



SPORTS WEARABLES IN THE 21ST CENTUARY

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MOTIVATION FOR WEARABLES

- In 2011, wearables had shipped a total of 14 million devices with a market value of \$2 billion.
- The number of wearables to be shipped is expected to rise to 171 million in 2016 at a market value of \$6 billion.
- 61% of shipped wearables are fitness based while 35.1% are in the medical sector.
- Wearables are not going to go away.
- Feb 2014, NBA D-League adoption of wearables.
- Oct 2014, NFL League adoption of wearables.
- Professional sports clubs adopting it since 2009 with quantifiable results showing in these recent years.

WHAT ARE WEARABLES?



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Wearable technology (also called wearable gadgets) is a category of technology devices that can be worn by a consumer and often include tracking information related to health and fitness. Other wearable techgadgets include devices that have small motion sensors to take photos and sync with your mobile devices.

Source: <http://www.webopedia.com/>

A wearable computer is a computer that is subsumed into the personal space of the user, controlled by the user, and has both operational and interactional constancy, i.e. is always on and always accessible.

Source: Steve Mann

A wearable computer is a digital device that is either strapped to or carried on a user's body. It is used most often in research that focuses on behavioral modeling, health monitoring systems, IT and media development, where the person wearing the computer actually moves or is otherwise engaged with his or her surroundings.

Source: <http://www.techopedia.com/>

1. MEASUREMENT

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1. MEASUREMENT

Metrics	Technology
Load	Accelerometer
Acceleration	Accelerometer
Velocity	Accelerometer / GPS
Jump height	Accelerometer
Sleep patterns	Accelerometer
Running distances	Accelerometer / GPS / RFID
Turns	Gyroscope
Heart rate	Electrodes / Photoplethysmography (PPG)

2. TECHNOLOGICAL DEVICE

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2. TECHNOLOGICAL DEVICE



WHAT IS INSIDE WEARABLES?



- Microcontroller
- Bluetooth Low Energy Chip
- Accelerometer
- Charger
- GPS
- Gyroscope
- Magnetometer
- Heart Rate Monitors
- RFID

ACCELEROMETERS (I)

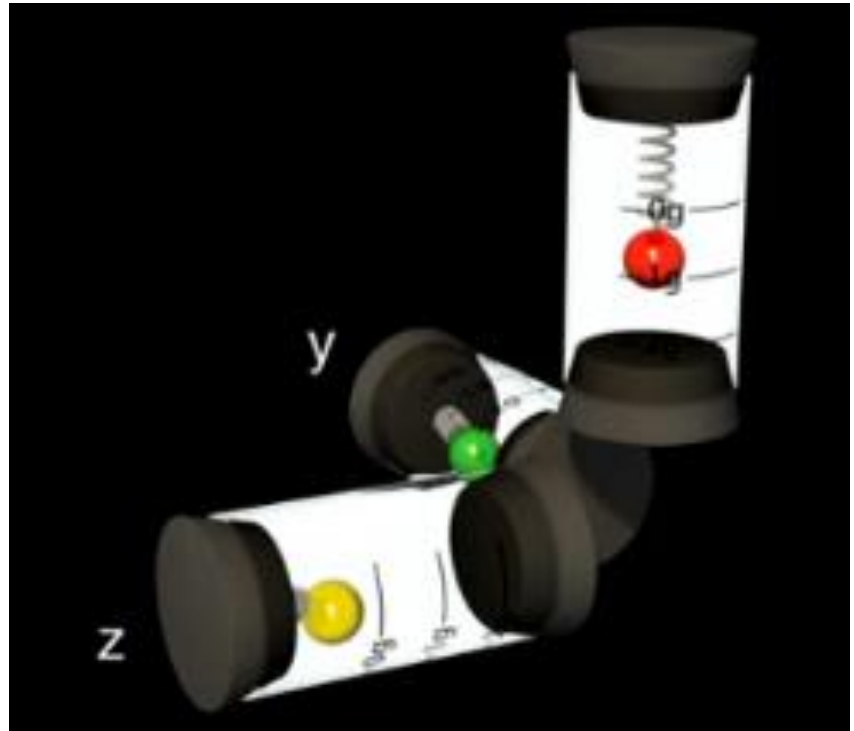


1 to 4 G

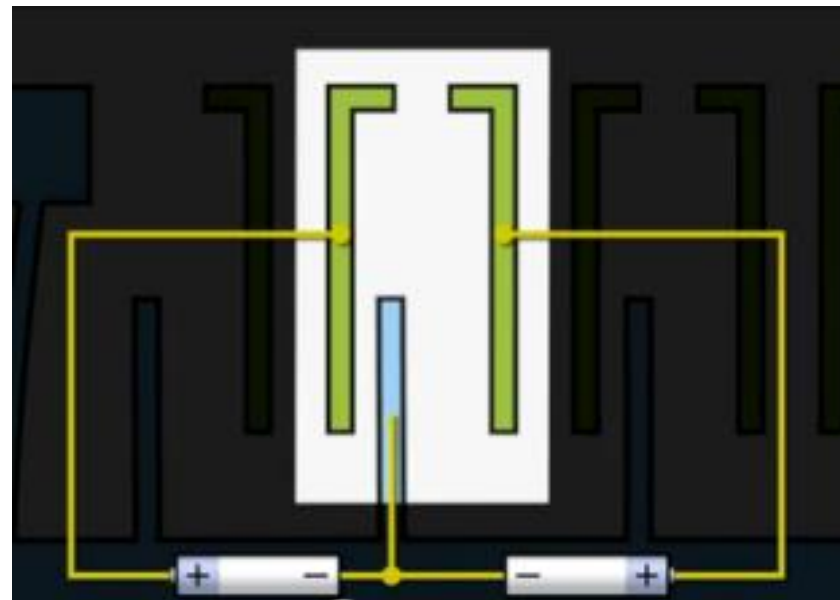
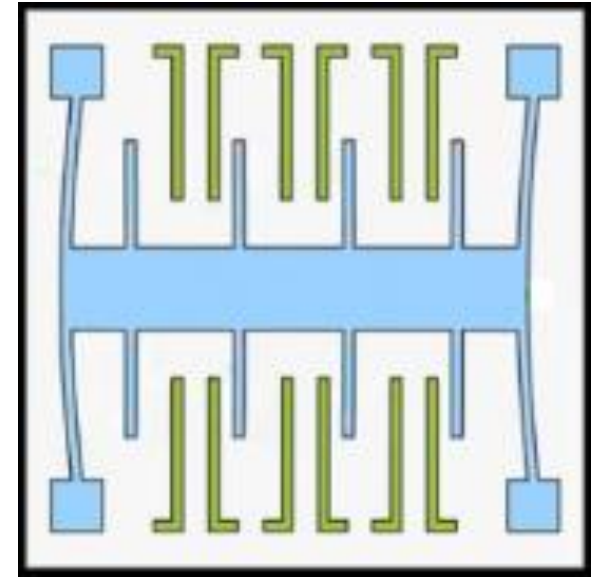
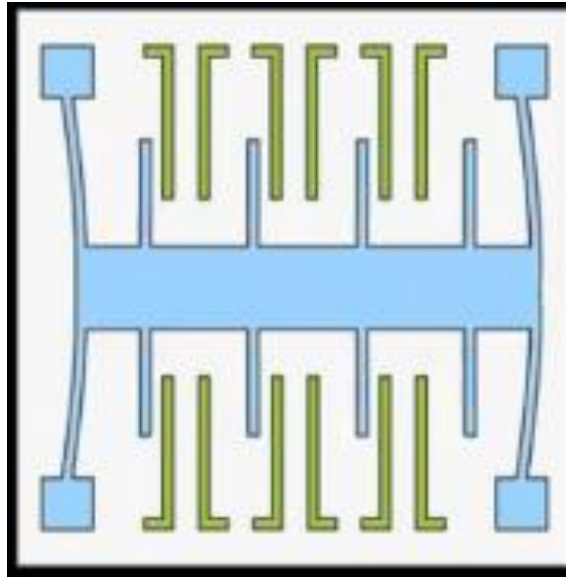
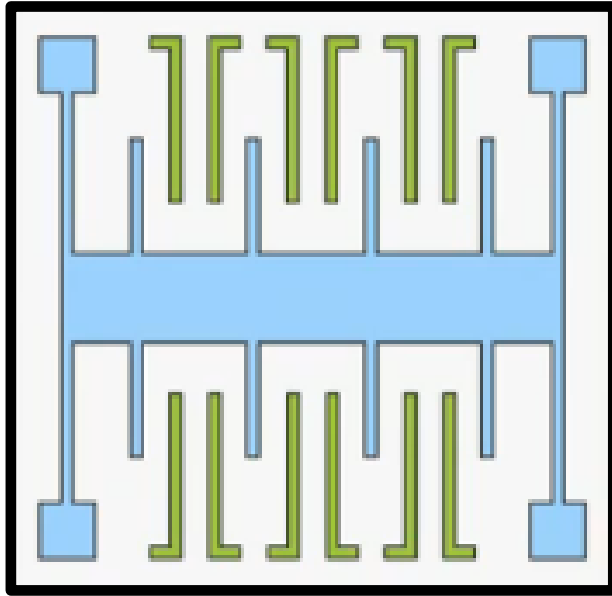


Up to 50 G

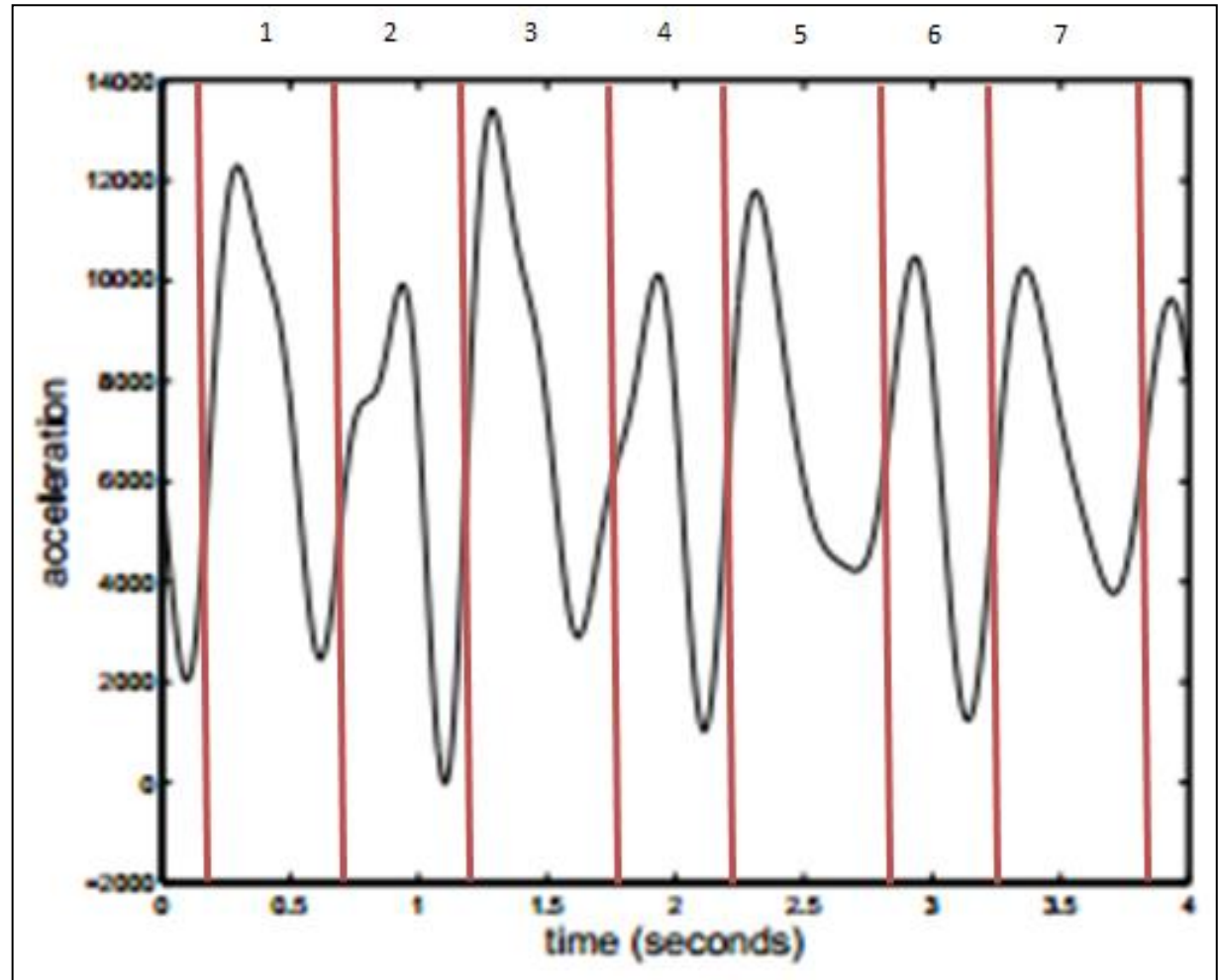
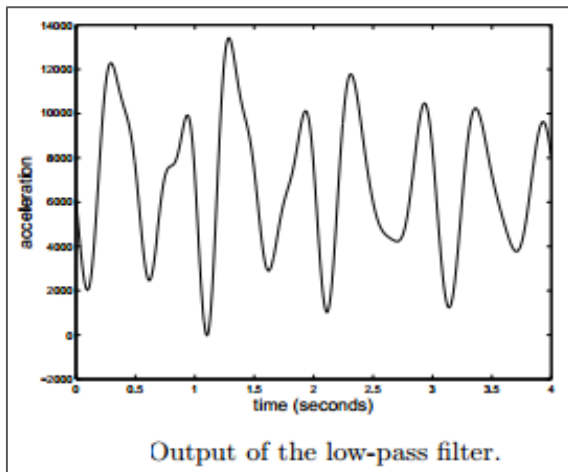
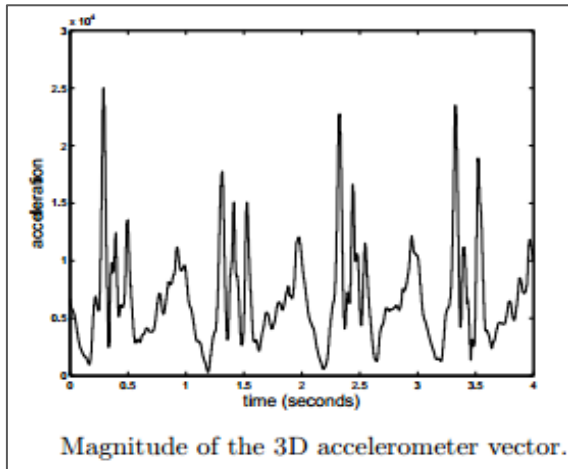
ACCELEROMETERS (II)



ACCELEROMETERS (III)



ACCELEROMETERS (IV)



3. THEY CAN BE WORN

Wearable technology (also called **wearable** gadgets) is a category of technology devices that can be **worn** by a consumer and often include tracking information related to health and fitness. Other **wearable** techgadgets include devices that have small motion sensors to take photos and sync with your mobile devices.

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2. THEY CAN BE WORN



ATTACHMENT METHODS

- Different attachment methods affect the accuracy of data.
- Different objectives require the device to be placed at different locations.
- Key is consistency, to try as much as possible to stick to one way of attachment.
- Affects the way data is collected.
- This affects the eventual usage of the data.

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WEARABLE CASE STUDIES



SEATTLE SOUNDERS FC CASE STUDY



BUY-IN

- Head coach was an ex-accountant before turning to soccer coaching. (Sigi Sdhmid)
- Fitness coach. (David Tenney)
- Assisted by computer / data scientist. (Ravi Raminen)
- Attitude: “The real assets, the real stars of the show are the players. You’re there to support them and to gain their trust. We have to do that all the time because many of them have little obvious incentive to be compliant in wearing heart monitors or sleep measuring devices.”

SEATTLE SOUNDERS FC CASE STUDY



OBJECTIVES

- To reduce non-contact injuries.
- To improve overall match readiness by:
 - Determining what activities will fatigue players and what will keep them active.
 - Improving response time through sleep monitoring.

SEATTLE SOUNDERS FC CASE STUDY



PLAYER MONITORING (I)

Wearable	Metrics	Objective
Catapult GPS	Velocity	Training loads
	Acceleration	Mechanical training load
	Changes in direction	
	Running distances	
Polar Team 2 / Omega Wave	Heart rate	Recovery times
	HRV (heart rate variability)	Internal load of heart rate response
	ECG / DC markers	CNS Fatigue
Fatigue Science	Sleep patterns	Correlate them to reaction times
		Match readiness

SEATTLE SOUNDERS FC CASE STUDY



PLAYER MONITORING (II)

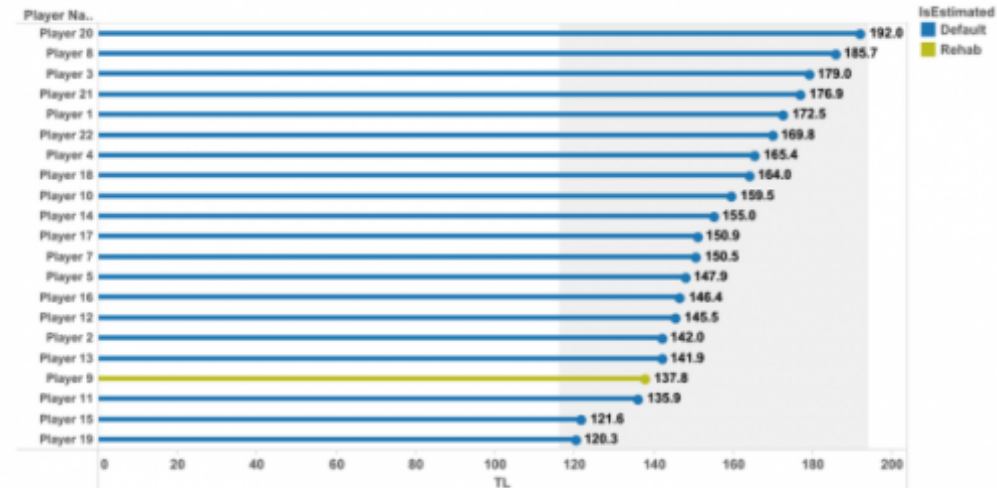
- Players wear Catapult GPS device and HRM as much as possible.
- GPS systems used for measuring the amount of effort are almost useless inside the stadium but that the accelerometer technology works well.
- To compensate for the GPS issues, cameras are set up to triangulate player activity.
- Of crucial importance is the data generated from the game, post-game recovery, and training.
- Four seasons of athletic data to know if their physical condition is deviating from the norm.

SEATTLE SOUNDERS FC CASE STUDY

PLAYER MONITORING (III)

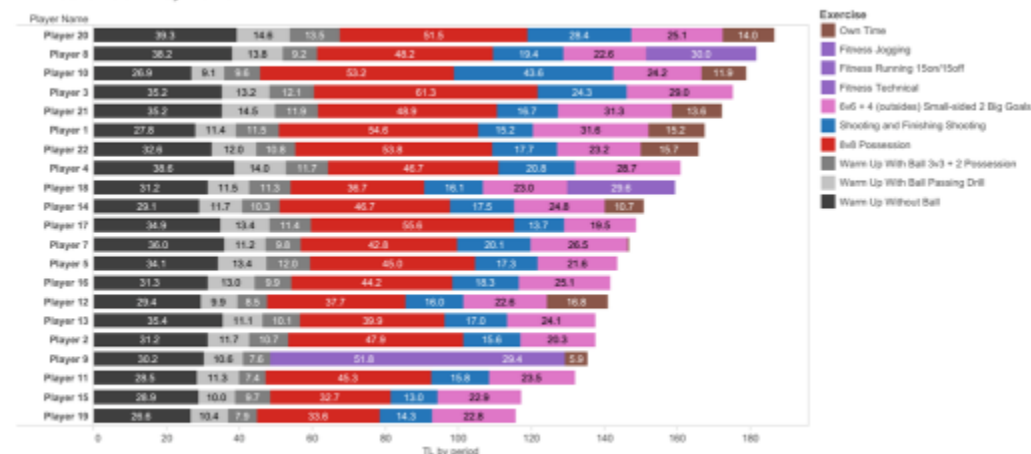


Training Load on July 1, 2014



Sum of TL and sum of TL for each Player Name. Color shows details about IsEstimated. The data is filtered on Training Date Year, Training Date (MDY) and Period Name. The Training Date Year filter keeps 2014. The Training Date (MDY) filter keeps July 1, 2014. The Period Name filter keeps Session. The view is filtered on Player Name, which keeps 24 of 70 members.

Total TL breakdown by Period



TL by period for each Player Name. Color shows details about Exercise. The data is filtered on Training Date (MDY) and IsEstimated. The Training Date (MDY) filter keeps July 1, 2014. The IsEstimated filter keeps Default and Rehab. The view is filtered on Exercise and Player Name. The Exercise filter keeps 221 of 248 members. The Player Name filter keeps 24 of 70 members.

SEATTLE SOUNDERS FC CASE STUDY



MODELING: DESCRIPTIVE RESPONSES

- Catapult GPS device produces 350 columns of data for every exercise the players do in practice.
- This data is correlated with data from other wearable devices to create just a few handful of metrics for easy analysis.
- This creates a few simple visuals that the coaches can look at to determine how hard the players worked in practice that day.
- The best players sleep 9-10 hours a night.
- After a late night, the reaction time will be slower for the next two days.
- Towards the end of the season, there are sharp declines in efficiency in internal load versus mechanical load.

SEATTLE SOUNDERS FC CASE STUDY



MODELING: PRESCRIPTIVE MEASURES

- If a particular player's heart rate is particularly high during a particular exercise, it shows that the player needs more training in that exercise.
- The coach might also chose to do less of that exercise directly before a game.
- Data from wearables worn used to build best physical profiles of player with low injury probabilities.
- Using wearables have enabled them to understand the right fatigue (eg HRV or CNS) and assign the right recovery treatment.

SEATTLE SOUNDERS FC CASE STUDY



MODELING: PREDICTIVE RESPONSE

- Four seasons of athletic data.
- Athletes have their own individual pattern on recovery.
- The further one is fatigued from that overall event, the longer the recovery time.
- Taking data from the recovery day, they are able to find out relative to their baseline response to games how far they are away from their normal state.

SEATTLE SOUNDERS FC CASE STUDY

RESULTS

- Days players out due to muscle-related injuries cut almost by half. Days are cut from 498 days in 2012 to 360 days in 2013 and 214 in 2014.
- A third of goals scored fall within the last 15 minutes of each game, meaning that players are staying fresh until the end of the game.

Western Conference

#	Club	PTS	GP	PPG	W	L	T	GF	GA	GD	HG	HGD	RG	RGD
1	s - Seattle Sounders FC	64	34	1.88	20	10	4	65	50	15	31	15	34	0
2	x - LA Galaxy	61	34	1.79	17	7	10	69	37	32	44	30	25	2
3	x - Real Salt Lake	56	34	1.65	15	8	11	54	39	15	33	19	21	-4
4	x - FC Dallas	54	34	1.59	16	12	6	55	45	10	33	11	22	-1
5	x - Vancouver Whitecaps	50	34	1.47	12	8	14	42	40	2	27	8	15	-6
6	Portland Timbers	49	34	1.44	12	9	13	61	52	9	34	6	27	3
7	Chivas USA	33	34	0.97	9	19	6	29	61	-32	14	-16	15	-16
8	Colorado Rapids	32	34	0.94	8	18	8	43	62	-19	26	5	17	-24
9	San Jose Earthquakes	30	34	0.88	6	16	12	35	50	-15	21	0	14	-15

NFL CASE STUDY (I)

- In season of 2014, 17 NFL Stadiums will be fitted with location based RFID receivers.
- All NFL players will be wearing shoulder pads with RFID tags.
- There is a half-second latency.
- The margin of error is less than 6 inches.
- Tags only have to be installed once per player per season and can last for years at a time.
- Technology from ZEBRA “Motion Works” system.

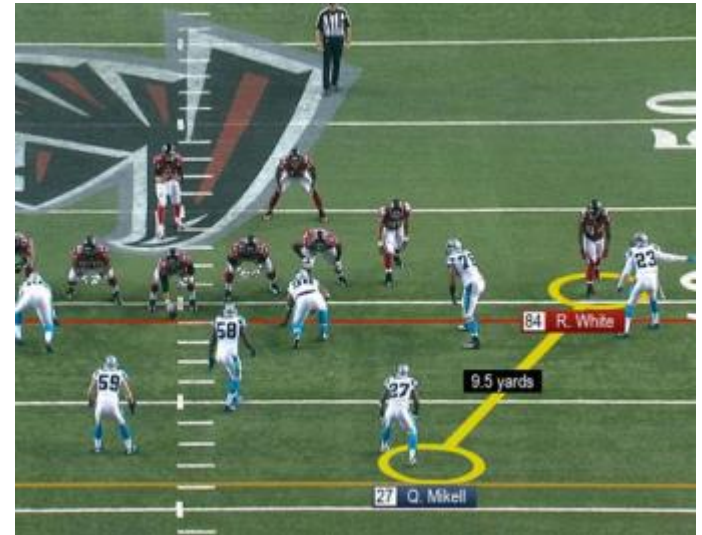
NFL CASE STUDY (II)

- This data shows player positioning, when a player starts to fatigue, speeds and other details in real time.
- Teams will not have access to this data until the 2015 season, when all stadiums will have the same tech.

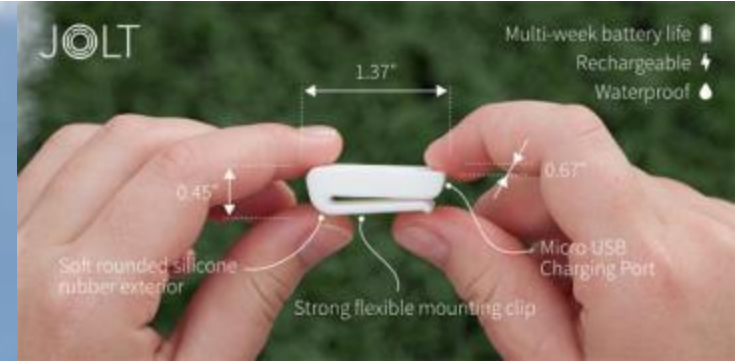


NFL CASE STUDY (III)

- In 2015, Zebra is planning to launch a new model with the ability to monitor heart rate, temperature and lung capacity.
- This leaves the ball as the only untracked entity on the field.
- Zebra is working on a custom transmitter that will make it possible to track the most critical object without affecting its flight or feel.



NFL CASE STUDY (IV)



NBA D-LEAGUE CASE STUDY (I)

- Players in 4 NBA D-League will be provided with wearable devices from Zephyr, Catapult and Stat Sport.
- This list is to be expanded to all D-League teams.
- The small devices weigh only one ounce, 28g.
- Worn under the jersey with a small disc or inside an undergarment pouch.
- Tracks both physical movements and cardiovascular changes.
- Examples are player speed, distance traveled, cuts, accelerations, decelerations and player jumps

NBA D-LEAGUE CASE STUDY (II)

- Transfers: so that agents and players can negotiate on the same footing.
- Eg. If a team's agent claims that a certain player tends to run slower at the ending moments of a game, there is the ability for that player to verify it as well.
- A player's long-term health and injury tendencies could affect a player's earning power based on this data.



DATA MANAGEMENT MODEL

**GAME
CHANGER
AHEAD**

A yellow diamond-shaped road sign with a black border and the text "GAME CHANGER AHEAD" in bold, black, sans-serif capital letters. The sign is tilted slightly to the right. It is mounted on a metal pole. The background is a bright blue sky with scattered white cumulus clouds.

DATA MANAGEMENT MODEL (I)

BUY-IN

- Coaches and players must agree due to the commitment financially and in time.
- Players must see this as a privilege and a tool to help them.
- Technology must have the proper support from the right sports and data scientists.
- As with all projects, mistakes are bound to occur. The key element is learning from the mistakes and improving on every iteration.

DATA MANAGEMENT MODEL (II)

OBJECTIVES

- Everyone on the table must agree on certain quantifiable outcomes to achieve.
- It might be as simple as to improve attendance, improve punctuality, achieve lower injuries.
- It can also be a bit more complex like measuring the load experienced on the foot during soccer training.
- When in doubt, always start very small.
- Its way much better to achieve small achievable outcomes in bite size portions then to aim for a huge goal which takes way too much commitment from all parties.

DATA MANAGEMENT MODEL (III)

TECHNOLOGY

- When choosing the technology, the two biggest considerations are
 - The long term goals / objectives set up in the previous section
 - The training / match conditions. i.e. how the data is to be captured
- The long term goals / objectives will make sure that you have the right tools for the job.
- The conditions will ensure that the devices you have are well suited to the conditions.
- For instance, some outdoor sensors are not suitable for indoor use, and vice versa. Eg. You can't use GPS indoors for location tracking.

DATA MANAGEMENT MODEL (IV)

PLAYER MONITORING

- Adequate data tracking must be implemented. Meaning that the conditions to be tracked must be noted down. Eg if a player is injured, this health state of the player must be noted.
- Consistency in the placement of sensors. Meaning that the location of the sensor should not change once it has been decided.
- It is better to have no data than wrong data.
- It is normally easier to roll out the plan to first 1-2 players first. Observe and learn. After which this privilege is extended to the other players.

DATA MANAGEMENT MODEL (IV)

MODELING

- Based on the desired output (aims and objectives), to learn a model which accurately describes / explains / predicts the outcomes.
- The approach we normally use is known as supervised learning.
- As modelling is an extremely complex topic, it goes grossly over the focus of today. However you are welcome to ask me or other data scientists if you have questions on this portion.

DATA MANAGEMENT MODEL (IV)

ITERATION

- Sports and data scientists should carry out a review (at least weekly) of the data generated. This is especially true in the early stages of the project.
- From there they should ascertain if the way they are collecting data works well and is able to achieve the objectives.
- From there the results need to be shared and communicated with the coaches and players. The key thing is to communicate results that makes sense to them.
- From this data, the coaches will be able to make the decisions how best to guide the entire process.

FINAL THOUGHTS



FINAL THOUGHTS

- Wearables are not going to go away.
- Not a silver bullet.
- Its going to take time, patience and commitment to roll out such a tool.
- “If you’re using the tool like a stick, and you hit him with it, you will lose him. The goal is to give coaches, trainers, and doctors better information.”