ITRAINONLINE MMTK
PLANNING AND BUDGETING HANDOUT

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1. About this document

These materials are part of the ItrainOnline Multimedia Training Kit (MMTK). The MMTK provides an integrated set of multimedia training materials and resources to support community media, community multimedia centres, telecentres, and other initiatives using information and communications technologies (ICTs) to empower communities and support development work.

1.1 Copyright information

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1.2 Degree of Difficulty

The degree of difficulty of this unit is Basic.

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2. Introduction

This unit focuses on the practical implementation of a wireless (link) network in terms of project planning and budgeting of equipment.

A detailed i*mplementation plan* of a wireless network is necessary to be able to produce a *good and consistent budget*. A good implementation plan should not just consider the physical location of the wireless equipment or our chosen technology and vendor but also which extra resources are needed to get a network up and running.

Sustainability aspects need also to be included in the implementation plan. The budget should also consider backup resources when things "go wrong". In this unit we show how being able to make a good implementation plan allows us to produce a good budget in terms of equipment and logistics.

The final cost of the *wireless project* can easily go well above your initial budget if other aspects (not wireless related) are not consider in your planning. When you build wireless networks, you must consider *non-wireless* elements too. It is not about buying the most expensive technology, it is about having a good plan how to use it.

You will probably experience that most of the content in this unit will sound pretty obvious to you but, keep in mind that is not to forget the obvious things what will make your project run smoothly.

A good and detailed budget will not only show that you master all the aspects related with the technology and its deployment but your project management skills.

A real life example of a hardware budget for a wireless backhaul Network in rural Nigeria is provided as case study (extra resource) with this unit.

3. Viability study

The project should start with a detailed *viability study*, this initial phase can be performed by yourself or outsourced to a third-party. If you do not have enough experience building wireless networks it might be a good idea to get someone with that experience to work together with you in this first phase.

Make sure that the consultant (commonly known as "expert") that you hire is going to be able to answer all your questions and justify properly his recommendations. Having a technical "guru" advising you is not enough if you can not learn from him or her.

Having an external and independent person that can review the results of the "expert" is also recommended.

Make sure that the viability study is always presented to you or your organization face-to-face. It is a good idea that you have at least one week to go through the written report in advance. Send your questions or request for clarification to the consultant/expert in advance.

Request/consider that the viability study answers the following four questions.

1. What physical infrastructure is available on site?
2. What technical infrastructure is already in use at the site?
3. Where is the closest point of presence for power/energy at site?
4. Where is the closest point of presence for Internet connection on site?

These four questions have great impact on the final *price tag* of the wireless implementation. Each and one of them will carefully be discusses below.

Additional facts that are of importance for the pre-study are:

- Weather conditions on site (temperature, amount of rain, thunder, humidity)
- Type of terrain (sand, soil, stones)
- Population (sparsely or dense populated)
- Access to road for transportation
- Radio/tower Legislation
- Conditions for importing equipment

3.1 Site survey of existing physical infrastructure

In order to be able to evaluate your options for the exact location of the implementation, start by studying existing suitable physical infrastructure on site in terms of existing masts, towers or high buildings. Ask for available and updated maps of the area to make a theoretical study before making the on-site visit.

The more information that you possess in advance the better chances that you will do something useful when you move to the site.

If masts or towers already exists, there might be a chance of co-location with other operators rather that building your own tower. If the site is located in a densely populated area, the regulators might not allow you to establish a new tower, due to certain regulations in populated areas.

The most practical solution is always to use an existing roof top that suits your implementation. Working at the top of a building implies easier maintenance of equipment and no need of maintaining big masts or towers. If neither a tower or a roof top is available on site, you must consider to build the necessary infrastructure yourself. For further reading, see section “Procurement and assembling of radio tower”.

The site survey is a very important “social engineering” task, you need to identify the *key people* that can help you establishing your infrastructure and gain their trust. Do not forget to keep records of all names of people that you talk to during your site survey research.

During the on-site visit there are a number of things that should be investigated:

- If many possible sites exists, perform a survey on those places by making relevant measurements with portable WLAN equipment running Netstumbler (Win32), Wavemon (Linux) or similar software.
- The distance to the other point(s) must be measured so that a proper *link budget* can be performed before you start to order and purchase equipment.
  The distance can be measured either with GPS equipment (preferable) or with an updated and accurate map with *scale*. If neither of that is available, the distance can be measured manually by car or a bike equipped with a "trip meter".
- Bring binoculars to perform a line-of-sight test to the other endpoint and a digital camera for documentation of the site.
- Bring binoculars and digital camera/video.
- Use blinking lamp or torch to communicate with the other node.
- Bring adequate clothes/shoes/gloves and fresh water.
- Bring tape measure, long light rope, climbing gear (including helmet).
- When measuring distances try to image the path that the cables are going to take to obtain accurate figures.
- Be pessimistic! It is better to have 5 extra meters of cable that miss one extra meter at the top of a 40 meters hight tower.

3.2 Site survey of existing technical infrastructure

If any kind of technical infrastructure exists on the site where you want to implement the link, start by contacting your new neighbours to get the necessary information regarding their equipment so that you can plan your project without interference. Also, discuss possibilities for co-location with them.

Other information that you should obtain are:

- Existing wireless infrastructure
- Existing antennas and cabling
- IP Network layout (if you are going to share IP infrastructure)
- Description of other equipment on site (take pictures of all specifications/labels)
- Frequencies/Channels.
- Radio power

3.3 Access to power/energy

Access to electricity on the site is of course vital. To ensure reliability of your service the source of electricity also needs to be reliable. In countries with frequent power cuts and frequency fluctuations, a UPS is mandatory.

If the equipment will be implemented on a roof top, powering the equipment with electricity might not be so complicated. But, if your tower needs to be far away from the closest power grid, you might have to work a bit harder.

If the distance to the closest power grid is reasonable, you should ask the power company for permission to hook on to the network by digging down an extension cable to the grid. Most probably, the connection to the grid has to be performed by the power company themselves.

If the distance is too long or digging is not feasible for other reasons, you should consider another source of energy as wind or solar panels. When you budget for energy you should not only budget for the equipment (solar panels, batteries, wind mild, diesel group) but for a fix cost of installation, transport and yearly maintenance cost.

Note about cables: When dealing with cables (data or electricity) think of a proper installation. Think of rats, sun, ice, wind and thieves.

3.4 Internet connectivity

In most of the cases you will need to procure a source of Internet access at the exact location where the wireless equipment will be located. That implies that you must extend the Internet connection from one place to the physical **location** of your wireless equipment.

Avoid, if possible, to use another wireless link to the top of a tower or roof (your wireless backbone). Having an additional wireless link can have serious implications in the overall performance of the main wireless backbone link.

1. Either reserve one single frequency/channel to link the Internet to your backbone or
2. Wire the Internet connectivity to your wireless backbone.

When bringing the Internet to your wireless network try to avoid any possible traffic bottlenecks. Consider optical fibre or twisted pair for that purpose.

If you need to place wires, they can be underground or aerial. You must figure out what is most suitable for you in terms of costs versus reliability.

Whether the cable (copper or fibre) is dug down or placed over ground, the cable needs to be protected from its surroundings in terms of weather and animals. The first enemy of cables are rats and without a proper PVC protection the cable will soon be damaged. PVC pipes can be dug down or left on the ground. When procuring PVS pipes, make sure that you purchase one that suits your implementation since there are many different PVC pipes on the market depending on climate, depth and other parameters. The PCV pipes must also be properly connected to each other (with glue) so that the whole construction is watertight. You can make sure that the connections are tight by performing a smoke test. The fibre itself is not so vulnerable to water but if water comes into the PVC pipe, roots from surrounding trees will start to grow around the pipe which eventually can brake (including the fibre) as the roots grow stronger.

- Always aim for a fibre or copper connection between the uplink and the backbone since a wireless link will effect the overall performance negative.
- Protect the fibre/copper with PCV pipes or similar to its extend lifetime.
- Think in temperature, animals and thieves

4. Budgeting Issues

A hardware budget for a wireless implementation requires a lot of thinking. Except for the actual radio and network equipment, there are a set of other items that you should consider.

This section points out a few things that should not be forgotten when doing a hardware budget.

4.1 Electricity

In many developing countries, the demand for electricity is far greater then what the provider of electricity can generate and deliver. This makes the grid power system very unreliable and blackouts and brownouts occur frequently. The situation in many countries is not stable enough to directly plug electronic equipment into grid powered outlets as the power from unstable grids is fluctuating which damages electrical equipment.

The solution to the unstable power is to add batteries, battery chargers, and inverters to every node in the system. These backup systems are relatively inexpensive and are very effective at providing both surge protection and a consistent power supply.

The chargers are connected to the grid electricity and keep the batteries charged whenever power is available. Inverters continually supply 240V AC to the devices from energy stored in the batteries. In this way, anything plugged into the system is never fed with power straight from the unstable grid. The only part of the system vulnerable to damage from power surges is the battery charger, which is the cheapest part of the system and easier to replace than expensive radio equipment.

There are off the shelf uninterruptible power supplies (UPS) that use similar systems, called an online UPS. These are different from the standard UPS because power is always going through filters and rectifiers. A standard UPS uses line interrupt technology, if a problem is detected; the power switches from the grid to the batteries. The problem with this is that in many cases, by the time the problem is detected it is already too late. An online UPS converts the grid alternating current (AC) to direct current (DC), and then rectifies it back to AC. Power in the output plugs of the UPS is never direct from the power grid and all power problems are blocked by this kind of UPS.

These issues need to be taken into consideration when doing the hardware budget for an implementation.

4.2 Electrical grounding and Lightening protection

An installation located on top of a roof or a tower needs protection against lightning. As lightening is a common enemy to wireless installations, it must be prevented as far as it can. There are generally two different ways that lightening can damage your equipment, direct and indirect hits.

Direct hits
Communication towers should be equipped with Franklin rods that are properly grounded at the base of the tower. However, if the lightening hits the tower itself (or the equipment) there is very little that can save the equipment.

Indirect hits
Induction currents (indirect hits) though nearby lightning strike can cause damage to outdoor radio equipment. That can be prevented by using surge protectors to vulnerable equipment and choosing radios that have a higher voltage rating. However, surge protectors does not protect the antenna, only the radio.

4.3 Tools

Tools that can come handy are for example climbing gear, walkie-talkie, ladders, backpackers, GPS equipment, maps, trip-meter, binoculars, blinking lamp or torch, ropes, tape and a standard tool box.

4.4 Local transport

An implementation project is always in great need of vehicles for local transport. Depending on the size of the team, the equipment, number of sites and distances between them, the number and size of vehicles should be budgeted. Consider also the location of the implementation sited. Are they easily accessible or is a 4x4 drive needed?

5. Licences and permissions

To obtain the adequate licences and permissions might both imply administrative work and financial means.

There are in general two different kind of permissions that are of importance in this matter:

- Permission(s) to build a tower or mount an antenna
- Permission (includes licence) to operate IEEE 802.11

5.1 Mast or Tower

If you intend to mount the antenna on the top of a house or in an existing tower, you must of course contact the owner of the premises for permission. If you intend to establish a new tower/mast, you must ask for permission from the plot owner.

If the tower or the top of the antenna is over a certain height (higher than the average landscape on the location) you must also apply for permission from the authority that regulates the airspace in the country since your implementation might be a danger to helicopters and other low-flying objects.

For further information see unit “Communication Tower”.

5.2 Permission to operate IEEE 802.11

To operate data communication in the 2.4GHz or 5,6 Ghz frequency band **may require a licence**. In some countries, the 2.4GHz frequency band does not require a licence, which implies that it is free (of charge) for anyone to operate an IEEE 802.11 network.
Do not assume that what is free in one country should be free and unlicensed in another. Normally it is the Commission for Communication (or similar) that handles the licenses for this type of communication.

The term “unlicensed” frequency can be misleading. Unlicensed does mean that a radio license is not needed to operate equipment at that frequency, but it does NOT mean that the use of that frequency is unregulated. To say that a frequency band like 2.4 Ghz can be used unlicensed, means that the maximum power output must be no greater than a certain effect (Watt) including the gain of the antenna.

Permissions to operate IEEE 802.11 varies a lot from country to country depending on the government in power.
Nigeria for example, is one of the leading countries in Africa when it comes to spectrum deregulation and licensing. The Nigerian Communications Commission (NCC) has kept the 2.4 GHz ISM band as unlicensed with a

maximum power at the point of transmission to be 1 Watt or 30 dBm. Also the 5.8 GHz band is in the process of becoming unlicensed in Nigeria
Uganda in another leading African country in deregulating the frequency spectrum. Recently, both the 2.4GHz and the 5 Ghz band became unlicensed.

In general, there are two types of license for IEEE 802.11 that you can apply for

1. Commercial use (ISPs)
2. Private use (closed groups)

If you plan to use the link for a dedicated group only, make sure that you apply for "private use" since the fees for ISPs are much higher. The license fees normally consists of an application fee (one time), an initial fee (one time) and an annual fee. The licence might have to be renewed in periods of 3-5 years.

As an example, the "Tanzanian Communication Commission" charges the following fees in Tanzania to operate an IEEE 802.11 network:

Fees	***Commercial use***	***Closed group****
Application fee	75 000 TZS (approx. 65 USD)	50 USD
Initial fee	1 000 USD	300 USD
Annual fee	5 000 USD	200 USD

Source: http://www.tcc.go.tz March 2005

- *Closed groups are defined as Governmental departments, Educational Institutions, Healthcare and Community Centres.*

6. Procurement of equipment

The procurement can be done locally (within the country) or be done externally via import. The choice should depend on the price, the availability and the support for the equipment.

A key issue in procurement is *Delivery time.* This is a factor (unknown in many cases) that can delay a project quite a deal.

6.1 Local Procurement

Procurement of low-tech equipment (not radio and network equipment) should always be done locally when it is suitable in terms of price and availability. Since overseas transport is very costly, and normally is charged by weight and/or volume, heavy and bulky equipment should preferable be procured locally.

More advanced radio equipment might sometimes be needed to import.

6.2 Import

Before the shipment of goods can take place, a *pre-shipment inspection* is required from the port of origin to confirm the cost of the items to be imported. If no such inspection is done prior to shipment, it needs to be done on site at destination which can be both a time consuming effort and expensive.

The import duty is based on the cost of the equipment and should be done before clearance papers are issued. It is preferable to use a clearance agent to ensure prompt clearance of goods. To facilitate the process of clearance, it is better to start the procedure before the arrival of the goods.

7. Implementation Phase

When the equipment has been procured and delivered, it is finally time for the implementation phase. By this time, you should already have the licences that you need. Also, all tools that are needed should be procured or leased at this time.

This section discusses a few practical issues that concerns the implementation phase.

7.1 Weather

In countries around the equator, the temperature can rise to 40° C (in the shadow) and heavy rains can fall for weeks. It is therefore a good idea, to plan well the time of the year when the installation will take place.

Installations in towers should be avoided during rainy seasons with frequent lightning. Also, the hottest seasons should be avoided since the metallic tower becomes an unpleasant place to work on.

The heat can also cause problems with overheated radio equipment. In most cases when this happens, the overheated part will cool off and start working again once it is back within the appropriate operating temperature range. However, repeated overheating will wear down the equipment and shorten the life time of the radio.
Any outdoor mounted equipment need to have an operating temperature range up to 70°C
Simple (self-made) cooling systems can also be mounted to outdoor equipment to cool down equipment by using the surrounding air flow.

When planning for the actual implementation you should consider the weather conditions for that that time of the year. In countries around the equator, you typically want to avoid the hottest season and the rain periods, while in Europe for example, you rather avoid the cold and wet winter.

7.2 Team members

This might sound trivial, but make sure that your team has the necessary knowledge before you the day of the implementation. If equipment needs to be mounted in a tower or a high mast, some experience in climbing will be useful. Also, mounting antennas on poles might involve some welding which requires some experience.

Obviously, knowledge in radio communication and networking is needed.

8. General advice about contracts

The whole wireless implementation will require a number of contracts between you and suppliers. There are some issues that should consider as critical when working out a contract with a supplier: pay attention to:

In contracts with suppliers of equipment, make sure that there is a clause for “delivery time” with fair conditions for you. Some hardware may need to be imported, and delivery can be delayed. A delay of the delivery of the tower for example, will have negative impact on your time plan which can lead to additional expenses due to equipment or labour that you already have ordered for the further implementation.

In contracts with the suppliers, make sure that there is a clear statement about transport of the purchased equipment. In the case of transporting a tower to the site, a 4x4 can not do it!

If the contract includes implementation of any kind, make sure that testing is included and evaluate the proposed testing methods.

In general, be careful to make financial agreements with other currency than your local currency. If the agreements are done in USD and your local currency suddenly drops compared to the USD after signing the contract, you might end up with a far higher bill than first expected.

9. Quality assurance

Quality assurance is the process of evaluating, testing and measuring the overall project performance to verify that the project satisfies the requirements set up in the contract.

Depending on whether you are the consultant or if you are the client, there are certain things that you should focus on. As a consultant, what can you guarantee to your client in terms of performance, quality and sustainability? As the client, what do you demand from the consultant in terms of performance, quality and sustainability? These questions need to be carefully addressed in the contract to avoid future conflicts. To assure a certain level of quality, you need to agree on *what* quality is in that specific case and *how* it can be measured. For a wireless link the following parameters can be measured and indicate a certain level of quality:

1. Uptime
2. Jitter
3. Throughput
4. SNR
5. Packet loss
6. Duplicates of packets
7. Round-trip time

Defining the exact method of measuring the specific data is of out most importance.

The measurements should be done several times under different weather and load conditions. For example, a dry sunny day compared to a humid rainy day will change your measurements of the SNR. Also, measures taken during a weekend can differ from the ones taken during the week.

Being the client, you should carefully read the specifications of the equipment so that you are certain about that the specified hardware is suitable for your implementation. Make sure that the equipment that you get is the one

you are paying for. Check labels and compare the specifications. You should also make sure to include in the contract a period of time that the implementation should guarantee a certain level of performance.

Do not forget to include a paragraph for quality assurance in the contract

- Specify WHICH parameters to measure and HOW to measure them
- Measurements should be done over a period of time to reflect changes in the environment.

10. Conclusions

In summary, you do not need to be a genius to plan and budget for a wireless implementation. What you need to be is one step ahead and always think of "what if?". Having a good implementation plan from the beginning will save you lots of trouble (and money) at the end of the project.

A wireless implementation does not only imply costs in wireless equipment. Do not oversee the costs of bringing Internet and electricity to the place, applying for licences, providing lightening protection, transporting the equipment and yourself to the site(s) and all the other small things you might need such as climbing gear, testing equipment, binoculars, walkie-talkies, ropes, maps etc.

A budget on its own is not a good plan. But a good plan has a good and detailed budget.

The five main issues you should remember from this unit can be summarized as:

1. You do not need to be a genius to plan and budget for a wireless implementation, just be realistic and a bit "pessimistic"
2. A good implementation plan from the beginning will save you lots of trouble and money in the end of the project
3. Do not forget that the hardware budget includes more that radio and networking equipment. The budget must also include bringing Internet and electricity to the site, obtain licenses, ensure lightening protection, transport equipment and people and making sure that all necessary tools are available.
4. Do not forget factors that are out of your control such as delivery time and weather conditions.
5. A budget on its own is not a good plan, but a good plan has a good and detailed budget.