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Kelly Foreman

University of South Australia, Kelly.Foreman@unisa.edu.au

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Global Positioning Systems in the AFL: Worthwhile or Waste of Time?

Kelly Foreman
School of Computer and Information Science
University of South Australia
Adelaide, Australia
Email: Kelly.Foreman@unisa.edu.au

Gaye Deegan
School of Computer and Information Science
University of South Australia
Adelaide, Australia
Email: Gaye.Deegan@unisa.edu.au

Grant Wigley
School of Computer and Information Science
University of South Australia
Adelaide, Australia
Email: Grant.Wigley@unisa.edu.au

Abstract

Global Positioning Systems (GPS) in the Australian Football League (AFL) are the big-ticket item that sees clubs trying to gain any competitive advantage over their opposition that they can. This paper explores whether the current application of GPS by clubs is worthwhile or a waste of time from three core perspectives: technical, organisational and personal. Issues include poor data storage and analysis, inaccurate units, lack of appropriate business processes in place, and resistance to use. Although many of these issues can be addressed through improved technology, resolving the organisational and personal issues will require a change in mindset to ensure the use of GPS in the AFL is a worthwhile endeavour. The paper concludes that the current use of GPS devices in the AFL is a waste of time.

Keywords

Global Positioning Systems, Australian Rules Football, Information Systems, Data Management, Decision Making

INTRODUCTION

The Australian Football League (AFL) is a billion-dollar sports industry with participation and viewing currently at record high levels. It is the number one attended sport in Australia with a total attendance in 2011 of just over 6.5 million people (Conway 2011). Nearly 3 million people watch televised AFL matches each week on free to air and pay-tv in Australia. AFL is a fiercely competitive sport that sees clubs employing any means available to obtain a competitive advantage over their opposition. Total player payments in 2012 have risen 7% from 2011 to \$8,787,35 per club in 2012 (Browne and Holmesby 2011) while the prize money for winning the AFL Premiership is 1 million dollars, which is split between the players and winning club (Rogers 2010). The stakes are high and this means that clubs need to carefully consider how to best use their resources to maximise competitive advantage. This paper will argue that investment in GPS devices is currently a waste of money by exploring the current application from three perspectives: technical, organisational and personal.

AFL clubs have been using GPS devices for the last eight seasons (Le Grand 2007), investing in multiple devices at a “cost [of] more than \$3,000 per unit” (Gill 2009). Athletes wear a small (approximately 80x50mm) transmitter on their upper back in a purpose-built supportive harness (Wisbey, Rattray and Pyne 2008) which measures and analyses data from sensors, including multi-axis accelerometers and heart rate monitors (Catapult 2009a). Figure 1 illustrates the GPS units worn by the athletes, the satellite signals, which are used by the devices to determine position and the remote computer, which receive data from the devices. The data is collected and broadcast simultaneously to the remote computer for ‘real time’ analysis. Sports scientists can therefore view real time performance and tactical data during matches or training sessions. From the analysis of

the data, the coaching team can make tactical changes, analyse player effort or manage player rehabilitation (Catapult 2009a).



Figure 1: Components of the GPS monitoring process (Catapult 2009a).

There has been a lot of hype associated with the use of GPS in elite sport surrounding its capabilities to assist coaches with decision making related to player performance. This paper will explore whether current GPS deployments in the AFL are realising the advertised benefits and will consider what is required to further enable teams and coaches to achieve the competitive advantage they are seeking through the use of GPS technology. It will be argued that although GPS devices have many features relevant to their application and use in Australian Rules Football the way they are currently being utilised does not lead to any significant improvement in individual player or team performance.

The arguments in this paper are organised into three different threads which follow the Mitroff and Linstone (1993) TOP (technical, organisational, personal) perspectives. According to Mitroff and Linstone (1993, p.101) “the value in using multiple T, O, and P perspectives lies in their ability to yield insights. None by itself suffices to deal with a complex system but together they give a richer base for decision and action”. This approach conceptualises AFL clubs as complex systems and evaluates the use of GPS from various perspectives in order to assist clubs with decisions about whether or not to invest in GPS technology and appropriate actions that will maximise the benefits derived through the use of GPS technology. The technical perspective examines problems and solutions in terms of cause and effect relationships with the need for validation and optimisation leading to problem solving as the main goal (Linstone 2011). The organisational perspective considers standard operating procedures, rules and institutional routines. Problems and solutions are viewed as part of an orderly progression incorporating incremental change with the goal being action, stability and process (Dunn 2003; Linstone 2011). The personal perspective emphasises, learning, experience and individual values/morality with the need for certainty and the primary goal being power and influence (Mitroff and Linstone 1993).

In the context of the AFL the technical perspective covers issues related to accuracy, sample rates and the synchronisation of GPS data with video. The organisational perspective is concerned with the usefulness of GPS data in the context of current practices. Finally, the personal perspective considers the use of GPS devices from various subjective viewpoints including those of the coaches and the players. Each of these perspectives will be explored in turn. Issues identified from each perspective will be described with supporting examples where possible and potential courses of action for addressing the issues will be considered. Equipped with the insights offered through examination of the different perspectives, AFL clubs will be able to make more informed decisions about the value of GPS technology now and in the future.

TECHNICAL PERSPECTIVE

There are primarily three varieties of GPS units in use in the AFL, 1Hz, 5Hz and 10Hz units. The sample rate of these units is the frequency at which samples of the signal are taken (Pyne, Petersen, Higham and Cramer 2010). Hargrave (2001, p.453) states that “the higher the sample rate (ie. the more samples per second), the closer the sampled signal approximates the original waveform”. Therefore the 10Hz units are the most accurate as they take a signal sample every 0.1 second creating a total of 600 samples per minute, whilst the 5Hz units have a sample rate of 0.2 seconds producing 300 samples per minute and the 1Hz units sample every 1 second with a total of 60 samples per minute. Clubs will generally purchase the most accurate (10Hz) devices, depending on available funds, but a number of clubs continue to use older, less accurate devices.

According to Catapult (2009) a leading manufacturer of GPS devices for sport, Australian Rules Football (AF) GPS units are very reliable with a minimal margin for errors. Specifically 2% (40 cm) inaccuracy is incurred for straight line sprinting over 20 meters and 4% (40 cm) over 40 meters measured by 10Hz units (Catapult 2009b).

These results are heavily refuted by the results from two independent studies, one of which show a distinct difference in accuracy of over 300%. Jennings, Cormack, Coutts, Boyd & Aughey (2010, p.333) found that when examining straight line sprinting over 10 meters there was an error rate of 30.9 ± 5.8 , over 20 meters an error rate of 17.0 ± 3.6 and over 40 meters a further error rate of 11.9 ± 2.5 meters, measured with 5 Hz units. Pyne et al (2010, p.337) found, while conducting the same straight line sprints over 10 meters, an error rate of $13.9 \pm 5.1\%$, over 20 meters $8.8 \pm 3.2\%$ and over 30 meters an error rate of $5.0 \pm 1.8\%$, measured by 10 Hz units.

When gradual change in direction tests were conducted by Jennings et al (2010, p.334) with 5 Hz units the results showed an error rate of 11.7 ± 3.0 meters and with a tight change of direction an error rate of 11.5 ± 3.0 meters. AFL footballers rarely run in a straight line for more than a few meters, let alone 20 – 40 meters in the course of one disposal. Results from the studies above show the large degree of inaccuracy for GPS devices measuring high speed running and short quick sprints in varying directions, which are the essence of AFL as well as short and quick sprints in varying directions. These results bring into question the accuracy of GPS in AFL. The inaccuracies are present regardless of the Hz unit that is being worn by the players and although there are new units coming out every few years not every club has the luxury of being able to upgrade their existing units with some clubs still using 1Hz units with large error rates. Foreman (2009) conducted a survey of all AFL clubs and discovered that not all clubs can afford to buy the units outright and it is only the wealthy clubs that can afford to purchase enough units for every player. GPS is accurate enough to use during training sessions when players are running at a constant speed and velocity around an oval, but the results suggest that they are not accurate enough to use live during games when the tempo of Australian Rules Football is very ‘start and stop’ and players are constantly accelerating and decelerating through sprints.

Video from the game and training sessions can be synchronised with GPS data so that coaching staff can correlate what was happening on the field at a given time with the GPS statistics. It is extremely difficult to achieve the required video and data alignment that is needed for this to occur (within 1 sec) as the timestamp on the GPS data and on the match views are different, therefore few teams use this feature as aligning the video with the data is a very time consuming and people centred process (Foreman 2009).

In an ideal world where money wasn't an issue for AFL clubs every team would own the latest 10Hz units, minimising the error rates created due to the sampling rates. An algorithm to combat inconsistent measurements amongst units can also be added into the software so that inaccuracies are taken into account. Manufacturers could also improve the software interface to simplify data and video synchronisation. Integrating differential GPS would also improve accuracy issues, as would a faster sample rate. It should be noted that GPS devices outside of those used in a sporting context are accurate up to and within 16 meters (Collinson 2011).

ORGANISATIONAL PERSPECTIVE

This section will examine the usefulness of GPS data in the context of current practices. One of the heavily advertised features of GPS data is the ability to observe a team's structure, movement and space. Coaching staff can see the team's structure, where individual players are represented by a circular dot, as illustrated in Figure 2, evaluate if players are moving into the correct positions and determine how much space they are creating on the field. This feature isn't helpful if AFL clubs do not own a full set (22) of GPS units, one for each player on the field or if they only own limited units and are using them, for example, all on the midfield in order to focus on the midfield structure and movement. As mentioned in the previous section, due to the cost of the units, few teams own enough that every player can wear one during the game. This is demonstrated in Foreman's study (2009) showing that only 8.7 players on average per club wear GPS during an AFL game. Many clubs also allocate units to their South Australian National Football League (SANFL), Western Australian Football League (WAFL), Queensland Football League (QFL) and Victorian Football League (VFL) subsidiaries as an average of 12.72 units are owned by every club (Foreman 2009). Allowing multiple players to wear the same device can create inconsistency and increase the error rate of the task as the measurement of each unit maybe slightly different. Therefore it is recommended that only one player is consistently allocated a particular GPS device to use. Foreman's (2009) study shows that only 40% of the clubs surveyed allocated the same unit to the same player every week.

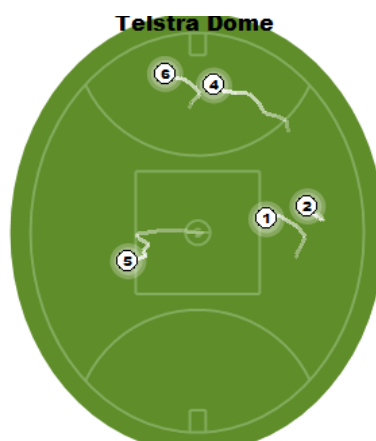


Figure 2: Player structure as shown by GPS software

There are many other benefits advertised in relation to GPS devices, but many of these do not provide any practical advantages. The software provided with GPS devices allows the comparison of a player's match day and training efforts with the intensity at which they are training and if they are getting the most out of the training session. This is a feature rarely used by coaching staff, as the aim of training sessions is not necessarily to create or match game intensity. The aim of the task at hand is different; therefore it is a comparison of two different situations, which are not comparable. GPS software allows the use of 'hotspots' on the field, which uses varying degree of colours to show the areas of the field where players have spent most of their time during the game or a section of the game. Unfortunately, this is another feature that is not used live during a game and rarely used on post-game analysis as the information can be seen in the video replay that the senior coach and all the line coaches watch and just because a certain player might have been, for example, inside the 50m arch for most of the quarter doesn't mean they had an impact on the game whilst in that position. The impact is better assessed using the video replay with the complete game context available. A player vs player comparison can also be made using GPS devices, which allows coaching staff to compare players in their team against each other. This feature is not used by coaching staff because players perform different roles on the ground, in different positions (even though they might both be in the midfield), have different opponents, and have different components of their personal game they are working to achieve during the game.

GPS can also be used to monitor injured players throughout their rehabilitation depending on the injury (obviously not if it's an arm, neck injury etc). This enables fitness staff to monitor a player's fatigue levels, heart rate and running to ensure they are not over doing it or not performing at the level of rehabilitation expected. Unfortunately, if this information is too heavily relied on the player may be put at risk of re-injury or spending too much time in rehabilitation rather than back in the field with their teammates. G-force is another attribute that GPS units' measure, which informs staff how hard a player has hit the ground. Previously there have been readings of rugby players being slammed into the ground at the same G-force as a NASA space shuttle takes off during launch (National Aeronautics and Space Administration 2009). This information is not examined at all by staff when a player is injured or takes a heavy hit (Foreman 2009). This information could be used to determine if a player should return to the field regardless of the results of a concussion test. Medical staff do not look at this information as they believe the concussion testing they do is adequate even though it does not determine how heavily a player hit the ground.

Another issue with the use of GPS data is the format and presentation of the information. The software provided does not assist with management of the overwhelming amounts of data provided by the units. A better user interface would allow coaches to focus on their primary role of managing the players rather than spending time deleting copious amounts of cells from excel spreadsheets that are not needed because the coaching staff at that club don't look at those specific data attributes. The present software outputs primarily into spreadsheet which hold a large quantity of '0' values if the maximum amount of attributes are not used. The role of members of the football department is not to be experts in IT rather experts in their field such as fitness and strength conditioning, their expectation are that software will come with a simple to use user interface which will provide them with all the information and allow customisation data sources they require.

Business processes in combination with information systems are required in order to interpret, manage and action the data produced by GPS units, pre, post and during the game. Information systems can be used to

automate existing business processes that are manually acted out by members of the organisation making them more efficient. This allows the organisation to make better decisions and improve the execution of their already existing business processes (Conway 2011). Foreman (2009; 2010) has developed four models – fitness and strength conditioning, tactical and strategic analysis, rehabilitation and injury management which demonstrate the flow of GPS information and recommended processes that should be followed for its application in AFL. This will assist in determining if players are fatigued, ensuring the work rate set for players is being met, rotating players based on set benchmarks, match reviews and change of tactical practices. Following these processes will minimise the lack of understanding by coaching staff surrounding the application of GPS and the conditions in which players should be monitored. The Economist (2009, p.15) argues that “because technology underpins nearly every business process today, it can help those in the workplace improve their use of critical data”. Therefore it is essential that AFL teams have structured business processes in place that allow information systems to leverage and automate them creating a more efficient use of time and resources for staff members.

If the AFL wants to ensure there is an even playing field between clubs whom have money and those that do not they could subsidise the purchase of GPS units for either low income clubs or all clubs. Allocating one unit to one player would also ensure improved data accuracy as well as ensuring that there are enough GPS files over the space of a season that can be analysed and practically used by club officials to make fitness or tactical related decisions.

Examining a players G-force as well as concussion testing which already takes place will ensure that after taking a large hit players are not returning to the field too early before they have fully recovered, preventing further long term injury and potential post career litigation. Information such as the G-force in which a player has hit the ground in conjunction with doctors’ opinions and expertise as well as concussion testing can also be incorporated for a real impact assessment of what happened to the player to decide if they should return to the ground.

In order to store the large amounts of GPS data generated each time a player wears the device it is recommended the data files be stored in a database or data warehouse in which data-driven decision support systems can be used to access the information and assist in decision making. “These systems analyse large pools of data found in major corporate systems. They support decision making by enabling users to extract useful information that was previously buried in large quantities of data” (Laudon and Laudon 2005, p.466). Data mining can also be used to analyse the data to assist coaching staff in making important decisions based on reliable information. This will not only ensure information from GPS units is stored in an easy to read and extract format but also that the data is useful to members of the organisation.

PERSONAL PERSPECTIVE

One of the positives of GPS is that when looking at the heart rate of a player you can determine their exertion. This means that before they encounter fatigue, or an increased risk of injury, coaching staff can lower the rate (speed) of the task at hand during training sessions, specifically pre-season training when players are pushed to their near maximum Vo2 Max ratings. Unfortunately due to the overwhelming amount of data provided by GPS units as well as the data not being in an easy to read format it is not heavily relied on in games and most coaches are not interested in GPS data. A coach at a prominent AFL football club justifies his use of video rather than looking at GPS statistics; “...You can see if the player was in fact running into the competition or to the ball...you can see they are working for their position instead of oh he bobbed up, he might say well I ran 4kms for that and he might have just jogged and the ball has just fallen in his lap, they can fool you a bit the smarter players” (2012, pers. Comm. 12 April). Just because players are wearing GPS devices and getting large running numbers it doesn’t mean they are having an impact on the game, they could be running up and down the ground without touching the ball. Occasionally coaches will observe a player not running at their normal speed or not being as involved in competitions and will ask the GPS manager ‘how their legs are’ to back up their own thoughts or suspicions, but that is the maximum use it gets during games at the majority of clubs.

Benchmarks can be set for individual players within GPS software to inform coaching staff when a player is fatigued and not running hard enough as well as other customisable statistical components. Unfortunately, this is not used by coaching staff live during the game, even though a fitness staff member is watching the GPS information on the screen, because the coaches are not interested in the GPS data. Only 40% of coaching staff manage player fatigue through GPS (Foreman 2009). They are more interested in what they can visually see on the field and their interpretation of the impact the player is having on the game in terms of their role in the team. In contrast players do not feel comfortable wearing GPS devices as they believe they are not being trusted by coaching staff to perform their on field role (Foreman 2009).

Australian Rules Football players have sued the Australian Football League in the past over injury with the most prominent case being Daniel Bell “after a neuropsychologist found his cognitive function had deteriorated significantly from concussions” (Lane 2011). Recently more than 100 players took action against the National Football League in America joining an existing 2000 who have and are taking similar action against the league claiming ongoing debilitating effects from head injuries (Holpuch 2012). It is only a matter of time until GPS data is used to assist in making cases like these as the units record the G-force in which a player hits the ground, creating a substantial collection of information to be used against the football club or league over a sustained period of time. At present there are no clubs that look at the force of a collision before allowing the player to return to the ground (Foreman 2009). In the future AFL clubs may reconsider their stance on the application of GPS live during games in light of potential litigation.

CONCLUSION

This paper has analysed the use of GPS in the AFL from three different perspectives. From a technical perspective, the main issues relate to the accuracy of the devices, the ability to synchronise the GPS data with video footage and the inconsistencies in analysis that arise when clubs do not have enough units to allocate the same unit to every player for the entire season. An analysis of the organisational aspects highlighted how the data collected by the devices may not be useful in practice because of the context and purpose of the analysis to be performed. The evaluation from the personal perspective emphasised and drew attention to the resistance of players to wear the devices and the fact that coaches have little interest in the data provided for various reasons.

The technical deficiencies are, perhaps, the easiest to address. Manufacturers will, undoubtedly, over time, produce more accurate devices. The AFL could consider subsidising clubs to ensure that all clubs have access to a full set of devices to cover every player over the entire season. The organisational issues are more difficult to overcome. Clubs need to evaluate their use of GPS data in the context of their business processes and practices and endeavour to incorporate the GPS data, where appropriate, into their analysis of player performance during training, games and for ongoing performance, injury and rehabilitation management. Issues related to the overwhelming volume of information and its presentation and analysis can be overcome with the development of better techniques for storing, viewing and analysing the data. In a sporting organisation with vast quantities of money where they can afford enough units for the entire team, it is likely they could overcome the technical difficulties. However, if coaching staff are not open to the idea of the use, abilities and application of GPS data during the game and simply want to reply on their ‘gut’ instinct and if the players do not want to be monitored and controlled then the application will be insignificant. This means that the organisational and personal issues will not be resolved.

Perhaps the most challenging issues to overcome are those related to the personal resistance of the coaching staff and the players. From the club’s perspective, the coach’s reluctance to incorporate GPS into their standard practices can be managed in the same way that change related to the introduction of a new information system is managed in any corporation – with consultation and training. However, in order to overcome players’ resistance and to achieve the maximum benefits from the data provided by the devices, it is suggested here that a significant change in mindset is required. All of the current practices and approaches view players as elements to be monitored and controlled in order to obtain maximum benefit from the players as resources. If the focus changes to conceptualise players as active participants in the processes surrounding their performance, the motivation of the players to be involved in these processes would be increased and this could have a direct beneficial effect on their performance. Rather than collecting and analysing data to use in program development, which is then communicated to players, there is an opportunity with GPS data to involve players in the whole process by sharing the information and involving everyone in discussions surrounding its implications. The mindset change could lead to improved results both on and off the field in regards to training habits, preparation and game style and play.

The AFL is a multi-million dollar business where teams rely on any technology or techniques at their disposal to obtain competitive advantage. This paper has analysed the current state of play in relation to GPS devices used for this purpose and concluded that, at this point in time, the application of GPS and the manufacturing and capabilities of devices is not advanced enough to be relied upon for gaining strategic advantage in the AFL environment. The paper has considered aspects, which need to change in order to ensure that the technology provides the advertised benefits. Most of these changes are reasonably straightforward and are likely to be achieved over time. However, it is not as simple as improving the accuracy of the devices or the effectiveness of the user interfaces. The more complex factors that need to be addressed centre around the processes and procedures in use by the club and the mindset with which the use of the data is approached. Therefore the

answer to the question proposed in the title of this paper is that GPS is not currently worthwhile and in order to ensure that it does not continue to be a waste of time, improvements need to be addressed from a range of perspectives.

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REFERENCES

- Browne, A., and Holmesby, L. 2011. "Afl, Players Reach Cap Deal." Retrieved 1 June, 2012, from <http://www.afl.com.au/tabid/208/default.aspx?newsid=124885>
- Catapult. 2009a. "Catapult." Retrieved 2 January, 2009, from <http://www.catapultinnovations.com/minimaxx.html>
- Catapult. 2009b. "Minimax V4 Gps Performance - Sprints," Catapult Innovations, Melbourne, pp. 1-6.
- Collinson, R. 2011. *Introduction to Avionics Systems*, (3rd ed.). New York: Springer.
- Conway, M. 2011. "Afl Hits New Mark in 2011." Retrieved 11 May, 2012, from <http://www.afl.com.au/tabid/208/default.aspx?newsid=122668>
- Dunn, W. 2003. *Public Policy Analysis: An Introduction*, (3rd ed.). New Jersey: Prentice Hall.
- Economist Intelligence Unit. 2009. "Organisational Agility: How Businesses Can Survive and Thrive in Turbulant Times," Economist Intelligence Unit, London, pp. 1-28.
- Foreman, K. 2009. "The Use of Global Positioning Systems (Gps) within Elite Sporting Clubs in Australia," in: *School of Computer and Information Science*. Adelaide: University of South Australia.
- Foreman, K. 2010. "A Conceptual Framework for Global Positioning Systems within the Australian Football League: A Discussion of Two Models," in: *Tenth Australasian Conference on Mathematics and Computers in Sport*. Darwin, Northern Territory, Australia: MathSport (ANZIAM), pp. 129-136.
- Gill, K. 2009. "Crows Investing in Technology." Retrieved 2 May, 2009, from <http://www.afl.com.au/news/newsarticle/tabid/4417/newsid/75570/default.aspx>
- Hargrave, F. 2001. *Hargrave's Communication Dictionary*, (1st ed.). New Jersey: Wiley-IEEE Press.
- Holpuch, L. 2012. "Nfl Players Join in Federal Lawsuit Alleging League Hid Risks of Head Trauma." Retrieved 18 June, 2012, from <http://www.guardian.co.uk/sport/2012/jun/07/nfl-players-lawsuit-head-trauma?newsfeed=true>
- Jennings, D., Cormack, S., Coutts, A., Boyd, L., and Aughey, R. 2010. "The Validity and Reliability of Gps Units for Measuring Distance in Team Sport Specific Running Patterns," *International Journal of Sports Physiology and Performance* (1:5), pp 328-341.
- Lane, S. 2011. "Former Afl Player Seeks Compensation." Retrieved 18 May, 2012, from <http://www.smh.com.au/afl/afl-news/former-afl-player-seeks-compensation-20110330-1cgf7.html?skin=text-only>
- Laudon, K., and Laudon, J. 2005. *Management Information Systems: Managing the Digital Firm*, (9th ed.). New Jersey: Prentice Hall.
- Le Grand, C. 2007. "Afl's Hi-Tech Future within Reach," in: *Australian*. Adelaide: Australian, p. 43.
- Linstone, H. 2011. "The Multiple Perspective Concept," in: *Future Research Methodology Version 3.0*, J. Glenn and T. Gordon (eds.). Washington: The Millenium Project, pp. 1-21.

Mitroff, I., and Linstone, H. 1993. *The Unbound Mind - Breaking the Chains of Traditional Business Thinking*, (1st ed.). New York: Oxford University Press.

National Aeronautics and Space Administration. 2009. "Nasa Hq Library." Retrieved 13 May, 2009, from <http://www.hq.nasa.gov/office/hqlibrary/aerospacedictionary/aerodictall/g.html>

Pyne, D., Petersen, C., Higham, D., and Cramer, M. 2010. "Comparison of 5- and 10-Hz Gps Technology for Team Sport Analysis," *Medicine & Sports Science in Sports & Exercise* (42:5), pp 337-337.

Rogers, M. 2010. "Clubs to Share Gf Windfall." Retrieved 22 May, 2012, from <http://www.afl.com.au/tabid/208/default.aspx?newsid=103376>

Wisbey, B., Rattray, B., and Pyne, D. 2008. "Quantifying Changes in Afl Player Game Demands Using Gps Tracking - 2008 Afl Season," FitSense, Melbourne.

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