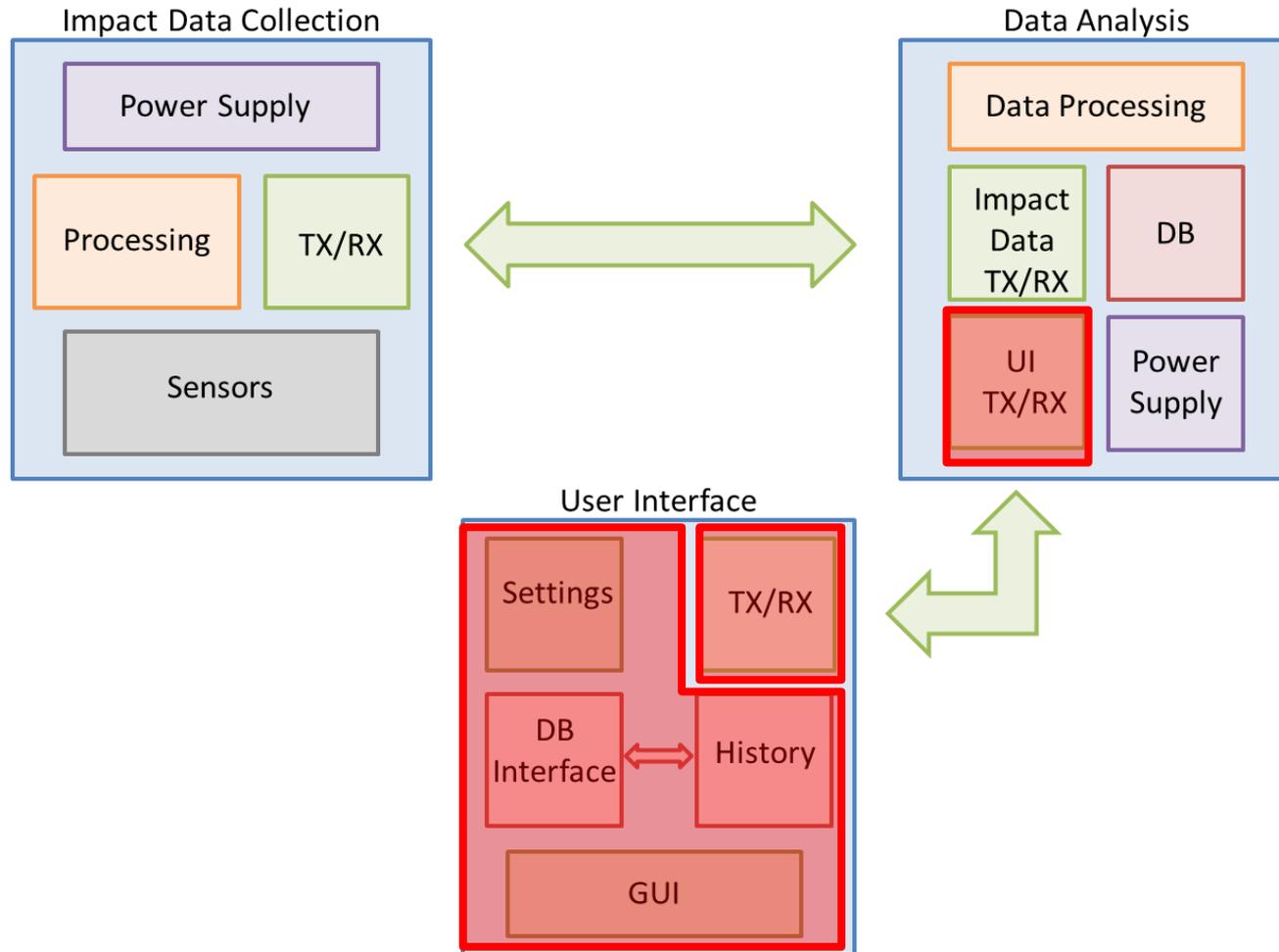
- Accelerometers, Gyroscope
- Successful Senior Design Projects
 - Motion Analyzer for Physical Therapy (2010) for Accelerometers
 - Personal Head-Up Display (2009) for Gyroscope

Power

- Requirements
 - 3.5 – 6 V in helmet
 - Safe, reliable and lightweight
 - Up to five hour run time

- Experience
 - Power supplies
 - Design experience in previous coursework
 - Theater design project

User Interface and Communication



UI

- Requirements
 - Easy to use
 - Deliver meaningful results
 - Medical staff
 - Coaching staff

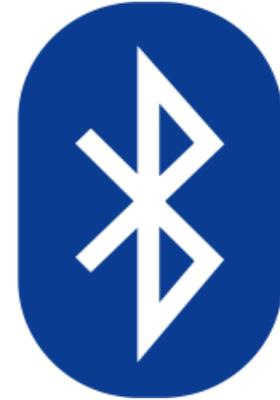
- Implementation
 - Android Development



Tx/Rx for UI

■ Requirements

- Reliable
- Response time under 500 ms
- Easy to implement

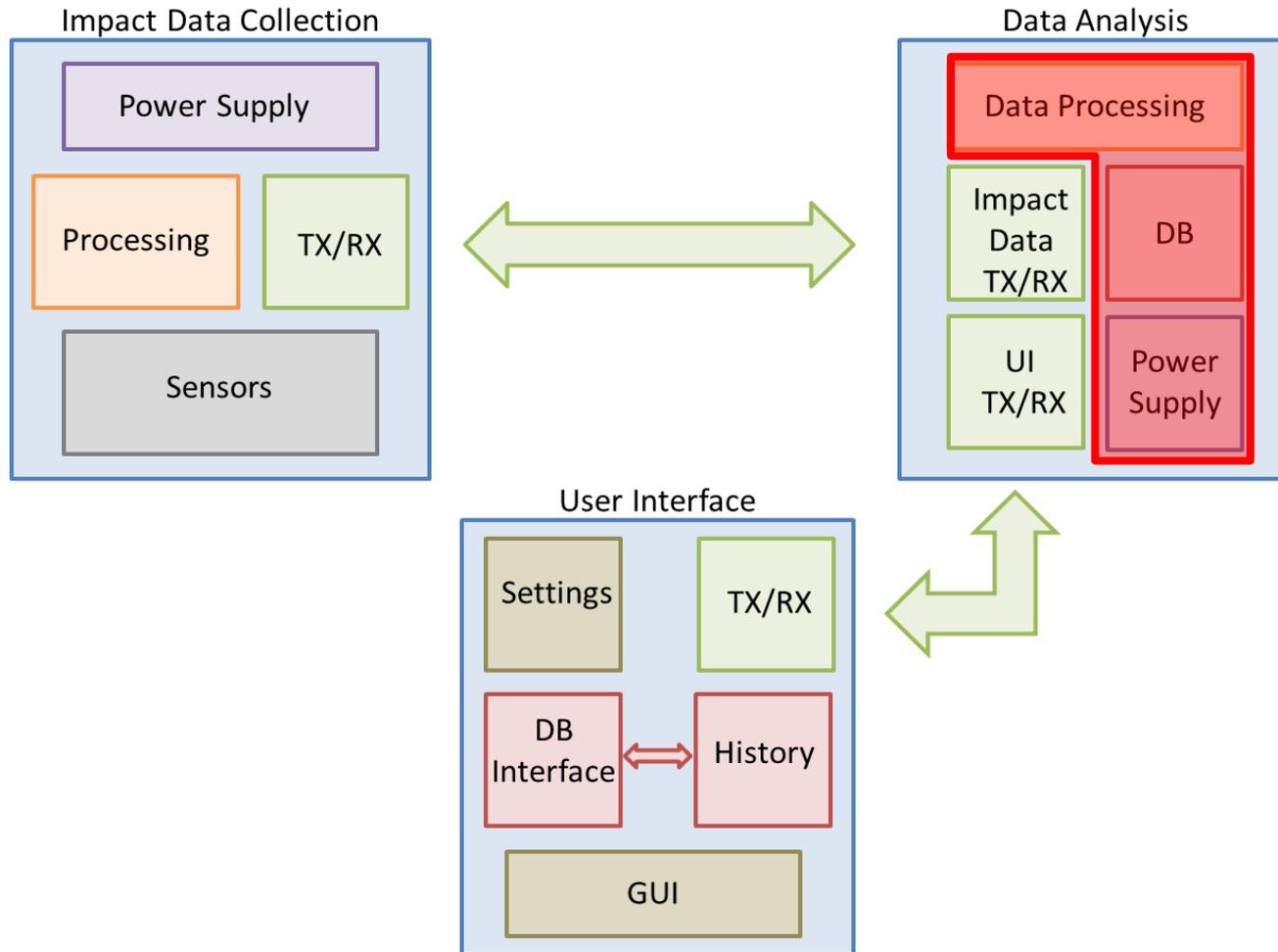


■ Implementation

- Android WiFi/ Bluetooth Integration
- Successful Senior Design Projects
 - BlueTag (2010) for Bluetooth
 - UMass Campus View (2010) for WiFi



Data Processing and Storage

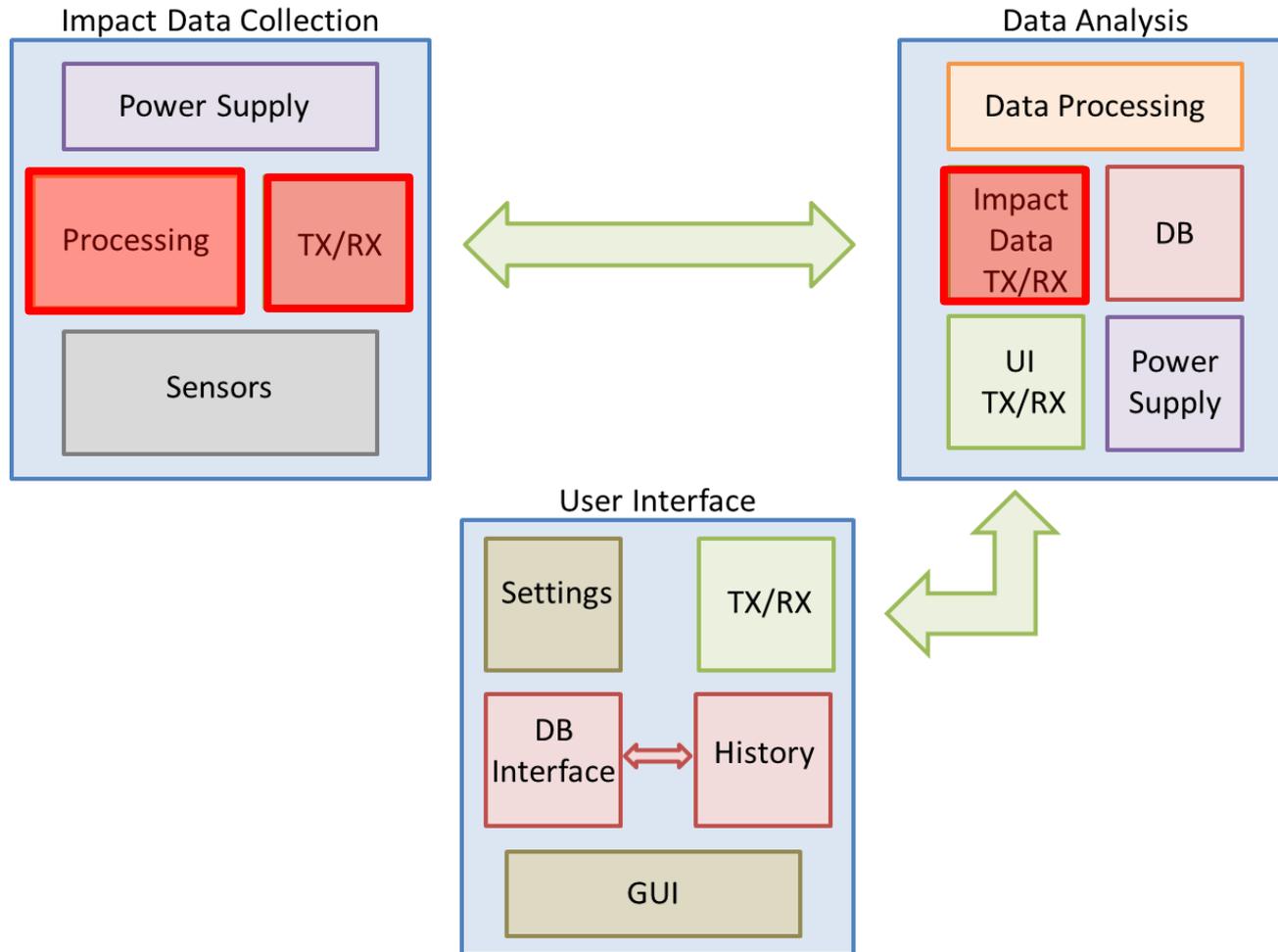


Data Processing and Storage

- Requirements
 - Calculates rotational acceleration
 - Determines probability of concussion
 - Output within 500 ms
 - Store all impact data efficiently

- Experience
 - Software development for Bose
 - Data organization and analysis algorithm development for ECM

Impact Processing and Communication



Impact Processing

- Requirements
 - Low power and lightweight
 - Inputs for at least 7 sensors
 - Tx/Rx Capable
 - Flash memory

- Experience
 - ATmega Microcontroller
 - Used in ECE 353
 - LED Cube



Impact Data Tx/Rx

■ Requirements

- Low power and lightweight
- Effective range up to 150 m
- Efficient data transfer rates
- Secure

■ Implementation

- XBee
- Successful Senior Design Projects
 - SAFE-T (2012) for XBee



Proposed MDR Deliverables

- Demonstration of Impact Data Collection
 - Accelerometer interfaced with processor
 - Helmet processor transmission

- Demonstration of Base Station/UI Interaction
 - Using test data
 - Receive from helmet
 - Run algorithm
 - UI able to receive and display test results

Thank You

Questions

Thank You

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Thank You

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Thank You

Questions

Preliminary Weight Analysis

- NFL Helmet Approximately 6lbs. or 2.722kg
- ATmega328P = 2g
- MEMS each approximately 1g
- Gyroscope approximately 2g
- Power approximately 23g
- Estimated total system weight (not including packaging) = 35g-40g

- 5% of helmet is approximately 136g