Senior Design Project:
Measured ***A***ccumulative ***U***nderlying ***R***eal-time ***I***mpa***c***t ***E***ndo-skeleton (***MAURICE***)

NEWTONIAN
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Qualitative Goals

As a team, Newtonian, proposes to contribute to efforts to reduce long-term and heavy traumatic injuries to critical body organs during high-impact collision activities.

Qualitative Goals

- Implement an endo-skeletal suit (wearable) of monitoring and detecting sensors
- Integrate monitoring and detecting sensors to generate data over an IoT framework
- Implement a dashboard to visualize accumulated data and speculative injury
- Notify relevant personnel to treat players for injury.

Quantitative Specifications

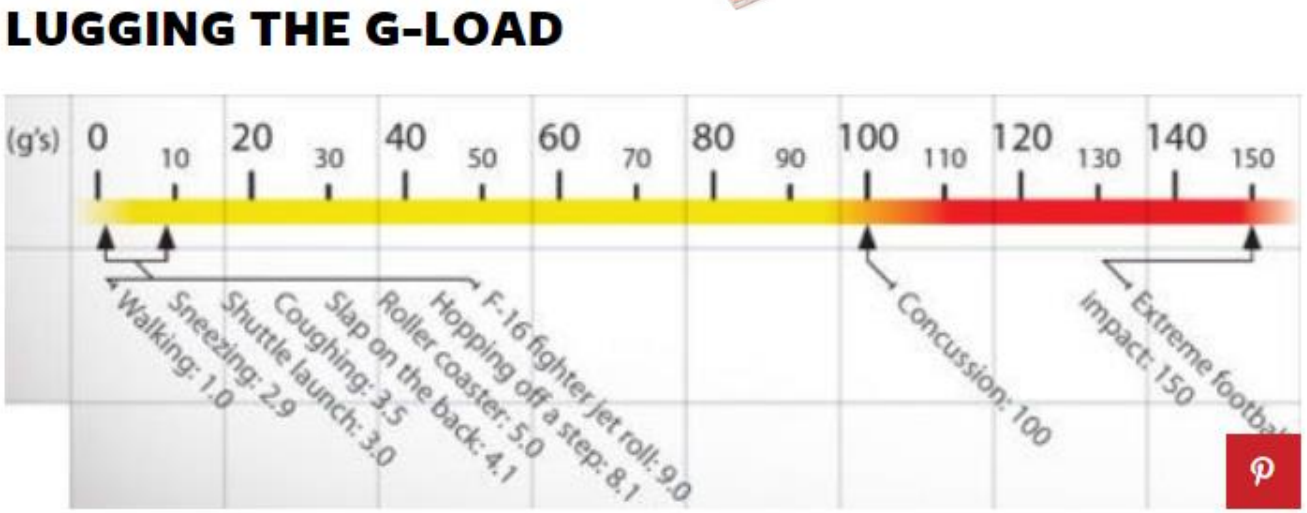
Microcontroller *(Raspberry Pi 3)*

Processor	• **Quad Core 1.2 *GHz* Broadcom BCM2837 64*bit* CPU**
Memory	• **1*GB* RAM**
Connectivity	• **10/100 Ethernet, 2.4*GHz* 802.11n wireless** • **Bluetooth 4.1 Classic, Bluetooth Low Energy (BLE)**
Storage	• **Micro SD port for storing operating system and data.** • **Up to 16*GB* External SD storage**
Ports and Pins	• **40-pin extended GPIO** • **4 USB 2 ports** • **4 Pole stereo output and composite video port** • **Full size HDMI** • **CSI camera port for connecting a Raspberry Pi camera** • **DSI display port for connecting a Raspberry Pi touchscreen display**
Power	• **Micro USB power supply (2.1*A*)**

Quantitative Specifications

Concussion detection *(Accelerometer)*

Acceleration (G Force)	**0 to 200 *Gs* (1*G* = 9.8 *m/s*)**
Sensitivity	**98 *mg/digit* @ (+-200 *g*)**
Operating Temperature	**+85 ˚*C* (Max)**



Quantitative Specifications

Impact detection *(Load Cell)*

Force	**0 to 200 Kg**
Sensitivity	**76 *mg/digit* @ (+-200 Kg*)***
Operating Temperature Range	**-20 to 60 ˚*C***

Quantitative Specifications

Pressure detection
(Flexi-Force sensor)

Maximum Force	**445 *N* (100 *lbs*)**
Sensing Area	**9.53 *mm***
Response Time	**< 5 *µsec***

Quantitative Specifications

Heart rate detection *(Pulse sensor)*

Range Pulse	**0 to 200 *bpm***
Max. Sampling Rate	**100 *samples/sec***
Range Waveform	**0 to 5 *V***

Quantitative Specifications

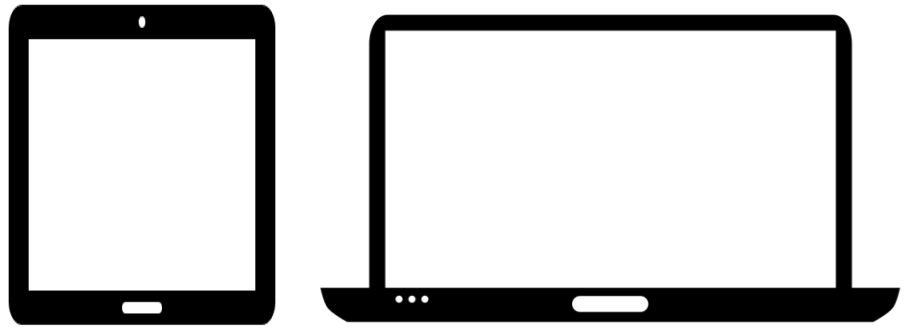
Cloud
(Amazon Web Services)

Queue	• **AWS Simple Queue Service (FIFO)**
Server(less) Architecture	• **AWS Lambda** • **AWS Elastic Compute Cloud** • **AWS Elastic Beanstalk** • **AWS Firehose** • **AWS S3** • **AWS Cognito** • **DynamoDB (NoSQL) database**
Data Handling (10 or less concurrent users)	• **3 Web Servers (2 cores, 8 GB RAM, 500 GB storage/ea.)** • **2 App Servers (4 virtual cores, 16 GB RAM)** • **15 GB Data transfer** • **30 GB Data Storage and Backup**

Quantitative Specifications

Dashboard *(Web-App)*

Front End Languages	• **HTML** • **CSS** • **Javascript**
Back End Languages	• **Python** • **C#**
Framework	• **Flask (Python)**



Design Approach

Hardware layer
(MAURICE Suit)

Cloud layer
(AWS)

Dashboard layer
(MAURICE Web-App)

Key(s):

Data flow

Design Approach – Hardware layer

Concussion
(Accelerometer/Gyroscope)

Hard Impact
(Load cell sensor)

Soft Impact
(Flex force sensor)

Wireless access point
(2.4GHz/802.11n)

Microcontroller
(Raspberry Pi 3)

Heart rate
(Pulse sensor)

Design Approach – Cloud layer

Real-time sensor data
(MAURICE Suit)

publish sensor data

Device
(MAURICE Web-App)

request

response

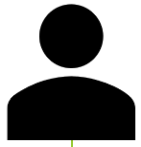
API
(AWS API Gateway)

user authorization request

user authorization response

post real-time data

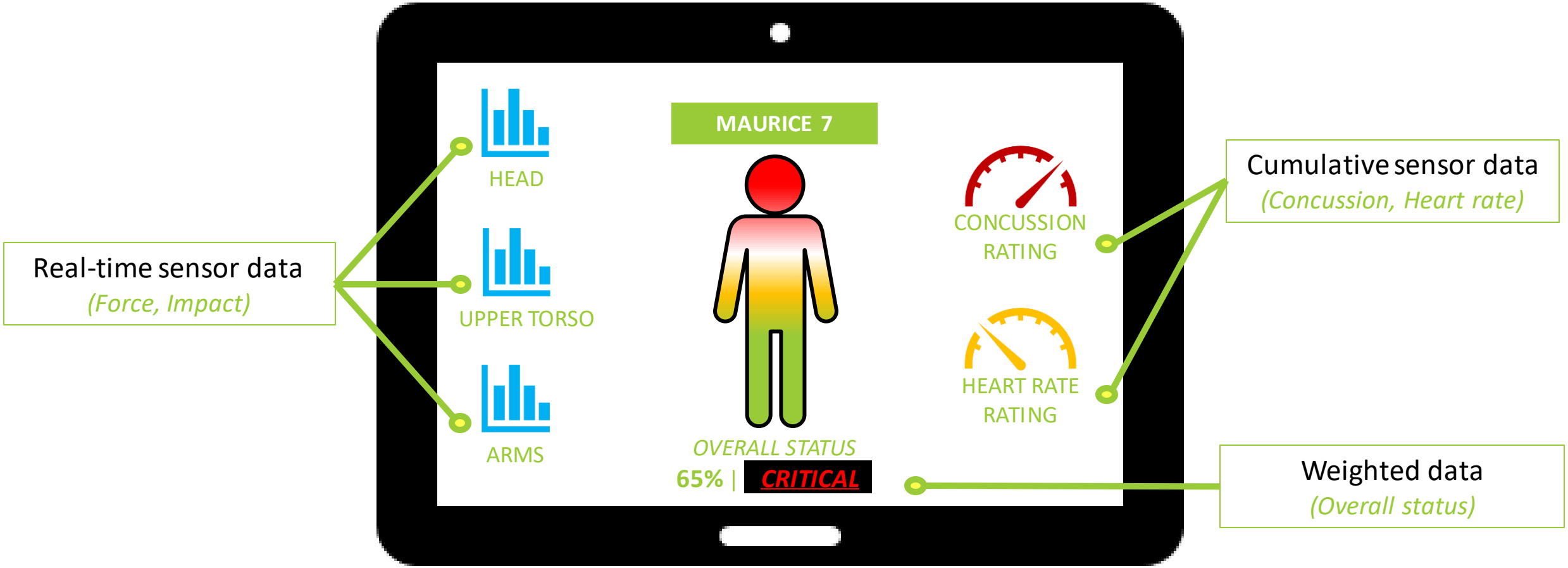
get real-time data



Account microservice
(AWS Cognito)

Data streaming microservice
(AWS Lambda, Firehose, SNS, S3, ElasticSearch)

Design Approach – Dashboard layer



Design Approach

Hardware

- Acquire all major components (accelerometer, pressure sensors, load cells)
- Acquire parts for PCB assembly (Op-Amp & ADC)
- Layout components on suit. (e.g accelerometer/gyroscope inside helmets, load cells under shoulder pads)
- Connect components to Raspberry Pi
- Sample readings and relay to cloud.

Software

- Establish successful communication with server via API
- Implement dashboard web-app to display streamed sensor data
- Dashboard web-app implemented in C# and Python to target Microsoft Surface Pro platform
- All server connectivity will be powered using the Verizon network
- Goal for data latency < 3 seconds

Schedule

Newtonian's MAURICE Project Planner

Select a period to highlight at right. A legend describing the charting follows. **Period Highlight:** 2

Plan Duration | Actual Start | % Complete | Actual (beyond plan) | % Complete (beyond plan)

ACTIVITY	PEOPLE ASSIGNED	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Website						
* Basic pages from templates, member profiles, proposal contents	KW OO DT	1	4			0%
* Update pages with progress content	KW OO DT	10	4			0%
Front-end/WebApp Dev						
* Login & user account authentication	KW DT OO	4	1			0%
* Dashboard UX design	KW DT OO	5	3			0%
* Integrating w/ back-end via API callbacks	KW DT OO	6	2			0%
Back-end/Cloud Dev						
* API Gateway	OO KW AT	4	1			0%
* Account Cognito micro-service implementation	OO KW AT	5	2			0%
* Streaming micro-service implmentation	OO KW AT	6	3			0%

PERIODS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36

Jan: 7 14 21 28 | Feb: 4 11 18 25 | Mar: 4 11 18 25 | Apr: 1 8 15 22 29 | May: 6 13 20 27

Schedule

Newtonian's MAURICE Project Planner

Select a period to highlight at right. A legend describing the charting follows. **Period Highlight:** 2 — Plan Duration — Actual Start — % Complete — Actual (beyond plan) — % Complete (beyond plan)

ACTIVITY	PEOPLE ASSIGNED	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
PCB	-					
** Design*	DA JL	6	3			0%
** Printing & fabrication*	DA JL	9	2			0%
	-					
Hardware	-					
** Sensor acquisition*	AT DA JL	2	4	2	4	10%
** Hardware programming*	AT DA DT OO JL KW	4	10			0%
** Hardware -sensor integration*	AT DA JL	11	3			0%
	-					
Testing	-					
** Alpha testing - hardware*	JL AT	12	3			0%
** Alpha testing - software*	JL OO	7	3			0%
** Beta testing - system-wide*	JL DT AT OO KW DA	13	3			0%
	-					

PERIODS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36

Jan 7 14 21 28 — Feb 4 11 18 25 — Mar 4 11 18 25 — Apr 1 8 15 22 29 — May 6 13 20 27

Schedule

Team-Member	*Initials*	*Team(s) Led*	*Other Obligation(s)*
Aaron Thurston	**AT**	Hardware	Back-end Hardware Testing
Daniel Albuquerque	**DA**	PCB Hardware	Website Testing
Dre Taylor	**DT**	Front-end Weekly Summary	Website Testing
Jiwon Lee	**JL**	Testing	PCB Hardware
Kevin Webb	**KW**	Website Front-end Design Book check	Back-end Testing
Olatide Omojaro	**OO**	Back-end	Website Front-end Hardware

Status

- Currently in possession of a Raspberry Pi 3 and will be using the product to test server communication.
- Amazon Web Services (AWS) is being used to store data sent from sensors in use
- Planning for the layout of the prototype has been agreed upon, awaiting assembly

What's Next

- In the process of obtaining the football equipment necessary for testing the load sensors
- Establishing the Pi 3's connections to our servers to test the latency of connections
- Finishing implementation of dashboard
- Awaiting accelerometer to be delivered to gather real results