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Guidelines for Network Planning Tools for Developing Countries and Countries with economies in transition

Reference Document

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Disclaim:

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PREFACE

These Guidelines for Network Planning Tools (GNPT) have been prepared with the contribution of many volunteers from different Administrations and Companies to provide assistance to Countries to plan their Telecommunication Networks.

Revision Status:

Chapter	Title	Revision Status
1	Introduction and scope	17 – August 2005
2	Needs for network planning by ITU members	17 – August 2005
3	Network planning problems to be addressed by planning tools	17 – August 2005
4	Technical requirements per planning domain	17 – August 2005
Annex	Example of request for proposals for supply of a network planning tool	17 – August 2005

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Guidelines for Network Planning Tools for Developing Countries and Countries with economies in transition

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Chapter 1 – Introduction and scope

1.1. ITU Vision on Network Planning

Background

Telecommunication networks architectures are changing to meet new requirements for a number of services/applications (Broadband, IP, Multimedia, mobile, etc.).
New generation equipment (soft switches, databases, service controllers, new protocols and interfaces, etc.) and new call/mix traffic cases are going to be introduced in the networks.
In this document such networks will be referenced with the name Next Generation Networks (NGN), as it is presently popular to call them within the telecommunications community.

Different solutions/network architectures can be taken into account for a smooth transition from existing network infrastructures (PSTN/PLMN) towards NGN as a result of the convergence process leading to different applications/services sharing network infrastructures.

Planning Strategy

Considering the different solutions/network architectures that exist and the continuing evolution of telecommunication networks, each Network Planning case has to be analysed and dealt with by using more than just one planning tool. It means that maintaining and updating a unique tool is not the correct strategy to be applied for Network Planning.
Therefore, any real Network Planning case should be dealt with by using different powerful and modern tools available on the market.

Taking into consideration the continuing evolution of telecommunication networks, adequate strategies have to be chosen by all stakeholder using Planning Tools if update and maintain planning tools inside or to rely on specialized companies capable of maintaining and updating such tools on regular basis and upon specific requests of customers. The major concerned telecommunication Companies normally use different tools (or different packages integrated on a unique platform) for network Planning. They usually rely on the services of software companies who are in a position to provide quick updates as soon as required.

1.2. Scope and use of this Reference Document

The Reference Document GNPT is intended to be used by network planning experts and managers from telecom operators, policy makers and regulators of developing countries and countries with economies in transition to facilitate the selection and the choice of appropriate Network Planning Tools needed for the development of their respective strategies for evolution of the present network architectures and transition to the next generation networks - NGN.

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The Reference Document GNPT is to provide recommended features and evaluation criteria of NGN planning software packages with the following objectives:

- To meet a large scale of view points and user-oriented requirements from regulators, network operators, and telecommunications equipment vendors when operating in deregulated and global telecommunications market.
- To meet the requirements in development of next generation networks of domestic and international network operators and service providers.
    - Forecast of voice and non-voice service demands and market shares.
    - Forecast of voice and non-voice traffic on converged networks.
    - Transport technologies: Ethernet/RPR/IP/NGI/MPLS/NGN & NG-SDH/ WDM/DWDM/Optical switching
    - Mobile technologies: 2G/2.5G/3G/4G and converged networks
    - Access technologies: copper cables, x-DSL, PON, power lines, CATV cables & WLAN, WMAN, WLL,
- To specify functional requirements
    - Describe functionality or system services.
    - Depend on the type of software, expected users (regulators/planners/designers) and the type of system where the software is used.
    - Functional user requirements may be high-level statements of what the system should do but functional system requirements should describe the system services in detail.
- To specify non-functional requirements
    - Product requirements which specify that the delivered product must behave in a particular way e.g. execution speed, reliability, etc.
    - Organisational requirements which are a consequence of organisational policies and procedures e.g. process standards used, implementation requirements, etc.
    - External requirements which arise from factors which are external to the system and its development process e.g. interoperability requirements, legislative requirements, etc.
- To specify domain requirements
    - Derived from the application domain and describe system characteristics and features that reflect the domain.
    - Domain requirements be new functional requirements, constraints on existing requirements or define specific computations.

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The Reference Document Guidelines for Network Planning Tools for Developing Countries and Countries with economies in transition (GNPT) intends to present an objective and tool neutral view of the issues to be addressed in the selection and acquisition of computer tools needed for planning of the telecommunications networks, including the transition to NGN.

1.3. Content of the Reference Document

This Reference Document Guidelines for Network Planning Tools for Developing Countries and Countries with economies in transition (GNPT) comprises 4 chapters and one annex.

Chapter 1 provides the objectives of the Reference Document and the context for planning at ITU members as well as the content of the different chapters of the Reference Document and relation to other ITU activities and documents.

Chapter 2 will review the needs for assessment on proper tools and tool combination, the needs for training on tool applicability and capabilities, the needs for documentation and the needs for tool support, updates and maintenance. The Main Characteristics and Features of planning tools are presented and common procedures to be followed in the process of a tool application and acquisition are described.

Chapter 3 identifies the most typical planning problems and activities as well as the network planning types and domains to which those activities have to be applied.

Chapter 4 gives requirements to the planning tools, organised by 8 planning domains, derived from planner needs and networking problems in order to group the different needs by affinity, minimise the number of tools to be applied and facilitate their interrelations.

In the **Annex,** example of request for proposals (RFP) for supply of particular network planning tool is presented. Purpose of the example is to clarify the structure of such document and to outline the different items in the RFP

1.4. Relation to other ITU documents

Additional information related to the topic of this reference document could be found in the following ITU documents:

- ***Reference Manual on Telecom Network Planning for Evolving Network Architectures*** Version 02, ITU, Geneva, 2005
  link : http://www.itu.int/ITU-D/tech/network-infrastructure/index.html

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Chapter 2 – Needs for network planning by ITU members

2.1. Needs for assessment on proper tools and tool combinations

Network planning activities evolve with the proper evolution of the network, the services, the technologies, the market and the regulatory environment. These evolutions imply a wider set of options to implement a network than in the past and as a consequence, the importance of careful planning and analysis for alternatives have larger impact on the network capabilities today in order to assure the needed capacities, the associated quality of service and the required investments.

Considering the initial status of the operator's network and the different solutions/network architectures that exist for the network evolution, each Network Planning case has to be analysed and dealt with by using proper planning tools and tool combinations.

Therefore proper planning tools and tool combinations need to be assessed and a portfolio of planning tools supporting different planning activities needs to be selected.

The main Characteristics and Features to be taken into consideration in choosing and selecting planning tools are:

- capability to model modern technologies and technical requirements
- commercial availability,
- capability to interrelate different planning tools among themselves and with the Operational Support Systems
- explicit documentation of models, inputs and results,
- commitment for periodical updates and maintenance,
- training program with reference cases,
- validation process for a range of cases
- and being well proven in the field.

The afore mentioned Characteristics and Features will be analysed below

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2.2. *Main Characteristics and Features of planning tools*

In this subchapter the main requirements and characteristics to be taken into consideration in selecting and choosing the planning tools for any specific Network Planning case are presented.

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2.2.1. Capability to model modern technologies and technical requirements

The tool should model current systems and new technologies for all network layers, taking into account NGN and convergent solutions based on IP protocols and standards. The modeling and capabilities for the following subsystems have to be explicit:

- Networks and sub networks
- Systems, nodes and links
- Routing procedures within a network and inter-networks
- Protocols for the carrying flows
- System Interfaces
- Capacities in the proper units of the network resource (Mbps, Packets per second, calls per second, erlangs, etc.) for each system
- Costs as a function of main drivers in fixed and incremental units
- Cost /revenue analysis

The tool shall be totally vendor independent and allow to conduct network planning for network elements of any system vendor. It shall also allow to model networks consisting of network elements from different vendors (mixed networks).

Past history of the tool or current state has to be known as well as the planned future development of the package, i.e. Road map for the evolution of the proposed solution with features incorporation.

The technical requirements are dealt with in details in chapter 4

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2.2.2. Commercial availability

The tool should be commercially available under clear and defined commercial conditions and should include the context and type for the tool license, timing, number of users, prices and discount factors by volume when several tools of the supplier are licensed to the customer or multiple users are allowed

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2.2.3. Capability to interrelate different planning tools

The tool should have the capability to interrelate with other planning tools in order to facilitate an overall planning coordinating the different network domains as well as with the Operational Support Systems implemented in the operational networks.

In particular, the following interrelations need to be available:

- Common information to the different network layers like geographical position, distances, physical media, etc.

- Information transfer for communication resources demand from each layer to the underlying layer and mainly between adjacent network layers like transmission and switching, transmission and physical paths, etc.

- Information transfer for network resources availability at each layer for the upper layers like fiber capacities, transmission capacities, point to point paths, etc.

- Network status and traffic demands obtained from Operational Support Systems applications at historical stages towards inputs definition modules at the corresponding network layer

- Performance measurements and QoS parameters for traffic flows from the corresponding Operational Support Systems to the quality design related planning programs

- Inputs from the planner and applications defining case studies and scenarios

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2.2.4. Explicit documentation of models, inputs and results

The tool content should be available with enough accuracy for the inputs, network models, algorithms, technologies and results in order to facilitate the applicability to the pretended solutions as follows:

- Model features with the functionalities related to the planning problem to be solved
- Level of description of the technologies represented
- Inputs required to run the tool end expected results
- User guide for a user that has to install, maintain and run the tool with the corresponding list of known error messages
- Range of tool validity in the network sizes and optimization degree
- Exchange of information with other applications and tools
- Editorial procedures for maps and tables associated to the network, nodes and paths

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2.2.5. Commitment for periodical updates and maintenance

Support and maintenance should be provided to the tools in their life cycle according to the specified Service Level Agreement as summarized:

- Timeframe for the generation of new tool versions

- Periodicity in the tools update either due to the regular upgrades or to the corrections of detected bugs

- Reaction time to solutions and/or corrections for the issues detected by the customer subject to the contract

- Updating for the features description and user manual

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2.2.6. Training program with reference cases

The tool should have available training program including the following:

- Training Packages on tool application and capabilities
- Training on reference cases with data from real networks
- Duration of each training block and the recommended number of participants
- Total time period that is necessary to conduct all training blocks and the training language
- Training Documentation to be delivered for each training module
- Training Logistics

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2.2.7. Validation process for a range of cases

Acceptance test procedures to verify that the tool guarantees compliance with all technical requirements specified by the customer during the acquisition process should be available.

In particular, the following validation process needs to be available:

- Validation process for network routing procedures, system functionality, capacity and costing models as described in Chapter 4.

- Validation process on the performance of the planning tool in terms of size of the network (number of nodes, links, cells, etc.)

- Validation process on the performance of the planning tool in terms of time to execute one typical planning case

Set of reference networks for the performance evaluation should also be available.

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2.2.8. Being well proven in the field

Reference information for the planning tool, showing that the tool has been well proven in the field, should be available:

- Reference list of customers who have obtained that tool
- Reference list of cases (networks) that have been planned with that tool
- Past history of the product and planned future development of the package
- References for the tool in publications (technical and scientific journals or magazines, etc.)

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2.3 Procedures to follow in tool application and acquisition

Common procedures to be followed in the process of a tool application and acquisition consists of:

- Planning problem identification and tool mapping

- Preparation of request for application and corresponding conditions

In the **Annex,** an example of typical request for proposals (RFP) for supply of network planning tool is presented.
Purpose of the example is to clarify the structure of such document and to outline the different items in the RFP
The particular planning tool, in this case fixed access planning tool, is not of main importance. Rather the example could be used as model for preparation of the related RFP document for a real case.

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2.3.1. Planning problem identification and Tool mapping

Evolution of the network, the services, the technologies, the market and the regulatory environment imply set of options to implement a network which assures the needed capacities, the associated quality of service and the required investments.

Different planning problems have to be identified and solved in appropriate sequence, so that investments and services are planned in a manner which makes sure there is no costly over-investment nor bad utilisation of already made investments and at the same time ensures fluent migration of the services for the large amount of existing subscribers.

Considering the different solutions/network architectures that exist, each network planning problem has to be analysed and dealt with by using proper planning tools or tool combinations.

Therefore proper tool mapping to each planning problem is an important task.

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2.3.2. Request for application and conditions

The standard procedure for supply of a network planning tool is through preparation of request for proposals (RFP).

Main topics in RFP for supply of a network planning tool cover:

• General conditions

• Technical specifications

• Support issues, documentation, training and maintenance

• Acceptance test procedures

• Commercial conditions

General conditions describe the common requirements, notations and purpose of the request for proposals.

The **technical specifications** include requirements to the software platform, system requirements (minimum configuration), recommended network connections, GUI, import/export of data, network models, forecasting methods, technology definition, dimensioning/optimization algorithms, network synthesis, reporting.

Conditions for the tool architecture.
If separate tools cover different planning domains, modular organisation of integrated suite of tools is preferable. All modules shall be of Windows type application including help features. They shall be easily upgraded

Common Data Repository is an advantage. All tools shall store and retrieve their data on a common data repository. This common data repository is accessible by all users who have the appropriate access rights.

Client/Server Solutions and stand-alone version.
The software shall be available in stand-alone version and/or supported in a client /server environment.

Wrapping of legacy tools
In order to interface to the legacy tools that are already used , the software platform should facilitate exchange of required information with that legacy tools.

Optional interface to an Inventory Management System (IMS) could be provided. The vendor shall explain details of this interface and the synchronisation mechanism.

See chapter 4 for the complete description of the technical specifications.

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Support issues, documentation, training and maintenance consist of update/upgrade strategy and pricing, defect categories and the response times to fix them, technical support and assistance available during system warrantee period and there after, proposed training package and time period that is necessary to conduct all training blocks, desired set of user and installation manuals.

Accurate user manuals related to the particular planning tools, clarifying not only the tools utilization but also the planning principles, network models, planning methods, margin of tool applicability range (such as network sizes and optimization degree) and list of error messages, are really needed.

Reliable support and maintenance need to be offered and provided by the tools manufacturer with a Service Level Agreement and timing for problem solution.

Organization of the training includes specification of:

- Training Package

The proposed training packages that will ensure staff familiarity for all planning tools. The description of the training package shall include the duration of each training block and the recommended number of participants

- Time Schedule and Language

The total time period that is necessary to conduct all training blocks and the training language, e.g. English, etc.

- Training Documentation

Necessary training manuals to be delivered for each training module organized at least in two classes of documents:

-Tool and model description explaining the methodologies, capabilities and validity ranges

-User guide illustrating the tool usage from installation procedures and updating up to the sequence of usage for every module.

- Training Logistics

If training is in-house at Telecommunications Company's premises, specification of training rooms, presentation facilities, PCs necessary to conduct the training, etc. should be provided

Important part of the training is example pilot case on real data delivered by the concerned Telecommunications Company.

Pilot case should be performed by the trainees under the guidance of the tools instructor and should develop and test capabilities of the planning team to continue on its own.

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Pilot case should serve also as a model of repeatedly performed network planning activates, e.g. planning of a local network.

- Maintenance

Tools should have included updates and upgrades due to new functionalities within the tool and/or new equipment types incorporated in the network solutions. Typically upgrade period is around 6 month for quick evolution functionalities and one year for stable application.
Clear indication of update/upgrade strategy and related pricing should be clearly indicated,.
Different defect categories and time to fix them should be clearly indicated.
Type of technical support and assistance available during system warrantee period and after should be clearly indicated.

Acceptance test procedures are to verify that the tool guarantees compliance with all technical requirements specified and all products' specifications (parameters and functionality), as indicated in the process referenced in 2.2.7.

Commercial conditions include the context for the tool license, timing, number of users, prices and discount factors by volume when several tools of the supplier are licensed to the customer or multiple users are allowed.

Different types of licenses could be applied:

- Perpetual license:

For the perpetual license the total amount of each tool is paid in the first year.
From the second year onwards, if support/maintenance/updates is needed, annual amount, usually calculated as percentage from the acquisition cost, has to be paid (e.g. 18% is typical case).

Depending on the tool installations, licenses are for:
- tool installed only on one PC (end node user)
- tool installed on several PCs
- non-simultaneous use of tool installed on several PCs in a network(floating license)

- License for simultaneous use of tools :

Conventional software licensing schemes typically require one floating license payment for every application the planning team may need.
The result is multiple license purchases for tools that address a broad range of technologies.
Practical option is one license for simultaneously used tools, e.g. the Annual Tokens license scheme.

Annually is paid amount for utilization of the tools through a token scheme.

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Under the token license system, the value of each tool is represented by a prescribed number of tokens for each tool use. If a user wants to start a tool, he will search for free tokens, the required number of tokens will then be blocked for the duration of tool use. When the user closes an application, the tokens required for its use are released.

For the annual tokens, the annual amount may remain the same every year.

Note: Individual tools are obtained with perpetual license, while annual tokens could be used for set of tools (price is multiple of token).

Preferential Licensing conditions

The preferential conditions of tool acquisition for Developing Countries and Countries with economies in transition, negotiated with the tool vendor, could include one or more of the following:

- Special price with considerable discount from the standard tool cost
- Extended training included in the standard tool cost
- Support of a pilot project with real data from the country included in the standard tool cost

Information required from the bidder

The Bidder should include for evaluation purposes the following:

• Experience in the telecommunications industry and list of customers;

• Partnerships with other industrial companies in technologies, methodologies or applications

• Company ownership, time in the business, financial status;

• Past history of the product and planned future development of the package, i.e. Road map for the evolution of the proposed solution;

• Tools availability and capability to deliver at the different worldwide regions within ITU with central or distributed structure
• Time required to deliver the tools, training seminars and consultancy

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The proposed tool should be a proven solution, i.e. solution which is operational in other operator's network planning units;

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Chapter 3 – Network planning problems to be addressed by planning tools

Most problems a network planner has to solve, require support by informatic planning tools either due to the volume of information to handle, the complexity of the task, the strong interrelations among variables or the high computation capacity needed like in the optimisation algorithms.

Within this chapter, the most typical *planning problems and activities* are identified as well as the *network planning types and domains* to which those activities have to be applied.

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3.1. Network planning problems and activities

- First problem the planner faces is the **knowledge** of the initial situation for the economy, the market, the customers, the services and the network. In this case, the high volume on information and the need for correlation among the data for a given time and space implies the use of data bases with both text and graphical tools to analyse, process, interpolate and extrapolate data. Those tools will be applied at different planning phases and need to be compatible with the other tools and to be used independently or also commonly with them.

- **Data gathering** is the immediate next task of the planner and most frequently a high time consuming one. Due to the high variety of information: social, economical, technical and operational, data has to be gathered from many sources at country level, so relational data bases are needed as well as procedures to allow information to be consolidated.

- Due to the complexity of a full network planning, activities have to be splitted in tractable problems and the planner task is the **partitioning** into modules**,** grouping and further interrelation. This impose a global requirement for all tools and associated platform that need to be modular in order to focus on specific technology issues and allow interrelation among them for the further integration of results.

- For all planning tasks, it is necessary to be able to **forecast** demands for the customers, services, traffic and equipment. This is one of the most difficult tasks for the planner and tools should have different projection methodologies for short, medium and long term forecasting.

- With the high variety of technologies available, a new planner problem is to perform the **mapping** of feasible solutions for that problem and evaluate best technology with techno-economical criteria. Tools that allow a number of iterations and what-if analysis are fundamental to perform this function and select the appropriate solution for each planning domain.

- Once that the planner is focussed on a specific problem and solution, the central activity for a planner is the future **network design**, equipment geographical location, dimensioning and costing. This set of functions are the more technical ones and require a set of tools which model correctly the architectures, technologies, network paths, systems, capacities and costs in order to ensure to carry the services demand which was predicted with the appropriate Quality of Service.

- In those networking issues in which a very high number of alternatives appear, the high combinatory complexity do not allow manual evaluation and it is required the implementation of **optimisation** algorithms which work frequently at the limit of the computational capacity for high size networks (i.e.: larger that 200 nodes). These are the key engines in the capacity/cost optimisation that generate high economical savings and require special attention when selecting most powerful tools.

- After all design and optimisation process, a strategic evaluation has to be performed with all external implications and a specific plan is selected with the consolidation **and reporting.** All decisions are registered and reported both for external company relations as well as for

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internal company departments. That reporting functions have to be available in the tools with enough flexibility to be applicable at all network segments and planning domains.

- High dynamic behaviour of current technological solutions generates the problem of high rate on information actualisation within the actual network and between the network and the plans. Tools require to perform the **linking of plans and OSS applications** by powerful relations that ensure information flow in the two directions: from network plans to OSS configurations and from OSS updated results to the input provision to the design of plans.

3.2. Network planning types and domains

The high complexities of the telecom networks imply the need to organise their analysis in many dimensions either by network type, segment, layer and time scale.

- From the **network type** dimension, we may address public or private networks, fixed or mobile, terrestrial or satellite, etc. and specific problems and requirements are a function of those characteristics

- From the **network segment** we consider, basically focussing may be given to the access, local, metropolitan, core national, core international and end-to-end segments. Again, planning activities, solutions and required tools are dependent on the segment type

- At the **network layer** side, most frequent splitting of the problems is done at the following ones: physical, transmission, switching/routing, control-NM, IT-OSS- Applications. Network evolution may be performed at all layers or at a given subset, being planning functionalities substantially different from the low physical layer with long time standing heavy infrastructure, to the upper layer with very flexible and dynamic evolution.

- Considering the planning types as a function of the **time scale**, most typical issues may be analysed at :

- Short term (less than 2 years), for the current telecommunications demands and services that have to satisfied with the already installed capacities without additional capital investments.

-Medium term (between 2 and 5 years), for the capacity upgrading of the network nodes and links, telecommunications systems to be installed or uninstalled location and routing that guarantee the specified quality of service

- Long term (5 or more years) to define the architecture to be used in each domain, physical nodes and paths as well as the topology and location of the network parts which are characterised by a long lifetime and large investments for their deployment.

- Strategic focussing within long term when a specific selection of the key issues are summarised as a master guide.

When observing the network planning problems, all the identified activities within 3.1 have to be characterised and customised to all planning types and domains in 3.2. This allows to organise the technical requirements as in the following chapter.

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Chapter 4 – Technical requirements per planning domain

In this chapter, requirements are organised by 8 planning domains, as in the figure, derived from previous planner needs and networking problems in order to group the different needs by affinity, minimise the number of tools to be applied and facilitate their interrelations.

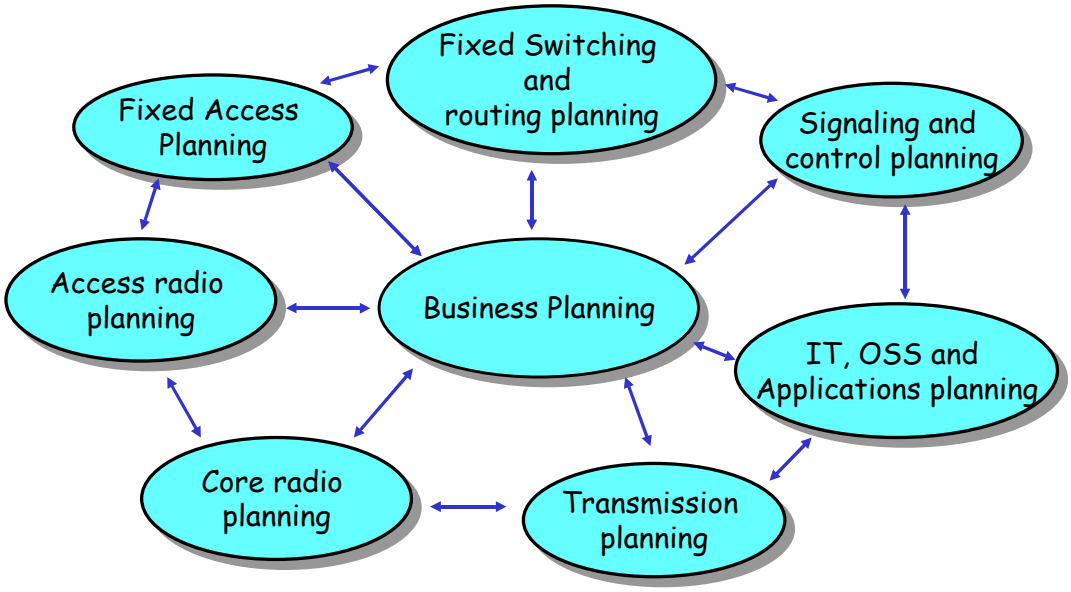

Fig. 4.0 Planning Domains for top level Requirement specifications

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4.1. BUSINESS PLANNING

Business planning refers to all business related projections, analysis and evaluations either for a full network and market or for any subset of them. It has a strategic orientation and pursues the evaluation of feasible and most profitable solutions. This activity receives inputs from social and techno-economical databases while provides results to all the technical planning domains as summarised in fig 4.1.

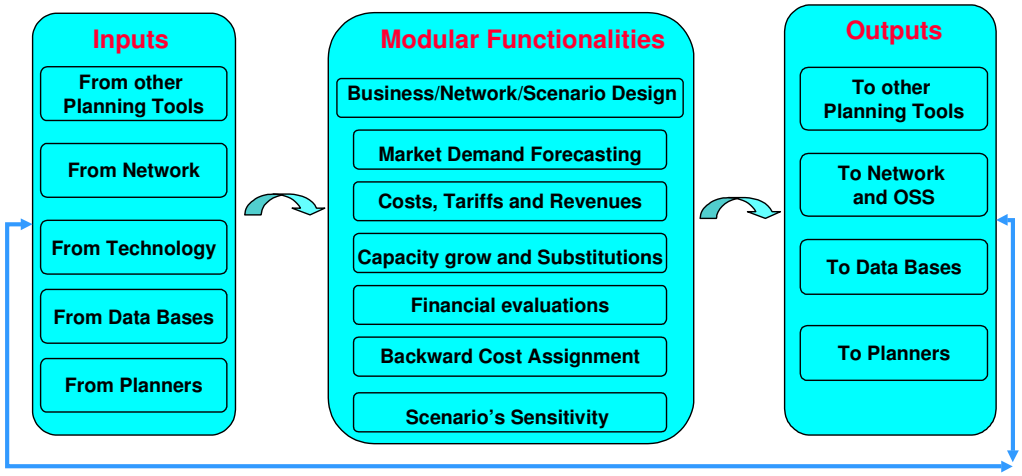

Fig 4.1 Functional modular requirements for the business planning domain

4.1.1. Tool scope - main characteristics

Main objective of the tools for business planning is the support to the business decision-making that enables the analysis of business models and cost assignment for telecommunication networks and services over a period of time**.** Business planning has to be based on a service demand model organised by market segments, service types and geo-scenarios, which will establish direct relations between demands, CAPEX and OPEX. That demands should drive the resource dimensioning, replacements, costing and revenue generation as well as the calculation of all standard and frequent financial parameters and ratios.

According to the different problems and degrees of detail identified in chapter 3, the tools should be able to analyse a business model with **different degrees of detail**, either at macroscopic level for a global network and large customer classes as well as at microscopic level for sub-networks, systems and services. Also it has to take capabilities **for backward cost assignments** in order to know causes of costs per service type and calculate profitability for service or group of services.

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Due to the high number of alternatives to analyse in short periods of time, a fundamental requirement is the capability to perform many **what-if analysis** for variation of scenarios, services, technologies, costs, economies of scale, tariffs, elasticity, revenues and grade of service with the easy evaluation and comparison of all of them.

4.1.2. Network model - network architecture, customers, services, traffic, etc.

Tools should provide modelling capabilities with the following characteristics:

- All network layers: physical, transmission, switching/routing, control/NM, IT/OSS/ Applications and technologies including voice, data, multimedia and NGN for any network type and size.

- Network resources modelling with several degrees of detail according to planning objectives: from full sub-networks to each individual element like fibers or line cards.

- Modelling multiple resource lifetimes per type of resource

- Modelling multiple time periods: months, quarters, years

- Typical customer classes as residential, business, SOHO, etc.

- Parametric definition of new customer classes

- Service of voice, data, video or multimedia type

- Service Demand Projection per customer class

- Modelling of the churn rates for customers or technologies

- Evaluation of network resources and associated investment (CAPEX)

- Representation of service tariffs for connections, rental and usage

- Modelling of demand elasticity to tariffs

- Evaluation of revenues per service and customer classes for given tariffs and installation rate

- Equipment substitution and terminal cost

- Operational and maintenance costs

- Interrelation between network growth and operational cost (OPEX)

- Cost assignment as a function of resource utilisation rates

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- Standard financial results like Cash Flow, Profit & Loss, Balance Sheet and all typical business related parameters

- Financial evaluators and ratios as: NPV, IRR, ROI, ROE, ROA, ROCE, etc.

4.1.3. Forecasting - services, traffic matrix, users distribution and user segments

Forecasting models should be given for application at customers, customer segments or services levels with at least the following models:

- Linear projection,

- Interpolation and extrapolation

- Logistic,

- Dual logistic

- Exponential,

- Time series

- Predefined curves

4.1.4. Calculation modules - network dimensioning and optimisation

Calculations within the tool need to have the following capabilities:

- All forecasting models identified above

- Traffic evaluation and dimensioning with classical erlang models for a given GoS

- Traffic evaluation and dimensioning with occupancy models

- Traffic evaluation models for equivalent sustained bit rate in multi-service environments

- Capability for traffic evaluation and dimensioning based on additional given predefined rules

- Annual traffic to busy hour and busy period traffic conversion

- Dimensioning formulas for equipment dimensioning and rounding to modularity

- Cost trends projections for technologies

- Cost allocation to services by given assignment rules

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- Financial formulas for interests, tax, dividends, working capital, cash-flow, operating profit, future value, past value, NPV, depreciation, amortisation, terminal values, etc.

4.1.5. Input/output data - GUI, maps, reports

Tools should provide:

- Import and export functions from/to other network layer planning
- Interface to Excel for input and output data
- Interface to word for results reporting
- Financial diagrams for all results in linear, bar or cake formats
- Customisation of diagrams to add new results in table or graphical formats

4.1.6. Platform - tool architecture and system requirements

Tools must work in a PC running Windows 98, Windows 2000, Windows NT or Windows XP. Platform should have object-oriented capability with an editing interface that associates data directly with modelling resources and links between modelling elements.

Audit and checking functions have to be provided to know explicit track of precedence, hierarchies, interrelations and causes for intermediate or derived final results.

Processing and editing functions should be available for graphical, table and text handling.

Internal handling of graphical functional network structures should provide explicit correspondence to associated parameters per modelled network resource.

4.1.7. NGN - requirements related to NGN and corresponding new technologies

Tools should have the capability to model new NGN networks, Convergence and intermediate migration steps for:

- NGN systems like Softswitches (SSWs) and Gateways (GWs) with their corresponding capacities, capital costs, operational costs, lifetimes, etc.
- Interrelations among NGN network subsystems, nodes and links
- Service demands characterisation and traffics for VoIP and NGN multi-service flows including constant rates, guaranteed flows and elastic traffics.

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- Network and systems dimensioning with the multi-service NGN criteria based on equivalent data bandwidth methods for the aggregation of service flows

4.2. FIXED SWITCHING AND ROUTING PLANNING

The domain of fixed switching and routing planning includes all traffic demand flows projections and the design, location, flow routing, dimensioning, costing and optimisation for any fixed network at local, metropolitan or transit level. It has a major technical focus and receives inputs from current network, business planning and transmission planning while provides results to transmission planning and control planning as summarised in fig. 4.2.

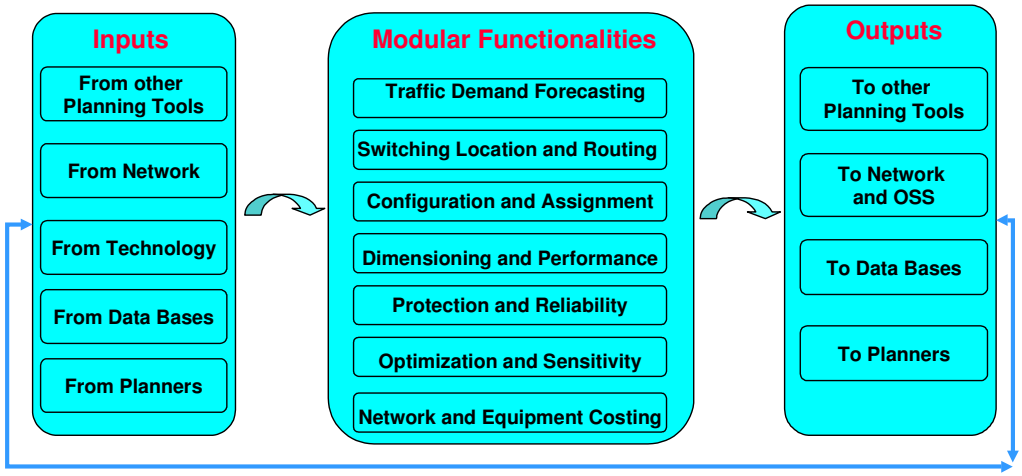

Fig 4.2 Functional modular requirements for the swictching and routing domain

4.2.1 Tool scope - main characteristics

Main objective of the tools for the fixed switching and routing planning is the support to the planner in the technical network design, definition of architecture and dimensioning in order to ensure that functional network carries the origin/destination traffic demands with the agreed quality of service for a given period of time.

According to the different network segments of application and the technologies used, a variety of functionalities is required that may be customised to each scenario either for voice, data or multimedia services types.

The strong interrelation with the other adjacent network layers imply the need to use information from the business planning, use and pass information to the transmission network layer as well as to the control and signalling layer.

4.2.2 Network model - network architecture, customers, services, traffic, etc.

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Tools should provide modelling capabilities with the following characteristics:

- Traffic Planning with pre-processing of traffic measurement data and integration with projected demands for the planning period

- Forecast of traffic matrices for origin destination sources with different traffic units: erlangs, bandwidth, calls, packets or circuits

- Conceptual Network Design and Capacity Planning

- Analysis of network consolidation with reduction of hierarchical levels and increasing sizes for nodes and links

- Consideration of hierarchical and non-hierarchical architectures with fixed, load sharing and dynamic routing

- Consideration of network topologies with different degrees of connectivity: mesh or partially meshed

- Capability for network sizes of at least 256 nodes and pre-processing with partitioning methods for larger networks

- Finding locations of transit switches for hierarchical networks

- Differentiation of customers by main residential and business classes

- Calculation of loads and capacities including dimensioning taking into account load sharing and traffic overflows

- Optimisation of trunk groups in an overflow structure

- Optimisation of locations and connections of network gateways

- Finding out the demand for transmission channels for the underlying transmission network

- Cost, Performance and Reliability Analysis

- Analysis of utilisation of network capacities and finding out the bottlenecks

- Estimation of the end-to-end traffic quality of service at global level and point to point

- Estimation of investment costs for the rollout and the extension of the investigated circuit-switched network

- Allocation of network cost to the traffic relations

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- Allocation of the 64kbit/s channels (with payload, signalling traffic, semi permanent connections)

4.2.3 Forecasting - services, traffic matrix, users distribution and user segments

Tools should provide:

Forecasting of traffic at network sources with linear, exponential and logistic procedures for typical customer types and service traffic flows (voice or data). Availability of aggregation and desegregation functions for the different traffic flow types of the customer classes.

Forecast of traffic NxN matrices for origin destination sources with typical methods like Kruithof, affinity and correlation for network scenarios with equal or different service areas between initial and final year. N should be at least 256 and pre-processing with partitioning methods when larger networks are needed.

4.2.4 Calculation modules - network dimensioning and optimisation

Tools should provide modelling capabilities with the following characteristics:

Dimensioning methods for loss based systems including Erlang-B formula, overflow routing, and equivalent random method. Application of the methods to circuit-switched networks including hierarchical alternative routing and non-hierarchical routing. Multi-hour dimensioning methods.

Dimensioning methods for delay based systems including Erlang-C, Erlang multi-rate, hyper-exponential models and processor sharing models. Application of the methods to packet-switched networks.

Traffic evaluation models for equivalent sustained bit rate in multi-service environments. Capability for traffic evaluation and dimensioning based on additional given predefined rules. Annual traffic to busy hour and busy period traffic conversion.

Evaluation methods for calculating link, path and route GoS, at the designed network and utilisation factors at nodes and links.

Evaluation methods for reliability of network, sub-networks and systems based on individual reliability parameters

Calculation of protection levels for end-to-end routes and diversity paths with single node, single link and combined failure survivability.

Evaluation of costs with polynomial models based on fixed and marginal costs per cost driver such as systems, cabinets, modules, racks, cards, ports, erlangs, Mbytes, Mbps, etc.

Optimisation algorithms for network topology and routing, including minimal connectivity, connectivity of level "n", flow optimisation, GoS objective functions, disjoint paths and

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protection. Associated dimensioning methods for resilient circuit-switched networks and packet-switched networks with single node, single link and combined failure survivability.

Calculation models for circuit switching and packet switching are applicable in an NGN in which subnetworks and Network Elements need both type of models such as the Gateways and Application Servers. It is preferred to have all models available in the tools with an integrated view of NGN and have the planner to decide were to apply each, as many hybrid situations appear both in the networks and the systems.

4.2.5 Input/output data - GUI, maps, reports

Tools should provide:

- Import and Export Functions from/to other Network layer planning
- Import/export from/to text files and Excel
- Device catalogue and configuration view for the network nodes
- Output of routing tables for switches
- Configuration of switching nodes with modules and ports
- Generation of reports about the allocation of devices
- Display of the routing of traffic relations and semi-permanent connections
- Inspector for the routing tables in the switching nodes
- Capability for customised import and export filters as a function of formats in other related tools
- Interfaces with existing databases using Microsoft ODBC and capability to extend it with further database modules under demand

4.2.6 Platform - tool architecture and system requirements

Tools must work in a PC running Windows 98, Windows 2000, Windows NT or Windows XP. Monitor with a minimum resolution of 1024 x 768 pixels, 256 colours

Modular architecture for the main functionalities of inputs, traffic demands, configuration, functional routing, circuit routing, costing and outputs.

Editing and checking functions for intermediate and final results.

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Internal handling of a GIS both for functional and geographical network structures as well as extraction and conversion capabilities from external GIS

Assignment and resource mapping capabilities with other network layers and planning domains

4.2.7 NGN - requirements related to NGN and corresponding new technologies

In addition to the capabilities for conventional networks, tools should provide explicit modelling capabilities for NGN technologies and Convergence such as:

- Service demands characterisation and traffics for VoIP and NGN multi-service flows
- Device catalogue covering most typical NGN technologies
- Routing and dimensioning taking into consideration protocol overheads and reservations mechanisms for QoS requirements (RSVP) and Call Acceptance Control procedures (CAC) based on conditions at origin, destination or combined.
- Routing flows for most typical cases including OSPF, shortest path, widest path and weighted cost functions.
- Optimising locations and connections of network gateways
- Formation of virtual networks
- Routing over ATM links or PDH/SDH systems or tunnelling via other IP links
- Routing methods for Labelled Switched Paths (LSP)
- Analysis of utilisation of network capacities and finding out the bottlenecks
- Handling and output IP routing tables
- Estimation of end-to-end delays
- Allocation of network cost to the bandwidth demands of carried services
- Exact allocation of the IP or MPLS links
- Sub networking and addressing
- Configuring the network elements (IP router)
- Mapping tables with overheads, multiplex factors, net(to) and brut (gross) bit rates

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- Standard import and export formats for the complex data structures required for the management of routes in IP/MPLS networks, which you can support from your network database quite easily

- Estimation of investment costs for the rollout and the extension of the investigated multi-service network

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4.3. TRANSMISSION PLANNING

The domain of transmission planning includes all circuit and link demand flows projections and the design, location, path routing, dimensioning, costing and optimisation for any network at local, metropolitan or transit level. It has a major technical focus and receives inputs from current network, business planning and switching and routing planning while provides results to switching and routing planning as summarised in fig. 4.3.

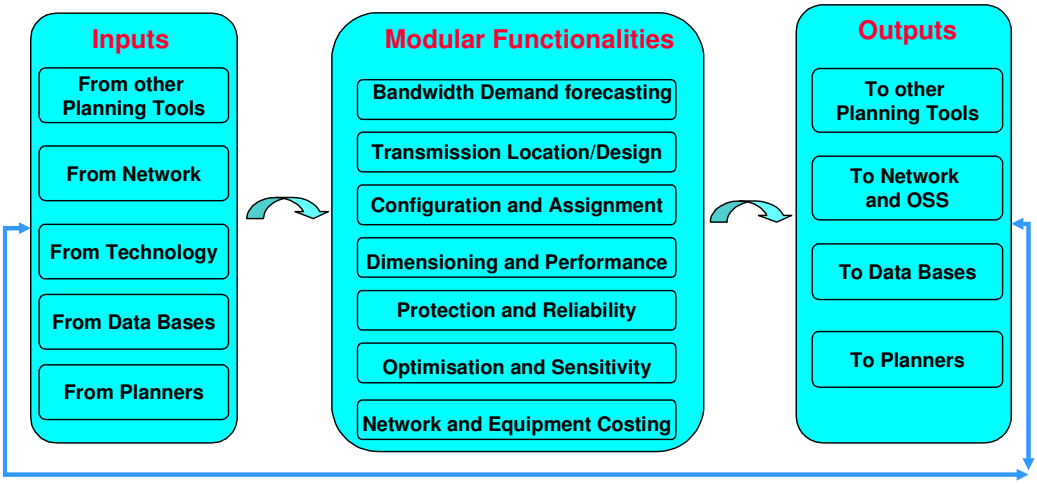

Fig 4.3 Functional modular requirements for the transmission domain

4.3.1. Tool scope - main characteristics

Main objective of the tools for the fixed switching and routing planning is the support to the planner in the technical network design, definition of architecture and dimensioning in order to ensure that functional network carries the origin/destination bandwidth or circuit demands with the agreed quality of service for a given period of time.

According to the different network segments of application and the technologies used, a variety of functionalities is required that may be customised to each scenario either for voice, data, multimedia services types as well as for or external sub-networks.

The strong interrelation with the other adjacent network layers imply the need to use and pass information to the switching and routing planning as well as to the business planning

4.3.2. Network model - network architecture, customers, services, traffic, etc.

Tools should provide modelling capabilities with the following characteristics:

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- Conceptual Network Design and Capacity Planning for SDH/SONET and WDM systems

- Consideration of a given infrastructure (e.g. fiber-optic cables, microwave systems, ducts)

- Comparison of different network structures (e.g. partly-meshed and ring-like network structures)

- Recommendation on sub-networks design and splitting by affinity criteria with derived ring formation

- Detailed allocation and grouping of containers

- Configuration of devices (multiplexers, cross-connectors, etc.) in the network nodes

- Definition of the transport medium for the systems (e.g. fiber-optic cable, DWDM system, microwave)

- Analyse alternatives for the wavelength conversion

- Routing of end-to-end connections by various criteria over disjoint paths and the possible protections

- Restoration systems including unprotected, dedicated restoration and shared restoration

- Calculation of loads and capacities, including dimensioning of rings

- Cost, Performance and Reliability Analysis

- Analysis of utilisation of network capacities and finding out the bottlenecks

- Calculation of end-to-end availability's and comparison with the requirements

- Estimation of investment costs for the rollout and the extension of the investigated transport network

- Allocation of network cost to the bandwidth demands

- Estimation of signal delay times

- Generating reports on routing and dimensioning

- Generation of reports about allocation of physical systems and allocation of devices

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4.3.3. Forecasting - services, traffic matrix, users distribution and user segments

Tools should be able to perform:

Forecasting of bandwidths and circuits at network sources with linear, exponential and logistic procedures for typical customer types. Processing and aggregation of bandwidth demands coming from upper network layers with the corresponding interpolation and/or extrapolation when needed.

Forecast of traffic NxN matrices for origin destination sources with typical methods like Kruithof, affinity and correlation for network scenarios with equal or different service areas between initial and final year. N should be at least 256 and pre-processing with partitioning methods when larger network needed. Handling capability of both real numbers (for bandwidth) and integer numbers (for circuits) in the transmission matrix calculation and alignment.

4.3.4. Calculation modules - network dimensioning and optimisation

Tools should provide modelling capabilities with the following characteristics:

Configuration models for the nodes of PDH, SDH, NG-SDH and WDM types, including multi-layer modelling.

Optimisation of routing, flows and capacity in the PDH, SDH and WDM transport networks, in particular including Flexible Multiplex Hierarchy.

Traffic evaluation models with bandwidth rate, needed for NG-SDH, Ethernet, and corresponding I/F equipments.

Provide capability for self-defined multiplex levels, for instance, to consider special types of microwave systems or concatenated containers.

Evaluation methods for reliability of network, sub-networks and systems based on individual reliability parameters.

Calculation of protection levels for end-to-end routes and diversity paths with single node, single link and combined failure survivability.

Evaluation of costs with polynomial models based on fixed and marginal costs per cost driver such as systems, cabinets, modules, racks, cards, ports, Mbytes, Mbps, etc.

Optimisation algorithms for network topology and routing, including minimal connectivity, connectivity of level "n", flow optimisation, QoS objective functions, disjoint paths and protection. Associated dimensioning methods for resilient transmission networks with single-node, single-link, and combined failure survivability, including the wavelength (lambda) routing.

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4.3.5. Input/output data - GUI, maps, reports

Tools should provide:

- Import and Export Functions from/to other network layer planning
- Import/export from/to text files and Excel
- Device catalogue and configuration view for the network nodes
- Generation of reports about the allocation of devices
- Displaying and tracing the routing in the cable or duct network
- Manual input of rings and ring inspector
- Finding out the routing of demand units through locations in the node inspector
- Tracing the allocation of containers in the inspectors of nodes, edges and paths
- Capability for customised import and export filters as a function of formats in other related tools
- Interface with existing databases using Microsoft ODBC and capability to extend it with further database modules under demand.

4.3.6. Platform - tool architecture and system requirements

Tools must work in a PC running Windows 98, Windows 2000, Windows NT or Windows XP. [in the following chapters only the requirements for Operation System are mentioned].

Modular architecture for the main functionalities of inputs, demand projection, network configuration, routing, protection, equipment assignment, costing and outputs.

Editing and checking functions for intermediate and final results.

Internal handling of a GIS both for functional and geographical network structures as well as extraction and conversion capabilities from external GIS.

Assignment and resource mapping capabilities with other network layers and planning domains.

4.3.7. NGN - requirements related to NGN and corresponding new technologies

In addition to the capabilities for conventional networks, tools should provide explicit modelling capabilities for new generation SDH and Convergence, such as:

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- Device catalogue covering Next Generation SDH technologies

- Formation of optical networks

- Capability to model IP over SDH and IP over WDM

- Modelling architecture and capabilities of Ethernet mesh topology with Spanning Tree Protocol (STP) and Ethernet ring topology with Resilient Packet Ring protocol (RPR)

- Modelling traffic adaptation procedures like the Generic Framing Procedure (GFP), Virtual Concatenation (VC) procedures and Link Capacity Adjustment Scheme (LCAS)

- Allocation of network cost to the bandwidth, circuit or fiber demands of carried services

- Estimation of investment costs for the rollout and the extension of the investigated multi-service network through the intermediate migration steps

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4.4. FIXED ACCESS PLANNING

The domain of fixed access planning includes optimization and dimensioning of access nodes numbers, capacities, locations, service areas, etc., for any local network as well as calculation of costs per network elements, considering both the capital (CAPEX) and the operational (OPEX) cost components. Different access modes and technologies, e.g. POTS / ISDN, xDSL, fixed wireless access, PON, etc., need to be considered. Market and service definition and forecasting are also important fixed access planning activities. It has a major technical focus and receives inputs from current network and business planning while provides results to switching and routing planning, as summarised in fig. 4.4.

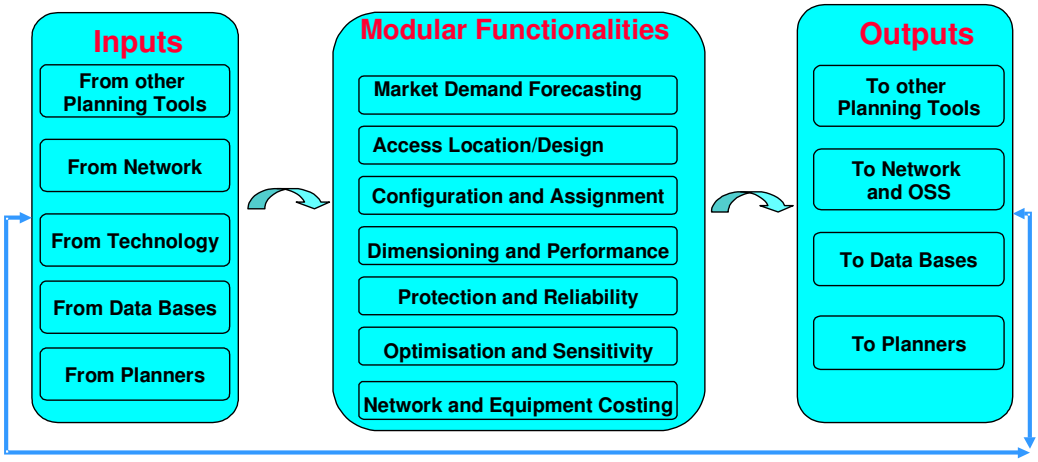

Fig 4.4 Functional modular requirements for the fixed access domain

4.4.1. Tool scope - main characteristics

Fixed access planning tools should aid network planning experts in planning of the access network and selection of the most appropriate technology solution for a particular network through market modeling and forecasting, access network optimization for each technology solution and cost analysis of the resulting network.
The main characteristics of fixed access planning tools are:

- modeling of the market as customer segmentation with respect to customer classes and service mixes, presenting of the different services with bandwidth and the nature of traffic (permanent/switched or packet)

- forecasting of customers as numbers and geographical distribution, as well as forecasting of the penetration of different services

- modeling of different access modes and technologies (POTS / ISDN, xDSL, Fixed wireless access, PON, etc.)

- optimization and dimensioning of particular access network in terms of access nodes numbers, capacities, locations, service areas, etc.

- network cost modeling and calculation of costs per network elements, considering both the capital (CAPEX) and the operational (OPEX) cost components

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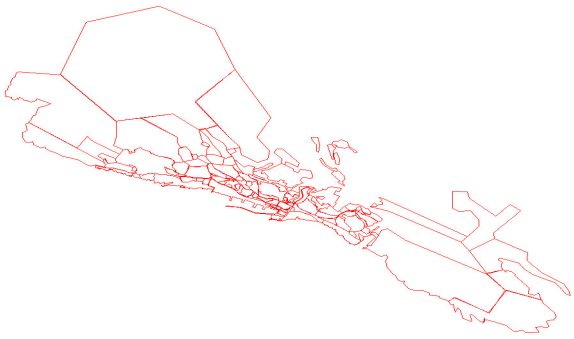
4.4.2. Network model - network architecture, customers, services, traffic, etc.

Tools should provide modelling capabilities with the following characteristics:

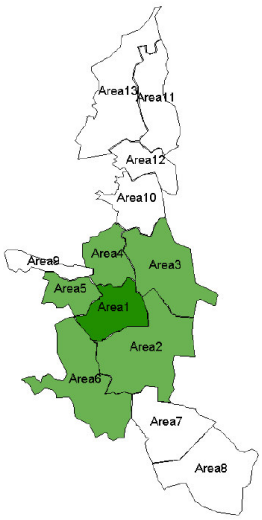
Modeling of customers distribution

A. Subscriber zones / areas
Subscriber zones/areas represent group of customers, homogeneously distributed in a geographical area (group of buildings, houses, etc.)



Typical model for customers in metropolitan areas, where the city center is surrounded by urban areas with high customer density, while the areas in the edge are suburban areas with less density.

Customer densities are defined per square kilometer and the tools should be able to model grids with quite different orders of magnitude to be able to map customer location into areas considering densities: from 0.1 up to 10.000 customers per square kilometer.



Each area should be described with a specified mix between different categories of customers.

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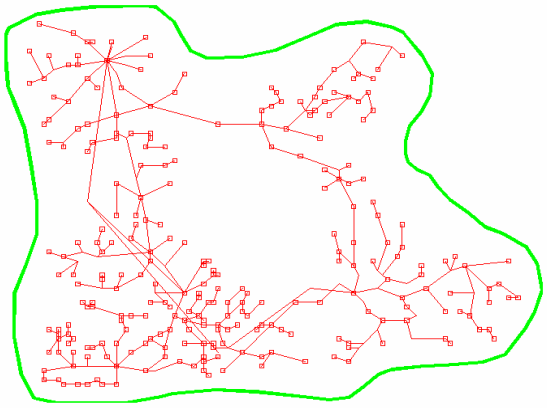
B. Subscriber nodes / sites

Subscriber nodes / sites represent group of customers, concentrated in one geographical point (one town, village, group of houses, business center, etc.).



Subscriber nodes / sites present typical graph model with customers in the nodes of the graph and arcs of the graph representing geographical distances.

Service modeling

Services should be modeled with required bandwidth or bit rate and generated traffic :

- **permanent services**, defined by required bandwidth or bit rate
  e.g. leased line

- **circuit switched services**, defined by required bandwidth and traffic
  e.g. POTS, ISDN BRA, dial-up Internet

- **elastic** (packet switched non real time) **services**, defined by access link data rate, average bandwidth and traffic
  e.g. DSL Internet access, FTP-based file transfer

- **real time CBR** (packet switched constant bit rate real time) **services**, defined by required guaranteed bit rate, delay constraints and traffic
  e.g. high-quality voice over IP , videoconference over IP

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- **real time VBR** (packet switched variable bit rate real time) **services**, defined by mean guaranteed bit rate, peak bit rate, delay constraints and traffic
  e.g. voice over IP using compression , WEB games

Network equipment modeling

Modeling of network equipment need to consider the network elements based on different technologies, like:
• POTS / ISDN
• xDSL
• Fixed wireless Access
• PON
• Fast Ethernet / Gigabit Ethernet

Network elements should be modeled with:
• Specification of capacity and interfaces IF
• Technological constraints (e.g. bandwidth, distances, compression)
• Set of different costs dependent on the IF type

Network element cost should include both CAPEX and OPEX, e.g. :
• Acquisition (procurement) costs
• Installation expenses
• Maintenance, e.g. Leased Line costs

Network equipment modeling should include estimation of equipment and infrastructure cost evolution over time.

4.4.3. Forecasting - services, traffic matrix, users distribution and user segments

Tools should be able to perform forecasting of different services and corresponding traffic for the different customer segments as well as geographical distribution of the customers.

Different forecast models and methods should be available:

Time trend forecasting methods – development will follow a curve, which has been fitted to existing historical data
Different curves should be available, like linear, exponential, logistic.

Logistic model

The development is supposed to follow a curve which first accelerates, then passes a point of inflection, and finally the development slows down and approaches an asymptote, the "saturation level", or "the maximum density".

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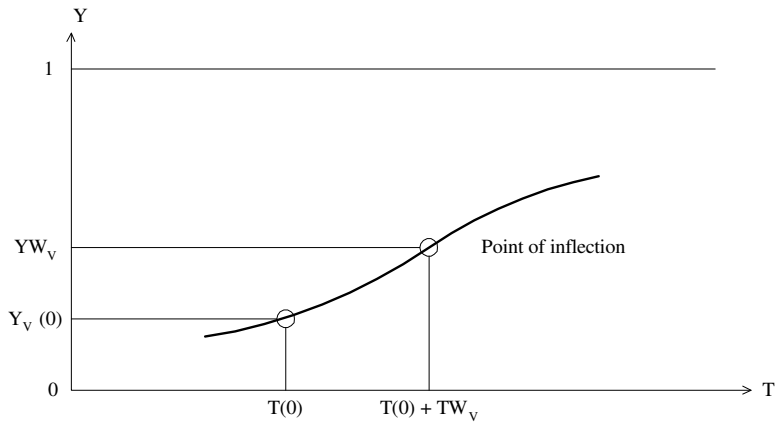

Explicit relationships between demand and various determining factors, which will remain the same in the future.

Comparing various steps of telecommunication development – it is assumed that the less-developed country (or area) will develop to the level of the more developed one.

Another classification of forecasting models :

- **time series forecast** - observation of a variable over time (usually in equidistant steps) - referenced as ***time trend*** above

- **causal model** (linear regression or econometric model) - assumes causal relationship between independent variable (e.g. residential customers) and several dependant variables (e.g. population, households) - referenced as ***explicit relationships*** above

- **neural network forecast** - mathematical model used to find hidden structures in data, organized in "network"; method consists in training the network to forecast the future from the data in the past - method is applicable when data from past and present are available, so that training could be done with the past data and verified on the present data.

4.4.4. Calculation modules - network dimensioning and optimisation

Calculations within the tool need to have the following capabilities:

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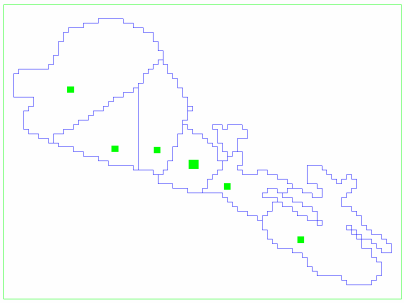
Optimal placement of exchanges, RSU, routers, DLC, DSLAM, etc.



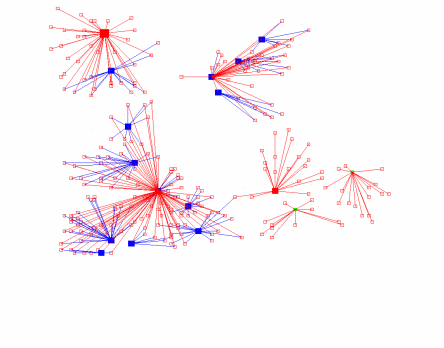
Optimization needs to consider the basic solution of calculating the total network cost, *C*, for ***all combinations*** (solutions) and find the smallest C = *Cmin*

With a variety of methods like:

- analytical methods - construct cost function and find minimum with the standard mathematical methods (find first derivatives, construct equal to zero equations and solve resulting system) - applicable for subscriber zones/areas model only
- Check of all network combinations - applicable for subscriber nodes / sites model - could be applied only for very small networks.
- Heuristic methods - eliminate the obvious senseless combinations and investigate only some of the combinations.
- Probabilistic methods - most known methods are Simulated annealing, Simulated allocation, Genetic algorithms.

Access nodes service areas optimization :

Optimal service areas of exchanges, RSU, routers, DLC, DSLAM, etc.



Service areas optimization should consider also finding of service area boundaries in such a way that the network cost is minimized.

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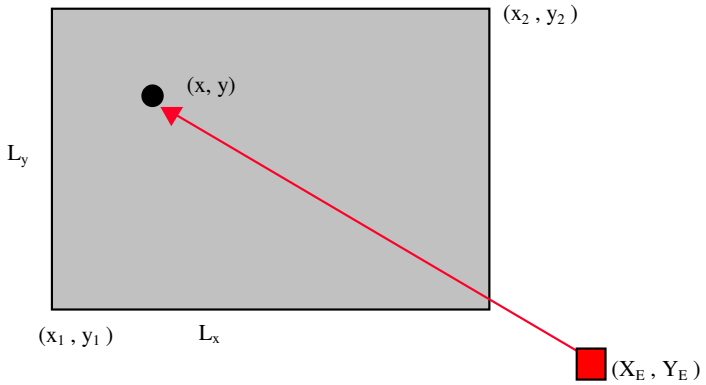
Location and service areas optimizations require distance measurement methods.



Distance is measured with different methods:

Distance measurement method along the cathetie (represents situation in a city, e.g. with wireline access equipment laid down along streets) :

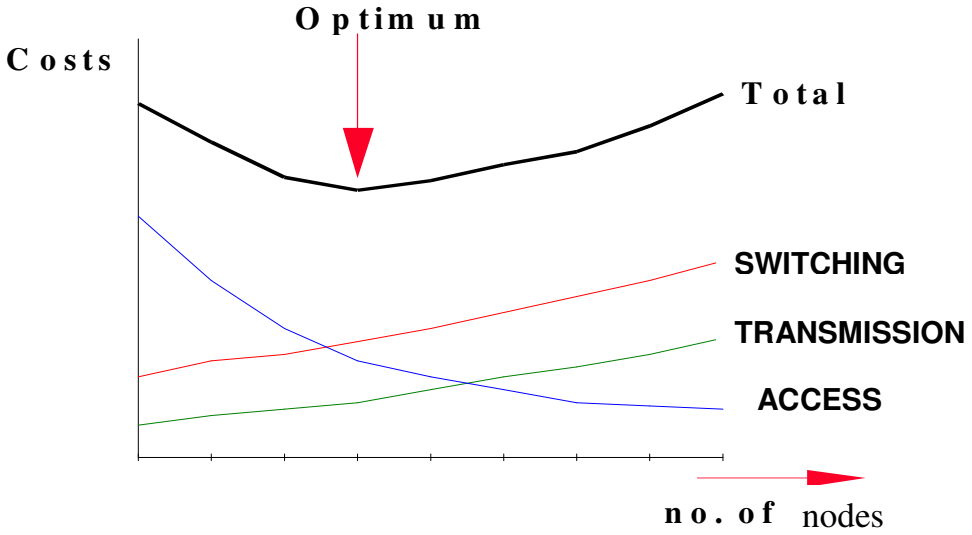
$$D(X_E, Y_E, x, y) = \sqrt{(X_E - x)^2 L_x^2 + (Y_E - y)^2 L_y^2}$$

Distance measurement method along the hypotenuse (represents situation in a city, with e.g. wireless access equipment):

$$D(X_E, Y_E, x, y) = \sqrt{(X_E - x)^2 \cdot L_x^2 + (Y_E - y)^2 \cdot L_y^2}$$

Distances measurement method with ***shortest path*** algorithms - calculation of distances in a graph (case of subscriber nodes / sites network model)

Costs calculations:
Tools should have the capability to calculate the balance of access network elements costs and the overall access network cost, including CAPEX (acquisition and installation) and OPEX (maintenance) components as illustrated in the following diagram



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4.4.5. Input/output data - GUI, maps, reports

GUI (Graphical User Interface)

The access network planning tool should present an interactive Graphical User Interface for creating, editing and deleting of new and existing sites, links, nodes, etc.

Preferably the GUI should be based on a Geographical Information System (GIS)

The topology of the network has to be presented at the GUI in an easy and logical way, which makes it easy to get a quick overview of the network.

The user should be able to click on an object to edit or obtain information.

The user should be able to resize or zoom in and out of window panes.

The user should be able to save and print the required work from the graphical view.

Import / Export

The user should be able to import/export several vector map formats, especially MapInfo and Esri.

The user should be able to import various bitmap formats (gif, tiff, jpeg, etc.)

The tool should support text file format for sites, service areas and market data (Interface ASCII file *.rif)

The tool should support customer sites imported and exported from/to MS Excel

The tool should support automatic import of customer sites, service areas and market data from GIS *tab (MapInfo)*, *shape (ESRI) and DGN* (Intergraph) files

The tool should support the import of existing technologies, or potential equipment locations with their x/y positions

Reports

The tool should generate reports on market data like:
- density,
- bandwidth,
- revenue,
- penetration,
- number of subscribers,
- number of lines,
- bandwidth per service,
- revenue per customer class

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The tool should be able to generate reports for the studied technologies and obtained access network configurations.
Reports should consist of technical parameters and costs data per network element and summary per network element type.

The tool should be able to produce summary reports on main economic parameters like:
• Revenue
• Cost
• Cash Flow
• Net Present Value
• Internal Rate of Return

All results should be represented graphically on the GIS and also in charts and tables which can be exported to Microsoft Excel.

4.4.6. Platform - tool architecture and system requirements

The tool should be Windows based application, i.e. to run on contemporary Windows OS of type Windows 2000 or Windows XP.

The vendor should state the minimum configuration required, in particular the following could be included:
• Processor speed
• Operating system
• RAM size
• Hard disk requirements

The tool should be of modular structure for easy upgrade and extension.
All modules should be of Windows type application including help features. They should be easily upgraded.

The tool should store and retrieve its data on a common data repository. This common data repository should be accessible by all users who have the appropriate access rights.
The common data repository should have an automatic back-up facility.

4.4.7. NGN - requirements related to NGN and corresponding new technologies

Access network planning tool should be easily upgraded for the requirements related to NGN and corresponding new technologies.

Expected requirements related to NGN are:

Modeling of new NGN services which do not fall in the present service models (as bit rate parameters, traffic model, etc.) and especially multimedia service types.

- Modeling of future NGN access network equipment, including equipment parameters, technological constraints, costs structures

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- Extending of the forecasting models and methods due to NGN service/customer requirements

- Adapting of the calculation modules to the NGN access network requirements

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4.5. SIGNALLING, CONTROL AND NM PLANNING

The domain of signalling, control and NM planning includes all circuit and link demand flows projections and the design, location, path routing, dimensioning, costing and optimisation for any signalling, control and NM dedicated networks. The most known problem currently is Common Channel Signalling Network SS7 planning. It has important technical focus and receives inputs from current network, business planning and switching and routing planning while provides results to transmission planning, as summarised in fig. 4.5.

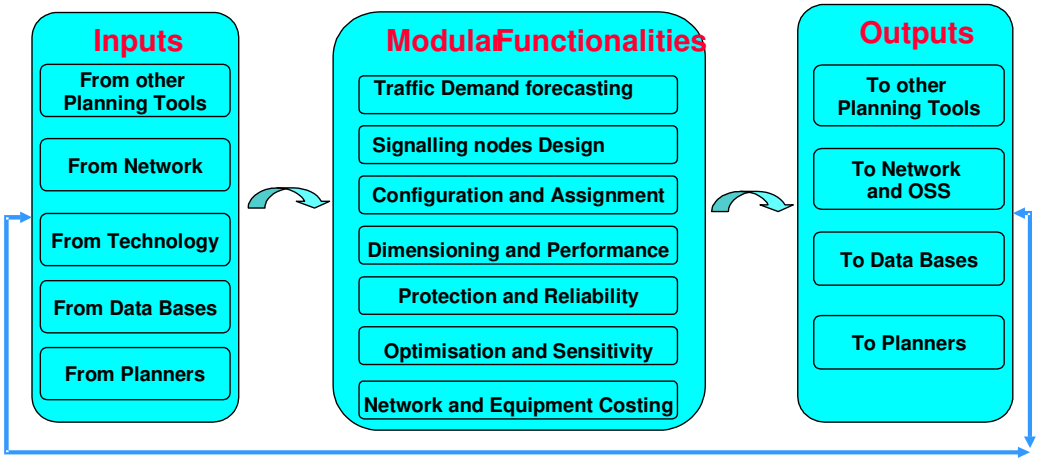

Fig 4.5 Functional modular requirements for the signalling domain

4.5.1. Tool scope - main characteristics

Tool should perform automatic routing generation and checks route sets with respect to whether all signalling points are accessible.

Dimensioning is needed for the signalling linksets by distributing the signalling load to the linksets according to the route sets and the given service matrix.

4.5.2. Network model - network architecture, customers, services, traffic, etc.

Tools should provide modelling capabilities with the following characteristics:

Network Nodes
Represent signalling end points (SEPs), signalling transfer points (STPs) and combined signalling end and transfer points STEPs.

Trunk Lines
Represent linksets with:
• Load
• Blocking rate

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• Number of trunks

Traffic Matrices
The load on a signalling network is determined by the services that are handled on the network.

Network model should be able to accept several separate matrices, allowing to represent every service with a different matrix.

Service Matrix Types
The following matrix types should be supported:
• BHCA matrix (units 1/h)
• Call matrix (units 1/s)
• MSU matrix (unit 1/s)
• Traffic matrix with Erlang values (units Erl)
• Trunk matrix (unit number of trunks)

Service Matrix Parameters
The assigned services should be modeled with a number of parameters.

For a BHCA matrix this should include at least:
• Percentage of effective calls
• Mean number of MSU per call
• Mean number of MSU per ineffective call
• Length of MSU per call
• Differentiation in effective and ineffective call parameters
• Differentiation in forward and backward parameters

4.5.3. Forecasting - services, traffic matrix, users distribution and user segments

Tools should be able to perform:

Forecasting of traffic at network sources with linear, exponential and logistic procedures for typical customer types and service traffic flows (voice or data). Availability of aggregation and desegregation functions for the different traffic flow types of the customer classes.

Forecast of traffic NxN matrices for origin destination sources with typical methods like Kruithof, affinity and correlation for network scenarios with equal or different service areas between initial and final year.

Traffic matrices produced for fixed switching and routing planning could be used.

4.5.4. Calculation modules - network dimensioning and optimisation

Calculations within the tool need to have the following capabilities:

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Routing

The tool should be able to ensure automatic generation of cycle free routing tables.

The user should be able to influence the automatic routing via parameters like:
• Operating mode (associate or quasi associate)
• Minimum and maximum number of routes
• Load sharing options
• Homing conditions

Should be foreseen to edit the automatically generated routing tables manually.

Complete manual setup of routing tables should be an option.

Signalling Load Distribution and Dimensioning

Automatic distribution of the signalling load to the link sets according to the routing tables created.

Optimise the signalling network by selection of link sets with low load and suggestion for deletion.

Calculation of the optimum number of links per link set.

Analysis

Evaluation of various traffic load conditions.

Evaluation of partial and total link failures.

Checking for cyclic routing of existing networks.

4.5.5. Input/output data - GUI, maps, reports

GUI (Graphical User Interface)
The SS7 network planning tool should present an interactive Graphical User Interface for creating, editing and deleting of new and existing sites, links, nodes, etc.

The topology of the network has to be presented at the GUI in an easy and logical way, which makes it easy to get a quick overview of the network.

The user should be able to click on an object to edit or obtain information.

The user should be able to resize or zoom in and out of window panes.

The user should be able to save and print the required work from the graphical view.

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Representation of Nodes:

Nodes should be represented as icons that can be chosen out of a list. The size of the icon should be adjustable in order to allow also the representation of large networks. Nodes should be labeled with their name.

Representation of Trunk Lines:

Links shall be represented as lines that can be adjusted for width of the line display. The colour and style of the links should be configurable. There should be the possibility to label the trunk line, e.g. with the following information:
• Load
• Blocking rate
• Number of trunks
• User defined text

Representation of Routing:

The routing between two nodes should be displayed graphically with different colours for primary routes and secondary routes

Import / Export
The user should be able to import various bitmap formats (gif, tiff, jpeg, etc.)

The tool should allow data to be imported from files of the following formats:
• ASCII text file with tab separated variables
• Microsoft Excel

The user should be able to export project data in
• Microsoft Excel format or
• Tab separated ASCII format.

Input
The user should be able to define the following input data:

General
• Maximum non-reliability
• Maximum number of STP transits
• Routing type (associated / quasi associated)

Node inputs
• Name
• Geographical coordinates and/or Cartesian coordinates
• Type (Signalling End Point SEP, Signalling Transfer Point STP or combined STEP)
• Hierarchical level
• Reliability level
• Maximum number of connectable links
• Permissible load for SEP in send and receive direction
• Assignment to different sub networks

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Trunk Group inputs
• Name
• Bitrate
• Threshold for associated mode
• Reliability level
• Existing links
• Maximum load

The user should be able to define different independent subnetworks

The tool should allow data to be manually input via the user interface.

Output
The tool should provide a report functionality with detailed information, e.g. on:
• load situation per node and subnet,
• number of links,
• load per link set,
• routing tables,
• reliability level
• maximum number of hops,
• statistical information on number of routes, links, loads etc.

The report should be in tabular format compatible with Microsoft Excel.

4.5.6. Platform - tool architecture and system requirements

The tool should be Windows based application, i.e. to run on contemporary Windows OS of type Windows 2000 or Windows XP.

The tool should be of modular structure for easy upgrade and extension.
All modules should be of Windows type application including help features. They should be easily upgraded.

The tool should store and retrieve its data on a common data repository. This common data repository should be accessible by all users who have the appropriate access rights.
The common data repository should have an automatic back-up facility.

4.5.7. NGN - requirements related to NGN and corresponding new technologies

SS7 network planning tool should be easily upgraded for the requirements related to NGN and corresponding new technologies in respect to the demand flows and protection level. Also capabilities should be provided to analyze and optimize signalling gateway locations and dimensioning.

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4.6. RADIO ACCESS PLANNING

The domain of radio access planning includes coverage and best server calculation, interference calculation, frequency planning, optimization and dimensioning of the access nodes as well as calculation of costs per network elements, considering both the capital (CAPEX) and the operational (OPEX) cost components. It has a major technical focus and receives inputs from current network and business planning while provides results to core network planning, as summarised in fig. 4.6.

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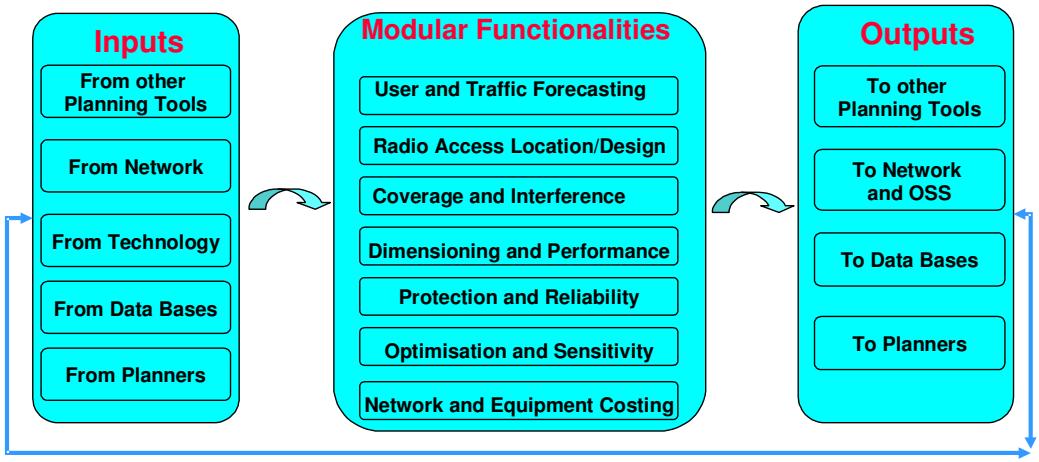

Fig 4.6 Functional modular requirements for the radio access domain

4.6.1. Tool scope - main characteristics

The radio access planning tool performs coverage calculation for a single cell, for a site, and any user selected combination of cells.

Best server calculation, traffic analysis, mutual interference calculation per cell-cell pair are necessary functions for radio access network planning.

Automatic frequency planning is necessary for mobile network planning.

The planning tool should support 2G and 2.5G functionality, where the following calculations should be provided:
- Calculation of 2G and 2.5 G coding scheme areas (best case, based on field strength level)
- Throughput of data in kbps/s per cell
- Coding scheme areas network wide
- Throughput network wide
- Real coding scheme and throughput calculations based on interference situation

The planning tool should provide different modules for 3G planning, which are intended to serve the planner for his different needs during the project phases, including:
- Propagation based planning module for initial bid-planning estimations

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• Capacity based models as a function of broadband traffic mix
• Monte-Carlo simulation module for regular network roll-out

4.6.2. Network model - network architecture, customers, services, traffic, etc.

Tools should provide modelling capabilities with the following characteristics:

Network Parameters

Basically a radio access network (mobile or fixed wireless) has hierarchical structure with different network elements on network level, site level, cell level, carrier level and antenna level.
The network parameters shall be organised according to the structure levels.
A detailed list of parameters contained in each level should be provided (e.g. for planning of a 2G network).

Maps

The overall performance of the planning tool depends on the method to store and access geographic data. This includes fundamental data like digital maps or digital terrain models as well as spatial data like field strength predictions or coverage calculations.

Display of scanned maps is a background image for other displayed data.

The geographic database consists of raster data (e.g. terrain height data, clutter data, population data and traffic data) and vector data (e.g. buildings, borders, roads, etc.).

Maps as Raster Data

The minimum resolution is at least 5 meter.
Resolution of mapping data always should be considered in relation with the used propagation model and frequency range. In case that models like Okumura Hata are used a resolution of 5m does not increase the accuracy but only the computation time. Thus for such models a resolution of 50m or 25m is sufficient. Resolutions of 5m and below are only useful in combination with advanced models like ray tracing. Higher frequency, higher resolution necessary.

The clutter data should supports at least 16 different clutter classes.

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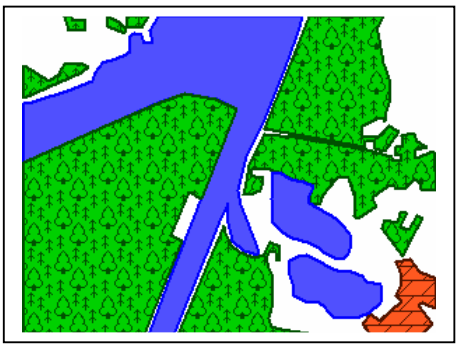
The population data should provide statistic information for population density.

The traffic data must be editable. The tool should support the user to update traffic data based on the clutter information and measurement of traffic from an operating network.

Maps as Vector Data

Vectors are used to depict polygonal objects like buildings, roads, etc.



The vector should have various attributes for displaying, including point shape, size, color, font, line style, etc.

Coordinate Systems

Maps and data sets are often georeferenced using different coordinate systems. Therefore, the planning tool shall be able to handle at least all commonly used coordinate systems.
The planning tool should support import of geographic data using WGS-84 geographic coordinates, as the most commonly used coordinate system.
The conversion function between different coordinate systems should be provided by the tool.

Radio Propagation Model

The planning tool is supposed to simulate the radio part of an access network (mobile or fixed wireless). The basis of the simulation is radio propagation model.

Both macrocell and microcell field strength prediction should be supported with selection of the most commonly used field strength prediction models for a single cell, a single site, or any selection of sites, cells or repeaters.
Field strength calculations are always dependant on the parameter of a single sector. Thus, field strength calculations for a site or a selection of sites always consist of consecutive field strength calculations for each sector of each site and an combination of the single results by another calculation (like network wide coverage) afterwards.

Modeling 3G

Definition of Services

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The tool should distinguish different radio bearer services with the modeling of main multimedia parameters like Sustained Bit Rate and delay constraints.

Terminal Type (User Equipment)

The tool should distinguish different terminal types.

The mobile user environment (e.g. indoor with certain penetration loss) should be taken into account.

The planning tool should be capable of modeling the simultaneous usage of terminals in different mobile environments (e.g. indoor, in-car and outdoor).

Traffic Model

The model should use traffic grid to determine the spatial distribution of the traffic from all services. The model should support simultaneous use of different traffic grids, e.g. one grid per service as well as the mix of different service classes.

Population density should also be taken into account in the traffic model.

4.6.3. Forecasting - services, traffic matrix, users distribution and user segments

Tools should be able to perform:

Forecasting of different services, corresponding traffic, customer segments as well as geographical distribution of the customers.

Different forecast models and methods could be applied:

Time trend forecasting methods – development will follow a curve, which has been fitted to existing historical data
Different curves could be applied, like linear, exponential, logistic as well as the substitution laws when migrating from 2G to 3G.

Explicit relationships between demand and various determining factors, which will remain the same in the future.

Comparing various steps of telecommunication development – it is assumed that the less-developed country (or area) will develop to the level of the more developed one.

Forecasting of traffic matrix (traffic grid) for origin destination sources with typical methods like Kruithof, affinity, etc.

4.6.4. Calculation modules - network dimensioning and optimisation

Calculations within the tool need to have the following capabilities:

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DATABASE

The database is an important part of the radio access planning tool as a large number of parameters have to be processed and many users are involved in the day-to-day work of maintaining and optimising these parameters. Not restricted to the specific implementation mechanism, the general capability and structure of the database shall meet the following requirements:
- The database shall support multi-user application. The user right (read/write parameters in the database) shall be defined on planning area as well as on network elements in a given area.
- Changing a parameter by any user shall not disturb the work of other users. Competing access of different users to same data records shall be prevented.
- The database shall support global change of individual parameters for a defined group of cells.
- In order to avoid loss of working data, the user shall be able to easily make a backup of the database either wholly or partly.
- The number of data records shall not be limited. The database shall be capable of handling no less than 100,000 cells.

Besides the performance of the network parameter database the overall performance of the planning tool depends on the method to store and access geographic data.
This includes fundamental data like digital maps or digital terrain models as well as spatial data like field strength predictions or coverage calculations.

The geographic database shall consist of raster data (e.g. terrain height data, clutter data, population data and traffic data) and vector data (e.g. buildings, borders, roads, etc.).

Calculation Modules for 2G

The following 2G calculation modules should be applicable

Coverage Calculation

The planning tool should support coverage calculation for a single cell, for a site, and any user selected combination of cells. The repeater shall be taken into account for coverage calculation.

The coverage calculation should take into account traffic distribution.
Different types of customers and different user environments have to be taken into account.

The planning tool should support calculation of coverage statistics and provide both area and population coverage percentage.

Best Server Calculation

Best server calculation is a necessary function for network planning.

The calculation should take into account the interference.

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Traffic Analysis

The tool shall support traffic planning, where the user can import measured OMC-data, create traffic distribution map, and edit the traffic map.

New traffic maps could be constructed based on information in the clutter data, vector data, or user-defined polygons.

In calculating the traffic per cell, the module should take into account hierarchical cell structure (macrocells, microcells) and dual band

Interference Calculations

The planning tool should support mutual interference calculation per cell-cell pair.

The tool should provide at least the following interference calculations:
• carrier-to-interference ratio (C/I) for co- and adjacent channel
• interference probabilities for co- and adjacent channel
• channel separation per cell-cell pair

The interference calculations could include a weighting with traffic density.

Neighbor Relation Generation

The planning tool should be able to generate neighbor relations.

The generation should take into account cell boundaries and cell overlap.

Automatic Frequency Planning

Automatic frequency planning is necessary for mobile network planning.

The module should contain an optimisation algorithm, which can optimise the frequency plan based on different criteria, e.g. interference and frequency occupation.

The algorithm should use the results from the interference calculation, neighbour relations and border restrictions.

For each cell the user shall have the possibility to specify which frequencies are fixed, which are preferred, and which are forbidden.

Calculation Modules for 2.5G

The planning tool should support 2.5G functionality

The following 2.5G based calculations should be provided:
• Calculation of 2.5G coding scheme areas (best case, based on field strength level)
• Throughput of data in kbps/s per cell

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• Coding scheme areas network wide
• Throughput network wide
• Real coding scheme and throughput calculations based on interference situation

Calculation Modules for 3G

The planning tool shall provide different modules for 3G planning, which are intended to serve the planner for his different needs during the project phases, including:
• Propagation based planning module for initial bid-planning estimations based on both voice and data services according to speed.
- Data services capacity module based on Sustained Bit Rate demand due to a mix of multimedia services and quality of service along the cell area.
• Monte-Carlo simulation module for regular network roll-out

Propagation Based Planning Module

The propagation based module provides static planning of the network based on propagation conditions only. That is, the field strength level of the pilot channel is used to determine cell ranges.

This calculation can be executed based on a single cell, a single site, or any user selected combination of cells.

Capacity Based Planning Module

For the multimedia services demands including voice, data and video, this module should calculate analytically the capacity of the cell and the required number of cells due to the aggregation of demands for the different flows in the area and the specified Quality of Service in terms of loss probabilities and delays exceeding requirements in a given percentage of cell area and population.

Monte-Carlo Simulation Module

Monte-Carlo simulation provides so-called “pseudo dynamic analysis”, which is based on snapshots of network situations. Mobile positions and service parameters shall be considered in this simulation.

The simulation results shall consist of at least:
• TX power per service for both downlink and uplink
• Coverage per service for both downlink and uplink
• Area covered by pilot
• Cell noise rise
• OVSF usage rate
• Average number of mobiles offered, connected, blocked per service
• Bits rate per service for both downlink and uplink
• Frame error rate per service for both downlink and uplink

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4.6.5. Input/output data - GUI, maps, reports

Geographic Data Handling

The planning tool must provide extensive support to guide the user through the handling of geographic raster, vector or point data. A list of data types (e.g. terrain, clutter, building, traffic, population density, etc.) supported by the planning tool should be provided.

Advantage is if planning tool supports multiple geographic map windows with "coupled cursor" function. The windows can be displayed simultaneously.

Two geographic data layers can be combined by using semi-transparent colours for one of them. This shall also work for two layers with different size.
The legend of map window shall be editable in terms of scale and colors.

Coordinate Systems

The planning of a mobile network forces the usage of digital maps and geographic data. These maps and data sets are often georeferenced using different coordinate systems. Therefore, the planning tool shall be able to handle at least all commonly used coordinate systems.

The planning tool shall support import of data using WGS-84 geographic coordinates.

User-defined coordinate systems shall be easily added to the planning tool.

The conversion function between different coordinate systems shall be provided by the tool. The user should be able easily to switch the display of maps between different coordinate systems.

Formats for Exchange of Geographic Data

The planning tool shall provide import and export interfaces to the commonly used geographic data formats like MapInfo and ArcGIS.

To include the graphical output of the planning tool in printed maps, project reports and other documentation, the support for the following printer file formats and graphic data formats is required:

- PostScript and Encapsulated PostScript
- Adobe Portable Document Format (PDF)
- Printer Command Language (PCL)
- Tagged Image File Format (TIFF)

In case that the software supports all types of system printers no direct support of the above mentioned printer file formats is required.

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4.6.6. Platform - tool architecture and system requirements

Requirements on Hardware and Operating System

The tool should be Windows based application, i.e. to run on contemporary Windows OS of type Windows 2000 or Windows XP.

The tool should be of modular structure for easy upgrade and extension.
All modules should be of Windows type application including help features. They should be easily upgraded.

The tool should store and retrieve its data on a common data repository. This common data repository should be accessible by all users who have the appropriate access rights.
The common data repository should have an automatic back-up facility.

When specialized requirements are needed due to network size, detailed information about the following requirements should be provided:

- Required operating system, and version, for the server and clients;
- Required hardware for the server and clients, specifically the computer type, processor and model;
- Amount of disk space required for the installation of the planning tool;
- Recommended RAM and hard disk configuration for the database server and clients;
- Amount of disk space required for storing the descriptive and resulting data, e.g. field strength files
  Example: assuming a 2G network of 30,000 cells today and a 3Gnetwork of 100,000 cells in the future;
- Printers and plotters supported by the planning tool

System Performance

System performance is always a question of used hardware, in case of server client environments also of the load share between server and client and the general activity of the system (how many users are concurrently active on the sever). The required time for a standard action like field strength calculation may even vary on the same system depending on the site parameter. It is obvious that the prediction time depends on the result area and the result resolution. Yet also the site location and the antenna height will impact the computation time. In case that the site is located in a hilly terrain several parts of the result area will suffer from shadowing. To compute these effects more computation time for prediction is required than for a site in flat terrain. Using higher antennas on the same site will reduce areas suffering from shadowing and thus reduce as well computation time.
From this example it can be seen that it is difficult to value systems based on general performance measures like it is done in the following sections.

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General performance

The performance of the planning tool shall satisfy the day-to-day work of network planner. The following reference network is given for the performance evaluation:
• The network consists of 12,000 cells with 40,000 carriers in an area of 200 km x 300 km.
• The resolution of terrain/clutter data is at least 50 meter.
• Client/server architecture is applied.

Showing the background map and network elements including cell locations in an arbitrarily selected area of 50 km x 50 km (about 500 cells) within 20 seconds.

Opening an edit window for the parameters of one cell or site within five seconds.

Committing a parameter change and storing the modification in database within 10 seconds.

Import of all site and cell parameters using ASCII-file format to the database and export of the parameters within 10 minutes.
The time for database export strongly depends of the number of parameter stored inside database. As the number of parameter used strongly varies between different products a fair comparison should consider the number of parameters as well.

Performance for 2G Network Planning

The following reference network is given for the performance evaluation:

• The network consists of 12,000 cells with 40,000 carriers in an area of 200 km x 300 km.
• The resolution of terrain/clutter data is at least 50 meter.
• The resolution of calculation results shall be at least 50 meter.
• Calculations for each individual cell shall extend 20 km around the base station location.

Calculating and displaying the field strength of a single cell within 20 seconds after changing a relevant parameter, e.g. antenna height.
Calculations always consists of three parts, a) Loading of parameter for calculation from database, b) calculation itself , c) storage and display of results.
For a system where database access is allowed to be in the range of 5s for read access, the parameter committing to database might take up to 10s. Thus 10s would remain for calculation .

Calculating and displaying the network coverage in an area of 50 km x 50 km (about 500 cells) within 10 minutes.

Interference analysis in an area of 50 km x 50 km (about 500 cells) within 20 minutes.

Neighbour relation generation and automatic frequency assignment for the complete reference network within 48 hours.

Performance for 3G Network

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The following reference network is given for the performance evaluation:
• The network consists of 10,000 cells in an area of 200 km x 300 km.
• The resolution of terrain/clutter data is at least 50 meter. The resolution of building data is at least 5 meter.
• The resolution of microcell calculations shall be at least 5 meter.
• Calculations for each individual cell shall extend 10 km around the base station location.

Calculating and displaying the field strength of a microcell within one minute after changing a relevant parameter, e.g. antenna height.

The complete propagation based planning with all calculations in an area of 50 km x 50 km with 500 cells and 750 carriers within 30 minutes.

Neighbour relation generation and scrambling code planning for the complete reference network within 48 hours.

Total calculation time for any Monte-Carlo simulation or real time simulation shall not exceed 48 hours.

4.6.7. NGN - requirements related to NGN and corresponding new technologies

Radio access planning tool should be easily upgraded for the requirements related to NGN and corresponding new technologies and the following requirements are emphasized:

- Modeling of new NGN services which do not fall in the present service models (as bit rate parameters, traffic model, etc.) and specially multimedia service types.

- Modeling of future NGN access network equipment, including equipment parameters, technological constraints, costs structures

- Extending of the forecasting models and methods due to NGN service/customer requirements

- Adapting of the calculation modules to the NGN access network requirements

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4.7. CORE RADIO PLANNING

The domain of core radio planning includes microwave link engineering and designing, path loss, coverage and availability calculations, interference calculation, channel assignment as well as calculation of costs per network elements, considering both the capital (CAPEX) and the operational (OPEX) cost components. It has a major technical focus and receives inputs from current network, business planning, fixed access planning, radio access planning, switching and routing planning while provides results to transmission network planning, as summarised in fig. 4.7.

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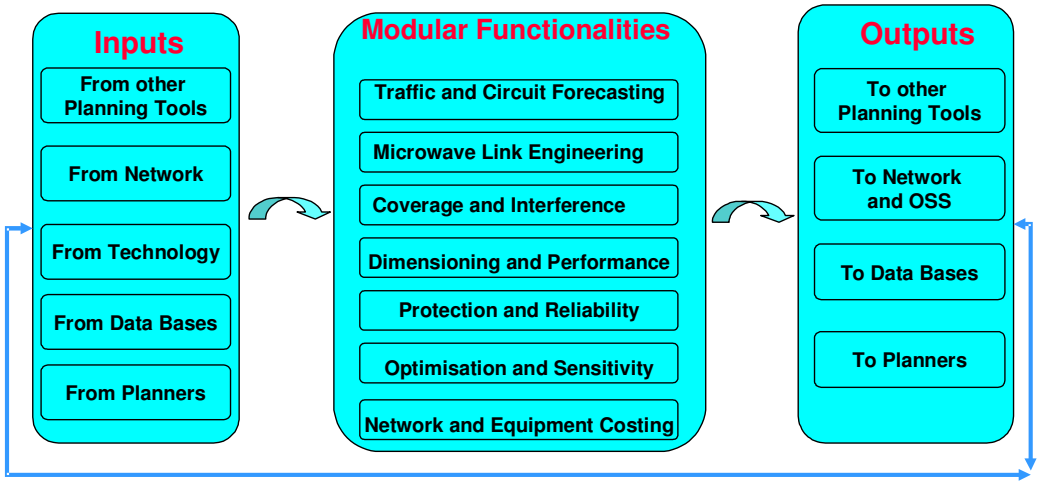

Fig 4.7 Functional modular requirements for the core radio domain

4.7.1. Tool scope - main characteristics

Main core network planning tasks are:

- Decide core network transmission topology and capacity;
- Dimension a number of core network interfaces.

Most problems in the core network planning are the same as in 4.2 "Fixed switching and routing planning" and 4.3 "Transmission planning", so that the corresponding planning tools could be used.

Core radio planning includes microwave link engineering and designing.

Core radio planning tool should be used for planning and optimizing single microwave links (e.g. path loss, coverage and availability calculations) as well as for doing network-wide analysis (e.g. interference calculation, channel assignment).

4.7.2. Network model - network architecture, customers, services, traffic, etc.

Tools should provide modelling capabilities with the following characteristics:

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Database

All data (e.g. terrain maps, technical data) should be stored in a database either locally or on a network server.

Based on Client/Server structure several users could be linked to a central database.

Each user should have a local working database for planning purposes. Easy copy and update processes have to be built in.

Data integrity should be established, e.g. using record locking procedures.

Terrain Map Database

Both raster and vector maps should be supported by the terrain map database.

Coordinate Systems

Maps and data sets are often georeferenced using different coordinate systems. Therefore, the planning tool shall be able to handle at least all commonly used coordinate systems.
The planning tool should support import of geographic data using WGS-84 geographic coordinates, as the most commonly used coordinate system.
The conversion function between different coordinate systems should be provided by the tool.

Radio Propagation Model

The planning tool is supposed to simulate the radio part of a core radio network (microwave link engineering). The basis of the simulation is radio propagation model.

4.7.3. Forecasting - services, traffic matrix, users distribution and user segments

Tools should be able to perform:

Forecasting of bandwidths and circuits at network sources with linear, exponential and logistic procedures for typical customer types.

Forecasting of traffic matrix for origin destination sources with typical methods like Kruithof, affinity, etc.

4.7.4. Calculation modules - network dimensioning and optimisation

Calculations within the tool need to have the following capabilities:

Main features of the calculation modules

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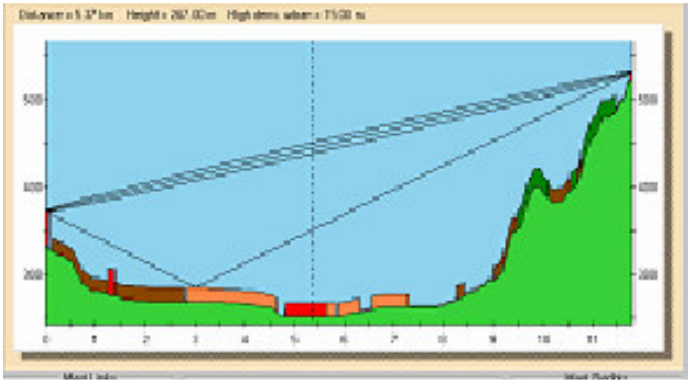
- Powerful Database containing Sites, Links, Receivers, Transmitters, Antennas, Devices, ITU/ETSI Frequency Plans.
- Advanced Map Handling / Network Viewing
- Interactive Link Engineering Desktop Environment
- Different Technologies handling: e.g. FDMA and TDMA
- Profile Handling
- Link Analysis
- Area-wide Field Strength Coverage Prediction (only required for PMP backhaul networks)
- Interference Analysis Calculation for both Long and Short Term
- Microwave Link Reports Creation

Microwave Link Planning



A network planner should have possibility to design his microwave link directly in an interactive Link Planning Window. All necessary calculations, like Fresnel zone, path loss, power budget, link availability, diversity, reflection points, etc, could be done in this window.

The calculations should incorporate the effects of atmospheric absorption at higher frequencies and the effects of different rain zones.

Microwave link report should be generated, containing all important data of the new designed microwave link.

Interference Analysis

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Detailed interference analyses of microwave networks are part of the calculation methods.

Short and long-term interference analysis should be performed in accordance with the propagation model, using terrain and clutter data.

4.7.5. Input/output data - GUI, maps, reports

Tools should provide :

Terrain Maps

Both raster and vector maps should be supported. Calculation results should be visualized as vectors (such as field strength or interference contours) or as raster data (for example area calculations).

Raster or vector calculation results could be overlaid on background maps with an adjustable transparency factor.

Geographic Data Handling

The planning tool must provide extensive support to guide the user through the handling of geographic raster, vector or point data. A list of data types (e.g. terrain, clutter, building, traffic, population density, etc.) supported by the planning tool should be provided.

Advantage is if planning tool supports multiple geographic map windows with “coupled cursor” function. The windows can be displayed simultaneously.

Two geographic data layers can be combined by using semi-transparent colours for one of them. This shall also work for two layers with different size.
The legend of map window shall be editable in terms of scale and colors.

Coordinate Systems

The planning of a mobile network forces the usage of digital maps and geographic data. These maps and data sets are often georeferenced using different coordinate systems. Therefore, the planning tool shall be able to handle at least all commonly used coordinate systems.

The planning tool shall support import of data using WGS-84 geographic coordinates.

User-defined coordinate systems shall be easily added to the planning tool.

The conversion function between different coordinate systems shall be provided by the tool. The user should be able easily to switch the display of maps between different coordinate systems.

Formats for Exchange of Geographic Data

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The planning tool shall provide import and export interfaces to the commonly used geographic data formats like MapInfo and ArcGIS.

To include the graphical output of the planning tool in printed maps, project reports and other documentation, the support for the following printer file formats and graphic data formats is required:

• PostScript and Encapsulated PostScript
• Adobe Portable Document Format (PDF)
• Printer Command Language (PCL)
• Tagged Image File Format (TIFF)

4.7.6. Platform - tool architecture and system requirements

Requirements on Hardware and Operating System

Detailed information about the following requirements should be provided:

- Required operating system, and version, for the server and clients;
- Required hardware for the server and clients, specifically the computer type, processor and model;
- Amount of disk space required for the installation of the planning tool;
- Recommended RAM and hard disk configuration for the database server and clients;
- Printers and plotters supported by the planning tool

Tool architecture

The tool should be of modular organisation for easy upgrade and extension.

4.7.7. NGN - requirements related to NGN and corresponding new technologies

Core Radio planning tool should be easily upgraded for the requirements related to NGN and corresponding new technologies with the functionalities as summarized below:

- Service demands characterisation and traffics for VoIP and NGN multi-service flows
- Device catalogue covering most typical NGN technologies

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- Routing and dimensioning taking into consideration protocol overheads and reservations mechanisms for QoS requirements (RSVP) and Call Acceptance Control procedures (CAC) based on conditions at origin, destination or combined.

- Routing flows for most typical cases including OSPF, shortest path, widest path and weighted cost functions.

- Optimising locations and connections of network gateways

- Formation of virtual networks

- Routing over ATM links or PDH/SDH systems or tunnelling via other IP links

- Routing methods for Labelled Switched Paths (LSP)

- Analysis of utilisation of network capacities and finding out the bottlenecks

- Handling and output IP routing tables

- Estimation of end-to-end delays

- Allocation of network cost to the bandwidth demands of carried services

- Exact allocation of the IP or MPLS links

- Sub networking and addressing

- Configuring the network elements (IP router)

- Mapping tables with overheads, multiplex factors, net(to) and brut (gross) bit rates

- Standard import and export formats for the complex data structures required for the management of routes in IP/MPLS networks, which you can support from your network database quite easily

- Estimation of investment costs for the rollout and the extension of the investigated multi-service network

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4.8. IT ARCHITECTURE, OSS AND APPLICATIONS PLANNING

The domain of IT architecture, OSS and Applications planning includes all IT traffic demand flows projections and the design, location, flow routing, dimensioning, costing and optimisation for the upper layer applications, operational applications and related IT servers structures. It has both, technical and business focus and receives inputs from current OSS applications, business planning, transmission planning, switching and routing planning and signalling planning, while provides results to business planning and control planning as summarised in fig. 4.8.

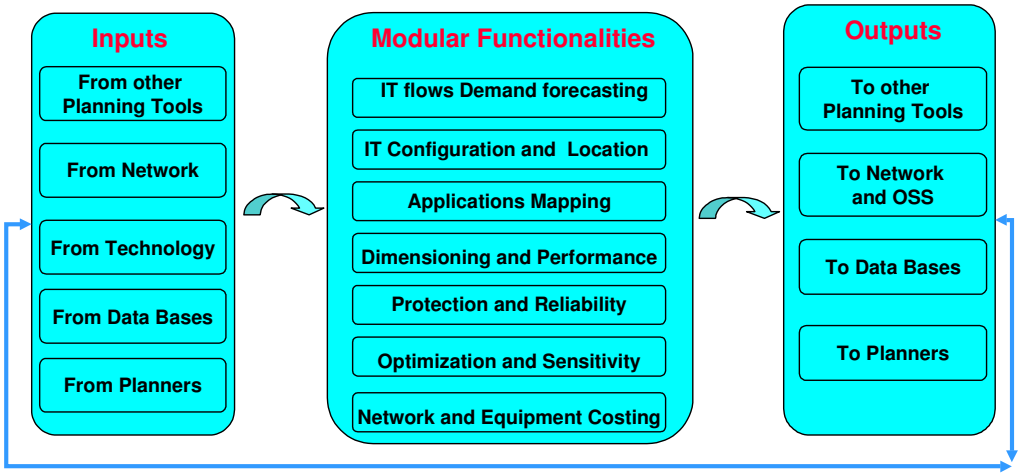

Fig 4.8 Functional modular requirements for the IT/OSS and Application domain

4.8.1. Tool scope - main characteristics

Main objective of the tools for IT architecture, OSS and Applications planning is the support to the planner in the design of IT architecture, dimensioning and performance in order to ensure that services, applications and operations fulfil the performance objectives for all the network layers in a given period of time.

Main functionalities to model and evaluate include: User Services provisioning, Service activation, Billing and Invoicing, Business Assurance, Service Monitoring and Management, Performance Measurement, Application Monitoring and Management, Security Management, Customer Care, Inventory, etc.

The strong interrelation with all the network layers imply the need to use and pass information to all network layers, specially to the control and signalling functions as well as to the business planning domain.

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4.8.2. Network model - network architecture, customers, services, traffic, etc.

Tools should provide modelling capabilities with the following characteristics:

- Evaluation methods for capacity planning of bandwidth, number of servers, Data Bases, routing and topology
- Methods for the application performance at different demand levels including nominal and overload situations
- Evaluation methods for reliability of IT configurations, sub networks and systems based on individual reliability parameters
- Performance analysis for the middleware structures
- Methods to design, measure and evaluate Service Level Management applications and SLA measurement and control
- Calculation of protection level for end to end routes and diversity paths with single node, single link and combined failure survivability
- Simulation of performance behaviour for nominal and overload flows with results of end-to-end delays, roundtrip delays and response times. Provisioning of results in average, standard deviation and distribution values
- Methods to find bottlenecks in the configurations when changing scenarios, configurations and traffic flows
- Models to analyse protocol behaviour
- Evaluation of costs with polynomial models based on fixed and marginal costs per cost driver such as systems, cabinets, modules, racks, cards, ports, Mbytes, Mbps, etc.

4.8.3. Forecasting - services, traffic matrix, users distribution and user segments

Tool should include forecasting of bandwidths, processing rates and IT elements with linear, exponential and logistic procedures for typical application types. Additional functionality is needed for processing and aggregation of bandwidth demands coming from other network layers with the corresponding interpolation and/or extrapolation when needed. Also it is required to have an integration of the internal forecasting procedures with the forecasting and results of demand flows coming from all the other network resources.

4.8.4. Calculation modules - network dimensioning and optimisation

Calculations within the tool need to have the following capabilities:

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Dimensioning methods for loss based systems including Erlang-B and Engset.

Dimensioning methods for delay based systems including Erlang-C, Erlang multirate, hyper exponential models and processor sharing models.

- Traffic evaluation models for equivalent sustained bit rate in multiservice environments

- Capability for traffic evaluation and dimensioning based on additional given predefined rules

- Annual traffic to busy hour and busy period traffic conversion

Evaluation methods for path GoS of the designed IT network and utilisation factors at nodes and links.

Evaluation methods for reliability of IT network, sub networks and systems based on individual reliability parameters.

Calculation of protection level for end to end routes and diversity paths with single node, single link and combined failure survivability.

Evaluation of costs with polynomial models based on fixed and marginal costs per cost driver such as systems, cabinets, modules, racks, cards, ports, erlangs, Mbytes, Mbps, etc.

4.8.5. Input/output data - GUI, maps, reports

Tools should provide :

- Import and Export Functions from/to other network layer planning
- Import/export from/to text files and Excel
- Device catalogue and configuration view for the network nodes
- Configuration of server nodes with modules and ports
- Generation of reports about the allocation of devices
- Capability for customised import and export filters as a function of formats in other related tools
- Interface with existing databases using Microsoft ODBC and capability to extend with further database modules under demand.

4.8.6. Platform - tool architecture and system requirements

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Tools must work in a PC running Windows 98, Windows 2000, Windows NT or Windows XP. Monitor with a minimum resolution of 1024 x 768 pixels, 256 colours.

Also for large networks and compatibility to OSS applications tools should work with most frequent Workstation platforms in the market like Openview, SUN, etc.

Modular architecture for the main functionalities of demand projection, servers configuration, equipment dimensioning and costing.

Editing and checking functions for intermediate and final results.

Internal handling of a GIS both for functional and geographical network structures as well as extraction and conversion capabilities from external GIS.

Assignment and resource mapping capabilities with other network layers and planning domains.

4.8.7. NGN - requirements related to NGN and corresponding new technologies

In addition to the capabilities for conventional networks, tools should provide explicit modelling capabilities for NGN and Convergence, such as:

- Device catalogue covering integrated IT platforms for voice, data and video
- Analysis of utilisation of network capacities and finding out the bottlenecks in multi-service environment
- Estimation of end-to-end delays, roundtrip delays and reaction times for multi-service flows
- Estimation of investment costs for the rollout and the extension of the investigated multi-service network

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ANNEX – Example of request for proposals for supply of a network planning tool

In this annex an example of typical request for proposals (RFP) for supply of a particular network planning tool is presented.

Purpose of the example is to clarify the structure of the document and to outline the different items in the RFP.

The particular planning tool, in this case fixed access planning, is not of main importance. Rather the RFP could be used as model for preparation of such document.

REQUEST FOR PROPOSALS

FOR SUPPLY OF

FIXED ACCESS NETWORK PLANNING TOOL

1. GENERAL

Telecommunications Company (TC) wishes to appoint a Contractor for the supply of Fixed Access Network Planning Tool.

1.1 Contents

This RFP consists of the following sections:

• General (this section)

• Technical Specifications

• Support issues, documentation, training and maintenance

• Acceptance test procedures

• Commercial conditions

1.2 Instructions to the Bidder

This document contains requirements with requirement identifiers in the format of **xx.yy.mm.nn**, where **xx** is the requirement section identifier, **yy** is the requirement subsection identifier, **mm** is the requirement sub-sub-section identifier and **nn** is the unique requirement

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number within that section/sub-section/ sub-sub-section. Every requirement identifier is contained within a separate paragraph.

The requirement identifier is used to aid in tracking of requirements and for preparation of the requirements test and validation matrix.

The Bidders should fully cover the requirements stated as "QUALIFICATORY REQUIREMENTS" designated by **"Qualificatory" (Q)**

2. TECHNICAL SPECIFICATIONS

Throughout the response to this section, the vendor must maintain the numbering scheme used and provide a response to every numbered requirement.

2.1 Platform

2.1.1 Architecture

2.1.1.1 **(Q)** Requirement to the software platform
The tool should be Windows based application, i.e. to run on contemporary Windows OS of type Windows 2000 or Windows XP.

2.1.1.2 Modular organisation of the tool
The tool shall be of modular organisation for easy upgrade and extension.
All modules shall be of Windows type application including help features. They shall be easily upgraded.

2.1.1.3 Common Data Repository
The tool shall store and retrieve its data on a common data repository. This common data repository is accessible by all users who have the appropriate access rights.

2.1.1.4 Back-up for Data
The common data repository shall have an automatic back-up facility. Back-up time intervals shall be configurable by the administrator.

2.1.1.5 **(Q)** Client/Server Solution
The software shall be supported in a client /server environment.

2.1.1.6 Wrapping of legacy tools
In order to interface to the legacy tools that are already used , the software platform should facilitate exchange of required information with that legacy tools.
This shall include the possibility to start the legacy tool from the platform GUI and to save the results in the common data repository.

2.1.1.7 Interface to Inventory Management System and OSS.
An interface to an IMS and OSS shall be provided. The vendor shall explain details of this interface and the synchronisation mechanism.

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2.1.2 System Requirements

2.1.2.1 Server
The vendor shall state the minimum configuration required for the server, in particular the following shall be included:
• Number of processors
• Processor speed
• Operating system shall be Windows 2000 or Windows XP
• RAM size
• Hard disk requirements (number, configuration, size)

Other requirements shall be stated clearly

2.1.2.2 Client PCs
The vendor shall state the minimum configuration required for the server, in particular the following shall be included:
• Processor speed
• Operating system shall be Windows 2000 or Windows XP
• RAM size
• Hard disk requirements

Other requirements shall be stated clearly

2.1.2.3 Network Connection
The vendor shall state the recommended configuration of the network connection to allow fast response times

2.2 Access Network Planning Tool

2.2.1 Multi Vendor Compliance

The tool shall be totally vendor independent and allow to conduct network planning for network elements of any system vendor. It shall also allow to model networks consisting of network elements from different vendors (mixed networks).

2.2.2 Network model

2.2.2.1 Market Segmentation

2.2.2.1.1 **(Q)** The user shall be able to define the bandwidth of the different services to be modelled

2.2.2.1.2 **(Q)** The user shall be able to define the nature of traffic (permanent/switched or packet)

2.2.2.1.3 **(Q)** The tool shall allow a customer Segmentation with respect to
• Customer classes
• Service mixes
• Tariffs, number of lines, usage, revenues (including time evolution through planning period)

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2.2.2.2 Technology Definition

2.2.2.2.1 **(Q)** The tool shall allow to specify an arbitrary network equipment. This shall include:
• Specification of interfaces and the different costs dependent on the IF type
• Technological constraints (e.g. bandwidth, distances, compression)
• Consideration of equipment and infrastructure cost evolution

2.2.2.2.2 **(Q)** The tool shall allow to model different network cost for
• Acquisition (procurement)
• Installation
• Maintenance (e.g. Leased Line costs)

2.2.2.2.3 **(Q)** The tool shall support different technologies like:
• POTS / ISDN
• xDSL
- DLC
• Fixed wireless Access
• PON
• Fast Ethernet / Gigabit Ethernet

2.2.3 Forecast

2.2.3.1 **(Q)** The user shall be able to select different forecast models

2.2.3.2 The tool shall support time series forecast

2.2.3.3 The tool shall support linear regression forecast

2.2.3.4 The tool shall support neural network forecast

2.2.4 Network Synthesis

2.2.4.1 **(Q)** With the inputs from the market (customers, services, densities, prices, etc) and the technology (network element details like interfaces, constraints, price) the tool shall perform an automated network design

2.2.4.2 **(Q)** The tool shall support multiple technologies for serving different service areas and customer sites

2.2.4.3 **(Q)** The user shall be able to manually fine tune the network

2.2.4.4 The results of the network synthesis shall be displayed in annual charts with details such as:
• number of interfaces
• cost figures per each element group (network and infrastructure)

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2.2.4.5 All data shall be displayed on the GIS

2.2.4.6 All data shall be exportable to MS Excel

2.2.5 GUI, Import / Export, Reports

2.2.5.1 **(Q)** The tool shall present an interactive Graphical User Interface for creating, editing and deleting with new and existing sites, links and nodes etc.

2.2.5.2 **(Q)** The GUI shall be based on a Geographical Information System (GIS)

2.2.5.3 **(Q)** The topology of the network has to be presented at the GUI in an easy and logical way, which makes it easy to get a quick overview of the network.

2.2.5.4 The user shall be able to click on an object to edit or obtain information.

2.2.5.5 The user shall be able to resize or zoom in and out of window panes.

2.2.5.6 The user shall be able to save and print the required work from the graphical view.

2.2.5.7 The user shall have the possibility to print the active window directly without the use of separate tools

• The tool shall allow to display results graphically on the GIS for each selected year with colorization of areas, diagrams and text labels.

2.2.5.8 **(Q)** The user shall be able to import/export several vector map formats, especially MapInfo and Esri.

2.2.5.9 **(Q)** The user shall be able to import various bitmap formats (gif, tiff, jpeg, etc.)

2.2.5.10 The tool shall support text file format for sites, service areas and market data (Interface ASCII file *.rif)

2.2.5.11 The tool shall support customer sites imported and exported from/to MS Excel

2.2.5.12 The tool shall support automatic import of customer sites, service areas and market data from GIS *tab (MapInfo)*, *shape (ESRI) and DGN* (Intergraph) files

2.2.5.13 The tool shall support the import of existing technologies, or potential equipment locations with their x/y positions

2.2.5.14 **(Q)** The tool shall generate reports on market data like:

• density,
• bandwidth,
• revenue,
• penetration,
• number of subscribers,
• number of lines,

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• bandwidth per service,
• revenue per customer class

2.2.5.15 **(Q)** The tool shall be able to generate reports on technology and network synthesis as described in the previous paragraphs

2.2.5.16 **(Q)** The tool shall be able to produce summary reports on:
• Revenue
• Cost
• Cash Flow
• Net Present Value for user defined interest rate
• Internal Rate of Return

2.2.5.17 All results shall be represented graphically on the GIS and also in charts and tables which can be exported to Microsoft Excel.

3. SUPPORT ISSUES, DOCUMENTATION, TRAINING AND MAINTENANCE

3.1 Technical Support

3.1.1 Types
The vendor shall state the type of technical support and assistance available during system warrantee period and there after.

3.1.2 Point of Contact
The vendor shall detail the single point of contact for technical support with name, telephone number, email address.

3.1.3 Response Times
Expected response times shall be indicated.

3.2 Documentation

3.2.1 Manuals

3.2.1.1 The vendor shall supply, for each site where the software will be installed, one complete set of printed user manuals and installation manuals.

3.2.1.2 These user manuals shall be updated with every new software release of the planning tools.

3.2.1.3 The language of the user manuals shall be English.

3.2.1.4 Soft copies of all user manuals shall be available to every user of the planning tools

3.2.2 Release Notes
Every new release of the software should be delivered together with release notes indicating the changes form the last version to the current version

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3.2.3 Known Problems List
Known defects and potential work-arounds of the software shall be made available to all users of the software.

3.3 Training

3.3.1 Training Package
The vendor shall submit the proposed training package that will ensure staff familiarity for all planning tools. The description of the training package shall include the duration of each training block and the recommended number of participants

3.3.2 Time Schedule
The vendor shall indicate the total time period that is necessary to conduct all training blocks.

3.3.3 Language
The training shall ensure at least the English language with other alternative languages as optional.

3.3.4 Training Documentation
Training Manuals shall be delivered for each training. The costs for the manuals shall be included in the total training costs.

3.3.5 Training Logistics
If training is in-house at Telecommunications Company 's premises, TC will provide the training room, presentation facilities and PCs necessary to conduct the trainings.

3.4 Maintenance

3.4.1 Software updates and upgrades

Software updates and upgrades shall be provided due to new functionalities within the tool and/or new equipment types incorporated in the network solutions.

The vendor shall detail his update/upgrade strategy and pricing.

Typically upgrade period shall be 6 months for quick evolution functionalities and one year for stable applications.

3.4.2 Defect Corrections

The vendor shall indicate the different defect categories and the response times to fix them. Critical defects shall be fixed within short time, e.g. from 1 day to 1 week.

4. ACCEPTANCE TEST PROCEDURES

The object of the test procedures is to verify that the tool guarantees compliance with:

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• all technical requirements specified in this RFP;

• all network elements' specifications (parameters and functionality).

The Supplier shall state acceptance of any additional tests required by the Telecommunications Company, in order to check the conformance of the Supplier's grade of compliance to the current RFP.

5. COMMERCIAL CONDITIONS

5.1. Licenses

The vendor shall submit the conditions and prices for each tool package with the corresponding options as a function of the number of tools, modules, number of users and response time to corrections for the defined Service Level Agreement.

5.2. Information required from the bidder

The Bidder should include for evaluation purposes the following:

• Experience in the telecommunications industry and list of customers;

• Company ownership, time in the business, financial status;

• Past history of the product and planned future development of the package, i.e. Road map for the evolution of the proposed solution;

• The proposed tool should be a proven solution, i.e. solution which is operational in other operator's network planning units.

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