IT and Telecom Consulting

Cellular RF Study Interim Report

University of British Columbia

History

On 4th June, Issue 1 of this report was produced for discussion with the Steering Group in a workshop feedback session. At that workshop the discussion identified several items that were restructured slightly and the revised report has been released as Issue 2 for wider distribution.

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1 Executive Summary

UBC is experiencing escalating requests for new cellular installations on campus and in the adjacent university neighbourhoods. TMC was engaged to conduct a study to determine existing and future coverage needs, and how these requests could be better assessed, managed and regulated.

The report reviews current and future coverage requirements as well as how technological change will influence growth.

Cellular carriers are not happy with the UBC process for assessing antenna installation applications. In general, the procedures are fine but the process needs clear management controls including specific timelines.

Contracts need to be changed to improve safety assessments. Currently, carriers calculate the RF energy that their installation is expected to generate and create a safety assessment without actual measurements. When multiple carriers share a site and when carriers come back to a site to `maintain their equipment` but actually add transmitters to their installation, there are completely unknown levels of RF energy. Carriers must be made to conduct proper testing to reduce UBC`s liability.

UBC could drive the planning process – currently they react to carrier demand and carriers just react to what they see in their networks. Working cooperatively in planning will provide improved outcomes.

Our vision is that UBC will build a plan of where cell sites will be located and the carriers will build on those locations as they see the need for growth. The current need for approving carrier designs could disappear as UBC could manage the design process themselves.

2 Project Objectives

The objectives in the following subsections come from the original Request for Proposal, which is regarded as the sponsorship document. In a formal Project Management scenario, meeting all these foundation objectives is the key to defining success.

2.1 Existing Cellular Installations

The existing cellular RF installations will be inventoried.

2.2 Future Demand

Future demand for cellular RF service on UBC academic and neighbourhood lands will be estimated.

2.3 Projected Technology Evolution

Likely future changes in the industry and its technology that may affect the nature of installations will be assessed and documented.

2.4 Site Sharing

The need and value of sire sharing by providers will be assessed.

2.5 Inappropriate Sites

Locations that are not appropriate for installations will be investigated and documented.

2.6 Proposed Site Evaluation Criteria

Criteria will be developed to evaluate new installation locations based on coverage needs and compatibility with relevant UBC land use planning policy documents and design guidelines (Land Use Plan, Vancouver Campus Plan, Neighbourhood Plans) and identify the types of installations that would be appropriate (e.g. building interiors or exteriors, monopoles) for these locations.

2.7 Proposed Approval Process - Technical

The current approval process will be assessed and recommendations for improvement made as required, to ensure an efficient, transparent, and rigorous consultative and technical review process.

2.8 Proposed Approval Process - Commercial

The process for licensing providers will be reviewed and recommendations on the commercial terms and rates structure made.

3 Project Methodology

This section is a summary of the steps taken to gather information on which to build our recommendations. Key to the process was a desire to meet with stakeholders who are deemed to have influence on the needs or deliverables related to the project.

3.1 Organize Project

The Project Work Plan was presented to the Steering Group on Monday May 7th and discussed. At the request of the Steering Group, the public input task has been deferred until after the draft report is published.

3.2 Review Current Situation

3.2.1 Stakeholder Meetings

Meetings were set up with five UBC Stakeholder Groups on Monday May 28th and Tuesday May 29th as follows:

Session	Attendees	
Monday 8am – 9:30	Gerry McGeough, Kavie Toor, Suzanne Poohkay, Bob Macdonald,	University Architect Associate Director, UBC Athletics and Rec Facilities & Business Development Director Facilities Planning, Infrastructure Development IT
Monday 1pm – 2:30pm	Chris Skipper, Greig Samodien, Rob MacDonald, Geoff Armstrong,	Facility Manager Facility Manager Facility Manager IT
Tuesday 10am – 11:30	Ed Lin, James Heth,	Chief Building Official UBC Treasury
Tuesday 1pm – 2:30pm	Bruce Anderson	Risk Management
Tuesday 3pm – 4:30pm	Jan Fialkowski,	Executive Director, University Neighbourhoods Association

The raw meeting notes, copied from the whiteboard, are included in the Appendix (Section 6.1 on page 29).

A meeting with Matt Yedlin to discuss EMC issues did not mature because Matt is in Europe and his suggested alternate attendees did not respond to repeated invitations. We need input from Matt to complete that work, so we plan to hold a telephone conference call with him as part of our follow-up research next week.

In addition to meeting with UBC staff, a telephone discussion was arranged with each of the carriers to gain their perspective. This approach was extended to two 3rd party companies involved in construction work for the cellular companies in order to better understand how these agreements worked. This included basic construction specialists as well as a company offering a novel approach using "fake trees" – a possibility being considered on the South Campus.

3.2.2 Inventory existing cellular RF installations

We received input from two UBC departments (Campus & Community Planning and Contracts & Leases) listing known sites on UBC property. We also researched input from the Industry Canada "Technical and Administrative Frequency Lists" (TAFL) to find out what cellular sites existed in the UBC area.

The two UBC sources show what UBC is "aware of" and the TAFL source shows what is "believed to exist".

A map presentation based on the TAFL data set, along with all the source data are included in the "As-Is Report". The map is also reproduced in section 4.1 below and the source data is in the Appendix (Section 6.3 on page 33).

3.2.3 Conduct sample test measurements

The aim was to plot field strength contours around Allard Hall using cellular receivers on the Rogers and Telus networks to highlight any coverage differences.

- The measurements were planned to extend out about 100m from the building on all sides, establishing where areas of good and poor coverage are located.
- No in-building measurements were planned.
- The planned result was to be in the form of an idealized contour map showing approximately where coverage issues are likely to be encountered on the two networks with the existing base station configuration.
- It was noted that the new base station locations at Buchanan and Gage Towers will significantly affect the signal strength in this area – rendering current measurements out of date.
- The results, however, should illustrate the problems of the "urban canyon" effect on cellular signals around buildings and will help explain some of the conclusions that will develop in our report.

When the actual measurements were taken, we changed our test plan because the measurements on the Telus network failed. We therefore took the opportunity to spread the survey over a much larger area than originally planned and to just measure the Rogers network.

We still surveyed around 100 points as planned – but we used a flexible rather than a fixed grid in order to cover more ground. This allowed us to extend the survey to cover over 5km around Allard Hall – limited a little in the northwest segment by the need to avoid disturbing the various Grad photo sessions in progress. We only took measurements when the signal level changed – allowing much greater scope of measurement.

These sample measurements are a reasonable guide as to what sort of service might be expected at various locations. The results have allowed us to develop several suggestions about radio coverage on campus, which will be discussed later in the report.

Maps and all the source data are included in the "As-Is Report". The maps are also reproduced in section 4.10 below.

3.3 Develop Strategy

3.3.1 Estimate future demand for cellular RF service on UBC lands

We discussed with carriers and UBC staff how they evaluate future demand. We added our own experience with industry trends.

3.3.2 Project pertinent future changes in wireless technology

We discussed this with carriers and UBC IT staff. We added our own knowledge of worldwide industry trends.

3.3.3 Assess site sharing issues

We looked at carriers' desires, at what UBC currently requires, and at what the regulations allow (or demand).

3.3.4 Identify locations that are not appropriate for installations

Various reasons, which were discussed with UBC stakeholders, might make a site unsuitable for use as a cellular base station:

- Safety
- Aesthetics
- Compatibility
- Structural
- Security

3.3.5 Develop criteria to evaluate new installation locations

We talked about this with the carriers and also discussed it in the UBC stakeholder workshops. In particular there was discussion around:

- Location
- Space
- Communications
- Power
- Access & Security
- Safety

3.3.6 Assess current approval process

We talked with the UBC stakeholders involved and also with the carriers to gain two different perspectives on the processes involved and the stages through which applications needed to pass. We also looked at the differences between the UBC processes and those involved with commercial buildings.

3.3.7 Review licensing, commercial terms and rates structure

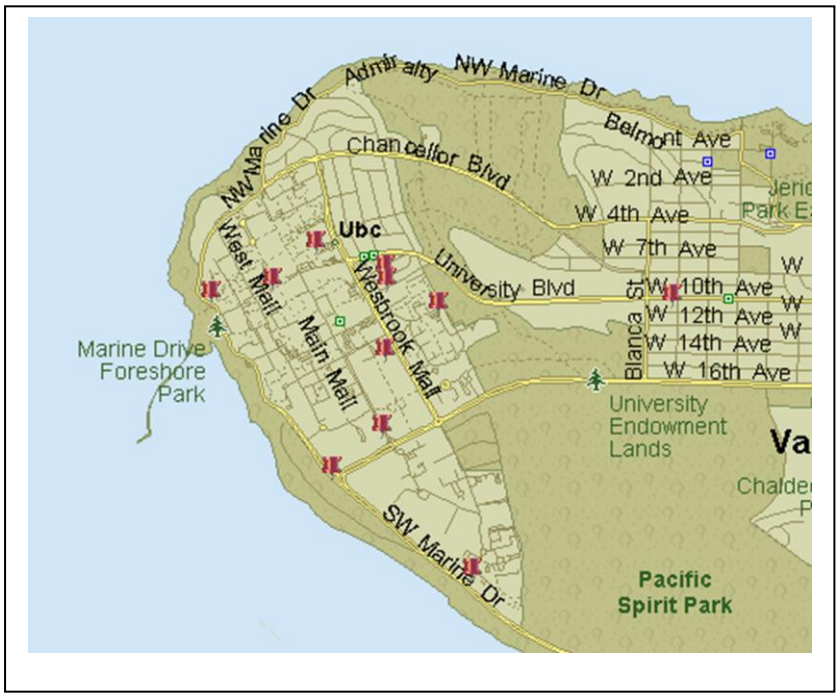
We are able to comment, from our experience, on how typical commercial processes work and what rates are typically set.

4 Research Results

4.1 Existing Cellular Installations

We have included full details of sites in the area culled from three different sources.

We were supplied with data from two UBC sources – Campus & Community Planning and Contracts & Leases. We looked up radio site data in the Industry Canada TAFL database. All the raw data, along with map presentations, is included in the "As-Is Report" and also in the Appendix (Section 6.3 on page 33). The Industry Canada map presentation is repeated below.



The first observation is that there are almost twice as many cellular sites in the region compared to the UBC lists. Two factors contribute to this difference:

1. The Industry Canada data includes sites that are located on non-UBC property. These sites have an impact on radio coverage and EMC – but will not be included in any UBC negotiations unless the carriers agree to add UBC into the loop. For this to happen would require some advantage to be offered to the carriers – and we have recommended that this be included in follow-on discussions with the carriers.

2. Some "sites" are too small to be "on the radar" of the standard approval processes. There is no reason why carriers need to have approval of building owners or landlords for small relay systems that are little more than booster amplifiers – physically they could be similar to small wi-fi routers. Again the carriers might be persuaded to include UBC in the planning loop as long as there was no disincentive to doing so (such as process delays or cost). We have recommended that this be included in follow-on discussions with the carriers.

The second observation, based on feedback from discussions with the Facility Managers, is that the actual inventory of equipment at each site often varies compared with what was approved in the original permit. Again multiple factors contribute to these differences:

1. Maintenance work done at a site does not require a new permit – yet it can result in changes to antenna systems. These changes can include replacing one antenna with two – yet the carriers often still regard that as "maintenance" and will not go for a new "approval".
2. Addition of new radio carriers might be done to add capacity without changing the antenna structures. Again no permit would be sought but the transmitted RF energy would likely have increased.

The UBC processes are seen by the carriers as more onerous than average. Whilst they respect the right of UBC to define its own processes it is only to be expected that they will look for "loopholes" that will allow them to avoid it. The standard UBC contract allows for maintenance work without revisiting the permit process – but does not limit what is defined as "maintenance work". An exception to this is the Henry Angus building – where, due to specific problems with work done there, the Facility Manager has taken a more aggressive "no-access without specific permission" stand (which we look at in more detail in Section 4.6.5 below).

The carriers want to avoid the time delays and financial penalties of having to re-visit the approval process. This does have an unintended consequence that the RF power levels in the site may increase without UBC being aware of it. Safety Code 6 obliges the carriers to measure RF power and ensure compliance after any changes are made but UBC will not be in that loop.

Clearly this needs to be addressed and we have included a pair of recommendations regarding the contract and the implications of Safety Code 6.

4.2 Stakeholder Meeting Summary

4.2.1 Carriers

We were able to have one-on-one discussions by phone with all the carriers except for Bell (the contact was not available during our data gathering window). All of them commented about the complexity of the UBC approval process yet all agreed in discussion that they could probably contribute to the process if more involved in it. The perception in all cases was of a confrontational process rather than a collaborative one.

Many of the carriers engaged the services of 3rd party companies to do some of the work. In some cases it was searching out sites and in other cases it was construction. All agreed that they would be prepared to discuss a better approach to both aspects as long as it was more effective and not significantly more costly.

We were also able to talk with two of the 3rd party companies – one concerned with site negotiation and the other with construction. The added value of the site procurement company could easily be replaced by UBC offering the same service itself by leading the process rather than reacting to it. The construction company is currently proposing a site solution based on a large artificial tree structure that builds on the idea of visual camouflage to disguise a cell site. The idea has merit but needs a buy-in from the service providers. The present feeling is that the carriers will likely see other, less expensive, options as being preferable. They need to be convinced either that this is the only way of solving a coverage problem or that someone else will pay the “aesthetic marginal cost”.

4.2.2 UBC groups

The UBC stakeholders were divided into functional groups so that discussion areas were common within a grouping.

A clear desire came out for improvements to the process of handling site approvals. Everyone was prepared to accept that the carriers might perceive UBC as the cause of the problems, though their perceptions were more that the carrier demands were often unreasonable. There is a clear need to get the groups around the same table and have a facilitated discussion as to how the whole process can be restructured as a co-operative system rather than a confrontational one. If UBC can adapt to seeing the need for cellular as a utility need in the same way as electrical service then the whole design process of new buildings and even entire neighbourhoods could involve the cellular providers from the very beginning instead of after construction was complete.

There was also a clear statement that the carriers needed to better understand the university needs in terms of building access etc. This was a clear mirror to the carrier demands for UBC to have a better understanding of their business needs. Together these two perspectives show that both sides experience pain caused by the other side and the solution is to move to a more co-operative process throughout.

Discussion about the UBC Neighbourhoods raised some interesting issues, apart from coverage. A key red flag items is that, unlike UBC property, not all the roads are private – presenting the carriers with an in-fill option not available to them elsewhere on the campus. Cellular service providers have a federal mandate that allows them to take whatever steps are needed to provide service. When they have access to federal or provincial property, the easiest way to exercise this privilege is to construct a microcell system based on a large street light fixture – as they have already done in some locations along Marine Drive to the west of the campus. At present, the carriers likely do not realize that this option is open to them – but, faced with strong opposition in some neighbourhoods to cell sites on rooftops, this may suddenly become an option visible to them. UBC needs to solve this problem first, or risk losing revenue and control over location.

4.2.3 UBC groups not represented

At the time of producing this version of our report we had not been able to get input from the EMC group. This is a major influencer as to where inappropriate sites might be located and a major player in the whole site approval process.

There has been no input from the academic side – neither faculty nor student. It is understood that the report will be circulated to some of these groups – but it must also be understood that their input could significantly affect some of the conclusions. Of particular concern is the fact that the key growth driver relates to what the end users need cellular capacity for. We, and also the carriers and the UBC staff, have our perceptions about the answers. However it is quite possible (perhaps even quite likely) that, to use a term offered by one of the UBC IT staff, there could be a “killer application” lurking in the wings that might have a major impact on technology plans. Examples might include moves to electronic textbooks or online real-time research, or collaboration, using either the public internet or UBC IT resources.

4.3 Future Demand

Discussions with the cellular operators have shown this to be both a fast moving target and also a largely undefined quantity. Cellular capacity growth does not seem to be driven by any predicted need but rather as a reaction to demand in two ways.

1. Measurement of call volumes, or data use, in specific geographic locations.
2. Feedback from users regarding dropped calls and poor coverage.

Both these drivers are demand related rather than, as might be expected for a conventional business case model, predicted growth.

The biggest issue here is that virtually all growth is reactive not proactive. There is no advanced planning of future needs 3 or 5 years out. Ideally there should be – and one might reasonably expect that business cases for expenditure like new cell sites would include planned capacity needs. However that is not the way the industry works.

We see a clear need, and the carriers understand and support this, for UBC and the cellular providers to have ongoing round-table discussions about growth plans. It is not reasonable to expect the carriers to share their own internal plans in a public forum – but they might share more information in confidence with UBC on an individual basis. The big advantage would be getting UBC growth information, which is public domain in most cases, in the hands of the cellular companies so that they are encouraged to react to planned growth rather than reacting after-the-fact as is done presently. In other words – make the planning more proactive.

One of the biggest benefits to UBC in this would be the ability to plan cell sites into building projects at the planning stage – when architects could design suitable disguising features to improve the visual appearance of a future site.

4.4 Projected Technology Evolution

None of the Cellular Operators was willing to speculate on how technology changes are going to impact the present network topology. They are all very much living in the "now" as far as their current network is concerned.

We are, however, aware of significant changes that are affecting networks in Europe – and also that such changes typically take around 3 to 5 years to move to North America. As a result we have given our own predictions as to how wireless technology is likely to develop over the next 5 to 10 years.

Technology will continue to evolve and, in the main, will retain backwards compatibility so that existing systems are not rendered redundant in the near future. All bets are off for timescales more than 10 years into the future but at least some stability should be available for a 5-year timeframe.

The biggest concern on the horizon is that cellular system use is drifting more towards data and away from traditional voice. The drivers behind this would seem to be the desire of the carriers around the world to get new "gadgets" into consumer hands – with first PDAs and now Tablets. To encourage use of PDAs, many carriers started offering reduced data tariffs – exploiting a largely unused aspect of cellular technology. At the time, cellphones were regarded as voice phones with a data option.

The entire cellular infrastructure is actually designed around vehicle-mounted voice phones – which is where it all began back in the 1980s. Inter-cell handoff is designed on the basis of how vehicles move from cell to cell. With the migration to pocket phones, the first change in use came with vastly increased numbers of cellphones and a corresponding reduction in cell size to accommodate the increasing traffic.

All this use was great news at the time for the carriers but it came with a price. Smaller cell size introduced more demands on the handoff protocol and the smaller cell sizes created yet more challenges in confined spaces.

On top of all of this came data – initially just considered a more sophisticated version of text messaging, which itself grew out of paging applications. Starting with PDA phones (larger screens and keyboards with mini applications to mimic portable computers to a degree) we have moved to laptop computers with built-in cellular data systems and now tablet computers. Many of these new devices are data only – simply using cellular as a convenient network to use “out in the field”.

What started to catch the mobile phone providers totally by surprise around the world was when the younger generation started to abandon landline phones in favour of pocket cellphones. This move will significantly impact UBC housing where units designed for students will likely not need landline phones and internet but the area will need powerful cellular service in lieu.

Technologists in Europe (which tends to be about 5 years ahead of North America in Cellular development) started a few years ago to worry that using the cellular system for data in a massive way was putting an unmanageable strain on handoff and the backhaul network – both of which were optimised for call-based voice use rather than IP data. A better cordless technology for data is that used for WiFi – the 802.11 set of standards. New developments there are permitting a degree of network authentication (common in enterprise systems but currently very rare in the domestic market) and the ability to move from WiFi node to WiFi node while connected to e-mail or the web. The European model has now linked WiFi and Cellular in a new generation of dual-mode devices that will use either network for “backhaul” without the user needing to know or care which.

Whilst it may seem that this is all rather esoteric in the context of UBC it is actually central to the problem of growth.

- If users of portable data devices are encouraged to stay with cellular by way of subsidized tariffs then there will be an uncontrolled and explosive demand for more capacity.
- If, on the other hand, users use dual-mode devices and preferentially use WiFi where it is available then it may be that, in a WiFi rich environment like UBC, there is little demand for extra cellular capacity.

It is difficult to predict where the data growth is going to hit home.

- If it is via cellular, as the cellphone companies would like to think, then there is a looming problem on the horizon.
- If, however, it is steered towards WiFi then UBC is already ideally positioned by virtue of having a state-of-the-art campus-wide WiFi system.

When European style dual-data-mode devices hit North America (possibly in around 3 to 5 years' time) users will be able to work in-buildings with WiFi and move outdoors onto the cellular network transparently. Until then our conclusions suggest that UBC needs to build closer links between its IT-based WiFi planning and the student/academic needs in order to ensure that the right capacity is provided where needed.

4.5 Site Sharing

Our research with the Carriers showed two conflicting views.

1. Carriers want new capacity at lowest cost.
2. They want exclusivity to gain a competitive advantage over the other carriers so as to make their network more attractive.

Shared sites can give the carriers a lower cost but the revenue benefit is less because their competitors also benefit. There is evidence (mostly anecdotal) that carriers "partner" with each other – for example Telus may develop sites in BC and share freely with Bell and in turn Bell will develop sites in Ontario and share with Telus.

Landlords, like UBC, can decide to enforce a site sharing policy – something that is entirely consistent with Industry Canada rules that actually mandate the carriers to share infrastructure where appropriate. Landlords can influence sharing policy to a degree in their site rental rules. However these are most effective if the carriers have no other choices. When a major airport tried to impose restrictive rules, the carriers jointly decided on a boycott approach and simply relocated to sites on adjacent land. However where such options are not available then the carriers are more likely to agree to restrictive rules.

Careful wording on the part of UBC should allow site sharing to be enforced.

4.6 Inappropriate Sites

4.6.1 Safety

The use of building rooftop areas or "penthouse suites" is fairly well understood by architects as far as building codes are concerned. However, when the roof is used for radio transmission systems (not limited to cellular), the provisions of Safety Code 6 apply and basic architectural design alone is insufficient. As a "rule of thumb" for systems with cellular power levels, people should not be able to get closer than about 2m from a transmitting antenna – increasing to around 5m in the "main beam" or front part of the antenna. The actual distances are established by measured field strengths in each instance.

To comply with Safety Code 6, a radio site must not have field strengths above the designated maximum level in areas where people can gain access. Mixed use rooftop sites are a hazard to manage and should be avoided if at all possible.

If it is not possible to secure a rooftop site against access by the general public then that rooftop might not be an appropriate site. The same issue would apply to lower levels of a stepped building if people occupying a lower terrace could get into the hazard zone (roughly within 5m of the antenna front) of antennae above. This might easily happen, for example, if antennae were to be located on a penthouse roof and the main roof had a paved access area below it.

With regard to Safety Code 6, which is the accepted Canadian standard regarding *"Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz"* – produced by Health Canada, we have a number of concerns about how conformance is certified and maintained.

UBC has the role of a landlord in most cases as far as its staff and visitors are concerned. As such it is expected that UBC will ensure that none of its people are exposed to RF energy levels exceeding those specified in Safety Code 6 in going about their daily business.

Where Cellular Base Stations are concerned, the normal process will be to ensure that a base station field strength is within the safe level range in all accessible locations. This can be done in several ways:

- UBC can decide to measure RF levels itself to ensure that all radio systems on its property are safe. This process may need to be repeated periodically to ensure continued compliance.
- UBC can require the service providers to test their installations for conformance – and to supply UBC with copies of the test results. UBC can maintain these test results on file to confirm its application of due diligence.

- UBC can require, as part of its site approval process, that an independent audit of compliance with Safety Code 6 is carried out at the expense of the service provider – and that UBC are provided copies of the test results. UBC can maintain these test results on file to confirm its application of due diligence.

The Service Providers satisfy themselves that their installations comply with the Safety Code 6 rules. They have indicated that they would be perfectly willing to supply UBC with copies of their certifications on request.

However what is really important on site is that the total installation, which may comprise several cell sites, is in compliance at all points where people may reasonably be expected to gain access.

If the Service Provider calculates RF levels numerically and applies those figures to drawings of the site in order to deduce compliance, which is one way that is used, then there may be a problem if the actual site differs from the drawings. Perhaps a walkway exists that was not on the drawing, or perhaps a second cell site overlaps coverage in a way that was not expected.

For free standing towers or other structures where people physically cannot get within about 5m of the antenna systems there is really no issue. The concern is particularly over rooftop sites where the antenna systems may end up illuminating an area where people might reasonably gain access. In this case it is essential that confirmation is established that the RF signal levels in those accessible locations are within Safety Code 6 levels.

Simply assuming that the carriers will do that is likely not sufficient.

We recommend that UBC establishes its own file copies of certified compliance for each site. These compliance certificates should be for the site – not for each base station. It is total RF exposure that matters, not what an individual antenna is radiating. With multiple Service Providers, it is recommended that these certificates are issued by an independent 3rd party auditor. A suitable authority would be a professional engineer registered in the Province of British Columbia, qualified in radio communications and not directly affiliated with the Service Provider. Test reports should bear the seal of the engineer so that it is clear who takes responsibility for the accuracy of the certificate. Radios and measurement equipment should have been tested for conformance to design specifications within twelve months prior to the conduct of the tests.

We further recommend that the Service Providers are instructed to call for a re-certification whenever any changes are made to their installation that could affect the transmitted field strength – including adding additional RF carriers or making mechanical adjustments to the antennae.

4.6.2 Aesthetics

UBC prides itself on building design. However indiscriminate additions of rooftop antenna systems can turn beauty into downright ugliness very easily.

The basic conflict is that, to be effective, cellular antenna systems need to be visible (in a radio sense) to the cellphones. Out-of-the-box antenna systems rarely look like parts of a building and the standard mounting techniques do little to change that.

Two approaches can be taken to reduce visual impact.

1. Use disguising techniques – where radio-transparent material (typically fibreglass) can be used to fabricate a cover that looks more like what one would expect to see on top of a building. There are companies that specialize in this type of work and who can make antenna systems "disappear" from view while leaving them in plain sight from a radio perspective. The movie industry does this all the time when needing to make objects less intrusive.
2. Adapt the building design to include locations for radio antennae that are behind protective screens – like windows that are transparent to radio but opaque to light. Architects like this approach but it generally works best of designed into the building when it is built.

In general, aesthetics issues can best be tackled when a building is first designed – which leads to the concept of planning where base stations will be permitted when a development is planned not after it is complete. Aftermarket options do exist by way of fibreglass outer walls to the rooftop area, making an appealing visual statement that can be textured to fit into the building style, while hiding the antenna systems out of visual sight. UBC might wish to further explore this option to retro-fit existing "radio-enabled" rooftops in a visually appealing way.

4.6.3 Compatibility

The project scope did not include a detailed assessment of other radio users, although our discussions with IT have looked at the WiFi network briefly. We will be getting further input from IT over the next week and will include that in our final report. We have also been unable so far to get EMC (Electro-Magnetic Compatibility – relating to experimental areas that might be affected by nearby radio transmissions) input. Again we may have further input to add over the next week.

In general terms, however, it should be possible for those interested parties at UBC to simply tag buildings that should be "no-go" zones for RF transmitters. This would be better than the present process of positive rejection of applications because the lack of a rejection does not necessarily mean that it has been approved. It would be far better to give CCP a list of no-go buildings.

4.6.4 Structural

We did not do any specific structural survey work because that is not our field of expertise. However, as with EMC in the previous section, it is considered that buildings could be tagged as structurally suitable or not suitable – giving CCP a faster way of deciding whether to proceed with an application or not.

4.6.5 Security

This issue alone sparked more discussion amongst the Facility Managers than any other – especially since the main UBC cell site atop the Henry Angus building has proved to have the most security issues because of its proximity to executive boardrooms. We have included copies of an e-mail instruction and an access permit (see section 6.2 on page 31) that now apply to this site.

It is difficult to see why these rules should only apply at the one site – unless they are effectively redefining the Henry Angus site as not an approved location. It is too early to know what the reaction will be of the cellular providers to being barred 24x7 access to their equipment, as implied by the original contract.

4.7 Proposed Site Evaluation Criteria

4.7.1 Location

The “ideal location” for a new site would provide capacity that balances existing capacity and better matches the need for growth.

Currently each carrier has a different pattern of cell sites on campus and also a different growth demand. On the face of it – each need would be different. Indeed that is how current site acquisition works.

The basic user pattern is virtually the same for each carrier. However the more mature carriers will have a larger volume to the pattern and will need more overall capacity.

Only rarely can carriers find a site at the “ideal” location. Usually they look for an acceptable nearby location. It is a set of compromises and is based more on empirical analysis than quantitative calculations.

Bearing this in mind it would be possible for UBC to take a more pro-active role in the process and to seek to define perhaps six key locations around the campus where cellular base stations would be ideally located from their viewpoint. Applying the rules of compromise, carrier input could be sought and the site choices refined to produce an idealized view of how the UBC campus might look in several years’ time when fully developed – with the appropriate number of cell sites that would then be needed.

Armed with this information, UBC could then "pre-approve" the selected sites and set up a common infrastructure of power and communications to support them. There would be no need for other sites to be considered in this scenario.

All such sites would, by definition, be shared facilities – with potentially all carriers at every location in due course of time. With a limited number of sites, UBC could consider requiring a common engineering contractor to be assigned to each site, with services subcontracted to each carrier. In that way there would be only one construction crew responsible for each site – with one set of drawings and one Safety Code 6 evaluation process.

Such an idea would appeal to the carriers if it reduced the complexity and/or cost to them – so it would need to be carefully crafted to be of benefit to everyone. If it was implemented then there would only be six approved locations (or whatever revised number was agreed).

4.7.2 Space

At present there is no clear growth plan for a site. The approved plans are based simply on a present day configuration – with the possibility that carriers might build in some growth and go for a partial implementation on day 1.

If the proposed pro-active process was adopted then it would be clear what overall capacity was available in each location and for whom it was reserved. This should include all radio users not just cellular.

The space needs to include antenna systems and equipment cabinets – which may be all on the roof or may be split between external and internal locations. If equipment is in a separate location then the site needs adequate cable riser trays (see section 4.7.3 below).

4.7.3 Communications

If all equipment is located on the roof then the requirement is for cable trays to keep the roof area tidy and secure. There may be a small need for back-haul communications landlines in the main building risers but that should not be a major problem.

If, however, the equipment is indoors there will need to be cable trays between the indoor and outdoor locations with special needs in terms of large bend radius to accommodate the RF cabling.

4.7.4 Power

The equipment bays at a cell site need standard a/c electric utility power. Either this can be contracted from the utility company by the cellular provider, or it could be provided by UBC in bulk for the site and included in the rental cost.

Ideally the carriers like to go for protected power supplies to reduce the risk of site failure due to power outage. In some cases, generator backup is provided.

UBC might consider offering higher grade "maintained power" if it has UPS / Generator service in the building.

4.7.5 Access & Security

Carriers generally expect 24x7 access to their equipment in order to be able to offer their customers a 24x7 service. The nature of cellular communication is such that failure of a single cell in a high density network will not cause a total service isolation but rather will introduce coverage and capacity problems. In other words service would be degraded not lost.

Many cell site locations do not allow 24x7 access to the antenna systems – for example those located atop electrical transmission towers require specialist expertise to access the antennae. However the carriers generally try to leave access available to their equipment cabinets – which covers most of the likely failures that would need emergency access.

Where access is a problem, such as was commented about earlier with regard to Henry Angus, it may be appropriate to encourage a split site design where equipment can be located where access is less of a problem. This may be a possible consideration for a retro-fit at Henry Angus – however there would be concerns over justifying the cost.

4.7.6 Safety

Physical

There are real concerns over physical safety at a site – which usually just means that confirmation must be obtained in the approvals process that the staff used by contractors are suitably trained, skilled and insured to do the work. This is standard risk management and is likely not a problem for UBC.

RF Energy

We have commented at length about the issues surrounding Safety Code 6.

Some sites lend themselves to easy approval – where the antenna locations are well away from areas accessible to the public. Other sites, usually those allowing some sort of roof level access to non-trained staff, can be a nightmare to plan and certify. Given a choice, these sites should be avoided in favour of more easily certified sites.

Perception

Probably the most difficult of all, because it is so intangible, is what people see as a "problem" even if it is not. This is largely similar to visual issues. If people can see antennae then some will perceive that there is a danger from the energy radiating from it. No matter how many tests are carried out to verify safe operation, these perceptions often remain. The only answer is to pay close attention to where antennae can be seen and where these perceptions might occur. Designing shrouded antenna systems that are basically invisible for what they are is a possible way forward in difficult cases.

4.8 Proposed Approval Process – Technical

This process is basically understood, although not as well controlled. It consists of approving a site application at the building permit level, followed by approvals for many different aspects of the proposed construction – which, confusingly, vary from site to site.

We have no issue with the steps involved. Where we have concern is with the overall process – a concern that is mirrored by the carriers.

This concern is deepened when drawings are returned to carriers with an "Approved" stamp from UBC – meaning that one stage of the process has been approved. However a reasonable interpretation might also be that the drawing, and hence the overall request, is approved.

What is needed is a single point of contact to deal exclusively with every stage of all applications – with no ambiguity. Likely that would be C&CP – who handle most of the current process. This single contact point needs a checklist that itemizes all possible stages of technical approval and which department is responsible for either giving that approval or waiving the need in a specific case. With that revised approach it would be clear what approvals are needed, and also when they have been given – by way of a positive sign-off. Currently approval may be seen to be implied if no negative response if provided – which is not a safe process. With this single contact point, the carriers would only have one process to deal with and only one approval would result – eliminating the ambiguity.

4.9 Proposed Approval Process – Commercial

There is often a perception that the cellular business is cash rich and well able to pay large amounts of money in site rental fees. Certainly in some limited cases, where no other options exist and a need for a site is paramount, landlords can attract fees in the order of $3,000 per month. Where more options exist, or where the need is less vital, the fees can be less than a tenth of that.

Carriers do not usually pay for the approval process. Landlords generally recover that cost over the life of the site from the monthly rental.

Based on averages in the marketplace, we would expect that a site at UBC could command in the order of $10,000 per year.

Alternative mechanisms can be devised where contra-deals are made for sponsorship or advertising. Sometimes these deals can result in higher payments because the benefits to the cellular company are not just associated with the site.

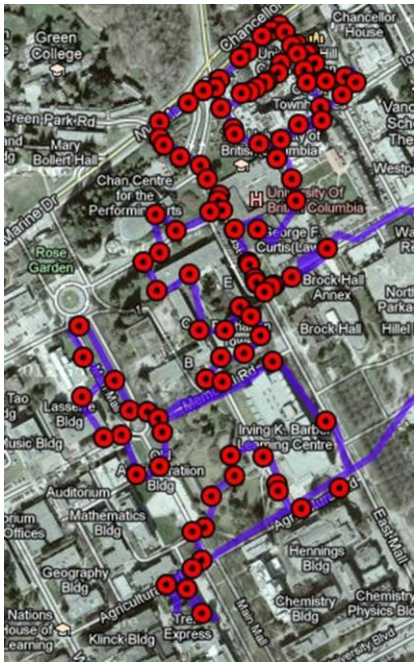
A fee structure could be devised where the operators pay a general site fee for access to all UBC sites, based on their cell capacity or some such measurement to share to cost fairly. In this case the aim would be to work out costs and required financial return for the network of sites and then establish a fair way of sharing that cost between the carriers. The opportunity would be there to factor in all manner of costs, including:

- project management
- construction by a UBC-sponsored company
- power, possibly including backup
- visual screening

4.10 Field Survey around Allard Hall

The original aim of this exercise was to spend around half a day of time and minimal cost on equipment to gather a sample set of measurements that would help in discussing some of the perceived coverage issues around the campus. With the time and budget constraint it was decided to limit the geographic scope to the area around one building and the Allard Hall region was selected for us to survey.

We estimated that we could survey and document around 100 measurement points and could do measurements on two cellular systems while leaving enough time to cover the area within about 100m of the Allard Hall building.

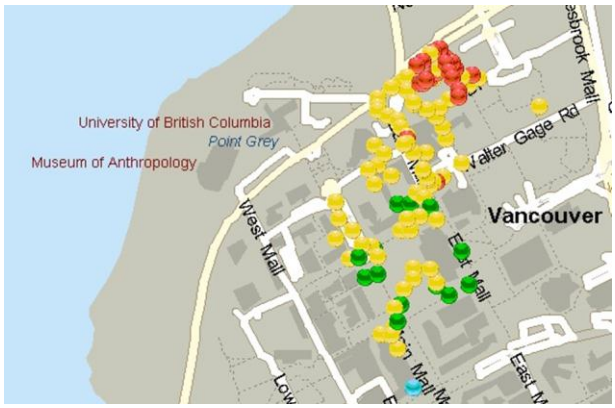


We had some issues with doing measurements on the Telus network with the simple tools available to us without going to the extent to calibrated test gear that would be used on a full survey. However the Rogers measurements worked fine. As a compromise, we decided to drop the second set of measurements and instead to increase the geographic scope and spread our 100 measurement points over a larger area. By registering measurements only when the value changed, rather than on a fixed grid as originally planned, we were able to cover over 5km of survey track around the designated building and much of the surrounding region.

The route taken and the survey point locations are shown on the map above. We managed to take the survey around the Chancellor neighbourhood and back almost as far as the Henry Angus base station.

At each survey location we took a GPS fix and a signal strength reading. The full table of results and large size maps are included in the separate as-is report. The measured signal is shown in the raw data as a dBm figure.

We have included a section in the Appendix (Section 6.4 on page 34) showing how a signal strength translates into perceived quality. Using that as a guideline the raw data measurements were classified into colours – indicating areas with unreliable signal level (red), acceptable for outdoor use (yellow) and good signal (green). The Henry Angus cell site is show as a cyan spot at the bottom of the map.



Several interesting conclusions can be drawn from these results, though none are entirely unexpected.

1. The green spots show where the Henry Angus rooftop can be clearly seen.
2. The yellow spots show where the cell site is obscured by other buildings or even by trees – showing that this site is not an ideal location on its own to cover the north campus.
3. The red spots are generally at more extreme range where the cell site is not visible. The fact that the ground level falls away from Walter Gage Road down to Marine Drive certainly does not help visibility of the Henry Angus roof. Even so there are pockets of good reception where gaps exist between buildings
4. The rooftop of the Buchanan Tower would seem to be the best location to improve coverage in this area, as even the Gage Tower is not clearly visible in all places.
5. The larger than expected number of yellow spots show that in-building coverage is likely to be poorer than would be expected. Combining this with increasing use of better insulation in new buildings - including low-e glass, which is notorious for poor RF transmission shows that UBC might need to consider its policy with regard to in-building coverage. If that is a necessary service then either active repeaters are going to be needed in many buildings or a restructuring of the main cell sites might be an option to give stronger outdoor coverage.

5 Recommendations

5.1 Existing Installations

- Follow-on discussions with carriers should include all sites that serve UBC property even if the sites are located on non-UBC land. It should be clear that UBC's aim is not to solicit payment nor to impose regulations for such sites (which it cannot do anyway) but that they impact the overall picture of what is needed by way of sites. *[from Section 4.1 on page 10]*
- Any non-permit related installations, such as small in-building systems, should be included in discussions even though they will not be involved in the permitting process. *[from Section 4.1 on page 10]*
- UBC might wish to consider aesthetics retrofit options for existing buildings. *[from Section 4.6.2 on page 19]*

5.2 Future Installations

- UBC needs to actively work at resolving opposition to cell sites serving neighbourhood areas before the carriers take steps to procure provincial land for the purpose as they have done in places along Marine Drive. *[from Section 4.2.2 on page 12]*
- This process has not, to date, had input from the academic side. UBC needs to be aware that they are the key "needs drivers" who will influence the use of the communications technology provided both by the WiFi and cellular data systems. Suitable facilitated discussions need to take place at an appropriate time to brainstorm potential future uses and their impact on communications needs. *[from Section 4.2.3 on page 13]*
- As part of the suggested pro-active discussions with the carriers, UBC needs to share its own future plans and elicit input from the carriers on the impact on their own future plans. *[from Section 4.3 on page 13]*
- UBC IT staff need to be closely involved with all growth plans related to cellular – particularly where both are competing for the same basic user need. *[from Section 4.3 on page 13]*
- Carriers need to look at possibly satisfying their demand using WiFi capacity from UBC on a contracted basis (eg private hotspots – virtualized on the UBC network). *[from Section 4.3 on page 13]*
- Aesthetics issues should, if possible, be tackled when buildings are planned. *[from Section 4.6.2 on page 19]*

- UBC should establish a process to tag all its buildings as "acceptable" or "non-acceptable" for rooftop RF installations (not specifically cellular) from a EMC (electro-magnetic compatibility) viewpoint. This classification would then guide C&CP in deciding where to process applications and where to decline them up front. *[from Section 4.6.3 on page 19]*
- UBC should establish a similar process to tag all its buildings as "acceptable" or "non-acceptable" for rooftop RF installations (not specifically cellular) from a structural viewpoint. This classification would then guide C&CP in deciding where to process applications and where to decline them up front. *[from Section 4.6.4 on page 20]*
- UBC should consider taking on the role of locating and planning new sites. This would effectively replace the role played currently by 3rd party site acquisition companies (typically affiliated with real-estate companies and paid by the carriers to negotiate sites). In this way, the carriers would pay UBC the same fee and UBC would carry out the entire role, incorporating site planning into the process. *[from Section 4.7.1 on page 20]*
- As part of this pro-active process, UBC should discuss with the carriers how to build a long term plan of the likely number of sites over a ten year period. Possibly a grid of six or eight sites might be needed if all are rooftop sites. This would allow for long term planning in UBC to be ready for upcoming carrier needs in a more timely way. *[from Section 4.7.1 on page 20]*
- A discussion should be had with all radio users about the possible growing need for in-building systems with the aim of planning them like existing utilities (lighting etc) and incorporating them into building designs and renovations as needed. *[from Section 4.7.1 on page 20]*
- Consideration should be given to offering higher grade power, possibly maintained by UPS / Generator if available. *[from Section 4.7.4 on page 21]*
- Consider resolving site security issues by encouraging the location of equipment indoors in a less secure area than the rooftop. *[from Section 4.7.5 on page 22]*

5.3 Contract Issues

- UBC should initiate the creation of a new co-operative framework of facilitated round-table discussions with the carriers aimed at restructuring the whole process of site selection – and also aimed at educating the carriers as to their objectives and needs. *[from Section 4.2.2 on page 12]*

- UBC should amend the contract words to clearly indicate that site sharing is not just desirable but is mandatory wherever possible – to the extent of looking at sharing nearby sites rather than choosing new. *[from Section 4.5 on page 16]*
- UBC should set up its own files of certified compliance for each site. These compliance certificates should be for the site – not for each base station. It is total RF exposure that matters, not what an individual antenna is radiating. *[from Section 4.6.1 on page 17]*
- These certificates should be issued by an independent 3rd party auditor. A suitable authority would be a professional engineer registered in the Province of British Columbia, qualified in radio communications and not directly affiliated with the Service Provider. Test reports should bear the seal of the engineer so that it is clear who takes responsibility for the accuracy of the certificate. Radios and measurement equipment should have been tested for conformance to design specifications within twelve months prior to the conduct of the tests. *[from Section 4.6.1 on page 17]*
- The new rules applied to the Henry Angus installation should be incorporated into the standard contract rules governing acceptable behaviour at all sites. *[from Section 4.6.5 on page 20]*
- Set up a single point of contact for all carrier dealings to replace the current system where carriers deal directly with several departments. *[from Section 4.8 on page 23]*
- Establish a checklist of signoff authorities and mandate them to either sign off their involvement as explicitly not required of to sign off when the process is completed to their satisfaction. *[from Section 4.8 on page 23]*
- Consider alternative options for levying fees for the use of UBC locations *[from Section 4.9 on page 23]* – such as:
    - $10,000 per year rental fee replacing permit fees etc
    - UBC access license to cover all sites
    - Site acquisition fees similar to those currently paid to 3rd party realty agents to find sites
    - Contra deals where payment might be made for a non-related UBC need (such as sports gear) on a sponsorship basis

6 Appendix

6.1 Stakeholder Meetings

These raw notes were taken from the discussion whiteboard and are included simply to record the key points raised in the discussions. They are not the only input from the meetings but represent those ideas which were presented by the delegates, recorded on the whiteboard and used as discussion catalysts. Some of the one-on-one meetings used a more relaxed discussion style, which resulted in fewer whiteboard notes and this reflects in less recorded detail here.

6.1.1 Monday – 8am

8am – 9:30 – Gardenia Room

Gerry McGeough	University Architect (first part)
Kavie Toor	Recreation Facilities (first part)
Suzanne Poohkay	Infrastructure Development (second part)
Bob Macdonald	IT (all meeting)

- Towers – 3rd party
  - Assets / revenue
- Campus Character
  - Environment
  - Co-location
    - Reduce roof maintenance costs
  - Plan layout of sites
  - Landscaping
    - Siting
- Bring Building Stewards in earlier
- Need UBC Plan
  - 5 – 10 year roadmap
- Reduce number of parallel networks
  - WiFi vs Cellular data
- UBC is a Cisco Beta Site
  - WiFi network has 2400 Aps
  - All APs support all SSIDs
- Need one centralized governance structure
  - Cellular is a Utility

6.1.2 Monday 1pm

13:00 – 14:30 – Room 221

Chris Skipper	FM
Greig Samodien	FM
Rob MacDonald	FM
Geoff Armstrong	IT

- Lack of Project Manager
  - C&CP assign PM?
- Need checklist
- Carriers think they have free reign once approved
  - Henry Angus e-mail
- If sites are built for growth – is growth a "new use"?
- What is "approval"?
  - Does it include layout specifics?
- Role of University Properties Trust

6.1.3 Tuesday 10am

10:00 – 11:30 – Room 221

Ed Lin	Chief Building Officer
James Heth	Treasury

- What do Carriers want?
  - Currently Reactive
  - No discussion re options
- Safety Issues
  - Additional work
- Need general MOU with carriers
- License fees
  - Up Front
  - Ongoing
- Process is not clear
  - Relies too much on individuals
  - Not defined who needs to be involved

- No development permits generally needed for in-building work
- Should be a Project Manager assigned (by UBC) for each site

6.1.4 Tuesday 1pm

13:00 – 14:30 – Room 220

Bruce Anderson Risk Management

- Meeting was a one-on-one general discussion
- Need to be sure that risk issues have been addressed
- Do not need to be in the loop of actual verification

6.1.5 Tuesday 3pm

15:00 – 16:30 – Room 220

Jan Fialkowski University Neighbourhoods Association

- Meeting was a one-on-one general discussion
- No specific key points were documented

6.2 Henry Angus Rules

The following is the text of an e-mail sent to Richard Lees on Mott Electric, one of the contractors needing access to the Henry Angus rooftop site, by Rob MacDonald, the UBC Facility Manager. This e-mail sets out the new policy that is being applied at that location to all companies requiring access.

From: MacDonald, Rob (Facilities Management, Building Operations)

To: Richard Lees (rlees@mottelectric.com) <rlees@mottelectric.com>

Cc: Din, Tariq

Sent: Thu May 03 15:17:36 2012

Subject: UBC REQUIREMENTS FOR ROOF TOP ACCESS

Hello Richard,

As discussed. Please provide the following information at your earliest possible convenience.

<u>Mandatory Requirements of the Carrier:</u>

- *WorkSafeBC proof of registration.*
- *Site Specific Fall protection plan for the Henry Angus site at 2053 Main Mall.*
- *Statement that employees assigned to work are trained and qualified to be working on the roof top. (includes all sub trades currently under contract to MTI/MOTT)*
- *Name and contact information of the MTI/MOTT agent responsible for health and safety activities.*
- *Name and contact information of the MTI/MOTT technician assigned to this Site. (if applicable)*

- *Name and contact information of the MTI/MOTT agent responsible for operations at this site.*
- *Complete and return the "One Year Roof Top Access Form".*

Keys will be issued upon receipt of this information.

Incident and Accident Reporting:

- *All incidents or accidents must be reported to the University of B.C. Please utilize this form when reporting incidents or accidents to the Facilities Manager. http://riskmanagement.ubc.ca/sites/riskmanagement.ubc.ca/files/uploads/Documents/Contractor_Incident_Form.pdf*
- *It is understood that MTI/MOTT and their contractors are responsible for First Aid while working on the UBC Point Grey Campus.*

Other Requirements:

- *Any future proposed development of the carrier's site must be brought forward to Campus & Community Planning. http://www.planning.ubc.ca/vancouver_home/licensing_and_permits/development_permits.php*
- *Utilize UBC Project Services for coordination of construction activities. http://www.projectservices.lbs.ubc.ca/*
- *Provide updated information on any changes to principal MTI/MOTT staff and contractors in a timely manner.*
- *This agreement to be reviewed and renewed annually prior to the anniversary date.*

Access Protocol:

Planned and unplanned work is at the discretion of the carrier. Building Operations requests timely notice of all work conducted at this site.

- *For planned work, please notify the Facilities Manager 24 hours prior to start-up of work.*
- *For unplanned work (urgent or emergency) 24/7, please contact the Facility Manager as soon as possible.*
- *In the event your Facilities Manager can not be reached, please contact his/her designate, or contact Building Operations Trouble Calls @ 604-822-2172.*

Until keys for roof access are issued, access will be provided by the Facilities Manager or his/her designate. Designate persons are: Mike Devolin, Facilities Manager. Mark Daigle, Architectural Systems Manager.

Note: The Penthouse Boardrooms of the Henry Angus Building sometimes facilitate meetings requiring security measures that prohibit access to the ninth floor and penthouse roof. These events can be unscheduled and will affect your access.

Regards,
Rob MacDonald
Facilities Manager, Zone 4

The "One Year Roof Top Access Form" referred to in the e-mail is reproduced opposite.

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

ONE YEAR ROOF TOP ACCESS
APPLICATION FORM

Company:

Agent:

Building: Henry Angus Building, 2053 Main Mall

Roof Area: Office Tower and Classroom Block

Requirement (Justification) For Roof Access:

Description of Roof Top Activities:

Start Date of Access:
To be completed by UBC
Finish Date of Access:
To be completed by UBC

We understand that building roof tops are inherently dangerous. We agree to limit our activities to that as described above and I will follow all the applicable procedures and safety requirements.

Name: _____

Position: _____

Signature: Date:

UBC Risk Management Signature: Date:
Tariq Din, Manager of Risk Management

UBC Building Operations Signature: Date:
Mark Daigle, Architectural Systems Manager.

UBC Building Operations Signature: Date:
Rob MacDonald, Facilities Manager

6.3 Cell Site Inventory

6.3.1 C&CP Permit List

Dev Permit	Bldg Permit	Address	Project Name	Applicant	Carrier	Permit Status
DP 06009	BP 08019	6288 Stadium Road	Bell Antenna for Matthews Field	Ian McBean, Scott Land & Lease Ltd	Bell	Complete
DP 06010	BP 07032	2053 Main Mall	Bell Antenna for Henry Angus	Ian McBean, Scott Land & Lease Ltd	Bell	Complete
DP 10026	BP 10076	2725 Melfa Rd	Acadia Tower Telecommunications	Marc Parras, Wind Mobile	Wind Mobile	Complete
DP 11006	BP 12011	2725 Melfa Rd	Wind Mobile - Acadia Tower	Robert Lepage, Wind Mobile	Wind Mobile	Complete
DP 11007	BP 11016	2053 Main Mall	Henry Angus Antennae	Gina MacInnes, Telus	TELUS/Bell/Rogers/ WindMobile	Complete
DP 11021	No BP	6393 NW Marine Dr.	MoA Antenna	Brent Laoun, Altus for Telus	TELUS	Complete
DP 11022	BP 11098	2725 Melfa Rd	Acadia Antenna	Chad Marlatt, Telus	TELUS	Complete
DP 11031	BP 12036	5959 Student Union Blvd	Gage Antenna	Irv Hildebrand, for Telus	TELUS	Under Construction
DP 11034	BP 12016	6005 Walter Gage Rd	West Point Antennas	Sarah Farina, Altus for Telus	TELUS	Under Construction
DP 12008	BP 12036	1873 East Mall	Buch Tower Antennae	Ryan McKeown, Data + Audio	Dave Wireless/Mobilicity	DP Pending
DP 12009		2601 East Mall	Feric Antennae	Brent Laoun, Altus for Telus	TELUS	DP Pending
DP 12011		2525 West Mall	Totem Residence Antennae	Brent Laoun, Altus for Rogers	Rogers	DP Pending
No DP	BP 12059	2211 Wesbrook Mall	Koerner Pavilion Antennae (In-Build)	Sarah Farina, Altus for Telus	TELUS	BP Issued
No DP		6066 Thunderbird Blvd	Thunderbird Sports Centre (In-Build)	Brent Laoun, Altus for Telus	TELUS	Upcoming

6.3.2 C&L Antenna Licenses List

Carrier	Building
Globalive Wireless Management Corp. - Wind Mobile	Acadia Tower
	Henry Angus
Bell Mobility Inc.	Henry Angus
	Matthews Field
Rogers	Henry Angus
	Matthews Field
	Totem Residence *(in process)*
Telus	Henry Angus
	Museum of Anthropology (in-build)
	Gage Tower North *(in process)*
	Koerner Pavilion (*UBC consent only, no license*)
	FERIC Building (*UBC consent only, no license*)
Mobilicity	Buchanan Tower *(in process)*

6.3.3 Industry Canada "Technical and Administrative Frequency Lists" (TAFL)

Station Location	Lat - Dec	Long - Dec	Location	Bell	Rogers	Telus	Globalive
B0247-4250 WESBROOK MALL	49.24527778	-123.2330556	IC01	y			
W1513-VANCOUVER BC 11.58M S/O MARIN	49.25194444	-123.2472222	IC03		y		
W2292-VANCOUVER BC SOUTH WEST MARIN	49.25472222	-123.2422222	IC04	y	y		
W2605-VANCOUVER BC 6066 THUNDERBIRD	49.25972222	-123.2419444	IC06		y	y	
"BC1159: 2725 Melfa Rd."	49.26194444	-123.2366667	IC10			y	y
"BC1175: 4620 W.10th Ave. (Univers"	49.26333333	-123.2127778	IC13	y	y	y	y
VANCOUVER UBC 6501 NW MARINE DRIVE	49.26361111	-123.2594444	IC19			y	
"BC0159: 2053 Main Hall, UBC"	49.26444444	-123.2533333	IC24	y	y	y	
W0298A-VANCOUVER BC 2233 ALLISON RO	49.26527778	-123.2419444	IC28		y		
W5252-VANCOUVER BC 6138 STUDENT UNI	49.26694444	-123.2488889	IC33		y		

6.4 Required Radio Signal Strength

From one of our professional RF engineers, the following guidelines are useful to show what received signal strength is required for "good coverage".

> *We have used a figure of -76dBm "on the street" as necessary to provide in-building coverage, allowing 20dB for building loss (thus -96 dBm minimum for adequate coverage in the open).*
>
> *This is based on a requirement for received signal quality of about DAQ 4.0 (Delivered Audio Quality 4.0 = "Speech easily understood, some noise/distortion present"). As an aid to system design, DAQ 3.4 ("Speech understandable without repetition, some noise/distortion present.") has been measured by NTIA (U.S. Department of Commerce, National Telecommunications and Information Administration) to be approximately equivalent to 22 dBs (22 dB SINAD) for analogue signals modulated with a 1 kHz tone at 1.5 kHz deviation, and to 2% BER (Bit Error Rate) for digital signals. It may also be approximately equivalent to a received signal level of -109 dBm (0.8 microvolts across a 50 ohm load), in the absence of other signals that may affect the receiver. Good design must provide a margin of not less than 10 dB to allow for uncontrolled variables, so say -99 dBm as a target. That's within 3 dB of what we used with one client to achieve approximately DAQ 4.0.*
>
> *Reinforced concrete buildings with reflective glass often show signal loss of more than 20 dB at 800 MHz and higher, but when loss approaches 20 dB the signal is deemed unreliable anyway, so that's the figure we use as a cut-off for design. (When the loss approaches 20 dB we find that whatever is received is usually via multi-path with severe delay distortion, making the signal unusable.)*

Based on this recommendation, we classified our survey data as:

1. Better than -76dBm – solid coverage – green
2. Between -77dBm and -96dBm – good outdoor coverage – yellow
3. Worse than -97dBm – unreliable coverage - red