# Executive Summary

This report provides a brief overview of my experiences with industry based experience at Telstra during my last thirty days of work experience. Telstra is Australia’s leading telecommunications company, which made it an ideal place for me to gain my industry based work experience, as that is my field of choice. I participated in a wide range of duties while at Telstra, including design work for the new LTE700 network and optimisation work to fix up a customer complaint.

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# 1.0 Workplace Background

This report covers 30 days of my time, while working full time at Telstra as a network engineer. As a network engineer I did a wide range of tasks which involved working on the Telstra mobile network, such as contributing to their new LTE700 network set to come out early 2015, working on customer complaints and many other tasks. The department I worked at during my time at Telstra was the Telstra MCD or mobiles coverage delivery group, which works on design and optimisation of the Telstra network to provide the best mobile service to their customers. Prior to the work discussed in the report I had already been working at Telstra for a 20 day period already during which I learnt a lot about various software, technology and other knowledge necessary to complete my job.

# 2.0 Work Activities

# 2.1 Work Activity 1

The main work I did while at Telstra was EME (Electromagnetic Energy) analysis, which involved running computer simulations to test whether EME outputted from the Telstra antennas met the safety limits set by the ARPANSA (Australian Radiation Protection and Nuclear Safety Agency). The reason for doing these tests was, because Telstra was preparing for their first round of LTE700 implementation in preparation for a handover of spectrum at the beginning of 2015 and they needed to know that when the new antennas are turned on that they still meet the ARPANSA guidelines. The below picture shows one of the near field analysis plots I made.

The basic process for doing this was first checking feeder loss to make sure there was no more than a 3dB loss, as well as a few other factors. Then afterwards I would check the existing antennas to see where I could add in the new LTE700, which often involved replacing an old antenna for a new one with the correct ports. Once I had decided on how the LTE700 was going to be implemented the next step was creating it in an in house program called RF-Map, which takes data from the RFNSA (Radio Frequency National Site Archives) and allows us to simulate the radiation from the antenna and overlay it onto map images, building schematics and various other useful images. The program can calculate vertical plots, horizontal plots and horizontal volume plots and then the radiation pattern is overlayed on top of the imported image. This program pulls in data for Optus and Vodaphone antennas too meaning that all of those antennas are taken into account when making predictions, as the radiation from them would be additive. It also has the ARPANSA standards and the new ICNIRP (International Commission on Non-Ionising Radiation Protection) 2014 standards that are going to replace them this year. This makes it easier to know if the radiation is meeting the correct standards. From there whatever locational information I had about the site was used to make a best possible judgement about whether or not any guidelines had been breached. Many information sources were used to do this, such as schematics, Google Earth and in one case a site visit to take measurements where it was a close call.

There were a large number of rules which had to be abided by and there were a few PEL (Public Exposure Limits) that were set to help with this. These zones include a red zone, which should not be entered while the antenna is active, a yellow zone which is 100% of the PEL and should only be accessed by trained RF workers and needs to be made inaccessible to the generable public. There is also a 25% zone which shouldn’t enter into any other properties such as a balcony in the next building. There is also special consideration that needs to be taken near certain points of interest such as a school or childcare centre, as this can cause problems with public opinion.

This work was good for cementing my knowledge on power calculations. It also gave me a good opportunity to learn about the rf plumbing and the antennas.

# 2.2 Work Activity 2

Another major activity that I did was my Atoll studies. Atoll is a powerful program for working on wireless operations such as telecommunications. It can run many predictions such as RSSI (received signal strength indicator) plots, SINR (signal to interference and noise ratio) plots and best server plots to show coverage areas. It can be used for GSM, WCDMA and LTE in a wide range of design and optimisation applications [1].

A large amount of my atoll studies were centred around the proposed LTE700 network, where I ran predictions to see how the new network would perform in its initial stages and once the full network was completed. For this I first took the sites that were decided on for the initial deployment of LTE700 antennas and I had to create them in the atoll workspace. To do this I first exported the existing LTE1800 ones that corresponded to the LTE700 ones that were going to be implemented. From there I had to add various other components that were used between the radio base station (RBS) and the antenna. There were also a lot of other values such as down tilts, power levels, antenna type, bearing and many others that had to be entered. Once all of these values had been entered it was cells had to be created too and then both of these spread sheets were imported back into atoll. Once the antennas had been created they were matched up to the tilts of the matching GSM or WCDMA technologies for that sector. The picture below shows a RSRP plot that I made for the initial stages of LTE700.

Now that the antennas had all been created various plots were created to see how the network would perform. These included a RSRP plot, a SINR plot, a max uplink plot and a max downlink plot, and a best server by RSRP plot. The SINR plot was used to see the quality of the signal. A SINR plot shows the strength of the signal above the noise floor. The RSRP (reference signal received power) is a measure of the signal strength [2]. Generally a RSRP above -95dB is required, as this is gives a fairly average signal. The max uplink and downlink plots were used to see what kind of throughput was going to be achieved by the new antennas. The best server by RSRP is very important, as it shows what is being covered by which antenna based on a strongest signal. Unlike a normal best server plot it shows the signal strength at all locations.

From this best server by RSRP it could be seen what had coverage and what didn’t. From this I had to do some optimisation work to try and cover as many holes as possible. Since the LTE700 was paired up with either a GSM or WCDMA technology when changing bearings or tilts on the LTE700 the GSM and WCDMA networks had to be taken into account too to make sure I wasn’t degrading coverage in either of those networks. Eventually the area of the initial deployment of LTE700 had almost complete coverage except for some terrain limitations.

This work gave me the opportunity to see how the mobile network worked as a whole by modelling large areas, which were covered by many antennas. I also learnt about the various ways to tell the quality of the signal that was being received.

# 2.3 Work Activity 3

An important task I did, while working at Telstra was contributing to the case they were making to the ACMA (Australian Communications and Media Authority) to get a testing licence for LTE700. The frequency band is currently owned by the TV stations and getting the testing licence would allow Telstra to test out the technology in their building. Basically we had to prove that we wouldn’t be interfering with the TV broadcasts.

Since the areas where they were still using that frequency spectrum was far away it wasn’t too hard. This was done in a similar method to the work done in the previous work activity, where I exported an excel spread sheet with the required data and edited it to fit the new antenna. In this case only IBC (in-building coverage) antennas were being used, which are small omni-directional antennas that emit only low power. Before putting in the parameters some of them had to be calculated such as the height of the highest antenna and the power that was being transmitted from this antenna. To do this estimations the distance from the roof to the floor was measured and then the cross section of the slab in the floor and the ceiling space were estimated. These lengths were used to calculate the height of the tallest antenna by multiplying the height of one floor and multiplying it by the number of floors. The next step was then to make a link budget from some schematics of existing antennas to calculate the loss before the antenna to find out the power being transmitted. A link budget is a tally of all the losses that are created from the many lengths of wire and components that are used between the radio base station and the antenna. This can be seen below.

Once all of this data was in atoll some RSSI (received signal strength indicator) plots could be made to show how far the signal would propagate at a useable level. To test this as a worst case scenario we used the highest antenna since it would propagate the furthest and used the shortest path loss on that floor to have the largest transmitted power. Various other losses and gains had to be applied such as gains for having multiple antennas, window loss and loss for only using a percentage of the bandwidth. To create the plots a computational zone was set up and a filtering zone around just that antenna, so that there is no interference from any of the other antennas. Since this one would be the only one transmitting on this spectrum the other ones were unnecessary. The results of this were given to a colleague who was building the case for Telstra getting the licence. The same was also done for a Telstra office in Sydney. It could be seen on the plot below that the signal wasn’t travelling very far.

Working on acquiring the licence for the LTE700 DAS (distributed antenna system) gave me the opportunity to apply my knowledge of power calculations, as well as applying my knowledge of RF plumbing and atoll gained from other work activities.

# 2.4 Work Activity 4

Where I was working at Telstra also acts as the last resort for a customer complaint. During my time at Telstra I worked on a complaint out at Redeemer College. A customer was complaining about bad service at his location, which it was since it was at the boundary of 3 coverage areas. RSSI plots showed a signal level of around -100dB, which isn’t very good.

The first step was to load up the surrounding area in atoll and run some predictions to see what was happening in the area. Once it was confirmed that the service there was poor due to us providing poor coverage the next step was to investigate ways of improving it. Many solutions were attempted, but one stood out by improving the signal strength by at least 5dB up to -95dB signal strength which is a reasonable level. It can be seen in the two pictures below how the signal has improved in the target zone in the red circle

Just raising the signal strength at the target location isn’t good enough though. In addition to increasing the signal strength at the target location the signal strength shouldn’t be degraded in other locations. To make sure of this I had to acquire an add-on that compares two plots and shows the difference between them. By using this it could be seen that the change was working at least in simulation. 97% of the plotted area showed either an increase or stayed at the same level and the other 3% showed minimal degradation.

To further make sure this was the correct solution I went and did a drive test with another colleague. To do this first a plot of the radiation of just the one antenna that was being moved was taken in its current position and was printed out. This was used for our map while driving. My colleague was driving and I was directing and using a software called TEMS, which connects up to a pair of mobile phones one making a long call and one that makes short calls and monitors a large number of variables related to the quality of the call. Using TEMS it is possible to monitor which cell is the serving cell, signal strength, SINR, handovers and many other things, but in this case we were mostly interested in signal strength and serving cell. The idea of this drive was to check that the data in atoll matched up to what was happening in real life. The outcome of the drive showed that it should be alright to go ahead with my proposed changes and they were briefed to happen with other optimisation work that is in progress.

This work gave me the opportunity to learn about optimising the mobile network. There were many new things I learnt such as using new software and also gave me the opportunity to apply knowledge on what defines good coverage.

# 2.5 Work Activity 5

After I had finished my work on the Initial LTE700 deployment one of my managers wanted to know how many of the sites in the POC zone we would be able to get LTE700 onto. The POC zone is an area that Telstra uses for testing various technologies and consists of about 80 sites. This gives a reasonably sized area, so that things can be tested as a network not as a singular access point. The problem with this is that a lot of the towers either don’t have any spare mounts for a new antenna or it is overloaded and cannot fit any antennas. Reasons for this is that we have to share towers with Optus and Vodaphone and they are currently putting up huge 8 port antennas, which weigh a lot and take up large percentages of the loading. There are already a large number of antennas up there from us for testing out the many different technologies.

The way I went about this was to make a large table of the antennas and technologies at each site. To get me started I asked the help of my manager to generate a table of the sites there with the correct antennas already present by using SQL programming. This is an effective way of data mining by taking bits of information from various databases that Telstra uses and joining them together in a meaningful way. Once I had created the rest of the table I then had to populate it with the structural data, so that I would know, whether or not we would be able to put up the correct antennas at the other sites. Generally the tower had to have a structural loading under 90% and for that to work some antennas had to be swapped out. This structural data was found in a Telstra database called Cadlink which stores all of the schematics and other structural information about the sites.

With the structural information I was then able to tell if the site was viable for LTE700 and if it was whether it was an easy installation or if a compromise would have to be made such as removing ports of another technology. Once this was done I sorted them all for easy access to the information and sent the information off to my manager.

# 3.0 Conclusions

My industry related work experience for the second thirty days gave me real world experience in the field that I want to work in. Working at Telstra gave me valuable insight into working in this industry and what was required for the role. There are many things necessary, such as computer skills, networking skills, problem solving, but the most important would be thinking about the community. If you create a brand that thinks of the community and creates products that benefit the community then the community will support your business. This can be seen when working on customer complaints. Working at Telstra gave me the opportunity to apply knowledge gained from university, as well as new knowledge gained from working at Telstra, such as the optimisation work, RF plumbing and quality of coverage.

# References

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| [1] | software.informer, “Atoll Radio Planning Software,” Informer Technologies, 2014. [Online]. Available: http://atoll-radio-planning-software.software.informer.com. [Accessed 27 April 2014]. |
| [2] | r. a. blogger, “LTE RF conditions classification,” radio access, 25 November 2012. [Online]. Available: http://radioaccess.blogspot.com.au/2012/11/lte-rf-conditions-classification.html. [Accessed 27 April 2014]. |

# Appendix A – Work Log

|  |  |  |  |
| --- | --- | --- | --- |
| Day | Date | Duration | Work Activity |
| 31 | 7/1/14 | 7.5 | Did some more EME analysis. Did all the missing polygons for the most recent check. Started doing more DACs. Found out how to make changes to CANRAD. Had software problems with my oracle caused by automatic updates, which reinstalled an old version that does not coexist with the newer one. |
| 32 | 8/1/14 | 7.5 | Did some quoll/atoll alignment and did some more DACs. Sent off some emails to fix my quoll access |
| 33 | 9/1/14 | 7.5 | Did some more DACs. Did some alignments between atoll actual and design databases. Started doing a link budget for an IBC at Nathan. Did the weekly dashboard report |
| 34 | 10/1/14 | 7.5 | Finished the link budget. Did some more DACs, did some EME analysis on another site. Did some radio base station design using the RBS design tool, some in-house software |
| 35 | 13/1/14 | 7.5 | Did EME analysis on some more sites. |
| 36 | 14/1/14 | 7.5 | I got whisper access, so I could sign off all the DACs I did. This took a lot of time as I did a large number of them and whisper is very slow. Went on a walking test, which involves walking around the CBD on a specific route testing the mobile experience of users in peak time. UL, DL, ping and user experience were all measured. Did EME for another site. |
| 37 | 15/1/14 | 7.5 | Did some more EME analysis |
| 38 | 16/1/14 | 7.5 | Did some more EME analysis, did the weekly dashboard report on PIM |
| 39 | 17/1/14 | 7.5 | Started inputting data into atoll for the LTE700 network to start running coverage predictions. |
| 40 | 20/1/14 | 7.5 | Finished putting in the transmitter data and put in all the cell data for the initial LTE700 network in atoll |
| 41 | 21/1/14 | 7.5 | Ran some predictions on the proposed LTE700 network to check coverage and began trying to maximises coverage from the small amount of sites without causing any negative side effects. Worked on a customer complaint at Wynnum about an EME complaint. A solution was found that reduced it by 0.4% and increased coverage, but increased EME in other locations, as well as increase the overall EME. In the end nothing was done as they wouldn’t be happy with the result. Their current EME reading was already only 1% which is tiny. |
| 42 | 22/1/14 | 7.5 | Finished optimising the LTE700 sites in Atoll. Some areas needed another antenna installed due to terrain. Optimisation was done using e-tilts and bearing changes. Plotted coverage at a newly proposed site at the airport and optimised it to get the required coverage. -95dBm minimum. |
| 43 | 23/1/14 | 7.5 | Presented the work I had done while my boss was away and I got some new work to make a slide pack for the ACMA, so that Telstra can install an LTE700 DAS for their building in the city. This involved making a link budget to find all the losses of the shortest path. This was used to build the antenna in atoll to generate an RSSI plot. |
| 44 | 24/1/14 | 7.5 | The same was done from yesterday for a Sydney Telstra building and I started some new work on getting LTE700 in the POC zone. |
| 45 | 28/1/14 | 7.5 | I got some more polygons to do and then I did some more work on the L700 for the POC zone. I got a table that John generated on SQL and used that to find sites that already had RVVPX310B2 antennas as the R ports are necessary. I started making a table of existing antennas and technologies for the other sites in the POC zone. Went to the weekly Monday meeting. |
| 46 | 29/1/14 | 7.5 | I worked on a table of all technologies and antennas in the POC zone |
| 47 | 30/1/14 | 7.5 | Finished the table and started using it to determine which sites would be able to have LTE700. The criteria for this would be having an RVVPX310B2 antenna with spare R ports. If a spare RVVPX310B2 isn’t present the tower needs to be able to support a new one |
| 48 | 31/1/14 | 7.5 | Kept working on L700 in the POC zone viability |
| 49 | 3/2/14 | 7.5 | Archived all of the LTE700 antennas in atoll, so now all other users have access to them. Also did EME analysis on a few more sites before the due date of C.O.B 4/2 |
| 50 | 4/2/1 | 7.5 | Finished the LTE700 sites for the initial deployment. Helped a new graduate using atoll. Went walk testing for LTE. Did the QUT route and continued working on LTE viability in the POC zone |
| 51 | 5/2/14 | 7.5 | Finished the table for LTE viability in the POC zone. Had a look at the process of a mobile call on nemo analyse an expensive program used by Telstra for collecting data on cell performance |
| 52 | 6/2/14 | 7.5 | Started doing EME analysis again. Went on a drive test using a program called tems, which shows a lot of information such as, signal strength, handovers and the serving cell. Started preparing to present the LTE700 antennas in atoll |
| 53 | 7/2/14 | 7.5 | Did some more EME analysis, presented the LTE700 in atoll, fixed up a few things before presenting. |
| 54 | 10/2/14 | 7.5 | Made another atoll workspace with all LTE technologies to see the impact LTE700 would have on the network as a whole. It improved coverage by closing up some holes in the coverage. Worked on a complaint at Redeemer college. I found a possible solution by changing the bearing of a nearby antenna by 30°. From atoll it improved coverage with no negative side effects. Did some more EME analysis |
| 55 | 11/2/14 | 7.5 | Did some more EME analysis for a site where a building was going up next door. 2 sectors may have to go off. Went on a drive test for the site yesterday to test EMPS and see what was receiving coverage from the antenna. I was running tems and giving the driver instructions. |
| 56 | 12/2/14 | 7.5 | Checked the results of the drive test and decided to go ahead with the proposed pan. Did some more EME analysis for round 2 of LTE700. Went on another dive test to investigate a drop call. |
| 57 | 13/2/14 | 7.5 | Did EME analysis for a site where we have to turn off 1 maybe 2 sectors, because of a new building coming up. I also had to write a report on my results. This included process, assumptions, results, ARPANSA guidelines and conclusions. Did EME analysis for LTE700 |
| 58 | 14/2/14 | 7.5 | Did EME analysis for some more sites and I started to work on creating a prediction for when all CBD+5 sites are on air for LTE700 |
| 59 | 17/2/14 | 7.5 | Ran some atoll predictions for what the coverage will look like when all sites have LTE700. This involved making transmitters and cells for all necessary LTe600 antennas. I made a coverage by RSRP plot and a SINR plot, did some more EME analysis for LTe700 stage 2. Learnt about inter and intra frequency handovers from another colleague. |
| 60 | 18/2/14 | 7.5 | Did some EME analysis for some more sites and made a slide pack of what I did at Telstra |
| 61 | 19/2/14 | 7.5 | Worked on the completed LTE700 network predictions |
| 62 | 20/2/14 | 7.5 | Presented all of the work I did to my bosses through use of a slide pack. They were all happy with the work I had done. I did some more EME analysis. |
| 63 | 21/2/14 | 7.5 | This was my last day at Telstra. I did some more EME analysis. I had a look at one of the briefs for the LTE700 I was working on. There was a barbeque to see of the vac workers and welcome the new grads. I did a few exit jobs such as handing over passes and transferring my work to a network drive. |

# Appendix B – Certificates of Time Worked

Attached in the back of the report

# Appendix C – Reflective Field Notes

***Situation:***The sites that were going to be used for the new LTE700 needed to be tested to make sure they still meet ARPANSA guidelines

***Task/event:***To simulate adding a new LTE700 antenna and checking if it still meets guidelines

***Action:*** first a plan was made on how to implement the new antennas. Then the antennas were made in a program called RF-map and various simulations were run to see how far the electromagnetic fields came out.

***Result:*** All of the required towers plus some extra ones were tested, which allowed Telstra to know which sites would or would not be able to be used for their initial LTE700 rollout.

***Learnt:***

* Learnt about the ARPANSA standards
* Learnt about EME
* Decision making
* Antennas
* Rf plumbing
* Antenna powers

***Situation:***Management wanted to see coverage from the new LTE700 antennas to see if the money spent on it was worth it.

***Task/event:***To simulate and optimise the LTE700 antennas to check and maximise coverage.

***Action:*** first all of the antennas had to be created in atoll, which required the input of many parameters for many antennas. The antennas had to be matched up to its paired technology for both bearings and down tilt. Various plots were created to see the effect of having the new antennas. The antennas could then be moved around to fill coverage holes.

***Result:*** Various plots were created of an optimised LTE700 stage 1 rollout. There were obviously a few holes in coverage, as there weren’t enough antennas on an initial rollout, so terrain limitations opened a few holes.

***Learnt:***

* Learnt about optimising a mobile network
* Learnt more about using atoll
* Learnt about various plots and what they represent.
* Learnt about the various parameters and other things necessary for the antennas

***Situation:***Telstra need to get a licence to test the new LTE700 in their building

***Task/event:***To run predictions to show that our testing won’t interfere with the tv stations that are already using the frequencies

***Action:*** This first required a calculations to see how high the antenna would be. Then a link budget was created to see how much power would be transmitted from the antenna. Predictions were made to show how far the signal would spread at a useable power level.

***Result:*** Various plots were created and put into a slide pack to the specifications that the person putting together the case wanted. The plots showed the signal only travelling a small distance at a useable power level.

***Learnt:***

* Learnt about link budgets
* Learnt about IBC antennas and rf plumbing
* Learnt about using atoll

***Situation:***A customer was complaining about bad coverage in their area

***Task/event:***To find a reasonable solution that doesn’t degrade coverage in other areas.

***Action:*** I loaded up the antennas in the area in atoll and ran an initial prediction to see the current coverage. I changed bearings and tilts on nearby antennas to find an optimum solution and ran various predictions. Went on a drive test to check if the change was going to be alright or not.

***Result:*** The drive test results came up positive and the change was briefed to be implemented.

***Learnt:***

* Learnt about optimising the mobile network
* Learnt about using the drive test software
* Learnt about parameters that determine good coverage

***Situation:***Some colleagues wanted to know how many sites we would be able to get LTE700 onto in the POC zone

***Task/event:***determining LTE700 viability in the POC zone

***Action:*** For this I asked my manager to give me a hand generating some tables to get me started. From there I made my own tables, which had information on the site, antennas, which technologies were present as well as loading data.

***Result:*** A large table was made describing which towers would be able to get the required antennas up as well as what had to be done to do so.

***Learnt:***

* Learnt about structural aspects associated with telecommunications work
* Improved my excel skills