5. Telecommunications Management Network (TMN) Plan

5.1 Objectives and Scope

Presently, a new approach to telecommunications management is being studied and specified in international standardization bodies. This approach is known as Telecommunications Management Network (TMN). Conceptually, the TMN is thought to be a supporting entity for all kinds of management actions required to provide, to operate, to maintain and to administrate (POM&A) telecommunications services. This includes (but is not limited to) management of the resources for service provision, the network elements.

Introduction of a TMN is thought not to happen in a revolutionary one time all-out effort, but in evolutionary process, which may start with partial solutions in priority areas, and which may take even a decade or more. One of these priority areas could be network management with transmission resource management in the lead, since the up-coming new Synchronous Digital Hierarchy (SDH) transmission technology offers a good opportunity to have the necessary management interfaces initially implemented.

A large-scale network expansion (at least compared with the size of the existing network) deploying new digital technologies in switching and transmission requires reviewing the organization and the technical arrangements for Operation and Maintenance (O&M). Furthermore, the technical arrangements for (centralized) O&M are at some point of time to be merged with the developing TMN.

In this context, the main objectives of this plan are:

- to devise a principle target projection and to provide the framework for a future TMN in Lao PDR as well as to provide guidance for the development towards that TMN
- to elaborate a concept for O&M responding to the requirements arising from the change in technology as well as from the network expansion, and to identify the preconditions and to devise a migration strategy for integration of technical O&M arrangements into the future TMN
- to elaborate a concept for network management making best use of the upcoming technical possibilities (especially in conjunction with the Synchronous Digital Hierarchy (SDH) transmission technology), and to devise a migration strategy for network management in the framework of the future TMN

The scope of this plan is focused on (but not limited to):

- a basic description of the TMN concept including an overview on its future application possibilities
- an initial concept for evolution from existing and soon to be implemented telecommunications management islands towards a Lao TMN with emphasis on technical arrangements to be made in advance
- a concept for O&M in the national network in conjunction with necessary organizational arrangements to be made, and including technical precautions and migration considerations for future integration into the Lao TMN
- a phased concept for network management introduction in conjunction with necessary organizational arrangements to be made, and including technical precautions and migration considerations for future integration into the Lao TMN

Since presently the Lao telecommunications network is still rather small, but digitalized to a remarkable extent, and thus, the analogue part of the network appears negligible, especially in the light of the digital expansion ahead, the scope of this plan is restrained to the digital network only.

5.2 Telecommunications Management Network (TMN)

As already the name indicates, TMN is intended to be a network that supports the management of telecommunications. The overall targets are:

- to speed up telecommunications service provision to the customers, and
- to make all actions which are necessary to operate, sustain and administrate telecommunications more cost efficient.

In this way, the most important feature of the TMN will be its intrinsic cost-minimizing function for the network operator. However, in the very end, it will surely benefit both, the customers and the network operator. Final benefits for the customers are easy to be imagined in terms of:

- faster and more flexible network operator response to customer demand for initial service provision and service profile modifications,
- faster and more flexible service characteristics modification, and
- a better grade of service in general.

5.2.1 What is Telecommunications Management?

Telecommunications management comprises all tasks related to:

- Service provision in a general, supply-oriented sense, such as telephone service provision, data service provision and value added services provision in an Intelligent Network (IN). Note that the so called Service Management Function (SMF) is explicitly identified as one of the functional components in the IN architecture.
- Modification of service characteristics for services already operational in the network, such as the up-grading of value added services in an IN or the up-grading of supplementary services in an ISDN from an initial version to an enhanced version.
- Service provision to a certain customer, which includes (but is not limited to):
  - allocation of a subscriber number from the range of designated but not yet allocated numbers in the subscriber numbers administration system for the respective exchange and up-dating of that system
  - allocation of a service profile as the customer requests
  - actual subscriber initialization in the exchange
  - allocation of a (physical) subscriber line from the pool of unallocated (physical) subscriber lines in the local cable administration system for the respective exchange area and updating of that system,
  - subscriber data and number registration for:
    - charging and billing,
    - the subscriber directory number inquiry service,
    - subscriber directory editing,
    - (automatic) line testing purposes,
    - fault clearing purposes,
    - statistics purposes
- Modification of subscriber service profiles, including (but not limited to):
  - modification of the service profile as the customer requests
  - actual subscriber profile re-initialization in the exchange
  - up-dating of the relevant subscriber data registers as required due to the subscriber profile modification
- Sustaining service at the network level, including (but not limited to):
  - gaining, collecting, evaluating and presenting data on network availability and utilization for:
    - overall grade of service determination,

- network management,
- Signalling System Nr.7 (SS7) signalling network management,
- network planning,
- SS7 signalling network planning,

- gaining, collecting, evaluating and presenting indications for fault detection and localization at network level,
- performing network management based on the data and indications available in terms of:
  - transmission facilities fault management,
  - traffic management,
- gaining, collecting, evaluating and presenting indications for fault detection and localization at equipment level;
- performing fault clearing based on the available indications in
  - exchanges and exchange-associated equipment,
  - transmission systems and transmission-associated equipment,
  - other equipment related to service provision,
- continuous monitoring of the spare part (circuit board) stocks and the faulty/repaired circuit board circulation, as well as in-time spare part stock complementation as soon as required,
- keeping and evaluating records on equipment faults down to the circuit board level to determine quality of the equipment,
- planning, optimization and implementation of network expansions based on the data collected for network planning,
- up-dating of the administration systems related to the network expansion such as
- the subscriber numbers administration system,
- the local cable administration system,
- initialization of newly implemented network resources including (but not limited to):
  - trunks and junction lines,
  - circuit groups,
  - routes,
  - SS7 signalling links,
  - SS7 signalling link sets,
  - SS7 signalling routes

- Sustaining service at the level of the
- particular subscribers including (but not limited to):
  - provision of state-of-the-art automatic subscriber line fault detection

capabilities in the local exchanges,

- provision of a complaint service in conjunction with an efficient fault clearing service,
- keeping records on subscriber complaints, faults and repair times for determination of the grade of service at subscriber level,
- on-line transfer of charging data or regular bulk transfer of charging data records to a billing centre directly or via a charging data collecting system,
- billing at regular intervals in conjunction with monitoring (and, if necessary enforcing) the payment of bills

❑ Termination of the entire service or a part of the service profile on the subscriber's request or for other reasons in conjunction with register updating and subscriber data extinction after expiration of the respective hold-over times.

NOTE: The above list does not claim to be exhaustive. It is rather the intention to show which types of actions and which wide range of activities is covered by the term telecommunications management. However, the list may serve as a starting point for an in-depth analysis of areas and tasks to be supported by a TMN.

As to be seen from the above list, telecommunications management is not a new task at all. It (or at least the most necessary parts of it) has (have) been performed all the time since telecommunications exist. However, what will change significantly due to the TMN, is the way in which telecommunications management is performed.

In the very beginning of telecommunications, all necessary telecommunications management actions have been performed manually, on paper and by means of card registers. In the subsequent development automatic equipment and computers, and later personal computers, have gradually taken over and have formed managed domains.

However, these managed domains have in most cases not been interlinked with each other and with the telecommunications network. This was caused by a lack of open interfaces for communication between computers of different vendors and between computers and computer-like entities in the telecommunications networks.

As a result, the managed domains are presently in fact isolated management islands. In between them, lots of paper or physical data carriers such as disks and tapes are exchanged, and the same or in large parts the same data are manually

inserted in different computers again and again.

Furthermore, real time influencing (and influencing in general) of software controlled entities in the telecommunications network is limited to those cases where the entities to be interlinked are provided by the same supplier. Rare examples are the operation and maintenance centre (OMC) systems and the exchanges as well as the transmission facilities management systems and the transmission systems. However, today it is not possible to operate or to maintain an exchange from one supplier through the OMC system of another supplier, or to manage the transmission systems from one supplier through the transmission facilities management system of another supplier.

TMN is the most promising approach ever made to solve the problem. The first step towards such a solution is to break down telecommunications management into functions and allocate them to appropriate layers in a management model. The model used for the TMN has the following functional layers (see also Fig. 5.1):

- business management layer,
- service management layer,
- network management layer,
- network element management layer,
- network element layer,

wherein the first layer (the business management) is managing only, the three intermediate layers are managed and are managing as well, and the lowest layer (the network elements) is being managed only.

5.2.2 The Basic TMN Concept and Architecture

For the purpose of basic understanding, a TMN can be imagined as a very large Operation System (OS) (see also Fig. 5.2). It has access to all telecommunications equipment in a network. Automatic monitoring and controlling of the telecommunications equipment via these accesses is based on indications and notifications received from the equipment. Triggering of actions by human intervention via the Work Stations (WS) is also an inherent feature of this system.

In a large public telecommunications network all the telecommunications management tasks (as listed in section 5.2.1 of this plan) are to be performed. It is obvious that one large OS running on only one physical machine (computer) cannot handle all these tasks at the same time for several millions of subscribers and the associated amount of trunks and junction lines.

Consequently, the above mentioned OS must be understood as cascaded Operating Systems running on several platforms (computers) distributed in the network. The distribution may be done on a per function/ task basis or on an area of responsibility/area to be covered basis. In reality, both ways of distribution will appear.

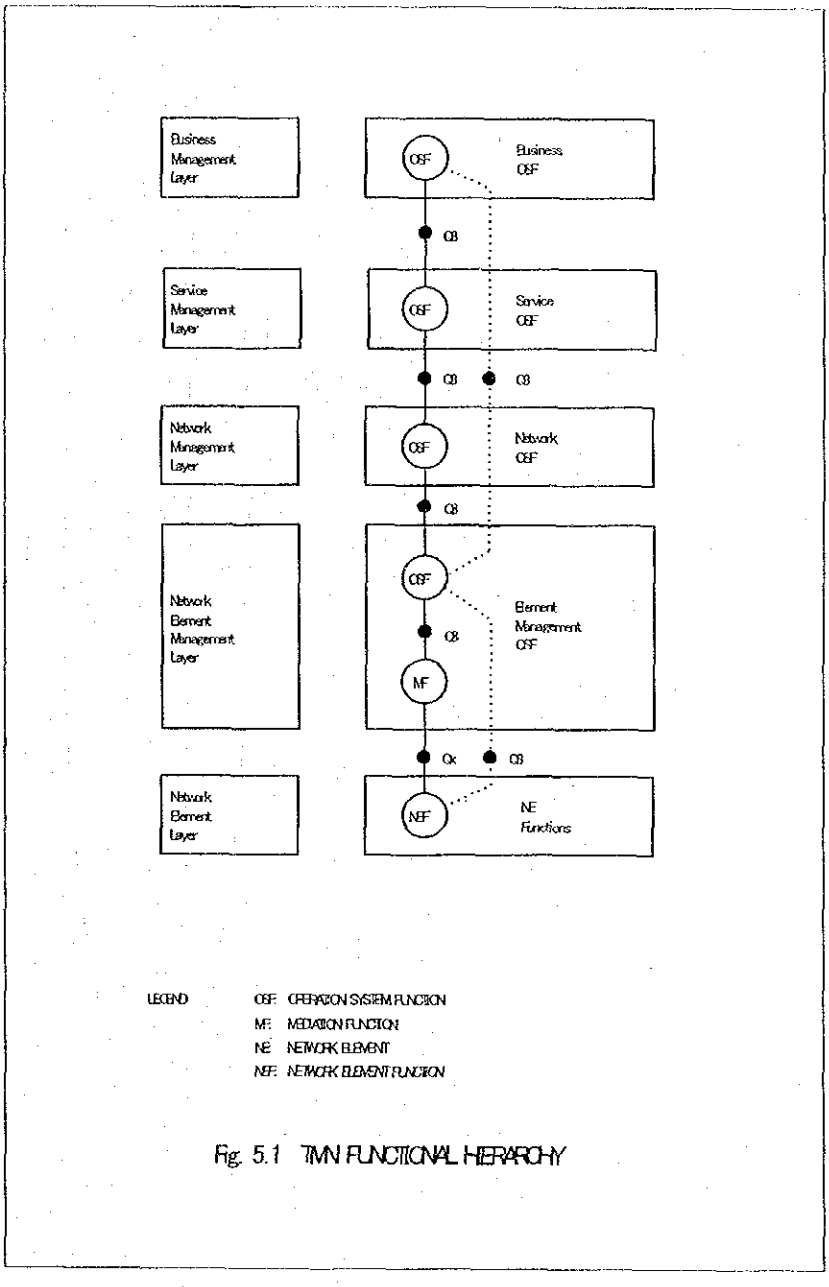


Fig. 5.1 TMN FUNCTIONAL HIERARCHY

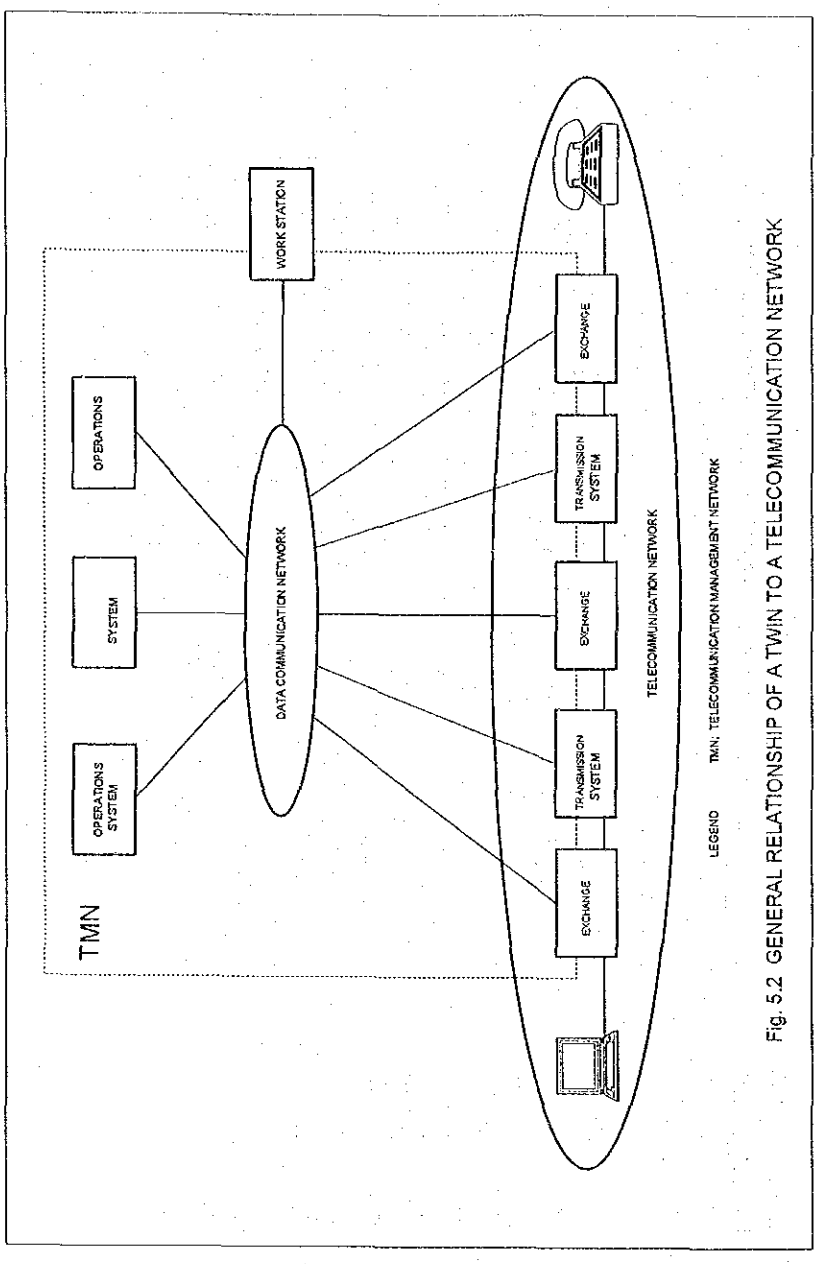


Fig. 5.2 GENERAL RELATIONSHIP OF A TMN TO A TELECOMMUNICATION NETWORK

However, independent of the way of distribution, the concept of cascaded Operations Systems requires that these OS can communicate with each other.

The above considerations borne in mind, the TMN concept is based on:

- an organized architecture for interconnection of various functional types of cascaded operation systems and telecommunications equipment with the aim of exchanging management information by means of standardized protocols and messages
- open standardized interfaces to be provided at any network element in the telecommunications network and throughout the TMN itself. The aim is to provide full management access to any network element in a telecommunications network, and thus, to all the manageable functions contained therein

In terms of network architecture, a TMN presents a logical overlay network to the telecommunications network as shown in Fig. 5.3. The particular entities in the TMN architecture (the TMN building blocks) are the places where the TMN functions reside (see also ITU-T [former CCITT] Rec. M.3010):

- The NETWORK ELEMENTS (NE) present the telecommunications equipment or telecommunications environment or groups or parts thereof, which are object to manipulation by telecommunications management. A NE has one or more standard Q-type management interfaces. NE's may optionally have F interfaces (to connect work stations directly), and exceptionally may have an X interface (if operation system functionality is contained in the NE).
- The Q ADAPTERS (QA) adapt non-TMN compatible interfaces to TMN standardized Q (Q3, Qx) -type interfaces. A QA can provide management access to NE-like equipment that does not possess Q-type interfaces.
- The DATA COMMUNICATIONS NETWORKS (DCN) provides all required communications functions between the particular entities in a TMN. The DCN's represent an implementation of Open Systems Interconnection (OSI) Layers 1-3 (OSI network service). DCN's do not contain any OSI-Layer 4-7 functionality. The DCN's may make use of any type of sub-network or combination of sub-networks available.
- The MEDIATION DEVICES (MD) provide mediation between operations system functions and network element functions / Q adapter functions represented by the respective Qx-type interfaces. Mediation may include (but is not limited to) storing, adapting, filtering, thresholding and condensing of information.

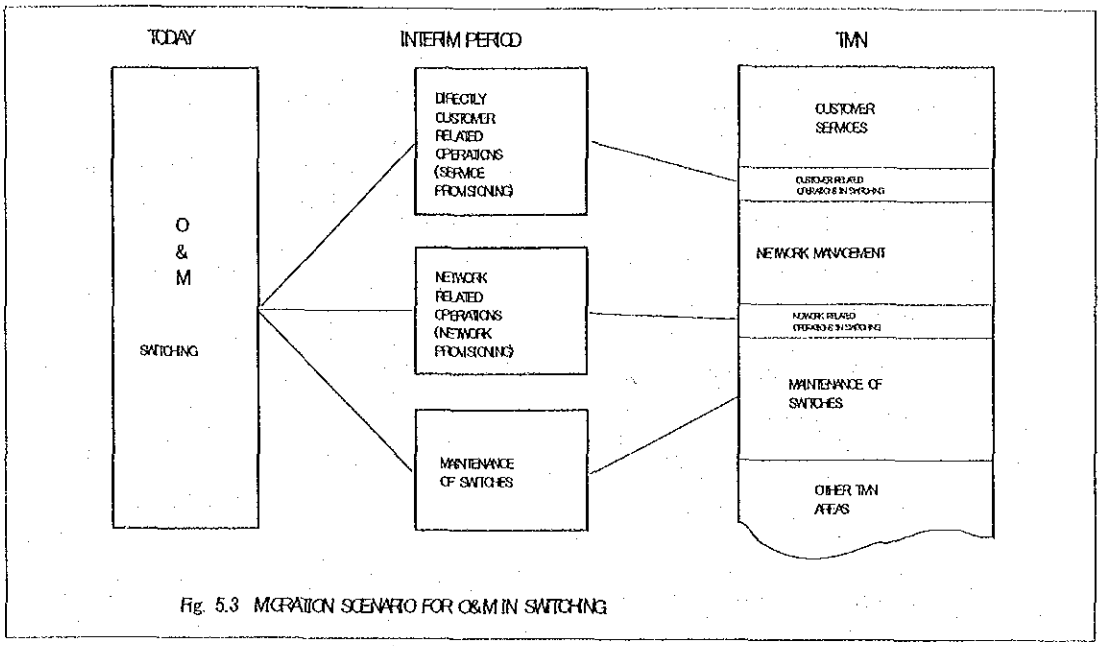


Fig. 5.3 MIGRATION SCENARIO FOR O&M IN SWITCHING

The Operations Systems (OS) provide the management applications functions at T

- The Operations Systems (OS) provide the management application functions at OS level by processing of information for the purpose of monitoring, coordinating and controlling telecommunications functions
- The Workstations (WS) provide the functions to interpret TMN information for the management information user. Outside the TMN boundary, the WS provide support for interfacing to a human user. However, this support is considered not being part of the TMN.

It should be noted that some of the TMN functions are distributed over different TMN building blocks. A typical example is the Management Application Function (MAF), which is distributed between the OS, the MD, the NE and/ or the QA.

Not all components of a TMN will necessarily be physically independent from the telecommunications network. The NE's are by definition members in both networks and the DCN's may be partly or even be fully integrated with the telecommunications network.

Three basic types of interfaces are defined for a TMN:

- The Q-type interfaces, which are internal interfaces for communication between the building blocks in a TMN, in particular:

- The Q3 interface family, which represents the original interfaces as defined for direct communication between an operation system and a network element in a TMN. By definition, Q3 allows for a variety of protocol stacks not only in the lower layers (layer 1-3) but also in the higher layers (layer 4-7).
- For the lower layers, the variety of possible protocol stacks reflects the option to use any available facility as a DCN (e.g. point-to-point circuits, a circuit-mode network or a packet-mode network). The facilities may be dedicated to the TMN or shared (e.g. an ISDN, an existing Packet switched public data network (PSPDN), or even the Signalling System Nr.7 signalling network). This allows for the optimum choice dependent on the characteristics of the envisaged management data transfer, which may range from spontaneous (alarm) message transfer, to dialogues, to bulk data transfer and file transfer. The possible range of protocol stacks for layers 1-3 is defined ITU-T Rec. Q.811/ Q.961/ G.773.
- For the higher layers, the protocol stacks are chosen in accordance with the needs for the transactions envisaged. However, for each set of TMN application functions with similar needs, the uniquely selected protocol stack should be used. The possible range of protocol stacks for layers 4-7 is defined ITU-T Rec. Q.812 / Q.962 / G.784.

It is possible to combine any lower layer protocol stack with any higher layer protocol stack, as long as it makes sense.

- The Qx interface family allows protocol stacks to be chosen by the Administrations or network operators. However, the components of these protocol stacks must be CCITT-standardized. Details of one of the chosen Qx interface specifications and a Qx family of protocol suites will appear in network specific recommendations.

  The common characteristic for the Qx interfaces is that a mediation function is needed for communication with an operation system. A certain Qx interface is characterized by that portion of the information model that is shared between the mediation device and the network elements it supports.

❑ The F interface provides for connection of workstations to the TMN and allows for interaction with a human user. However, the interface between the human user and the workstation function (G interface) is considered being outside the TMN, and thus, subject to Administrations and network operators own specifications. This allows e.g. for language adaptation.

The X interface provides for the possibility of interconnection with other TMN's or other management networks with TMN like interfaces. Basically, such interconnection requires an elevated level of security compared with a Q3 interface (which is very similar at least in the basic functionality).

5.2.3 The Present State of International TMN Definition

The present state of basic TMN definition is documented in the following ITU-T Recommendations:

- Principles for a TMN, ITU-T Rec. M.30 (old) / M.3010 (new);
- TMN Interface Specification Methodology, ITU-T Rec. M.3020;
- Generic Network Information Model, ITU-T Rec. M.3100;
- Catalogue of TMN Management Information, ITU-T Rec. M.3180;
- TMN Management Services, Overview, ITU-T Rec. M.3200;
- TMN Management Functions, ITU-T Rec. M.3400;

With these ITU-T Recommendations the basic principles for further TMN definition are available. However, present specifications are not yet fully sufficient for implementation, and there is still a rather long way to go.

An overview about the continuing activities concerning TMN definition, about further ITU-T Recommendations available or still under study, and about the responsible international bodies is to be found in the "Overview On Telecommunications Management Standardisation".

5.2.4 Organizational Aspects of a TMN

The TMN concept defines functions and architectural entities where these functions are thought to reside. It does not define any interdependence of particular functions and particular physical machines (computers/ platforms) and organization units, i.e. the concept does not preclude that a certain management function is performed by a certain computer, "owned" by a certain department of the organization.

In other words, not every department or province needs to have its "own" TMN. As long as the telecommunications network in Lao remains one single resource and is not divided up amongst several independent corporate network operators, the TMN in Lao should be seen (in terms of functionality) as one system. Subdivision of that system into operation systems should be planned and implemented in accordance with the overall management concept and the

functional requirements of the various management domains.

On the one hand, the TMN gives every degree of freedom as to where supervision and control may be placed geographically. On the other hand, TMN requires a well-defined task-oriented organization in accordance with the respective management functions. This requires that the person handling a certain management domain must have full data access, full supervision, full control, full authority and also full responsibility for this domain.

As a typical example, the traffic manager in charge of the long distance network may be considered. If, in a major fault situation, the traffic manager decides on a routing reconfiguration action to restore traffic to the extent possible, he must also have full authority to execute his decision on the exchange level without the need to obtain approval from any province heads and/ or provincial department leaders. That means the traffic manager must be authorized to bypass the administrative hierarchy completely. Before making the final decision, the traffic manager should consult the transmission network manager and may consult advisors to support the decision making process.

However, the advisors should be in their position first of all for their special knowledge about the network and about network management, but not for their position in the administrative hierarchy.

This example makes unambiguously clear, that only with a suitable functional organization all the capabilities of a TMN can be fully exploited.

5.2.5 Security Aspects of a TMN

In a TMN with fully interlinked operation systems, theoretically, every workstation (WS) and any person having access to a workstation could "manage" everything. Such a situation is not bearable, since it could lead to major disturbances due to intrusion by incident or even by will. Therefore, two kinds of system access authorization and system access security should be introduced. Internally they may again have several levels of authorization:

- Terminal access authorization and security should limit each particular terminal to the application function(s) it is designated to by the functional organization. As an example, any terminal in e.g. a customer application office, which is designated to the subscriber line provision, should blocked to access e.g. the traffic management application function.
- Such authorization can be allocated and modified by a system master console. Even several levels of system master authorizations may exist. However, there

must be at least one terminal which has absolute overall control on the system, and its authorization must not be changeable.

- Personal access authorization and security should limit each particular person to the application function(s) this person is allowed to access based on the functional organization. This prevents that unqualified persons initiate management actions which are beyond their capabilities and beyond their responsibilities and which may result in things out of control, e.g. that the network managers new assistant initiates (incidentally or by trail and error) major reconfigurations in the network, the results of which he cannot control any more due to a lack of experience.
  Such authorization may be based on personal passwords or chip cards (at higher security levels) or even a combination thereof.

5.2.6 The Way to TMN in Lao PDR

Taking into account the various types of activities and the wide range of applications to be covered by a TMN, it becomes obvious that a TMN cannot be implemented in a single effort.

On one hand, there are still a lot of open study items to be addressed in ITU-T and several TMN related ITU-T Recommendations are still to be finalized. On the other hand, the Lao telecommunications network is still in an early phase of development with its major growth phase still ahead. Therefore, strategic and technical pre-preparations for a future TMN introduction taken in due time are surely to pay out on a larger scale due to a much smaller amount of equipment modification costs in the actual TMN introduction.

(1) Strategic Preparation for TMN Implementation

TMN is one of the most important future directed developments in telecommunications. Ultimately, it has the potential dramatically to improve and to cost-optimize provision, operation, maintenance and administration of telecommunications. However, TMN cannot be bought from the shelf.

It requires sound preparation from the network operators' side. This must include the planning and introduction of an appropriate functional organization to enable optimum exploitation of the TMN. Preparation should be started right now by introducing and staffing a project organization in charge of definition, planning and implementation of the TMN. The responsibility of this organization should not be limited to technical aspects but must also cover the organizational aspects and the scheduling of implementation. A possible outline organization is shown in

Fig. 5.4.

The main tasks of this organization should be to:

- provide overall coordination (e.g. by a special coordination staff),
- systematically collect, analyze and make available the present state of TMN definitions and specifications (the ITU-T Recommendations of the M.3xxx series in their White Book version must serve as a starting point),
- keep abreast with the latest development in the international bodies in charge of TMN definition (the key to everything here is observation of TSB [former CCITT Study Group IV],
- observe what the suppliers offer at the market,
- observe what other network operators are planning and doing (try to learn from their initial experiences),
- ensure that any telecommunications equipment ordered has TMN defined management interfaces (or at least that the supplier is contractually bound to implement them as soon as definitions and specifications are available),
- define and plan the Lao TMN at the functional level on an overall basis as a target projection and draft an implementation scenario,
- define, plan and specify appropriate functional implementation portions and steps (e.g. transmission network management system, traffic management system, switch maintenance support systems, customer services management system, charging data collection and billing system, etc.), and allocate implementation priorities,
- define the associated functional organization structures

For some of these tasks, special working groups and working teams may be established temporarily.

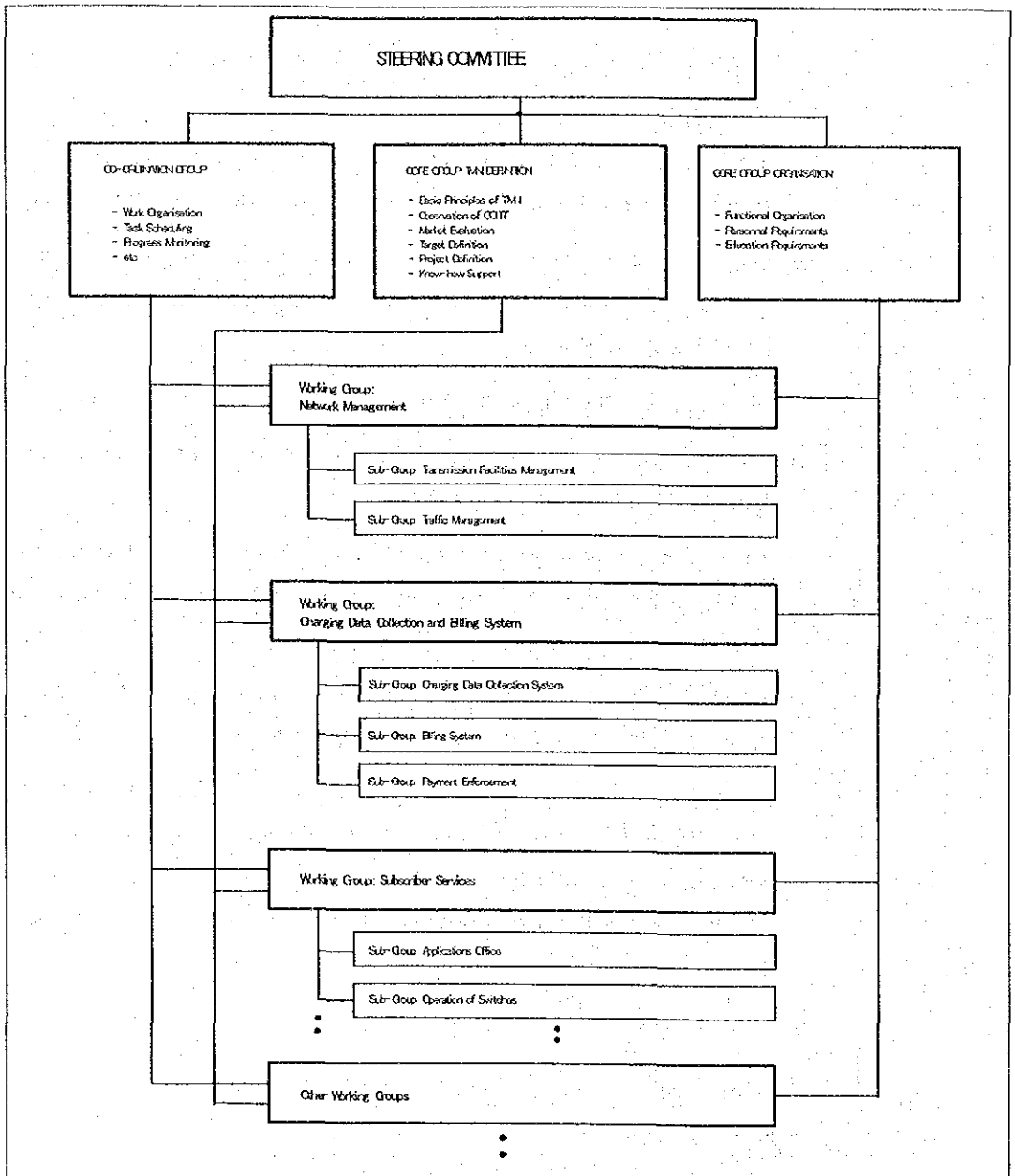


Fig. 5.4 POSSIBLE PROJECT ORGANISATION FOR TMN DEFINITION AND IMPLEMENTATION

(2) Technical Precautions for TMN Implementation

First of all it is indispensable that all equipment procured in the future has open interfaces for TMN access. Open interfaces in this sense means that the supplier cannot or (by binding commitment in advance) does not reserve any proprietary protection rights on the interface(s) designated for TMN access.

The best way to obtain this is to require mandatory implementation of Q3 or Qx-type interfaces for any piece of equipment to be deployed in the network. The Q3 and Qx-interfaces are the TSB specified interfaces for TMN, and thus are open interfaces.

If this is not possible (e.g. due to lack of specifications for the upper layers or lack of the appropriate object models), the supplier must be committed in the initial contract to upgrade the equipment as soon as the specifications are available and the network operator requests it.

However, the physical interfaces with the layers 1 to 3 should be provided right at the beginning whenever the basic communication needs of the equipment are clear to that extent that the lower layers protocol stacks can be chosen. For a switch this could even mean a variety of interfaces.

For existing telecommunications equipment in the network, it must be decided, based on its remaining useful lifetime, whether upgrading by means of Q3 or Qx-type interfaces or Q Adapters is to be considered. In addition, it must be examined thoroughly whether the equipment under consideration has already sufficient internal management intelligence or whether this management intelligence can be inserted or upgraded to the extent desired at acceptable costs. Unless this is the case, the equipment under consideration shall remain outside the TMN and/ or be replaced as soon as feasible.

(3) Existing Telecommunications Management Islands

In the Lao network (as in other networks as well) there exist already some (partly) automated telecommunications management functions. Typically, these functions have been provided in tailored systems (e.g. on PC's) to suit a certain task and are not directly interlinked with other functions (systems), which e.g. are triggered by the same event. If there is information flow required between these systems, this is performed by exchange of tapes, disks and even paper. Consequently, these systems appear as isolated telecommunications management islands. Typical examples of such existing functions (systems) are:

- the customers directory inquiry system
- the charging data collection - charge calculation - billing function
- the local cable administration system
- the transmission resource supervision (and management) systems

New telecommunications management islands may be created in the course of time, since TMN introduction is thought to be an evolutionary process taking several years, and the benefits of such islands may be so significant that rapid implementation appears to be preferable, even if e.g. the interlinking with other functions in the TMN is not yet possible.

However, if new telecommunications management islands are created, their future integration into the TMN must not be neglected and their migration to the TMN must be planned in advance. Creation of new telecommunications management islands, which cannot be integrated into the TMN later on, must be avoided under any circumstances.

(4) Integration of the Islands

Integration of the existing telecommunication management islands does not necessarily need to take place for all of them at exactly the same time. This process should be regarded as an evolutionary one, too. In this process integration of those telecommunications management islands, which create the most additional benefit by being interlinked with the other TMN functions, should make the lead.

In the first step, all existing telecommunication management islands should be thoroughly examined:

- whether they are to be integrated into the TMN in their existing form
- whether they should undergo minor or major redefinition or reshaping
- whether they should be merged with or absorbed by other management functions

and the necessary modifications should be initiated.

The second step then will be to define the communication needs including the necessary communication protocols.

In a third step, the telecommunication management islands (respectively the equipment used therein), which are designated to be integrated into the TMN, should be upgraded by adding Q3 or Qx-type interfaces or Q-Adapters (QA) as appropriate.

5.2.7 Strategic Considerations on the TMN Operations Systems

An operating system (OS) in the TMN consists of (an) Application System(s) which run(s) on a so-called Platform.

The Application System can be understood as the programs, data and communication protocols to execute the management functions allocated to that operation system function.

The Platform is the physical hardware (computer) where the applications system(s) run on. The platform includes its own operating system (which in this case means the system that keeps the computer organized and going as e.g. Windows for PC's, and which is not identical with an operations system as defined in the TMN) and the physical communication interfaces.

Several application systems may share the same platform, provided the platform is powerful enough to support them in parallel.

Two important criteria must influence the decision for a particular platform:

First of all, some major TMN applications (e.g. network management) require fault tolerance (also called continuous availability) from the platforms. Fault tolerance means that neither major hardware faults nor software faults should cause termination of operation. Only a limited amount of computer manufacturers at the world market offer such fault tolerance. However, it must be decided on a per-case base and based on the application envisaged, whether the platform under consideration really needs to be fault tolerant.

Secondly, it is very desirable for the network operator that the application systems are portable from platform to platform, ideally without any or at least without major adaptations in the application system. This would allow the network operator to chose and change platforms freely and without major extra costs for adaptation of the application systems software. This is only possible when the original platform had and the new platform has an UNIX or UNIX-derived operating system. It is not possible with platforms from different manufacturers having proprietary operating systems.

NOTE: Whereas smaller fault tolerant platforms with UNIX operating systems are available at the market already, huge and more powerful fault tolerant platforms are still using proprietary operating systems, since the definition and implementation of multi-processor-UNIX is still under way.

5.3 Operation and Maintenance (O&M)

The overall objective of O&M in a telecommunications network is to provide and to sustain telecommunications services to the customers

- in the fastest and most flexible way,
- with a continuously satisfying grade of service, and
- at the lowest possible costs for the network operator.

Before going deeper into the particular areas and concepts associated with O&M, the definitions of some terms need to be clarified:

- **Operations**: All regular day-to-day activities directed to provision of telecommunication services to the customers. These activities may be directly associated with a particular customer (such as to set up new subscribers, to change service profiles of existing subscribers, to change a subscriber number, to block or unblock subscribers, to terminate a subscription, etc.), or may be indirectly associated with a group of or all customers (such as to set-up new trunks and junction lines, to set-up new circuit groups and routes, to modify the routing pattern, to modify the charging pattern, etc.).

- **Maintenance**: All activities directed to keep the grade of service at the desired level. The actions may be of preventive, corrective or controlled nature (see also ITU-T Rec. M.20 and M.21):

  - **Preventive Maintenance**: The main activities are aimed at fault prevention, i.e. activities which should show effect before faults occur at all. The quality of preventive maintenance is directly reflected by the rate of faults occurring.

    Preventive maintenance is very labour-intensive, and shows best effects for equipment which is subject to wear and tear. It is recommended for mechanical and electromechanical equipment, e.g. for manual and electromechanical exchanges. As far as the digital technology is concerned, the digital switches and the digital transmission equipment do not need preventive maintenance. However, there are peripheral units (such as printers, tape drives, disk drives, disk arrays) containing sophisticated mechanical components, which should be subject to regular preventive maintenance.

  - **Corrective Maintenance**: All activities aimed at fault detection and fault clearing, i.e. activities which show effect only after a fault has occurred. The quality of corrective maintenance is directly reflected by the downtimes of the

affected domain.

- **Controlled Maintenance**: The main activities are to systematically apply analysis techniques (i.e. using supervisory facilities and/ or sampling) with the aim to minimize preventive maintenance and to reduce corrective maintenance.

In a series of ITU-T Recommendations (M.1510, M.1520, M.1530, M.1550, M.1560) the ITU provides principles for a standardized exchange of released information, constant prints between different entities or operators and national and international procedures to refer "a matter to an organization entity with a greater degree of expertise or authority" the so-called "escalation procedures".

5.3.1 O&M Strategy

The Lao telecommunications network is to undergo major transitions in quality and in quantity at present or at least in the next five years:

- ❑ Digital technology (i.e. digital switches and digital transmission) are being deployed in the network.
- ❑ Transition to the Synchronous Digital Hierarchy (SDH) transmission technology.
- ❑ A major network expansion has been started this year, and will most likely go on for the next years.
- ❑ ISDN is planned for introduction in the near future.
- ❑ TMN matures rapidly and initial implementation may be considered for the next five years.

Consequently, the O&M strategy and the O&M concept have to be adapted in accordance with the network development. However, the network expansion will be (or at least should be) a continuous process over the years to come. The implementation of the new O&M concept must be aligned with the network expansion. In addition, the transition to the TMN must not be neglected. The corner stones of the new O&M strategy for Vietnam are:

- ❑ As an overall aim, the new O&M strategy must ensure the desired grade of service at the lowest possible costs.
- ❑ Cost effectiveness must supersede all existing organization schemes including all such very hampering interests as department influence, provincial standing and equipment ownership.
- ❑ Considering the rapid growth of the telecommunications network in the years

to come, the best use of the presently available very limited amount of skilled man power must be made.

- Any arrangement for O&M made from now on must not hamper the migration to the TMN, but contribute to a smooth transition.

(1) Maintenance in the Digital Era

Maintenance of digital equipment in general should be based on a maintenance philosophy as outlined in ITU-T Rec. M.20 and M.21, which prefers controlled maintenance in conjunction with corrective maintenance. The Mean Time Between Failures (MTBF) for digital equipment is very high and as a consequence it has become normal proceeding to operate digital equipment regularly unattended and to send maintenance personnel to the site only in case of indications and alarms.

In fact trails in some countries have shown that especially digital transmission equipment suffer less failures when unattended in sealed compartments than when continuously attended.

Consequently, if digital equipment is continuously attended for certain reasons (e.g. if the travelling distances are to large), ways must be found to prevent the maintenance staff from contact with the equipment unnecessarily.

(2) O&M for Switching

When reviewing and rearranging O&M for switching, the future migration to the TMN must be borne in mind. Due to the wide variety of actions involved, and due to their different nature, a one-to-one integration of O&M into the future TMN seems not to be recommendable.

Based on an in-depth analysis, three areas are to be considered separately concerning their migration to the TMN:

- Operations directly related to service provision to the particular subscribers (such as setting up new subscribers, changing subscriber profiles etc.) is to be seen customer-oriented. Therefore, in the TMN, it should migrate into the customer services operations system. Since it is the desire of network operators worldwide to be able to offer the same services, service profiles and supplementary services independent of the switching systems, there is a fair chance that this migration can take place very early.
- Operations related to service provision to the generality of subscribers (such as setting up new trunks and junction lines, amendment of routing tables, etc.) has to be seen in the framework of provisioning in the network. Therefore, in

the TMN, it should migrate into network management. However, as to be seen from section 4 of this plan, this will be on the highest level in network management, and thus, be implemented rather late.

- Maintenance will remain very switching system oriented. It is most unlikely that functions for fault indication and fault localization for the different switches could and would be standardized in the foreseeable future. Consequently, maintenance should migrate to the TMN as a function of its own right

Consequently, the three areas of O&M as identified above must be considered separately. The migration scenario is shown in Fig. 5.5.

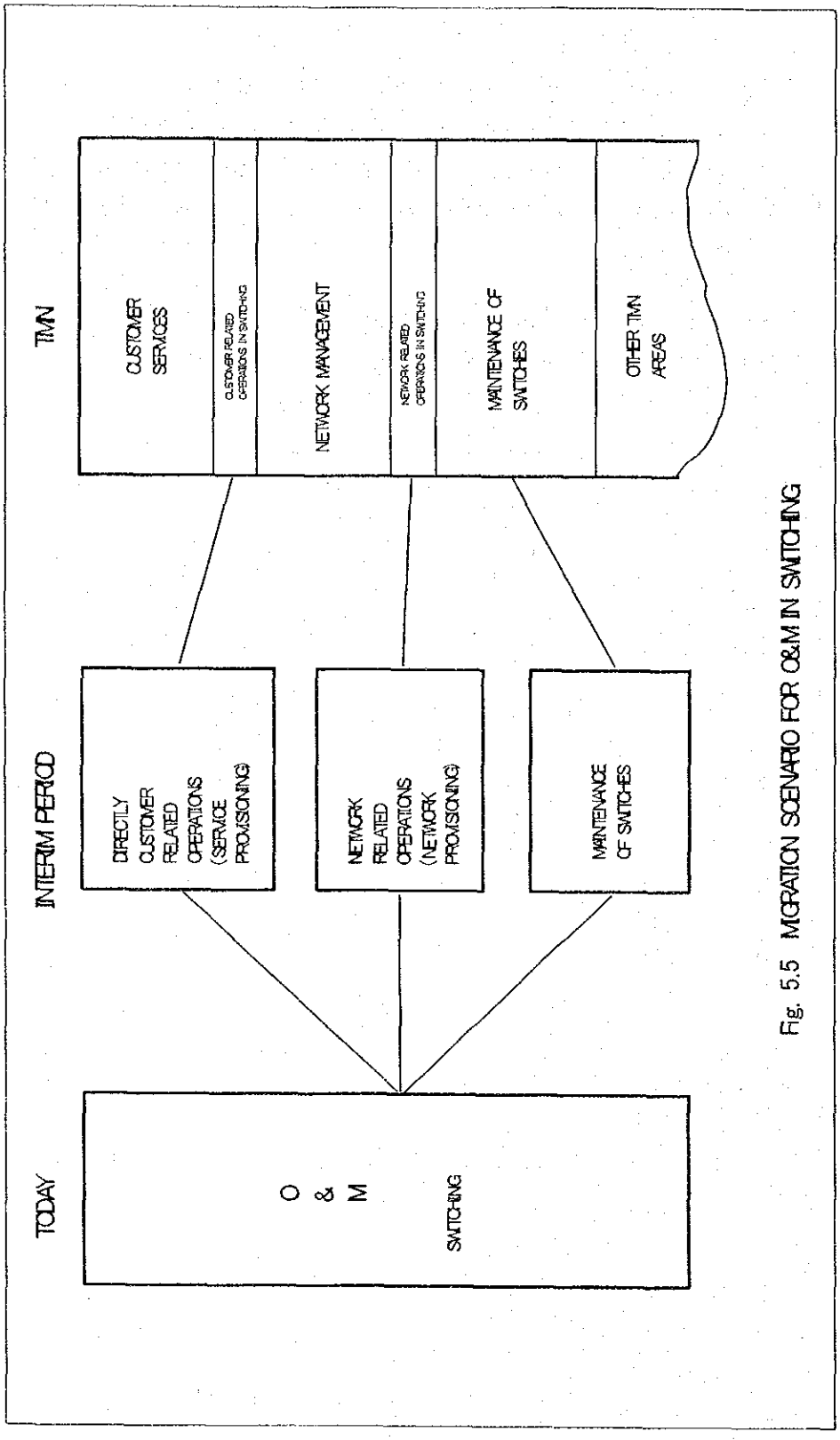


Fig. 5.5 MIGRATION SCENARIO FOR O&M IN SWITCHING

(a) Centralized O&M versus Local O&M

Normally, in the more developed networks, centralized O&M is applied for digital exchanges whenever possible. Centralized O&M means:

- All exchanges are connected to so-called Operation & Maintenance Centres (OMC) where operation is done during normal working hours and monitoring and supervision for these exchanges is done around the clock.
- Remote Switching Units (RSU), smaller- and medium-sized digital exchanges are run unattended.
- In larger exchanges, maintenance personnel are deployed during normal working hours, when the amount of work to be done there justifies it and/ or when the exchange is situated at a geographical centre position amongst unattended exchanges.
- If a fault occurs in an unattended exchange, the alarm will be recognized and analysed in the OMC and during normal working hours a maintenance technician or engineer will be sent to the exchange affected to clear the fault. Outside normal working hours a decision is to be made first based on the alarm indications as to whether the fault needs immediate attention or whether fault clearing can be postponed to normal working hours.

This O&M organization is arranged with the aim to reduce operation and maintenance staff costs by better utilization of manpower. Normally, one digital exchange does not create enough work to justify full time staffing.

However, there is a hard limitation to this approach. The decisive factor is travelling time to the unattended exchanges. First of all, the travelling time contributes to its full extent to the down time and thus directly to the degradation of the grade of service. Secondly, the travelling time reduces the actual working time off the staff.

In Lao PDR this approach cannot be applied without paying proper attention to the local frame conditions:

- O&M staff wages and salaries in Lao PDR are very low at present and can be expected to remain at the lower side for the foreseeable future. Roughly, they can be estimated to 5 - 10% of O&M staff wages and salaries in Europe.

- The variety of different switching systems deployed in the country makes it even more difficult to cut O&M staff costs by work concentration since each system requires a different training especially in the area of maintenance, so that different work groups are to be established for the different systems.

- Transportation costs, especially when cars are used, are rather high. Roughly, they can be estimated to 60 - 70% of transportation costs in Europe.

- The density of the telephones in Lao PDR is still very low. Thus, the density of exchanges is also very low. The distances between the exchanges and also between the exchanges and the RSU's are comparable large. Taking into account the road and traffic conditions in addition, travelling times will be long and, thus, down times become unacceptable. An exception is the multi-exchange area Vientiane, for which the exchange density is higher than for the rest of the country.

Based on these facts, it must be recognized that, for the time being, centralized O&M will not result in a major reduction in O&M staff costs. This is mainly due to the very low salaries. In the contrary, the relatively high transportation costs will even make centralized O&M more expensive. In addition, due to the long travelling times caused by the large distances and the insufficient road and traffic conditions, the grade of service cannot be kept at an acceptable level.

However, there is still another important issue to be addressed:

- The Laos telecommunications network is supposed to grow at rates of approximately 15 to 20% throughout the next years. This growth involves the deployment of additional digital switches at a large scale.
  At present, there is only a small base of senior technicians and senior engineers experienced in maintenance of digital switches. To train such senior staff and to expose them to experience takes remarkable time.

- The moving of Laos towards market economy will result in a strong growth in the private telecommunications sector. This will go hand in hand with an escalating competition for experienced and well trained telecommunications staff. In this situation, the higher salaries in the

private sector will most likely attract a part of the experienced staff of the public telecommunications sector.

This scenario is to result in a serious shortfall in experienced maintenance staff, which cannot be compensated for on the short run by training of additional staff.

Consequently, an O&M concept is needed, which allows to make best use of the available experienced maintenance personnel. This is only possible, if the existing experienced staff is deployed in some centralized way to give on-demand support to less experienced personnel. However, at the same time it must be ensured that transportation costs and travelling times remain low. This is only possible in a kind of partly centralized set-up for O&M as described in the following.

(b) O&M Arrangements for Switching

Throughout Lao PDR, all exchanges and RSU's should be manned by two maintenance technicians during normal working hours. In the multi-exchange area Vientiane those RSU's which are less than 20 km away from their host exchange may be considered for unattended operation, provided sufficient transport can be made available.

Outside normal working hours, all exchanges and RSU's should be unattended.

OMC's should take over monitoring and supervision of the exchanges allocated to them outside normal working hours.

As a long-term target, 3 Operation and Maintenance Centres (OMC) should be established in Lao PDR, e.g. Luangphabang, Vientiane and Khantabouli.

They should be colocated with the transit centres.

As far as allocation of exchanges to OMC's is concerned, the following rules should apply:

- All exchanges in the province where the OMC is located shall be allocated to that OMC.
- All exchanges in a province, which does not have an own OMC, shall be allocated to that OMC in an adjacent province, which has the lowest work load, in order to keep the work load as balanced as possible. A good indication for the workload in an OMC is the amount of subscribers

located in its service area.

(c) Size of OMC's and Phased Implementation

In general, the upper and lower size limits for an OMC area are determined by the following factors of influence:

- Amount of subscriber line units /trunk and junction lines expected to be deployed in the OMC area.
  Since no fully centralized O&M will be applied, and since the OMC's in Lao PDR have only a supporting role in maintenance, and since the operations tasks are to be transferred in the TMN to customer services and to network management, the upper limit for the OMC size can be higher in Lao than usual in countries which apply fully centralized O&M. *200,000 subscriber line units in conjunction with the associated amount* of trunks and junction lines should be the upper limit for the OMC size.
  As far as the lower limit is concerned, an OMC may be established as soon as the amount of 6 switching sites (exchanges and RSU's) is reached in the OMC area under consideration.

- Distances (in terms of travelling times and transportation costs) from the OMC to the exchanges supported.
  Since travelling of maintenance staff will be the exception and distant support the regular action in the concept lined out here, this factor of influence does not need to be considered here.

- Organizational borders and topography of the country.

To get an overview on the sizes of the OMC's planned for Lao, the following calculations based on the low range and the high range demand forecast should be considered (all figures are rounded).

ITEM	LOW RANGE	HIGH RANGE
Total subscribers (year 2005)	80,000	90,000
Total subscribers (year 2010)	140,000	160,000
Total subscribers (year 2015)	180,000	200,000
Subscribers/average OMC	50,000	65,000

For the OMC's outside Vientiane, an implementation schedule with priorities dependent on the size (amount of subscribers and of exchanges and RSU's in the service area) must be established.

As an initial step, 3 OMC's should be established.

(d) Internal Configuration of OMC's

The proposal for the target network 2005 foresees 108 (host) exchanges for the entire country. That means that (on average) each of the 3 OMC's gives support to 3 to 4 exchanges.

Such small numbers in conjunction with the present procurement policy (buying a very wide variety of different switching systems) cannot justify the deployment of OMC systems (OMC computers). Consequently, only distant (remote) O&M terminals are to be applied in the OMC's. This means that one remote O&M terminal for each exchange supported must be placed in the OMC. In addition care must be taken in case a terminal fails. That means that one spare terminal for each exchange type must be available.).

An alarm/supervision panel for each exchange must also be placed in the respective OMC.

In the larger multi-exchange areas (Ho Chi Minh City and Hanoi), where more exchanges than the average amount will be supported, deployment of OMC systems might be considered in the distant future, especially if splits of OMC's are considered in accordance with switching systems.).

However, before such configurations with OMC systems are deployed, sound cost comparisons with the normal configurations are to be made. For the time being, no cost advantage is to be expected from deployment of OMC systems under present frame conditions (procurement policy) and with the very low costs for O&M staff.

(e) *The Operations Concept for Switching*

In the short term (i.e. as long as OMC's are not yet established), all operation activities should be performed in the exchanges by the maintenance technicians during normal working hours. Additional staffing will not be required, since the maintenance staff will not be fully loaded anyway.

In the medium term, all operation activities should be performed in the OMC's during normal working hours:

- Operations directly related to service provision to particular customers should be executed by an operations group of staff. It should be considered to train this operations staff in operations for more than one switching system. In principle the operations staff needs a much lower qualification and much shorter training than the maintenance staff. For more demanding tasks, which may arise from time to time, they can call in maintenance staff for support.

- Operations related to service provision to the generality of subscribers should be performed by the maintenance personnel in the OMC.

In the long term, operations should migrate into the TMN.

- Operations directly related to service provision to particular customers is to migrate to the customer services department and shall directly be triggered and be controlled from the work station in the customers application office. All the detailed tasks required are then executed by the cascaded operation systems including printing out an order for the linemen containing the connection instructions for the main distribution frame (MDF) and the cross connecting cabinet.

- Operations related to service provision to the generality of subscribers is to migrate to network management and will become part of the configuration management on the logical network level.

(f) The Maintenance Concept for Switching

The following principle strategies should be applied for switching:

- Corrective maintenance for switches

- Preventive maintenance (in regular intervals as recommended by the suppliers) for peripheral equipment being subject to mechanical wear and tear such as tape drives, disk drives, printers, etc.

- Controlled maintenance to an extent, which would allow to identify weak components in the switching system and production quality shortfalls, and which would allow to require quality improvements from the supplier based on provable data.

Four levels of maintenance and maintenance support should be introduced:

- Local Maintenance Level: Two maintenance technicians should man each exchange during normal working hours to handle all faults and should be on call (in turn) outside normal working hours to respond to major faults. They must be trained to the extent that they can handle 90% of all faults appearing under normal operating conditions. For the remainder they can call in support from the OMC level.

- OMC Maintenance Support Level: Two maintenance engineers for each type of switching system deployed in the OMC service area should man the OMC during normal working hours and should be on call (in turn) outside normal working hours. They must be trained to the extent that they can handle 98% of all faults appearing under normal operating conditions. Their main tasks should be:
  - to support the local maintenance technicians in the respective exchanges to handle faults beyond their capabilities
  - to keep the spare part (circuit board) circulation system going
  - to collect data and keep records on the faults appearing in their respective types of switching systems and forward it regularly to the national maintenance support level for in-depth analysis

  In addition, there should be three shifts working around the clock, each staffed with one experienced senior maintenance technician for each type of switching system deployed in the OMC service area. Their main tasks should be:
  - during normal working hours: to monitor, to control and to supervise the local maintenance technicians and
  - outside normal working hours: to perform an initial analysis of alarms and faults surfacing with the aim to decide whether the local maintenance technician has to be called in immediately or whether the fault clearing can be postponed to the normal working hours next day

- **System Maintenance Support Level**: This level should have the following tasks:
  - to give support to the lower maintenance levels for faults which are beyond their capabilities
  - to reproduce extraordinary faults to gain fault data such as processor and register contents (dumps) for escalation to the supplier/factory level

- to call in the supplier for hard faults in the system such as software faults
- to perform initial acceptance tests for new equipment, e.g. new hardware components and new software releases
- to evaluate fault recordings from their respective type of switching system with the aim to identify weak points in the system, e.g. circuit board types which show failures very frequently
- to manage the central spare parts stock for their respective type of switching system including initiation of repair

The system support level should be organized on a per switching system basis. That means that a System Support Centre (SSC) should be set up for each type of switching system in the country.

Normally, the SSC's should be manned only during normal working hours. Each SSC should be staffed with:

- 2 system specialists, who should have profound and in-depth knowledge about the respective system
- 2 senior maintenance engineers (designated to become system specialists)
- 2 maintenance engineers
- 2 senior maintenance technicians

Each SSC should be equipped with a reference switch configuration including all associated telecommunications equipment, which must be always identical (in hard- and software) to the switches and equipment of that type deployed in the network. An exception would be that period of time when a new software release/ new hardware components is / are tested.

To make more efficient use of the reference switch configuration, it may be considered to use it also as a training exchange. However, this would require sound coordination for allocation of usage time shares.

- **Supplier/Factory Maintenance Support Level**: This support level is outside the network operators direct control. The suppliers should be bound by contract to make available such support. The contract must also cover the commercial conditions for such support. However, all support related to hard system faults (e.g. software faults) and quality assurance is usually free of charge.

As long as the OMC Maintenance Support Level is not yet established, i.e. as long as OMC's do not yet exist, maintenance will almost exclusively rely on the local maintenance staff. In this situation (which must be considered on a per province basis), the exchanges and RSU's should be attended around the clock.

However, what should be implemented as soon as possible are the System Maintenance Support Level and the Supplier/Factory Maintenance Support Level. This would provide at least some support for the local maintenance level in the early stage before OMC's are established.

As far as migration to the TMN is concerned, maintenance for the switches can be expected to stay as a function in its own right for a rather long time. This is due to the fact that the application functions will remain switching system independent. In this context it can be expected that the maintenance applications for each switching system in the network will remain as an own system specific functional operation system in the TMN. What can be done and what should be done, is to provide standardized maintenance access to the various exchange systems by harmonizing the layers 1 to 3 for access via the DCN and to harmonize the layers 4 to 6 to the extent possible.

(g) O&M for International Switching Centres

Normal internationally defined and agreed O&M procedures have already been established in the International Switching Centre (ISC) in Vientiane. No change or adaptation is required for the time being. O&M for the ISC should remain as it is.

(3) Fault Hand-Over Procedures

Fault hand-over procedures and overall fault clearing responsibilities must be defined and enforced carefully in order to avoid faults "falling into a responsibility gap" and thus being manifested forever or at least for a very long time. Such a system should be organized in accordance with the following lines:

- Overall fault clearing responsibility and supervision remains with that entity where the fault surfaced initially (e.g. with the O&M entity for subscriber lines if the initial indication was a subscriber complaint, with the switching OMC if the fault was recognized during exchange routine tests, etc.) till the fault is finally cleared.
- If it is unambiguously clear that the fault is not in the responsibility of that

entity where it surfaced originally, the fault is to be formally transferred to the entity where it is assumed to reside. This includes a special book keeping for faults not yet cleared where this fault is to be registered with the own fault number and the fault number under which it is registered in the newly responsible entity.

- If the newly responsible entity can clear the fault, it closes its own register on the fault and indicates back that the fault is cleared.
- Then and only then the entity where the fault surfaced initially can close its own record on this fault.
- If the newly responsible entity has unambiguously made sure that the fault does not reside in its area of responsibility, it closes its own register on the fault and indicates back in which area of responsibility the fault is most likely to be found.
- In this case, the entity where the fault surfaced initially amends its record and transfers the fault by means of the procedure above to the indicated new area of responsibility.
- In regular intervals the fault records must be examined for faults whereof clearing is pending for unacceptably long time and a special inquiry must be made for these faults.

5.3.2 Spare Part Stocks and Spare Part Repair

The term "spare parts" for digital switching systems and digital transmission systems translates mainly into "spare circuit boards". In maintenance for digital switches and digital transmission, it is usual to replace faulty circuit boards by spares from a stock. The faulty circuit boards are then repaired or discarded, dependent on how expensive repair would be compared with buying new ones. In this context the following actions are required:

- Spare circuit board stock keeping is to be optimized in such a way
  - that spare circuit boards are available when and where they are needed and in the amount they are needed, and
  - that the capital bound in the spare circuit board stock is kept to a minimum. A multi-level spare circuit board stock keeping system may help to keep the stock at exchange and transmission node level at an absolute minimum due to common (regional and central) stock buffers, which could be smaller than the total of all full scale local stocks.

However, this will require a very efficient spare circuit board exchange cycle.

- A spare circuit board exchange cycle for changing faulty circuit boards against repaired/new ones has to be organized and kept going. As smaller the individual spare circuit board stocks can be kept, as faster the cycle works.
- Repair and/ or discarding and replacement of faulty circuit boards have to be organized.

NOTE: The more different switching and transmission systems are deployed in the network (especially if they are deployed in small numbers), the more difficult it becomes to optimize spare circuit board stock keeping, circuit board circulation and circuit board repair, and the more expensive the entire spare circuit board stock system becomes.

5.4 Network Management

Several network operators have implemented network management systems during the last decade. However, when having a closer look to these solutions, it will be recognized that all network management implementations, which are operational by now are based on network operator's own definitions and are tailored to their special needs and their networks.

Furthermore, network management implementations, having been offered up to now by the suppliers as "ready to use", are partial, almost exclusively based on proprietary interfaces, and restricted to the particular supplier's transmission and/ or switching equipment.

Both observations reflect the fact that there has not been any standardized definition or any generally agreed concept for network management in the past.

The first approach ever to come to standardized definitions for network management is presently made in the framework of the TMN definition. The work in the relevant bodies (CCITT, ETSI and ISO) is still ongoing and will require several more time to be completed. However, some areas, as e.g. the management definitions for the new Synchronous Digital Hierarchy (SDH) transmission equipment, are fairly progressed.

5.4.1 The Goals for Network Management

In very broad and open terms network management can be described as the total

of all activities and procedures aiming at an effective exploitation of network resources and network functions.

In particular, these activities are directed at improvement of:

- network supervision and network control by enabling centralized
  - acquisition of network supervision data in a fast way
  - analysis of network supervision data
  - decision making based on this analysis
  - application of network control functions
- network utilization efficiency by enabling
  - better network planning based on better data (from supervision)
  - real time resource management (incl. automatic reconfiguration)
  - faster network recovery after failures
  - less provision of redundancy for network protection
- provisioning, operations, maintenance and administration by enabling
  - provision of better network status information
  - better overall control due to increasingly centralized POM&A
  - more efficient fault handling procedures
  - application of controlled maintenance
- network performance and quality of service by
  - providing enhanced supervision data more rapidly
  - providing enhanced network status information
  - reduction of network (components) / services down times
  - enabling better traffic management

Eventually, all these improvements are directed to the overall goal of enhancing the relation between revenues obtained and expenses made for investment and operations.

To which extent the above objectives can be met, depends not only on the features and facilities provided in the management system but also on the supervision intelligence and the control capabilities of the managed network elements. It also depends on the organizational arrangements and operational procedures developed to exploit the network management.

However, experience in other countries shows that it takes typically 2 to 3 years of continuous well directed efforts after initial installation to get a network management system fully effective and to exploit its capabilities to the full extent.

5.4.2 Network Management Definition in the Framework of TMN

Based on the principle considerations introduced above, a network management system must be defined.

Regarding the "network" being subject to network management, a few initial considerations show that, for the purpose of a network management, this network cannot be regarded as a single homogenous resource. It consists of several functional layers:

- The **physical network** of transmission resources, which consists of the transmission media (cables, optical fibres, micro-wave links and satellite links), the transmission systems, the transmission nodes and the repeater stations.
- The **logical network** of switches and circuit groups, which uses the physical resources in a flexible way by means of the routing capabilities and the routing data base in the exchanges. In abstract terms, the routing function in the switches super-imposes the logical network structure on top of the physical network structure.
- The **common channel signalling network** (after Signalling System Nr.7 (SS7) introduction) as a supporting network for the logical network. It should be borne in mind, that SS7 already includes an considerable amount of signalling network management functions in its signalling network level specification (ITU-T [former CCITT] Rec. Q.704) and, thus, that the need for external management depends largely on the signalling network structure. When, like proposed for Lao, an associated signalling network structure is to be applied, implementation of external signalling network management is not an urgent issue.

As a consequence, network management has to cope with at least two layers, the "transmission network" as well as the "switching network". Considering this, it becomes obvious that:

- Management activities must be different in nature; dependent on the characteristics of the respective layer they should apply to
- Management activities at the different layers must be specified and executed in a coordinated way in order to avoid that they turn out to be counter-productive and work against each other

The above considerations show that network management is a rather complex issue. On the other hand, network management is an indispensable function for future optimized network operation.

Definition, specification and implementation should be started as soon as possible, especially in a situation as for the Laos telecommunications network, where major expansions are planned.

5.4.3 An Approach to Network Management Implementation

In the light of the above, it seems advisable to approach implementation of network management from two directions. Separate efforts should be made in parallel to implement:

- **Transmission Facilities Management**, which should be understood as the management of the transmission network
- **Traffic Management**, which should be understood as the management of the switched network

However, both efforts must be accommodated inside the framework of the future Laos TMN and must strictly adhere to TMN definitions and TMN standards. This will leave the door open for a future integration if this is desired.

(1) Basic Strategic Principles

For the definition, the specification and the implementation of both, transmission facilities management and traffic management, the project organization for TMN should be put in charge.

For transmission facilities management implementation as well as for traffic management implementation in the Lao telecommunications network, strict adherence to the following strategic principles is recommended:

- All arrangements for network management must be in accordance with the TMN framework.
- All transmission and switching equipment (network elements) procured from now on must have TMN-defined management interfaces (Q3 or Qx-type interfaces). If this is not possible (e.g. if definitions or specifications are not yet available), the supplier must make a commitment to implement interfaces on request from the network operator as soon as definitions and specifications become available.

- All transmission and switching equipment (network elements) procured from now on must have supervision intelligence and control capabilities. If this is not possible to the full extent (e.g. if definitions or specifications are not yet available), the supplier must make a commitment to upgrade on request from the network operator as soon as definitions and specifications become available.

- All digital equipment (network elements) already existing in the network must be classified concerning its remaining usage time and its existing build-in management intelligence (supervision intelligence and control capabilities).
  If the envisaged remaining usage time is more than 3 years, implementation of TMN-type interfaces should be initiated, under the precondition that the existing management intelligence is sufficient or can be upgraded at acceptable costs. Possibly existing management interfaces of non-TMN type should be adapted to TMN-type interfaces.
  If the envisaged remaining usage time is less than 3 years, no actions are required. If the existing build-in management intelligence is insufficient and cannot be upgraded at acceptable costs, the equipment should remain outside the managed network till its lifetime expires or till it is replaced.

(2) Transmission Facilities Management

Three main areas can be identified in transmission facilities management:

- **Configuration Management** is mainly oriented to provisioning (setting up and cancellation of transmission links for the switched network and for other purposes such as leased lines). Another major activity in configuration management is transmission network reconfiguration for optimization purposes.
  Configuration management in the transmission network may also be used to support fault management at the traffic management level (e.g. after major disasters at a transit switch such as fire, flooding, etc., which disables the switch for a rather long time). However, this needs close coordination with the traffic manager.

- **Performance Management** is the basis for controlled maintenance. Performance data collected real-time are used to evaluate network performance. Based on this evaluation maintenance actions targeted to performance and quality improvement are initiated.
  In an advanced stage, even transmission network planning could be supported by data collected to evaluate transmission network performance.

- **Fault Management** is targeted to initiate corrective maintenance actions for clearing of equipment faults and to help neutralizing major fault situations in the transmission network (e.g. when transmission systems or even complete physical resources such as optical fibres or microwave lines) are down. This starts with the switching in of protection resources (automatically or initiated by the network manager) and may even result in major reconfiguration of the remaining transmission resources dependent on the impact of the fault.

- However, such actions as the latter must be performed
  - always in close coordination with the traffic manager
  - only after a sound analysis of the possible consequences and
  - never over-hasty, must always be based on the network managers final decision and must not be done automatized.

(a) Functionality of a Transmission Facilities Management System

A transmission facilities management system needs the following basic functionalities:

- Management "intelligence" at network element (transmission equipment) level consisting of:
  - data collection capabilities
  - supervision capabilities and
  - control (execution) capabilities

- Open TMN (Q-type) interfaces at the network element level and at the management operation system level

- Access capabilities (data communication) between all components of the system (by means of a DCN)

- Central management "intelligence" (a management operation system) capable of:
  - data analysis and storage
  - proposing appropriate actions based on the data analysis, stored data and pre-imposed patterns of action

NOTE: In an advanced stage, the management operation system may be upgraded into a so-called expert system, capable of learning by accumulating experience from former management actions. However, the definition and development of such systems will still require considerable efforts and

considerable time.

As far as the transmission facilities management operation system is concerned, the platform should be of continuous availability (fault tolerant).

- A visual display should give a comprehensive overview on the current situation in the transmission network.

(b) Organization of Transmission Facilities Management

In the long term, three transmission network management centres should be established:

- Vientiane, which should serve as
  - master control centre for transmission facilities management for the entire country, thus supervising all other transmission facilities management centres and controlling their authorization
  - transmission facilities management centre for all transmission backbone routes and
  - transmission facilities management centre for the central region
- Khantabouli, which should serve as transmission facilities management centre for all regional and local transmission routes in the southern region
- Luang Prabang, which should serve as transmission facilities management centre for all regional and local transmission routes in the northern region

In the long term, the allocation of the transmission facilities management areas of responsibility (and thus, the areas of authorization) to the particular centres should be based on (software) network maps.

In the introduction phase, this allocation may be done based on physical systems.

The network managers must have full authorization and also full responsibility in their areas of control. When they make a decision, they may consult specialist advisors from certain areas. However, after the decision has been made, execution must take place right away on their instruction only. Execution must not be dependent on any approval of any other manager in the administration hierarchy.

(c) Phased Implementation

Implementation of transmission facilities management should start with the introduction of the Synchronous Digital Hierarchy (SDH).

The following start-up arrangements should be made:

- Each new (SDH) transmission equipment (network element) should have built-in management intelligence (supervision capabilities, data collection capabilities and control capabilities) accessible from TMN (Q-type) interfaces.
- Each new (SDH) transmission system should have an element manager / system control station, which allows management of the system from this station.
- The element managers / system control stations should be placed at those locations which are planned to serve as transmission facilities management centres.
- The suppliers must make the commitment to upgrade the SDH equipment to full TMN management capabilities as soon as definitions and specifications are available and the network operator requests it.

In a second step the existing PDH transmission equipment must be examined in accordance with the basic strategic principles outlined before. Upgrading should be initiated as indicated there.

In a final step full integration into a TMN (national) management system should take place.

(3) Traffic Management

The ITU-T E. 41x - series of Recommendations are basically aimed at international traffic management. However, the basic principles established in ITU-T Rec. E.410 are valid for national traffic management as well. In addition, the management controls defined in ITU-T Rec. E.412 are also applicable in national traffic management.

ITU-T Rec. E.410 defines traffic management as the function of supervising the traffic flow in a network and taking actions when necessary to control the flow of traffic.

Four main areas can be identified for traffic management:

- **Overload handling** should protect the network against traffic overload in terms of:
  - foreseeable traffic peaks (e.g. at a sentimental holiday like Tet) and
  - unpredictable traffic peaks (e.g. caused by natural or man made disasters with everybody calling to know whether the relatives are well)
- **Fault handling** should during major fault situations (if e.g. a major resource in the network or major parts of the network is / are down):
  - reorganize the remaining resources in such a way that maximum throughput in terms of traffic is possible (see also configuration management)
  - protect the remaining network against spreading of any traffic overload resulting from the loss of resources in order to avoid the situation becoming even worse
- **Configuration management** should allow for reconfiguration at the logical network (circuit group) level (i.e. setting up, expanding, contracting and cancellation of logical routes including the associated manipulation of the routing tables) in order to compensate (at least partly) for major network faults. As a very advanced form of configuration management, the application of load-dependent routing, controlled by the traffic management centre, is to be considered.

  In the long term, configuration management should also accommodate for provisioning (i.e. setting up, expanding, contracting and cancellation of circuit groups including the associated manipulation of the routing tables). Today, these tasks are handled in O&M for switching. However, as outlined in the migration scenario they are supposed to migrate to network management.

- **Performance management** should in the long term
  - support real-time grade of service evaluation by collecting and analyzing of information on the current traffic situation
  - keep records on these performance data
  - support data collection for network planning

(a) Principles of Traffic Management

The following principles should apply for the definition and specification of traffic management:

- ❑ Maintain maximum revenue from the network by ensuring that
  - as much circuits as possible are in service
  - all available circuits are utilized
  - all available circuits are kept filled with successful traffic
  - switching congestion is inhibited and its spread is prevented
  - traffic with high success probability is given priority over traffic with lower success probability
  - traffic with poor success probability is blocked at or near the source

- ❑ Ensure that the customers obtain the best possible service from the network resources available

- ❑ Make the most effective use of the network under
  - heavy load conditions
  - plant failure conditions
  - national disaster conditions
  - changed traffic patterns (Tet-holiday)

(b) Traffic Levels

The traffic being managed can be distinguished in terms of revenues it generates in:

- ❑ International traffic consisting of:
  - incoming international traffic including its distribution in the national network
  - outgoing international traffic including its collection in the national network

- ❑ National traffic consisting of:
  - long distance traffic
  - regional traffic
  - local traffic

Under heavy load conditions, different handling strategies for these different traffic portions in accordance with their "value" (revenue they generate) may be considered and applied.

(c) Basic Functionality of a Traffic Management System

A traffic management system needs the following basic functions:

- ❑ Management "intelligence" at network element (switch) level consisting of:
  - data collection capabilities
  - supervision capabilities incl. thresholding and
  - control (execution) capabilities

- ❑ Open TMN (Q-type) interfaces at the switches and at the management operation system level

- ❑ Access capabilities (data communication) between all components of the system (by means of a DCN)

- ❑ Central management "intelligence" (a management operation system) capable of:
  - data analysis and storage
  - proposing appropriate actions based on the data analysis, stored data and pre-imposed patterns of action

NOTE: In an advanced stage, the management operation system may be upgraded into a so-called expert system capable of learning by accumulating experience from former management actions. However, the definition and development of such systems will still require considerable efforts and considerable time.

As far as the traffic management operation system is concerned, the platform should be of continuous availability (fault tolerant).

- ❑ An (optional, since costly) visual display should give a comprehensive overview on the current situation in the switched network.

(d) Technical Arrangements for Traffic Management

First of all, the switching systems in the network must have efficient build-in automatic overload protection mechanisms, which ensure maximum traffic throughput in case of overload. Such mechanisms are and must be system dependent due to the different architecture of the switching systems. However, before it is decided to buy a switching system, it is of prime importance to thoroughly examine the overload protection philosophy and the overload protection mechanisms of that system.

When Signalling System Nr.7 is introduced, the Automatic Congestion

Control (ACC) procedure must be mandatory.

As far as technical arrangements for external traffic management are concerned, the exchanges (being NE's according to the TMN definition) must contain build-in management intelligence (supervision capabilities, data collection capabilities and control capabilities):

- ❑ Means for real time monitoring of traffic on the particular traffic carrying entities (circuit groups, control elements, etc.), e.g. based on pre-set (and adjustable) thresholds
- ❑ Means for setting and adjusting these thresholds on-line
- ❑ Means for execution of control as the preventive and expansive management controls defined in ITU-T Rec. E.412, requested already in the national routing plan and explained concerning their effect in the Handbook on Quality of Service, Network Management and Network Maintenance.
- Means for communication with the traffic management operations system (Q3 interfaces)

For management access (DCN) any existing network (e.g. the existing packet switched public data network or the packet-mode service in the ISDN when already implemented) could be used, provided they are appropriate for the data transfer envisaged.

The traffic management application system must be defined to make the best use of the management intelligence in the switches.

NOTE: To obtain uniform traffic management capabilities and management performance throughout the network is the more sophisticated and the more expensive, the more different switching systems are deployed in that network.

(e) Organization of Traffic Management

In the long term, three traffic management centres should be established to control the national traffic in Laos. For the purpose of close coordination, they should be colocated with the transmission facilities management centres:

- Vientiane, which should serve as
  - master control centre for traffic management for the entire country, thus supervising all other traffic management centres and controlling their authorization
  - traffic management centre for all inter-regional traffic routes and
  - traffic management centre for all regional traffic routes and all exchanges in the central region

- Khantabouli, which should serve as traffic management centre for all regional traffic routes and all exchanges in the southern region

- Luang Prabang, which should serve as traffic management centre for all regional traffic routes and all exchanges in the northern region

The traffic managers must have full authorization and also full responsibility in their areas of control. When they make a decision, they may consult specialist advisors from certain areas. However, after the decision has been made, execution must take place right away on their instruction only. Execution must not be dependent on any approval of any other manager in the administration hierarchy.

(f) Phased Implementation

In a preparation phase, management intelligence to be located in the switches and protocol stacks for the Q3 interfaces must be defined and specified in detail. In parallel the traffic management application functions must be defined and specified. Both actions must include continuous coordination with the switch suppliers.

The traffic management system should be accommodated in the TMN framework. Proprietary solutions should not be considered any more.

The implementation phase can follow only if preparation is fully finalized. However, starting with a system with an initially limited functionality and undertaking continuous efforts for subsequent upgrading to more functionality is an acceptable way to go.

(g) International Traffic Management

For international traffic management, a proprietary traffic management centre can be accepted (provided the functionality is sufficient). This centre should be located in Vientiane, collocated with the ISC. The international

traffic management centre preferably should not be under the overall control of the Vientiane master centre.

(4) Coordination of Transmission Facilities Management and Traffic Management

In general, the transmission facilities manager(s) should inform the traffic manager(s) (and vice versa) on all actions (minor provision actions excluded) they intend to take. For more sophisticated actions even consultation is recommended.

Major failures in the network (e.g. a larger transmission mechanically damaged, a transit exchange damaged by fire or flood), which cannot be repaired in short time, may result in the remaining resources being not capable of handling the total traffic and thus to the network being affected for a longer time.

In this case, coordinated actions of the transmission facilities management and the traffic management will be needed to ensure maximum utilization of the remaining resources and maximum traffic throughput in the affected network.

For these cases, coordination and advisory bodies consisting of specialists from the technical disciplines involved should be predetermined. They should be activated immediately on occurrence of such faults to support the transmission facilities managers and traffic managers in the decision making process.

6. Standard

6.1 Design of Outside Plant (Exerpt)

6.1.1 Design Period

- 5 years, (Primary Cable)
- 10 years, (Secondary Cable)
- 15 years (Manhole and Duct)

The optimum period for each facility is decided on economical comparison of the model case, if the actual period is shorter than the above figure, the installation work will be repeated and if longer , it will be as the state of over-investment.

6.1.2 Underground or Aerial Cable

(1) Aerial Cable up to 600 P totally in the span, the maximum pairs of a cable 400 p

(2) up to 3 cables

6.1.3 Fixed Distribution Area (C.C.C Area)

(1) 600 to 1,200 subscribers - 15 years demand

(2) Big Business buildings, offices business (Special demand) more than 100

6.1.4 Aerial Cable Design (Refer to Fig 8.8.3.1)

(1) Selection of route

i) Suitable for distribution 05 cable

ii) Shortest route

iii) Safety of poles (traffic, road construction work etc.

iv) Re electricity other facilities

(2) Selection of diameter of cable core

i) Uni gauge or two gauges

(3) Decision of number of pairs

i) 10 pairs sub unit – 10 years demands

ii) Assembly of sub units from the end pole to feeding poles.

iii) Calculation of summary of sub unit

6.2 Standard and Regulation

- Attenuation Loss 7dB
- Loop Resistance 1500 Ω
- Clearance from the ground (Regulation) 5.5 m to 7.0 m
- Separation from electrical
- Power line (Regulation)

0,25 to 0,4 KV	20 cm to 1,0 m
~ 22 KV	1,5 m to 2,5 m

- Earthing Resistance

DP	⩾ 30 Ω
Cabinet	⩾ 5 Ω
MDT	⩾ 2 Ω
Messenger Nine	⩾ 30 Ω
Network Equipment	⩾ 5 Ω

6.3 Installation Manuals

i) As a whole, manuals as the same in Thailand is used. Illustration, Dimensions, and Figures of the plant facilities are shown.

ii) The process of installation, method to construct materials to be adapted, to be used, and caution to be taken are not explained in detail.

7. Rehabilitation Work in Vientiane

Due to the budget constraint, the secondary cable has not installed in proportion with the primary cable.

Also, the small size cables as 20 to 30 pairs cables have repeatedly been installed.

In order to recover those situations, the following items should be planned and carried out.

The basic figures of existing facilities are collected from LTC Maintenance office in November, 2001. The details of Rehabilitation Work shall be studied in the feasibility study.

7.1 Additional Secondary Cable

Drop wires have been laid for many years instead of aerial distribution cable.

There are too many deteriorated drop wires causing many faults – 80 to 90% of total faults.

Those drop wires shall be replaced with additional aerial cables.

The number of additional cable pairs is the difference between the necessary pairs (1.4 times of existing primary cable pairs) and the existing cable pairs of secondary cable.

The necessary pairs (1.4 × 38,860) - existing secondary cable pairs (40,606) = 13,798 pairs

Average length per pair of the existing secondary cable is calculating in dividing total length of existing secondary cables.

The average length per pair is 217,582/40,606 = 5.36 Meters

Thus, the additional length of the secondary cable is calculated as following ;

13,798 pairs × 5.36 meters = 73,957.28 Meters.

7.2 Additional Distribution Point and telephone Pole

Together with the additional secondary cable, because Distribution Point is put on the secondary cable, DP shall be added simultaneously.

On the other hand, the existing interval length of each DP position is about 150 meters , because the pole which supports the secondary cable is mostly the electric pole (more than 80 % of the total poles) and it is difficult to put DP on the electric pole , usually the telephone pole is installed between the electric poles in order to put DP..

The additional DP is necessary on existing secondary cable which has DP at interval of 150 meters. — It is necessary to shorten the interval as the average length of 75 meters at least.

This interval length shall be applied on additional secondary cable

i) The additional DP on existing secondary cable
The number of DP on existing secondary cable is calculated as follows;

The total length of the existing secondary cable in Vientiane as of Nov.2001:	217,582 m
The present interval length	150 meters
The present number of DPs on existing cable 217,582/150 =	1,451 pieces.
The required number of DPs 217,582/75 =	2,901 pieces
Additional number of DPs on existing cable 2,901 - 1,451 =	1,450 pieces

ii) The additional DP on additional secondary cable
The number of DP on additional secondary cable is calculated as follows;

The additional cable length/average interval; 73,957.28/75 =	986.09

iii) Total number of additional DP

i) + ii) = 1,450 + 987 = 2,437

iv) Additional installation of poles to put Distribution Point
The pole should be installed at the new DP.

Total number of poles is 2,437.

7.3 Replacement of small size cables to 200 pairs or 400 pairs cable

We observed that there are many cable spans exceeding 4 cables in one cable span (approximately 10 km). Details shall be studied in the feasibility study.

This situation causes violation of Regulation to keep distance from the ground and difficulty of cable work.

7.4 Relocation of aerial cable to Duct System and Underground Distribution System

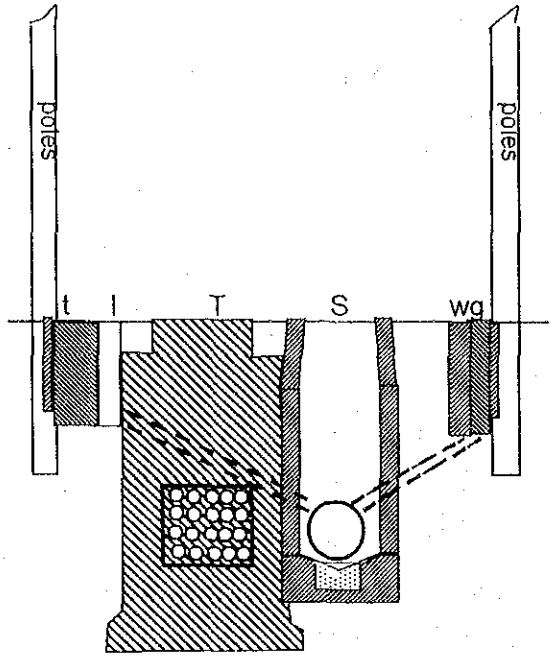
We observed that there are some cable spans exceeding 600 pairs in one span (approximately 3 to 5 km). The pole cannot hold heavy load of cables and it is slanting and dangerous. Those cables shall be relocated to duct system.

On the other hand, it has become difficult to keep regulated distance from the electricity and from the ground especially at commercial areas in Vientiane

For the sake of safety of maintenance work and facilities the underground distribution system shall be installed in the future.

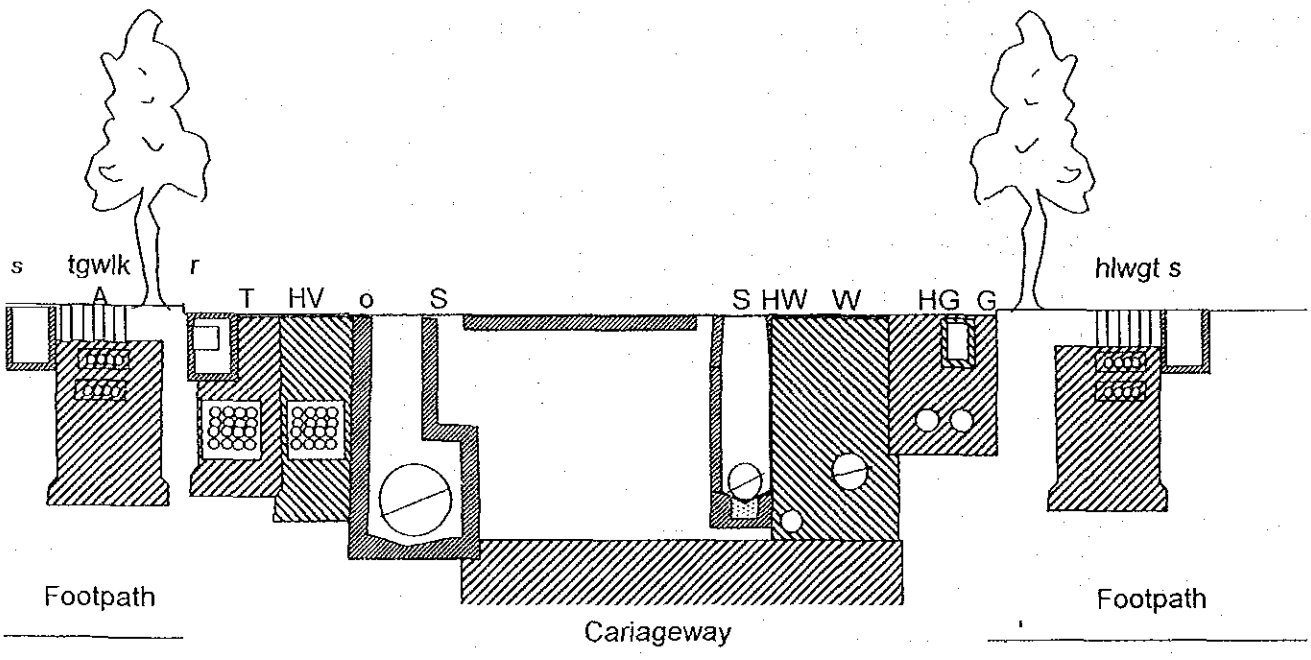
In order to promote the installation of underground distribution system, the following items shall be considered ;

i) the present road composition and the future plan of Road Authority
ii) Unfortunately Road Authority does not have the standard dimension figure of the road at present time, but the carrier shall get permission from the Authority and shall have coordination with other lifeline companies.
Refer to Example of standard dimension figure.
iii) It often happens that the underground distribution system become expensive, however, the suitable underground system shall be studied.



LEGEND				
Kinds of Facilities	Main Line		Branch Line	Note
Telephone Line	T.A		i	
Hight Voltage Power	HV_1	HV_2	k	HV_1:Dukt type HV_2::Trough type
Distrbution Line of Power			l	
Water Pipe	W	HW	w	
Drainage	S		s	
Gas pipe	G	HG	g	

(a) Road Width 8m (No discrimination of footpath and carriageway)



(b) Position of Underground Facilities (Example of Tokyo Metropolitan Area)

Fig. 7.1 Road Configuration and Life Lines

8. New Public Telecommunication Numbering Structure

All telecommunications bodies should use the single national numbering structure. The numbering should be decided based on the MCTPC numbering policy. The national numbering structure is as follows:

(a) International prefix : 00

Dialed by a calling subscriber from Lao P.D.R. making a call to another country to obtain access it is automatically routed to the outgoing international switch. Dialing procedure for international call is :

International Prefix + Country Code + Toll Code + Subscriber's Number

(b) National (Toll) prefix : 0

Dialed by a calling subscriber from Vientiane making a call to a subscriber outside his or her toll numbering area (Province). It is automatically routed to the outgoing toll switch. Dialing procedure for international call is :

Toll Prefix (02x, 03x, 04x) + Local Code + Subscriber's Number (Total 8 digit)

Toll Prefix adopted (for domestic numbering plan) by Lao P.D.R. is shown in the Table 8.1 and 8.3.

(c) Intra Province Call :

Dialed by a calling subscriber from a province to a subscriber within the same province. It is automatically routed within the same switch or via tandem switch if the caller is not settled in the same ones. The dialing procedure for an intra province call is :

Subscriber's Number (6-7digits)

(d) Mobile telephone service : same structure with toll calls

Calling is the same with the toll calls for the fixed telephone. The call is automatically routed to the mobile switching system from the toll switch with the toll prefix with 06, 07, 08. Dialing procedure for a mobile call is:

0 + Area code + Operator code + Subscriber's Number (total 8 digits)

Detail numbers are allocated in the Table 8.2

(e) features of new numbering plan

- The total number of population of Lao PDR toward 2050 when the population is about 100,000,000 and 8 digit to cover whole country.
- The total number of mobile telephone is larger than that of fixed telephone. The numbering structure are the same structure for fixed and cellular mobile

- The toll prefix of fixed and mobile telephone for Vientiane is 1 digit. 2 for the fixed and 6 for the mobile.
- The allocation is made for Vientiane and adjacent areas for "2X", southern parts for "3X", and northern parts for "4X" in order to the people to remember easily.
- Large cities (Luangprabang, Savannakhet, and Pakse) are allocated two adjacent prefix.
- Mobile number is allocated as follows.
  - Mobile operator identification is provided.
  - Area code + Operator code + (4 to 6 digit)
- VoIP numbering for the future (Table 8.3)
  - IP switches are interconnected to the existing PSTN and therefore same numbering scheme is applied. Toll prefix should be assigned different way such as to allocate opposite direction from the end. (referring to the VoIP type (c) for chapter 7.3)
  - Special number such as"050" is allocated for the users form computer connecting through IP network. (referring to the VoIP type (b) for chapter 7.3)
- Special services numbers should be kept for the future services.
  - Some services which equal to all operators should be allocated the same number in order not user to be confused. (Table 8.3)
  - Allocation of special numbers for ISPs should be 4 digit special numbers such as 9901, 9902. (Table 8.4)

(g) How to sift to the new numbering plan

- Change should be done for the toll prefix, and it should be minimized for the changes of local prefix. This is because the minimum changes for the local calls are considered.
- However, these changes may become difficult if the number of subscribers is increased. The study team recommends that the earliest adaptation reduce the confusion among users.
- First change following cities where new prefix has not been utilized. Because of the new allocation, it is not difficult to change. It should be necessary one year for the notice to the usres, half year for new number and previous number, and half year for announcement to the previous prefix numbers.
- Huaphanh (64 to 42), Luangprabang (71 to 44), Xayabury (74 to 45), Oudomxay (81 to 46), Bokeo (84 to 47), Luangnamtha (86 to 48), Phonsaly (88 to 49), Savannakhet (41 to 37), Saravane (34 to 33), Borikhamxay (54 to 39) and Sekong (38 to 35)

- If completed, the change of overlapped prefix as follows. Those prefixes have been used once, so that at least one year is necessary before reuse.
- Xienkhang (61 to 41), Attapeu (36 to 34), Khammuane (51 to 38), and, Savannakhet (36 for future use)
- The allocation for mobile can be done after first changes are completed. 61 is allocated to the Xiengkhuang, however 61 will not be used for mobile. Also, the mobile telephone is applied 020 and is rather easy to apply new numbers. The Study Team recommends that new numbering scheme should be applied from the mobile.

Table 8.1 Proposed PSTN Numbering Plan and Switches in Lao P.D.R.

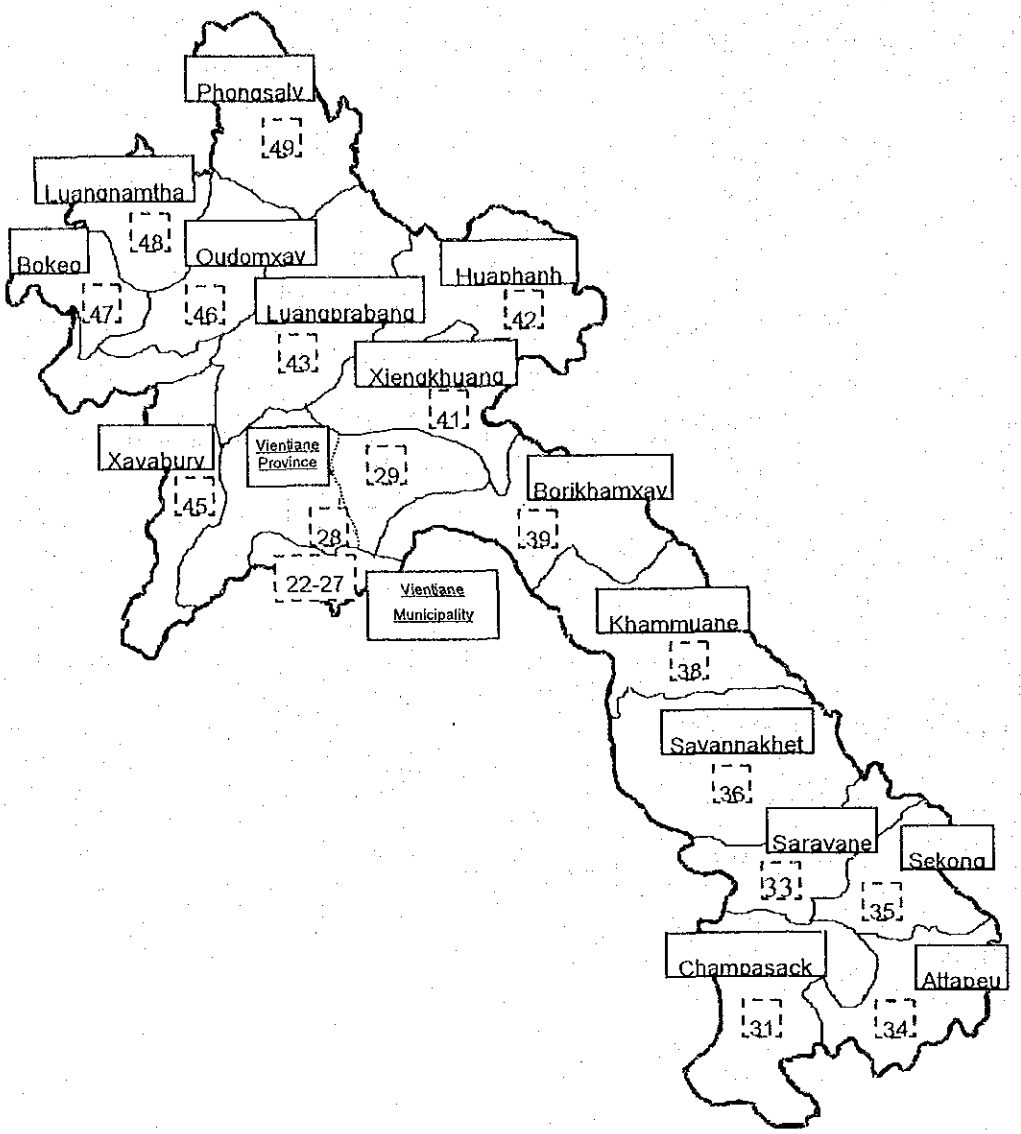
n/n	Province Name	District Name	Exchange Name	Abb	Area code	Ex code	Number	Numbers Range
1	VIENTIANE	Chanthabury	NUMPHOU	NMP	2	220-225	0000-9999	60,000
2	MUNICIPALITY		SAYLOM	SAY	2	226-229	0000-9999	40,000
3			Nahaidio	NDO	2	291	0000-9999	10,000
4			Phontong	POT	2	256	0000-9999	10,000
5		Sisattanak	Sisattanak	STN	2	231-235	0000-9999	50,000
6			B. Home	BHO	2	236	0000-9999	10,000
7			Chinaimo	CHI	2	293	0000-9999	10,000
8			103 Hospital	103	2	295	0000-9999	10,000
9		Xaysetha	Xaysetha	XST	2	241-245	0000-9999	50,000
10			Samkhe	SKE	2	246	0000-9999	10,000
11			Nakhuay	NKA	2	247	0000-9999	10,000
12			Phonkheng	PKE	2	290	0000-9999	10,000
13		Sikhottsbong	Airport	APT	2	251	0000-9999	10,000
14			Wattay	WAT	2	292	0000-9999	10,000
15			Thongpong 1	TPG	2	261	0000-9999	10,000
16			Thongpong 2	TPG	2	262	0000-9999	10,000
17		Naxaithong	Naxaithong 1	NXG	2	263	0000-9999	10,000
18			Naxaithong 2	NXG	2	264	0000-9999	10,000
19			Ilai	ILI	2	265	0000-9999	10,000
20			Numxuang	NXO	2	298	0000-9999	10,000
21		Sangthong	Sangthong	STO	2	266	0000-9999	10,000
22		Xaythany	KM 6	KM6	2	271	0000-9999	10,000
23			Donnoon	DNN	2	273	0000-9999	10,000
24			Thangon	TNG	2	275	0000-9999	10,000
25			Nongxuam	NXU	2	296	0000-9999	10,000
26			KM21	K21	2	276	0000-9999	10,000
27			KM24	K24	2	297	0000-9999	10,000
28			DDK	DDK	2	277	0000-9999	10,000
29			Nongphaya	NPA	2	294	0000-9999	10,000
30		Hadxaifong	Nahai	NHI	2	281	0000-9999	10,000
31			Thadeua	TDA	2	283	0000-9999	10,000
32			Salakham	SLK	2	284	0000-9999	10,000
33		Maypark-ngum	Park-ngum	PNG	2	322	0000-9999	10,000
34			Naxone	NAX	2	323	0000-9999	10,000
35			B.Phao	PAO	2	324	0000-9999	10,000
36			B.Hai	HAI	2	325	0000-9999	10,000
037	VIENTIANE	Phonhong	Phonhong	PHO	28	2X	0000-9999	100,000
38	PROVINCE		KM 52	K52	28	33	0000-9999	10,000
39		Viengkham	M.Kao	KAO	28	40	0000-9999	10,000
40			Phonmee	PME	28	43	0000-9999	10,000
41		Thoulakhom	Thoulakhom	THO	28	52	0000-9999	10,000
42		Feuang	M.Feuang	FEU	28	62	0000-9999	10,000
43		Xanakham	Xanakham	XNK	28	72	0000-9999	10,000
44		Keo-Oudom	Keo-Oudom	KEO	28	82	0000-9999	10,000
45		Vangvieng	Vangvieng	VAN	28	92	0000-9999	10,000
46		Kasy	Kasy	KAS	28	12	0000-9999	10,000
47		Mad	M.Mad	MAD	28	22	0000-9999	10,000

n/n	Province Name	District Name	Exchange Name	Abb	Area code	Ex code	Number	Numbers Range
48	XAYSOMBOON	Xaysomboon	Xaysomboon	XSB	29	32	0000-9999	10,000
49	SPECIAL	Hom	M. Hom	HOM	29	22	0000-9999	10,000
50	REGION	Thathom	Thathom	TAT	29	52	0000-9999	10,000
51		Longsane	Longsane	LOS	29	51	0000-9999	10,000
52		Phun	M.Phun	PHU	29	52	0000-9999	10,000
53	Champasack	Pakse	Parkse	PKX	31	2X	0000-9999	100,000
54		Phonthong	Phonthong	PTH	32	22	0000-9999	10,000
55		Champasack	Champasack	CPS	32	23	0000-9999	10,000
56			Dontalad	DLA	32	24	0000-9999	10,000
57		Sanasomboon	Sanasomboon	SAB	32	92	0000-9999	10,000
58		Bachiang	Bachiang	BAC	32	82	0000-9999	10,000
59		Pakxong	Pakxong	PXO	32	32	0000-9999	10,000
60		Pa Thoom Phone	Pa Thoom Phone	PTP	32	42	0000-9999	10,000
61		Khong	M.Khong	MKO	32	52	0000-9999	10,000
62		Moonlapamok	Moonlapamok	MOO	32	62	0000-9999	10,000
63		Sukhuma	Sukhuma	SUK	32	72	0000-9999	10,000
64	SARAVANE	Saravane	Saravane	SAR	33	2X	0000-9999	100,000
65		Lakhonepheng	Lakhonepheng	LAK	33	51	0000-9999	10,000
66		Vapy	Vapy	VAP	33	52	0000-9999	10,000
67		Toomlam	Toomlam	TOO	33	53	0000-9999	10,000
68		Ta-Oi	Ta-Oi	TAO	33	54	0000-9999	10,000
69		Lao-ngarm	Lao-ngarm	LNG	33	55	0000-9999	10,000
70		Khongxedone	Khongxedone	KDO	33	56	0000-9999	10,000
71		Samuoi	Samuoi	SMO	33	57	0000-9999	10,000
72	ATTAPE U	Samakkhixay	Samakkhixay	SAM	34	2X	0000-9999	100,000
73		Sanamxay	Sanamxay	SNA	34	71	0000-9999	10,000
74		Xaysetha	Xaysetha	XSA	34	72	0000-9999	10,000
75		Sanxay	Savxay	SAN	34	73	0000-9999	10,000
76		Phouvong	Phouvong	PVO	34	74	0000-9999	10,000
77	SEKONG	Lamarm	Lamarm	LAM	35	2X	0000-9999	100,000
78		Thateng	Thateng	TTE	35	90	0000-9999	10,000
79		Dakcheung	Dakcheung	DAK	35	91	0000-9999	10,000
80		Kaleum	Kaleum	KAL	35	92	0000-9999	10,000
81	SAVANNAKHET	Khanthabury	Khanthabury	KTB	37	2X	0000-9999	100,000
82		Ou thoomphone	Ou thoomphone	OUT	37	30	0000-9999	10,000
83		Xaybury	Xaybury	XBL	37	31	0000-9999	10,000
84		Xayphoothong	Xayphoothong	XPT	37	32	0000-9999	10,000
85		At sa Phangthong	At sa Phangthong	AST	37	33	0000-9999	10,000
86		At saphone	At saphone	ASP	37	34	0000-9999	10,000
87		Phine	M.Phine	PIN	37	40	0000-9999	10,000
88		Nong	M. Nong	NON	37	41	0000-9999	10,000
89		Sepone	Sepone	SEP	37	42	0000-9999	10,000
90		Champhone	Champhone	CHA	37	60	0000-9999	10,000
91		Xonbury	Xonbury	XON	37	61	0000-9999	10,000
92		Songkhone	Songkhone	SON	37	62	0000-9999	10,000
93		Thapangthong	Thapangthong	TPT	37	63	0000-9999	10,000
94		Vilabury	Vilabury	VIL	37	64	0000-9999	10,000
95		Thaphalanxay	Thaphalanxay	TAP	37	65	0000-9999	10,000

n/n	Province Name	District Name	Exchange Name	Abb	Area code	Ex code	Number	Numbers Range
96	KHAMMUANE	Thakhek	Thakhek	THK	38	2X	0000-9999	100,000
97		Xebangfay	Xebangfay	XEB	38	20	0000-9999	10,000
98		Hinboon	Hinboon	HIN	38	21	0000-9999	10,000
99		Nongbok	Nongbok	NBO	38	22	0000-9999	10,000
100		Mahaxay	Mahaxay	MAH	38	30	0000-9999	10,000
101		Bualapha	Bualapha	BLP	38	31	0000-9999	10,000
102		Nhommalath	Nhommalath	NML	38	32	0000-9999	10,000
103		Xaybuathong	Xaybuathong	XBT	38	33	0000-9999	10,000
104		Nakai	Nakai	NAK	38	34	0000-9999	10,000
105	BORIKHAMXAY	Pakxanh	Pakxanh	PKN	39	2X	0000-9999	100,000
106		Thaphabath	Thaphabath	TPB	39	52	0000-9999	10,000
107			Thabok	TBO	39	53	0000-9999	10,000
108			Pakthouy	PTY	39	54	0000-9999	10,000
109		Bolikhanh	Bolikhanh	BOL	39	55	0000-9999	10,000
110		Pakkading	Pakkading	PKD	39	56	0000-9999	10,000
111		Khamkheuth	Khamkheuth	KKE	39	60	0000-9999	10,000
112			Lao-Viet Border	LAV	39	61	0000-9999	10,000
113		Viengthong	Viengthong	VTB	39	62	0000-9999	10,000
114	XIENGKHUANG	Pek	M.Pek	PEK	41	2X	0000-9999	100,000
115		Morkmay	Morkmay	MOR	41	61	0000-9999	10,000
116		Kham	M. Kham	KAM	41	62	0000-9999	10,000
117		Khoune	M.Khoune	KOU	41	63	0000-9999	10,000
118		Phaxay	Phaxay	PAX	41	64	0000-9999	10,000
119		Nonghed	Nonghed	NHE	41	65	0000-9999	10,000
120		Phoo Kood	Phoo Kood	PKO	41	66	0000-9999	10,000
121	HUAPHAN	Xamneua	Xamneua	XAM	42	2X	0000-9999	100,000
122		Xamtay	Xamtay	XTY	42	2	0000-9999	10,000
123		Viengxay	Viengxay	VXY	42	2	0000-9999	10,000
124		Xiengkhor	Xiengkhor	XKO	42	2	0000-9999	10,000
125		Huameuang	Huameuang	HUA	42	2	0000-9999	10,000
126		Viengthong	Viengthong	VTH	42	2	0000-9999	10,000
127	LUANGPRABANG	Luangprabang	Luangprabang	LPB	43	2X	0000-9999	100,000
128		Chomphet	Chomphet	CHO	43	70	0000-9999	10,000
129		Nan	M. Nan	NAN	43	71	0000-9999	10,000
130		Xieng ngeun	Xieng ngeun	XGE	43	72	0000-9999	10,000
131		Phonxay	Phonxay	POX	43	73	0000-9999	10,000
132		Park-Ou	Park-Ou	POU	43	74	0000-9999	10,000
133		Phoukhoune	Phoukhoune	PHK	43	75	0000-9999	10,000
134		Pak xeng	Pak xeng	PXE	43	30	0000-9999	10,000
135		Nambak	Nambak	NAB	43	31	0000-9999	10,000
136		Ngoi	M. Ngoi	NGO	43	32	0000-9999	10,000
137		Viengkham	Viengkham	VKA	43	33	0000-9999	10,000
138	XAYABURY	Xayabury	Xayabury	XYB	45	2X	0000-9999	100,000
139		Phiang	M.Phiang	PHI	45	51	0000-9999	10,000
140		Ngeun	M.Ngeun	NGE	45	52	0000-9999	10,000
141		Parklai	Parklai	PAL	45	60	0000-9999	10,000
142		Kene thao	Kene thao	KEN	45	61	0000-9999	10,000
143		Botene	Botene	BOT	45	62	0000-9999	10,000
144		Khop	M. Khop	KOP	45	63	0000-9999	10,000
145		Thongmyxay	Thongmyxay	TMX	45	64	0000-9999	10,000

n/n	Province Name	District Name	Exchange Name	Abb	Area code	Ex. code	Number	Numbers Range
146		Xienghone	Xienghone	XHO	45	34	0000-9999	10,000
147		Hongsa	Hongsa	HON	45	35	0000-9999	10,000
148	UODOMXAY	Xay	M. Xay	XAY	46	2X	0000-9999	100,000
149		Beng	M. Beng	BEN	46	81	0000-9999	10,000
150		Nga	M. Nga	NGA	46	82	0000-9999	10,000
151		La	M. La	MLA	46	83	0000-9999	10,000
152		Namor	Namor	NMO	46	84	0000-9999	10,000
153		Pakbeng	Pakbeng	PAB	46	30	0000-9999	10,000
154		Hoon	M. Hoon	HOO	46	33	0000-9999	10,000
155	BOKEO	Huaixay	Huaixay	HUO	47	2X	0000-9999	100,000
156		Tongpheung	Tongpheung	TON	47	51	0000-9999	10,000
157		Meung	M. Meung	MEU	47	52	0000-9999	10,000
158		Pha-Oudom	Pha-Oudom	POD	47	53	0000-9999	10,000
159		Paktha	Paktha	PTA	47	54	0000-9999	10,000
160	LUANGNAMTHA	Namtha	Namtha	NAM	48	2X	0000-9999	100,000
161		Sing	M. Sing	SIN	48	71	0000-9999	10,000
162		Long	M. Long	LON	48	72	0000-9999	10,000
163		Viengphoukha	Viengphoukha	VPK	48	73	0000-9999	10,000
164		Nalae	Nalae	NAL	48	74	0000-9999	10,000
165	PHONGSALY	Phongsaly	Phongsaly	PSL	49	2X	0000-9999	100,000
166		Nhot-Ou	Nhot-Ou	NHO	49	81	0000-9999	10,000
167		Bootai	Bootai	BTI	49	82	0000-9999	10,000
168		Samphanh	Samphan	SAP	49	83	0000-9999	10,000
169		May	M. May	MAY	49	84	0000-9999	10,000
170		Khua	M. Khua	KHU	49	85	0000-9999	10,000
171		Boon Neua	Boon Neua	BNA	49	86	0000-9999	10,000
	Total	140	159					

Source: JICA Study Team



Source: JICA Study Team

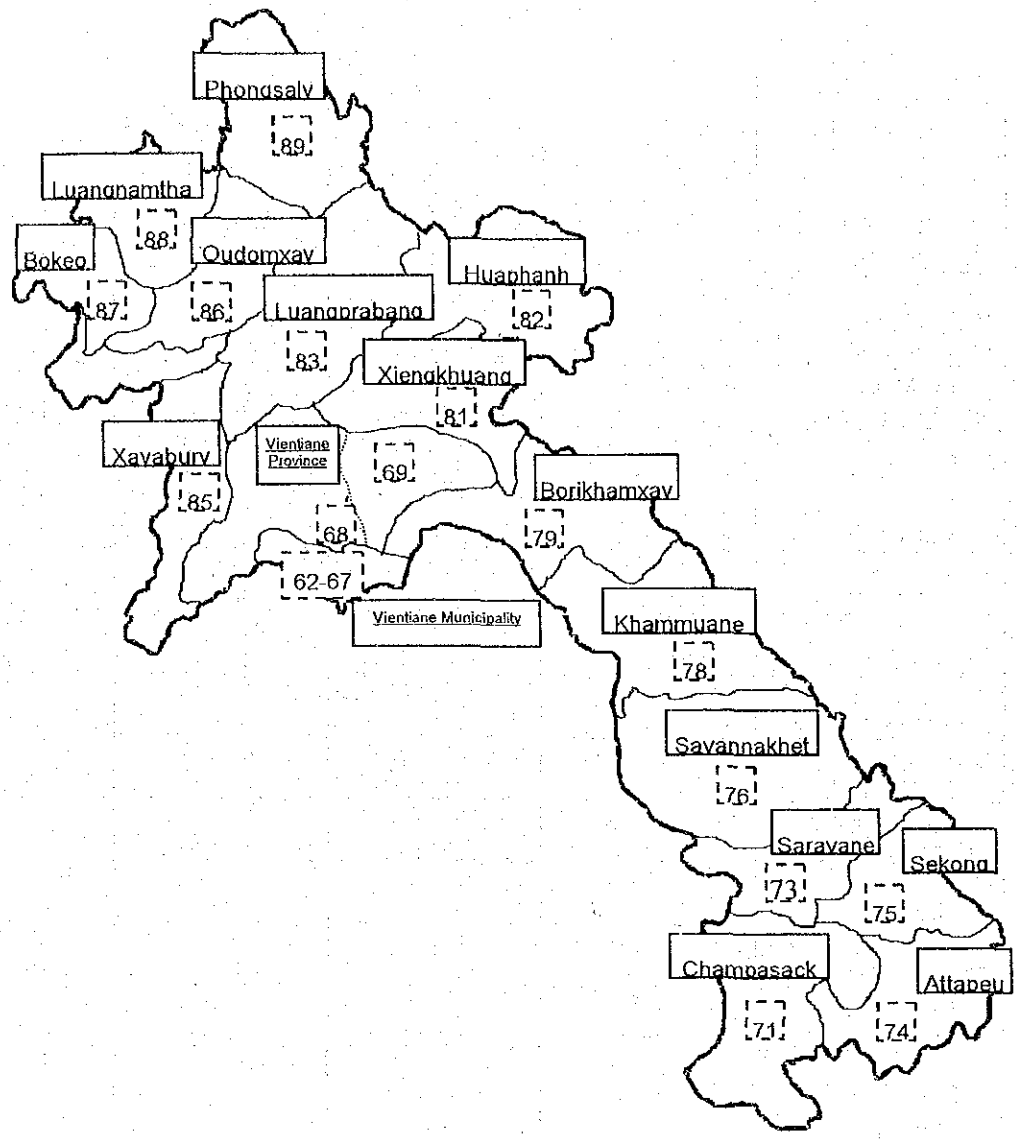
Fig. 8.1 Numbering Plan for Fixed Telephone in the LAO P.D.R.

Table 8.2 Proposed Mobile Numbering Plan and Switches in Lao P.D.R.

	Province Name And IDENTIFY	Operator IDENTIFY*			
		ETL	LTC	PRIVATE	LAT
		2 xxxx-3 xxxxx	5 xxxx- 6 xxxx	7 xxxx- 8 xxxx	9 xxxx
1	VIENTIANE MUNICIPARITY 61-67	6y2 xxxx 6y3 xxxx y=1-7	6y5 xxxx 6y6 xxxx y=1-7	6y7 xxxx 6y8 xxxx y=1-7	6y9 xxxx y=1-7
2	VIENTIANE PROVINCE 68	682 xxxx 683 xxxx	685 xxxx 686 xxxx	687 xxxx 688 xxxx	697 xxxx
3	XAYSOMBOON SPECIAL REGION 69	692 xxxx 693 xxxx	695 xxxx 696 xxxx	697 xxxx 698 xxxx	699 xxxx
4	CHAMPASACK 71-72	712 xxxx 722 xxxx 713 xxxx 723 xxxx	715 xxxx 726 xxxx 715 xxxx 726 xxxx	717 xxxx 728 xxxx 717 xxxx 728 xxxx	719 xxxx 729 xxxx
5	SARAVANE 73	732 xxxx 733 xxxx	735 xxxx 736 xxxx	737 xxxx 738 xxxx	739 xxxx
6	ATTAPEU 74	742 xxxx 743 xxxx	745 xxxx 746 xxxx	747 xxxx 748 xxxx	749 xxxx
7	SEKONG 75	752 xxxx 753 xxxx	755 xxxx 756 xxxx	757 xxxx 758 xxxx	759 xxxx
8	SAVANNAKHET 76	762 xxxx 763 xxxx	765 xxxx 766 xxxx	767 xxxx 768 xxxx	759 xxxx
9	KHAMMUANE 78	782 xxxx 783 xxxx	785 xxxx 786 xxxx	787 xxxx 788 xxxx	789 xxxx
10	BORIKHAMXAY 79	792 xxxx 793 xxxx	795 xxxx 796 xxxx	797 xxxx 798 xxxx	799 xxxx
11	XIENGKHUANG 81	812 xxxx 813 xxxx	815 xxxx 816 xxxx	817 xxxx 818 xxxx	819 xxxx
12	HUAPHAN 82	822 xxxx 823 xxxx	825 xxxx 826 xxxx	827 xxxx 828 xxxx	829 xxxx
13	LUANGPRABANG 83-84	832 xxxx 833 xxxx 842 xxxx 843 xxxx	835 xxxx 836 xxxx 845 xxxx 846 xxxx	837xxxx 838xxxx 847 xxxx 848 xxxx	837 xxxx 838 xxxx 847 xxxx 848 xxxx
14	XAYABURY 85	852 xxxx 853 xxxx	855 xxxx 856 xxxx	857 xxxx 858 xxxx	859 xxxx
15	OUDOMXAY 86	862 xxxx 863 xxxx	865 xxxx 866 xxxx	867 xxxx 868 xxxx	869 xxxx
16	BOKEO 87	872 xxxx 873 xxxx	875 xxxx 876 xxxx	877 xxxx 878 xxxx	879 xxxx
17	LUANGNAMTHA 88	882 xxxx 883 xxxx	885 xxxx 886 xxxx	887 xxxx 888 xxxx	889 xxxx
18	PHONGSALY 89	892 xxxx 893 xxxx	895 xxxx 896 xxxx	897 xxxx 898 xxxx	899 xxxx

Note: 4 prefix is reserved for future use

Source: JICA Study Team



Source: JICA Study Team

Fig. 8.2 Numbering Plan for Mobile Telephone in the LAO P.D.R.

Table 8.3 Possible Future Numbering Plan for Lao P.D.R. detail allocation example

A B	0	1	2	3	4	5	6	7	8	9	
0											
1											
2			Vientiane Municipality Area						Vientiane Province Area	Special Zone	Fixed Telephone
3		Champasack Area		Saravane Area	Attapeu Area	Sekong Area	Savannakhet Area		Khammuane Area	Borikhamxay Area	
4		Xiengkhuang Area	Huaphanh Area	Luangprabang Area		Xayabury Area	Oudomxay Area	Bokeo Area	Luangnamtha Area	Phonsaly Area	
5	IP Telephony for future use										
6			Vientiane Municipality Area						Vientiane Province Area	Special Zone	Mobile Telephone
7		Champasack Area		Saravane Area	Attapeu Area	Sekong Area	Savannakhet Area		Khammuane Area	Borikhamxay Area	
8	Free phone for future use	Xiengkhuang Area	Huaphanh Area	Luangprabang Area		Xayabury Area	Oudomxay Areea	Bokeo Area	Luangnamtha Area	Phonsaly Area	
9											

Note: codes (2 to 3) are allocated to the fixed telephone and codes (6 to 8) are allocated to the GSM

Source: JICA Study Team

Table 8.4 Special numbering chart for Fixed Telephone services

Code	Emergency service /Special service	Operator	Location
100	ETL Complain (SW & Mobile)	ETL	Several
101	ETL Local / Area Information	ETL	Several
102	ETL National & International Information	ETL	Several
112	LTC GSM Emergency	LTC	Several
115	Automatic Line Test	ETL/LTC	Several
131	LTC Lao Link for Automatic	LTC	Several
132	LTC Lao Link for Operator	LTC	Several
133	LTC Lao Link for Voice Mail Box	LTC	Several
141	Exactly Time	ETL/LTC	Several
150	ETL Survey & Installation	ETL	Each Local / Area
170	LTC International Operator	LTC	Several
171	LTC National Operator	LTC	Each areas
172	LTC Public Telephone Control	LTC	Several
173	LTC Telephone Installation Survey	LTC	Each Local / Area
175	LTC Telephone Complain	LTC	Each Local / Area
178	LTC Local or Area Information	LTC	Each Local / Area
179	LTC National / International Information	LTC	Several
180	ETL I-Card	ETL	for VOIP
190	Fire Service	ETL/LTC	Each Local / Area
191	Police Service	ETL/LTC	Each Local / Area
195	Ambulance Service	ETL/LTC	Each Local / Area
199	Electricity Complain	ETL/LTC	Each Local / Area

How to use Special Number:
- Dial only 3 digits, it will service you for each service facility
- For Local or Area service: the number can be use only Local or Area.
- For Service: the number can be use for all area with the same service information

Source: JICA Study Team

Table 8.5 Additional Special Number for the ISPs

Code	Emergency service /Special service	Operator	Location
9913	ETL Internet Dial	ETL	Several
9914	LTC Internet Dial	LTC	Several
9924	Laotel Internet Dial-Up	LTC	Several
9925	Planet Internet Dial-Up	ETL	Several
9926	KPL Internet Dial - Up		Several
9927	STENO Internet Dial		Several
9928-9999	Reserved for future use		Several

Source: JICA Study Team