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Deliverable D2.2

System Design and Implementation Plan

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Abstract: This Deliverable presents the overall system design and the implementation plan of the TEQUILA system. The tasks pertaining to the development of the TEQUILA system are identified, dimensioned in terms of resources and projected in time in the form of system releases. The implementation plan is a refinement of the WP2 plans compiled at the time of proposal. The refinements were made based on: the actual progress of the project as of the end of its first year (December 2000), the system functional model, algorithms and protocols as published in deliverables D1.1 and D1.2, and the overall system design (set of components and interfaces) as reported in this deliverable. A second version of this deliverable, due in April 2001, will augment the current version by elaborating on the detailed implementation design per sub-component of the entire TEQUILA system.

Keyword List: DiffServ, Intserv, Traffic Engineering (TE), Router, OSPF, RSVP, Network Management, Service Level Specifications (SLS), Monitoring, Performance Management, Policy Management.

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The TEQUILA Consortium consists of:

Alcatel	Co-ordinator	Belgium
Algosystems S.A.	Principal Contractor	Greece
FT-CNET	Principal Contractor	France
IMEC	Principal Contractor	Belgium
NTUA	Principal Contractor	Greece
RACAL/Global Crossing	Principal Contractor	United Kingdom
UCL	Principal Contractor	United Kingdom
TERENA	Assistant Contractor	The Netherlands
UniS	Principal Contractor	United Kingdom

Executive Summary

Following the functional specification of the TEQUILA system (D1.1) and its algorithms and protocols (D1.2), this report presents the overall system design and implementation plan of the TEQUILA project, leading to the development and delivery of the *TEQUILA system*.

The TEQUILA system has been decomposed into eight subsystems: *SLS Management, Traffic Engineering, Monitoring, Policy Management, Router, Customer, Testing* and *Simulation*. Each sub-system has been further decomposed into a set of components, which are further decomposed into implementable sub-components. Each component and set of sub-components has been allocated a number of tasks covering implementation design and subsequent development activities, interface specification, sub-component integration and testing. This detailed view of the TEQUILA system forms the overall system design.

The implementation plan covers the period January 2001 to June 2002 and is described in terms of:

- *List of tasks*: the tasks pertaining to the technical development of the TEQUILA system, their allocation to partners and the effort estimated for their accomplishment.
- *Gantt chart*: The time plan for carrying out the required implementation tasks, highlighting major milestones along the critical path as well as the planned releases of the system under development.
- *Resource plan*: The distribution of the required effort per partner and overall project per calendar month.

An analysis of the risks associated with system implementation is also included. Potential risks are identified, their likelihood and impact on the development is assessed and strategies for avoiding their occurrence and minimising their impact are described.

The implementation plan is a refinement of the WP2 plans compiled at the time of proposal. The refinements were made based on: the actual progress of the project as of the end of its first year (December 2000), the system functional model, algorithms and protocols as published in deliverables D1.1 and D1.2, and the overall system design (set of components and interfaces) as reported in this deliverable. The plan identifies a complete set of required implementation tasks and it dimensions them in terms of time and effort required.

By decomposing the overall system implementation into a set of well-defined (in terms of scope and expected results) tasks at a level where effort allocation per partner is justifiable, it is shown that the implementation of the TEQUILA system is feasible within the time and budget constraints of the project.

A second version of this deliverable, due in April 2001, will augment the current version by elaborating on the detailed implementation design per sub-component of the entire TEQUILA system.

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1 INTRODUCTION

1.1 TEQUILA Overview

TEQUILA's overall objective is to study, specify, implement and validate service definition and traffic engineering tools for the Internet. The TEQUILA system should provide qualitative and close to quantitative service guarantees through planning, dimensioning and dynamic control of qualitative traffic management techniques based on DiffServ. TEQUILA addresses static and dynamic, intra- and inter-domain Service Level Specifications (SLSs) for both fixed and nomadic users and the protocols and mechanisms for negotiating, monitoring and enforcing them. The other main dimension of the project studies intra- and inter-domain traffic engineering schemes to ensure that the network can cope with the contracted SLSs - within domains, and in the Internet at large.

The overall work in the TEQUILA project is split over 3 WorkPackages (WPs), and follows a phased approach: a theoretical phase followed by a refinement phase and then an experimentation and dissemination phase.

WP1, *Functional Architecture and Algorithms*, specifies the system architecture and related protocols and algorithms. WP2, *System Design and Implementation*, develops the system components and simulators. WP3, *Integration Validation, Assessment and Experimentation*, configures the testbeds and conducts experiments on the TEQUILA system through the testbed prototypes and the simulators.

1.2 Scope and Organisation of the Deliverable

This document is an important deliverable for the organisation of work in WP2. It defines the implementation view of the TEQUILA system and plans the development activities per task and per partner over time.

The reader should be familiar with the functional components of the TEQUILA system, which are described in Deliverables D1.1 and D1.2. Based on the functional and algorithmic view reported in those deliverables, this document presents the overall system design and implementation plan of the TEQUILA project. The plan is, basically, a detailed refinement of the WP2 plans compiled at the time of proposal, which are contained in the technical annex of the TEQUILA contract. The refinements were made according to the actual progress of the project as of the end of its first year, the main results of WP1, i.e. the specific system functional model, algorithms and protocols to be adopted by the project, and the overall system design (set of components and interfaces) as reported in this deliverable.

A second version of this deliverable, due in April 2001, will augment the current version by elaborating on the detailed implementation design per sub-component of the entire TEQUILA system.

The Deliverable is organised as follows:

Chapter 2 presents the overall system design by decomposing the system proposed by WP1 into eight sub-systems: *SLS Management, Traffic Engineering, Monitoring, Policy Management, Router, Customer, Testing* and *Simulation*.

Chapter 3 decomposes the sub-systems into a set of components, which are further decomposed into implementable sub-components. Each component and set of sub-components is allocated a number of tasks covering implementation design and subsequent development activities, interface specification, sub-component integration and testing. Each task is dimensioned in terms of human resources per partner.

Chapter 4 projects the implementation tasks in time, depicting also important milestones corresponding to system releases; note that a phased incremental approach has been adopted in developing the system.

Chapter 5 presents the resource plan in terms of the estimated effort per month, per partner.

Chapter 6 analyses the risks associated with the compiled plan. Potential risks are identified, their likelihood and impact on the system development are assessed and strategies for avoiding their occurrence and minimising their impact are drawn up.

2 TEQUILA SYSTEM ARCHITECTURE

From an implementation viewpoint, the TEQUILA system consists of the following sub-systems:

- *SLS Management* sub-system, which encompasses the following components:
  - *Service Subscription Management* (and associated GUI) responsible for handling service negotiations with customers through the TEQUILA-defined SrNP protocol.
  - *Router Service Invocation Management* is responsible for handling the server side of service invocations (via a modified RSVP protocol) and applying policy-based admission control according to monitored resource consumption.
  - *Traffic Forecast Management* which maps the set of service subscriptions to traffic predictions which form the main information flow from the SLS Management subsystem to the network dimensioning algorithms in the TE subsystem.
  - The *Service Subscriptions Repository* maintains a database of customers and their subscriptions in terms of the negotiated Service level Agreements.
  - A *Location and Customer Repository* responsible for maintaining information on customer network access capabilities and the mapping between physical locations and network edge nodes.
- *TE* sub-system, which is comprised of:
  - *Network Dimensioning (ND)* which is responsible for embedding the MPLS-based traffic engineering algorithms for determining QoS-based feasible trees of paths through the network according to the traffic predictions generated by SLS Management.
  - *Dynamic Route Management (DRtM)* which is a distributed, dynamic counterpart to ND, mapping trees to specific MPLS LSPs in the network and for load-balancing amongst multi-path LSPs.
  - *IP Traffic Engineering Management (IP-TEM)* which is responsible for IP-based traffic engineering through the management of link metrics per DSCP according to traffic predictions. This component combines the equivalent functionality of ND and DRtM and makes use of the COPS-PR framework.
  - *Dynamic Resource Management (DRsM)* is a distributed component which dynamically manages PHB-enforcement parameters (queue scheduling and buffer allocation) at each router. This component is applicable for both IP- and MPLS-based TE approaches.
  - *A TE GUI* for visualising the physical and logical network configuration and the activity of the TE components.
  - A *Network Topology and Resource Repository* component which maintains the database of network resources, their topological relationships with each other and their configuration. This component models that reference network configuration for the entire TE subsystem.
- *Monitoring* sub-system, which includes:
  - *Node Monitoring:* a distributed component responsible for implementing active monitoring agents and passive monitoring data collection from the nodes of the TEQUILA system. This component also undertakes statistical analysis with the scope of a single node.

- *Network Monitoring* is responsible for aggregating node statistics to calculate network-wide statistics on a range of performance parameters on behalf of its clients: the TE and SLS Management components.
- *SLS Monitoring* collects data from the ingress and egress nodes of the autonomous system for comparing and reporting on delivered performance versus that specified in the contracted SLSs.
- *A Monitoring Repository* which stores the gathered raw data as well as derived statistics at the node, network and SLS levels.
- The *Monitoring GUI* which is able to present monitored data and derived statistics in a graphical manner. This component is capable of displaying historical information as well as real-time measurements during experimental runs. This GUI will work with the main TEQUILA monitoring system while running on the physical testbeds as well as with the simulated (NS) network.

- *Policy Management* sub-system, encompassing:
  - A *Policy Management Tool and Storing Service* which allows the human network operator to define and store policies to be applied to the network and to the TEQUILA management and control algorithms. This component will validate the policies and assist with policy conflict resolution.
  - *Policy Consumer* instances which interpret and apply the defined policies, as stored in the policy storing service, to the other components of the SLS Management and TE subsystems. These components may be triggered by specific network conditions, through the services of the Monitoring subsystem, so that they, in turn, may apply appropriate policies for those conditions.
- *Router* sub-system, which consists of:
  - *Linux-based Routers* are being enhanced by the project to support the RSVP, MPLS, DiffServ, COPS and OSPF capabilities required by the TEQUILA system.
  - *IP Fast Translator NEs* have been enhanced by the project to support the fast switching of IP packets under the control of a Linux workstation. The router supports MPLS and IP layer switching with load balancing capabilities for multi-path LSPs.
  - The *Generic Adaptation Layer (GAL)* which provides a common, abstract view of the underlying routers to the rest of the TEQUILA system. The interface will allow the configuration and monitoring of the routers in a consistent way, which is independent of whether the node is a Cisco or experimental router (Linux-based PC or IFT). An instance of this component will be present for each node of the testbed. A set of interface drivers resides below the common GAL software to interface to the specific interfaces available on each node type (see below).
  - *Interface Drivers to Cisco Routers* communicate with the SNMP and CLI interfaces of the Cisco equipment and implement resource abstractions for the upper layer GAL software.
  - *Interface Drivers to Linux-based Routers* communicate with the SNMP and proprietary interfaces of the Linux PC-based routers developed by the project and implement resource abstractions for the upper layer GAL software.
  - *Interface Drivers to IFT Experimental Routers* communicate with the IP Fast Translator provided by FTR&D and enhanced by TEQUILA implement MPLS, IP forwarding and PHB resource abstractions for the upper layer GAL software.
- *Customer* sub-system, which includes:

- *Customer Service Subscription* components which implement the client side of the service negotiation process and a GUI to support experimenation and demonstration activities.
- *QoS Request Utility* components which provide an API to customer applications for invoking services through a modified RSVP protocol. These components are also capable of marking the packets generated by the application with appropriate DSCP values. This component will allow standard applications to make use of the TEQUILA system by intercepting traffic and invoking appropriate service invocation requests.

- *Testing* sub-system, which consists of:
  - A *Bulk Service Request Generator* which is capable of generating service subscriptions and invocations as well as traffic forecasts according to usage profile programmed through a GUI. This generator is an essential part of the TEQUILA experimental framework and will interface to Smartbits traffic generator tools in the project testbeds and to the NS and OPNET traffic generation scripts.
  - *Interface Drivers to Traffic Generation and Analysis Tools*: these drivers are needed to interface the above component to the traffic generation capabilities of the Smartbits equipment in the testbeds and the simulated traffic sources in OPNET and NS. Through this approach the same traffic and user profiles may be experimented with in both physical and simulated networks.
- *Simulation* sub-system, encompassing:
  - *NS Enhancements:* the project has taken the open source NS simulator and enhanced it with specific support for DiffServ, MPLS, dynamic PHB and LSP configuration, and DSCP-aware routing.
  - *TEQUILA Subsystem within NS.* The TE components described above are designed to work in the full TEQUILA system running on the project's testbeds. The intra-domain TE algorithms are also to be experimented with in a simulated environment to cater for traffic or network conditions which would otherwise be prohibitively expensive in the real testbeds, e.g. large network topologies. For this reason the dynamic algorithms for IP- and MPLS-TE need to be ported to run in the NS environment. Also the basic capabilities of the Monitoring subsystem needs to be present in NS to support the needs of the embedded TE algorithms.
  - *TEQUILA Subsystem offline NS.* The MPLS ND algorithms and initial weight calculation mechanisms of IP-TEM do not require a continuous interaction with the simulator during an experimental run. These algorithms can generate initial conditions and configurations which are then applied to NS through initial configuration scripts. For this reason these components may run offline when ported to the NS environment. In addition the Policy Consumer component may run offline to modify initial condition and operation parameters of the simulator according to the policies to be enforced.
  - *OPNET Enhancements:* OPNET is being used to experiment with inter-domain TE approaches in the TEQUILA project. OPNET is being enhanced with QoS-based features in its implementation of BGP routing algorithms and these capabilities are being driven by the contracted SLSs.

3 LIST OF TASKS

The tasks required to be undertaken for the development of the TEQUILA system are grouped per sub-system (cf. previous chapter) and named self-evidently after the components and/or algorithms/protocols identified in the system functional specification (cf. D1.2 [D1.2]). They are described in terms of:

- *Sub-tasks*; analysing further the work to be done for accomplishing the task; the sub-task analysis is at the granularity where direct correspondence with system specifications can be made (e.g. at the granularity of algorithms, interfaces).
- *Partner(s) involved*; a single partner is allocated to a sub-task.
- *Effort required*; the effort has been estimated based on the system functional specifications (cf. D1.2) and draws from previous project and professional experience.
- *Corresponding WP2 Activity*; for project management purposes.

It should be noted that although the tasks refer to the period 1/1/2001 to 30/6/2002, for completeness reasons, sub-tasks already accomplished are included. These sub-tasks are explicitly indicated.

The tasks are described in Table 1.

Task	Sub-tasks	Partner	Effort (PMs)	WP2 Activity
SLS Mgt Sub-system Tasks			**19.80**	
Service Subscription Management (SSM)			**6.95**	
	• Design and implementation of GUI and related abstractions	NTUA	3.00	AC2.4
	• Design and implementation of the server-side service negotiation protocol (SrNP) engine, message transport services and APIs	ALGO	0.95	AC2.4
	• Design and implementation of negotiation logic	ALGO	1.30	AC2.4
	• Design and implementation of interactions with the RSIM, SSRep components and components of the TE sub-system	ALGO	0.70	AC2.4
	• Integration of sub-components and stand-alone testing	NTUA	0.50	AC2.4
	• Support integration in testing environment and experimentation	NTUA	0.50	AC2.4
Router Service Invocation Management (RSIM)			**6.00**	
	• Design and implementation of mapping of Intserv-type of service requests (through RSVP) to TEQUILA SLS-based services	NTUA	1.25	AC2.4
	• Design and implementation of policy-based admission logic	NTUA	1.25	AC2.4
	• Design and implementation of resource-based admission logic	NTUA	1.25	AC2.4
	• Design and implementation of interactions with SSM, SSRep components and components of the TE and Router sub-systems	NTUA	0.50	AC2.4
	• Design and implementation of enhanced RSVP-based invocation procedure for invoking the TEQUILA SLS-based QoS services	NTUA	0.75	AC2.4
	• Integration of sub-components and stand-alone testing	NTUA	0.50	AC2.4
	• Support integration in testing environment and experimentation	NTUA	0.50	AC2.4
Traffic Forecast Management (TFM)			**5.00**	
	• Translation and extrapolation of service subscriptions to traffic predictions	ALGO	0.90	AC2.4
	• Aggregation per traffic trunk of traffic predictions over all service subscriptions	ALGO	1.65	AC2.4
	• Design and implementation of interactions with SSM, CustRep components and components of the TE and Policy sub-systems	ALGO	0.70	AC2.4
	• Integration of sub-components and stand-alone testing	ALGO	0.75	AC2.4
	• Support integration in testing environment and experimentation	ALGO	1.00	AC2.4
Service Subscriptions Repository (SSRep)			**1.00**	
	• Design and implementation of data abstractions, representing subscribers, their subscriptions and their constituent SLSs	NTUA	0.50	AC2.4
	• Design and implementation of storing and retrieval operations	NTUA	0.50	AC2.4
Location and Customer Repository (CustRep)			**0.85**	
	• Design and implementation of data abstractions, representing customer network access details and mapping locations to network edges	ALGO	0.40	AC2.4
	• Design and implementation of storing and retrieval operations	ALGO	0.45	AC2.4
TE Sub-system Tasks			**34.90**	
Network Dimensioning (ND)			**7.18**	
	• Design and implementation of minimum weight, hop count tree finding algorithm	ALGO	2.05	AC2.4
	• Design and implementation of network optimisation algorithm	ALGO	1.60	AC2.4
	• Design and implementation of interactions with other TE sub-system components and components of the SLS Mgt, Monitoring and Policy subsystems	ALGO	0.80	AC2.4
	• Integration of sub-components and stand-alone testing	ALGO	0.65	AC2.4
	• Support integration in testing environment and experimentation	ALGO	1.16	AC2.4
		ALGO	0.92	AC2.4

	• Implementation and testing of algorithmic improvements			
Dynamic Route Management (DRtM)			**5.44**	
	• Design and implementation of optimum load forwarding assignment algorithm	ALGO	0.80	AC2.4
	• Design and implementation of load forwarding reassignment algorithm on PHB and LSP performance updates/deterioration alarms	ALGO	1.30	AC2.4
	• Design and implementation of interactions with other TE sub-system components and components of the SLS Mgt, Monitoring, Policy and Router subsystems	ALGO	0.75	AC2.4
	• Integration of sub-components and stand-alone testing	ALGO	0.90	AC2.4
	• Support integration in testing environment and experimentation	ALGO	0.99	AC2.4
	• Implementation and testing of algorithmic improvements	ALGO	0.70	AC2.4
Dynamic Resource Management (DRsM)			**6.05**	
	• Design and implementation of bandwidth tracking algorithm	UCL	1.50	AC2.4
	• Design and implementation of link and buffer sharing algorithm	UCL	1.50	AC2.4
	• Design and implementation of interactions with other TE sub-system components and components of the Monitoring, Policy and Router sub-systems	ALGO	0.75	AC2.4
	• Integration of sub-components and stand-alone testing	UCL	0.80	AC2.4
	• Support integration in testing environment and experimentation	UCL	0.70	AC2.4
	• Implementation and testing of algorithmic improvements	UCL	0.80	AC2.4
IP TE Management (IPTEM)			**8.00**	
	• Design and implementation of the logic of the IP TE policy decision point (PDP) - design and implementation of link weight calculation algorithm	FTR&D	5.00	AC2.4
	• Design and implementation of interactions with other TE sub-system components and components of the SLS Mgt, Policy, Monitoring and Router subsystems	FTR&D	0.50	AC2.4
	• Integration of sub-components and stand-alone testing	FTR&D	1.40	AC2.4
	• Support integration in testing environment and experimentation	FTR&D	0.80	AC2.4
	• Implementation and testing of algorithmic improvements	FTR&D	0.30	AC2.4
TE-GUI			**4.38**	
	• Design and implementation of GUI and related abstractions	ALGO	1.95	AC2.4
	• Design and implementation of interactions with the TE sub-system components	ALGO	0.40	AC2.4
	• Integration of sub-components and stand-alone testing	ALGO	0.50	AC2.4
	• Support integration in testing environment and experimentation	ALGO	0.93	AC2.4
	• Support visualisation of TE algorithmic improvement	ALGO	0.60	AC2.4
Network Topology and Resource Repository (NetRep)			**3.85**	
	• Design and implementation of data abstractions representing physical network topology	UCL	0.70	AC2.4
	• Design and implementation of IP TE related policy information model (required logical resource abstractions and related configuration parameters e.g. link metrics)	FTR&D	2.00	AC2.4
	• Design and implementation of MPLS TE related policy information model (required logical resource abstractions and related configuration parameters e.g LSPs)	ALGO	0.80	AC2.4
	• Design and implementation of storing and retrieval operations	ALGO	0.35	AC2.4
Monitoring Sub-system Tasks			**29.40**	
Node Monitoring (NodeMon)			**8.40**	
	• Design and implementation of active monitoring agents for delay, loss and PHB metrics	IMEC	1.50	AC2.4
	• Design and implementation of passive LSP and SLS related traffic (throughput) monitoring on ingress/egress nodes	IMEC	2.00	AC2.4
	• Design and implementation of local performance management agent for short-term data analysis (e.g. EMWA)	IMEC	1.20	AC2.4

	• Support for threshold crossing event handling	IMEC	1.20	AC2.4
	• Design and implementation of interactions with the other Monitoring sub-system components and components of the Router sub-system	IMEC	0.80	AC2.4
	• Integration of sub-components and stand-alone testing	IMEC	0.55	AC2.4
	• Support integration in testing environment and experimentation	IMEC	1.15	AC2.4
Network Monitoring (NetMon)			**7.70**	
	• Design and implementation of NodeMon agents' configuration	GCX	1.70	AC2.4
	• Design and implementation of mechanisms for collecting and aggregating measurements from NodeMon agents	GCX	1.20	AC2.4
	• Support for threshold crossing event handling	GCX	0.50	AC2.4
	• Design and implementation of a centralised performance management agent (library for statistical functions)	GCX	1.65	AC2.4
	• Design and implementation of interactions with the other Monitoring sub-system components and components of the TE sub-system, including threshold crossing event handling	GCX	0.75	AC2.4
	• Integration of sub-components and stand-alone testing	GCX	1.00	AC2.4
	• Support integration in testing environment and experimentation	GCX	0.90	AC2.4
SLS Monitoring (SLSMon)			**8.40**	
	• Design and implementation of ingress/egress monitoring agents' configuration	GCX	1.30	AC2.4
	• Design and implementation of mechanisms for collecting and aggregating measurements from ingress/egress and NetMon monitoring agents	GCX	1.35	AC2.4
	• Design and implementation of a comparison algorithm for evaluating contracted SLSs against measured data	GCX	1.80	AC2.4
	• Design and implementation of a SLS performance report generator	GCX	1.70	AC2.4
	• Design and implementation of interactions with the other Monitoring sub-system components and components of the SLS Mgt sub-system	GCX	0.35	AC2.4
	• Integration of sub-components and stand-alone testing	GCX	1.00	AC2.4
	• Support integration in testing environment and experimentation	GCX	0.90	AC2.4
Monitoring Repository (MonRep)			**2.60**	
	• Design and implementation of data abstractions representing mass raw and analysed data measured by the NodeMon, NetMon and SLS Monitoring components	GCX	1.85	AC2.4
	• Design and implementation of storing and retrieval operations	GCX	1.75	AC2.4
Monitoring GUI (Mon-GUI)			**2.30**	
	• Design and implementation of GUI and related abstractions for graphical view of performance and traffic related measurements against time	GCX	1.55	AC2.4
	• Design and implementation of interactions with the NetRep component and the Monitoring sub-system components	GCX	0.30	AC2.4
	• Integration of sub-components and stand-alone testing	GCX	0.25	AC2.4
	• Support integration in testing environment and experimentation	GCX	0.20	AC2.4
Policy Mgt Sub-system Tasks			**5.80**	
Policy Management Tool and Storing Service (PolMTSS)			**1.80**	
	• Design and implementation of validation and conflict detection algorithms	UniS	0.50	AC2.4
	• Adaptation of directory access means for policy management	UniS	0.60	AC2.4
	• Integration of sub-components and stand-alone testing	UniS	0.20	AC2.4
	• Support integration in testing environment and experimentation	UniS	0.50	AC2.4
Policy Consumer (PolC)			**4.00**	
	• Interface design and implementation	UniS	0.80	AC2.4
	• Design and implementation of interpreter logic for ND, DRsM, DRtM and TFM components	UniS	1.60	AC2.4
	• Design and implementation of triggering logic	UniS	0.60	AC2.4

	• Integration with the rest components of the sub-system and stand-alone testing	UniS	0.50	AC2.4
	• Support integration in testing environment and experimentation	UniS	0.50	AC2.4
Router Sub-system Tasks			**34.90**	
Generic Adaptation Layer (GAL)			**3.75**	
	• Design and implementation of interfaces for configuring and monitoring the forwarding, routing, traffic conditioning and PHB enforcement capabilities of the network elements	NTUA	1.00	AC2.4
	• Design and implementation of data model abstracting NEs' resources/capabilities	NTUA	1.00	AC2.4
	• Integration with interface drivers and stand-alone testing	NTUA	1.00	AC2.4
	• Support integration in testing environment and experimentation	NTUA	0.75	AC2.4
Linux Enhancements (LinuxEnh)			**16.05**	
	• Enhancement of MPLS support with DiffServ capabilities (filling in the EXP filed, multiple table support, traffic control support)[1]	IMEC	0.75	AC2.3
	• Upgrading the MPLS/DiffServ capabilities and enhancements to the new Linux stable branch 2.4.x	IMEC	0.30	AC2.3
	• Updates of firewalling/socket/routing table selection rules to handle DSCP values	IMEC	0.10	AC2.3
	• Enhancements of Linux RSVP daemon to support RSVP-TE for (ER-)LSP set-up (add DSCP signalling support, automatic avoiding of RSVP PATH messages to follow its own LSP, add support for EXP field when forwarding, add FIB operations, multiple routing table support) [2]	IMEC	2.15	AC2.3
	• Functional interoperability and testing between Linux RSVP-TE enhancements and commercial equipment	IMEC	1.00	AC2.3
	• Enhancements of Linux RSVP daemon to support the invocation of the TEQUILA SLS-based QoS services (handling of TLVs representing TEQUILA SLSs)	NTUA	0.75	AC2.3
	• Design and implementation of TE extensions of OSPF in Linux-based routers (support for appropriate TLVs, modification of the SPF algorithm, development of QoS-based –per DSCP- LSDB and FIB)	FTR&D	6.00	AC2.4
	• Design and implementation of the configuration actions of IP TE client (PEP)	FTR&D	5.00	AC2.4
	(each of the above sub-tasks includes stand-alone testing and support in integration and experimentation in the testing environment)			
IFT Enhancements (IFTEnh)			**0.00**	
	• Counter allocation to look-up entries and counter reading	FTR&D	Done	AC2.3
	• Load-balancing	FTR&D	Done	AC2.3
	• MPLS header label and EXP field update	FTR&D	Done	AC2.3
	• Migration from Solaris to Linux	FTR&D	Done	AC2.3
Interface Drivers to Cisco Routers (IFD-cisco)			**4.25**	
	• Incorporation of communication means (SNMP, CLI) with the specific equipment	NTUA	0.75	AC2.4
	• Support in Cisco configuration commands through CLI and SNMP MIBs	GCX	1.75	AC2.4
	• Realisation of GAL resource abstractions (related to forwarding, traffic conditioning and PHB enforcement) according to the capabilities of the specific equipment	NTUA	1.25	AC2.4
	• Stand-alone testing with the specific equipment	NTUA	0.50	AC2.4
Interface Drivers to Linux-based Routers (IFD-linux)			**3.85**	
	• Incorporation of communication means (SNMP, CLI) with the specific equipment	IMEC	0.85	AC2.4

[1] Activity started from previous year

[2] Activity started from previous year

	• Realisation of GAL resource abstractions (related to forwarding, traffic conditioning and PHB enforcement) according to the capabilities of the specific equipment	IMEC	1.50	AC2.4
	• Stand-alone testing with the specific equipment	IMEC	1.50	AC2.4
Interface Drivers to IFT Experimental Router (IFD-ift)			**7.00**	
	• Realisation of MPLS forwarding GAL resource abstractions	FTR&D	2.00	AC2.4
	• Realisation of IP forwarding GAL resource abstractions	FTR&D	1.00	AC2.4
	• Realisation of traffic conditioning GAL resource abstractions through look-up chaining and switch fabric	FTR&D	2.00	AC2.4
	• Realisation of PHB enforcement GAL resource abstractions through switch fabric	FTR&D	1.00	AC2.4
	• Stand-lone testing with IFT	FTR&D	1.00	AC2.4
Customer Sub-system Tasks			**4.45**	
Customer Service Subscription (CSS)			**2.25**	
	• Design and implementation of GUI and related abstractions	NTUA	1.15	AC2.4
	• Design and implementation of the client-side service negotiation protocol (SrNP) engine, message transport services and API	NTUA	0.75	AC2.4
	• Integration of sub-components and stand-alone testing	NTUA	0.25	AC2.4
	• Support integration in testing environment and experimentation	NTUA	0.10	AC2.4
QoS Request Utility (QoSRU)			**2.20**	
	• Design and implementation of API for requesting TEQUILA SLS-based QoS services (according to subscriptions)-design and implementation of interactions with CSS component	NTUA	0.75	AC2.4
	• Enhancements of RSVP	NTUA	0.50	AC2.4
	• Adaptations to applications for using the enhanced DSCP-based invocation API	IMEC	0.45	AC2.4
	• Adaptations to applications for using the RSVP-based enhanced invocation API	NTUA	0.25	AC2.4
	• Support integration in testing environment and experimentation	NTUA	0.25	AC2.4
Testing Sub-system Tasks			**4.45**	
Bulk Service Request Generator (BSRGen)			**2.30**	
	• Design and implementation of GUI and related abstractions for generating service subscriptions and invocations	NTUA	0.75	AC2.5
	• Service subscriptions generation	NTUA	0.40	AC2.5
	• Service invocations generation	NTUA	0.35	AC2.5
	• Traffic forecasts' generation	ALGO	0.30	AC2.5
	• Uploading to the SLS Mgt/TE sub-systems, integration with traffic generation tool(s) and stand-alone testing	NTUA	0.25	AC2.5
	• Support integration in testing environment and experimentation	NTUA	0.25	AC2.5
Interface Drivers to Traffic Generation and Analysis Tools (IFD-TrfGen)			**2.15**	
	• Realisation of interface drivers to SmartBits test tool	GCX	1.00	AC2.5
	• Realisation of interface drivers to NS traffic generator	UCL	0.90	AC2.5
	• Realisation of interface drivers to OPNET traffic generator	ALCATEL	0.25	AC2.5
	(each of the above sub-tasks includes stand-alone testing and support in integration and experimentation in the testing environment)			
Simulation Sub-system Tasks			**19.83**	

NS Enhancements (NSEnh)			**3.70**	
	• DiffServ/MPLS integration and customisation[3]	UniS	0.90	AC2.2
	• Support for dynamic configuration of PHBs[4]	UCL	0.80	AC2.2
	• Support for dynamic configuration of LSPs[5]	UniS	0.60	AC2.2
	• Design and implementation of DSCP-aware routing (LSA modifications, LSDB and FIB modifications, modifications to SPF algorithm) [6]	UCL	1.40	AC2.2
	(each of the above sub-tasks includes stand-alone testing and support in integration and experimentation in the testing environment)			
TEQUILA Sub-system within NS (NS-in)			**4.50**	
	• Design and implementation of dynamic parts of MPLS/IP TE functionality for NS	UCL	1.80	AC2.2
	• Design and implementation of tracing and logging facilities	UniS	1.00	AC2.2
	• Integration of sub-components and stand-alone testing	UCL	0.60	AC2.2
	• Support integration in testing environment and experimentation	UCL	1.10	AC2.2
TEQUILA Sub-system offline NS (NS-off)			**6.50**	
	• Design and implementation of Network Topology Definition Tool	UniS	0.90	AC2.2
	• Design and implementation of Policy Consumer adaptations to NS	UniS	0.80	AC2.2
	• Design and implementation of static parts of MPLS/IP TE functionality for NS	UniS	2.90	AC2.2
	• Integration of sub-components and stand-alone testing	UniS	0.70	AC2.2
	• Support integration in testing environment and experimentation	UniS	1.20	AC2.2
OPNET Enhancements (OPNETEnh)			**5.13**	
	• Design and implementation of new BGP decision process for basic QoS route calculation[7]	ALCATEL	1.45	AC2.2
	• Design and implementation of BGP enhancements for advertisement of QoS information and route calculation	ALCATEL	2.10	AC2.2
	• SLS-driven QoS route calculation	ALCATEL	1.18	AC2.2
	• Support integration in testing environment and experimentation	ALCATEL	0.40	AC2.2
Common Tasks			**2.50**	
Directory Access Means			**1.00**	
	• Design and implementation of LDAP-like interface in CORBA	UniS	0.70	AC2.4
	• Stand-alone testing	UniS	0.30	AC2.4
COPS Implementation			**1.00**	
	• Survey of public COPS implementations	NTUA	0.25	AC2.4
	• Adaptations of COPS implementations and stand-alone testing	NTUA	0.75	AC2.4
Common communication infrastructure			**0.50**	
	• Adaptations of existing message oriented middle-ware over CORBA and stand-alone testing	IMEC	0.50	AC2.4

Table 1: List of implementation tasks.

[3] Activity started from previous year

[4] Activity started from previous year

[5] Activity started from previous year

[6] Activity started from previous year

[7] Activity started from previous year

Table 2 summarises the effort required per sub-system tasks.

Tasks	Effort
SLS Management sub-system tasks	19.80
TE sub-system tasks	34.90
Monitoring sub-system tasks	29.40
Policy Management sub-system tasks	5.80
Router sub-system tasks	34.90
Customer sub-system tasks	4.45
Testing sub-system tasks	4.45
Simulation sub-system tasks	19.83
Common tasks	2.50
Total	**156.03**

Table 2: Sub-system tasks

4 GANTT CHART

4.1 System Releases

The project has envisaged a *phased incremental approach* in releasing its system to facilitate integration, experimentation and allow experience from experimentation to be gained. Each release encompasses specific aspects of the functionality of the system and is further decomposed into a number of sub-releases as described in the following:

- The first release (R1) includes the components addressing the basic customer-network service subscription negotiation and invocation aspects and the basic enhancements of the network and simulation infrastructure. It proceeds through the following sub-releases:
  - ◊ R1.1: Components realising the NS enhancements.
  - ◊ R1.2: Components realising the basic BGP enhancements for QoS route calculation in the OPNET simulation environment.
  - ◊ R1.3: Components realising the enhancements of Linux-based routers and the IFT experimental router.
  - ◊ R1.4: Components realising the service negotiation protocol between customers and the network.
  - ◊ R1.5: Components realising the reception and translation of Intserv-type of service requests (through RSVP) to TEQUILA SLS-based services.
- The second release (R2) includes the revised components of R1 and the components addressing the intra-domain traffic engineering aspects, including monitoring and policy management, as well as the necessary test components. It proceeds through the following sub-releases:
  - ◊ R2.1: TE algorithms for NS simulation. The revised versions of NS enhancements of R1.1 will be included.
  - ◊ R2.2: Components related to the configuration of the enhanced network infrastructure (generic adaptation layer components and related interface drivers, network configuration components), components related to node and network monitoring, and related test components. The revised components of release R1.3 will be included.
  - ◊ R2.3: In addition to the R2.2 components, components related to network dimensioning (time-dependent TE functions) and policy management as well as related network resource configuration and test components. Note that the network dimensioning components will be the revised versions of the TE algorithms following experimentation with R2.1 in the NS simulation environment.
  - ◊ R2.4: In addition to the R2.3 components, components related to dynamic network (route and resource) management (state-dependent TE functions) and related test components. Note that the dynamic network management components will be the revised versions of the TE algorithms following experimentation with R2.1 in the NS simulation environment.
  - ◊ R2.5: Complete set of components for customer-network service subscription and invocation and intra-domain TE. These components will be the revised versions of the components of release R2.4 incorporating the interactions with the SLS Mgt sub-system and of releases R1.4 and R1.5 incorporating the negotiation logic and the policy-based and resource-based admission control logic respectively and their

interactions with the TE sub-system. In addition, this release will include components related to SLS monitoring and compilation of traffic forecasts.

- The third release (R3) includes
  - ◊ the full set of components realising the inter-domain TE aspects in the OPNET simulation environment (R3.1), and
  - ◊ enhancements in the corresponding SLS Mgt and TE sub-system components (of release R2.5) for realising the invocation (RSVP-based) of enhanced SLS-based QoS services and bi-directional services (R3.2).
- The fourth release (R4) includes all system components revised in terms of interfaces and internal logic through experimentation with the previous system releases. It proceeds through the following sub-releases:
  - ◊ R4.1: Final customer-network service subscription and invocation and intra-domain TE components. These components will be the revised versions of the components of release R2.5.
  - ◊ R4.2: Final NS simulation system components. These components will be the revised versions of the components of releases R2.1 and R2.5.
  - ◊ R4.3: Final OPNET simulation system components. These components will be the revised versions of the components of release R3.

Table 3 summarises the envisaged system releases with their due dates.

System Release	Description	Due Date
R1	Basic infrastructure enhancements and customer-network interactions	
R1.1	NS Enhancements	31/03/01
R1.2	OPNET basic BGP enhancements	31/03/01
R1.3	Linux and IFT enhancements	31/03/01
R1.4	Service Negotiation Protocol	30/04/01
R1.5	Intserv/DiffServ mapping	30/04/01
R2	Customer-network interactions and intra-domain TE	
R2.1	TE algorithms for NS	31/07/01
R2.2	Configuration and monitoring of enhanced network infrastructure	31/07/01
R2.3	Time-dependent TE and policy management	30/09/01
R2.4	State-dependent TE and policy management	31/10/01
R2.5	Customer-network service subscriptions, invocations, and intra-domain TE	30/11/01
R3	Inter-domain TE and enhanced QoS-based services	
R3.1	Complete inter-domain TE in OPNET	30/09/01
R3.2	Invocation of enhanced QoS services and bi-directional services	31/01/02
R4	Final system	
R4.1	Final customer-network service subscriptions, invocations and intra-domain TE	28/02/02
R4.2	Final Intra-domain TE system in NS	28/02/02
R4.2	Final inter-domain TE system in OPNET	28/02/02

Table 3: System releases.

Each of the above releases corresponds to a milestone in the implementation plan (see next section). With reference to the milestones M2.x included in the originally (at project proposal time) compiled WP2 plans:

- Milestone M2.2 (enhanced simulation tools, due end Jan. 2001) corresponds to system releases R1.1 and R1.2.
- Milestone M2.3 (enhanced routers, due end of March 2001) corresponds to the system release R1.3
- Milestone M2.4 (SLS user-network components implemented, due end of April 2001) corresponds to system releases R1.4, R1.5 and R3.2. In essence the originally put milestone M2.4 is decomposed into two milestones: one concerning uni-directional services and Intserv-type of services (R1.4, R1.5) and one concerning enhanced (TEQUILA SLS-based) QoS services and bi-directional services (R3.2). This decomposition is necessary considering the underlying complexity in the invocation procedure, which could not be foreseen at the time of proposal.
- Milestones M2.5/M2.8 (test tools release 1/final release, due end of April 2001/end of October 2001) become obsolete, as test tools are included in all system releases.
- Milestone M2.6 (initial set of intra-domain TE components implemented, due end of August 2001) is detailed into system releases R2.2, R2.3, R2.4 and R2.5. In essence, the originally put milestone M2.6 is decomposed into a number of other milestones (system releases) taking into account the detailed specifications and hierarchical nature of the architecture of the system, which could not known at the time of proposal.
- Milestone M2.7 (final delivery of simulation tools enhanced with TEQUILA algorithms, due end of Sept. 2000) corresponds to system releases R2.1 (intra-domain TE) and R3.1 (inter-domain TE).
- Milestone M2.9 (final TEQUILA system, due end Feb. 2002) corresponds to system releases R4.1, R4.2 and R4.3.

As it can be seen from the above mapping, there is no significant deviation from the original project plans. The implementation plan, built around the aforementioned system releases, details the original plan, in the light of actual work progress and knowledge of the details of system functionality and architecture, which could not be known at the time of proposal.

4.2 Time Plan

Figures 1-9 project in time the identified implementation tasks (cf. chapter 1), overall project (Figure 1) and per sub-system (Figures 2-9).

A number of milestones related to the system releases presented in the previous section are included. The milestones are set per sub-system tasks and correspond to epochs where the tasks contributing to a particular system release will be accomplished. The milestones are named following the convention:

<system release>-<contribution of the sub-system tasks to the release>

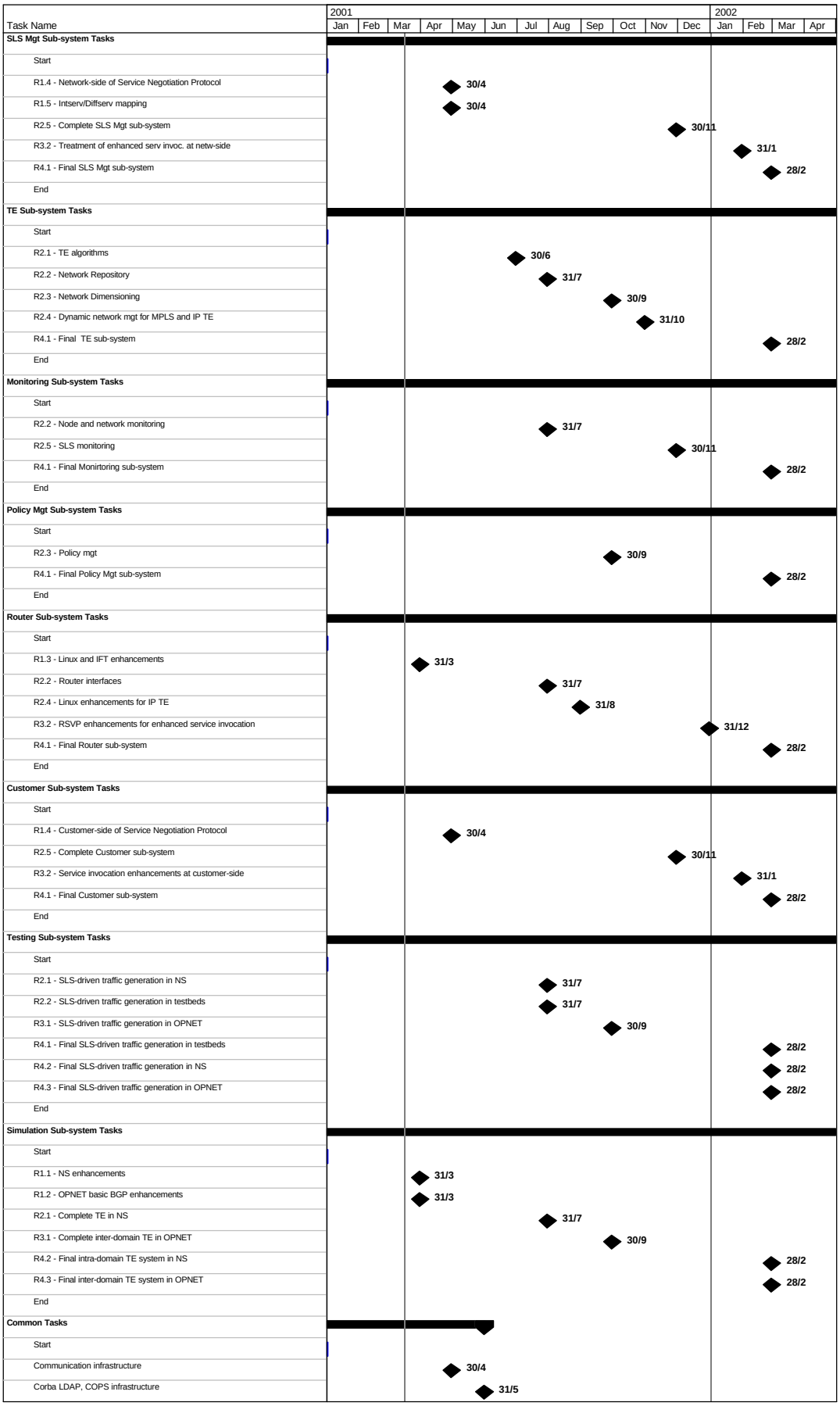

Figure 1: Overall plan and milestones.

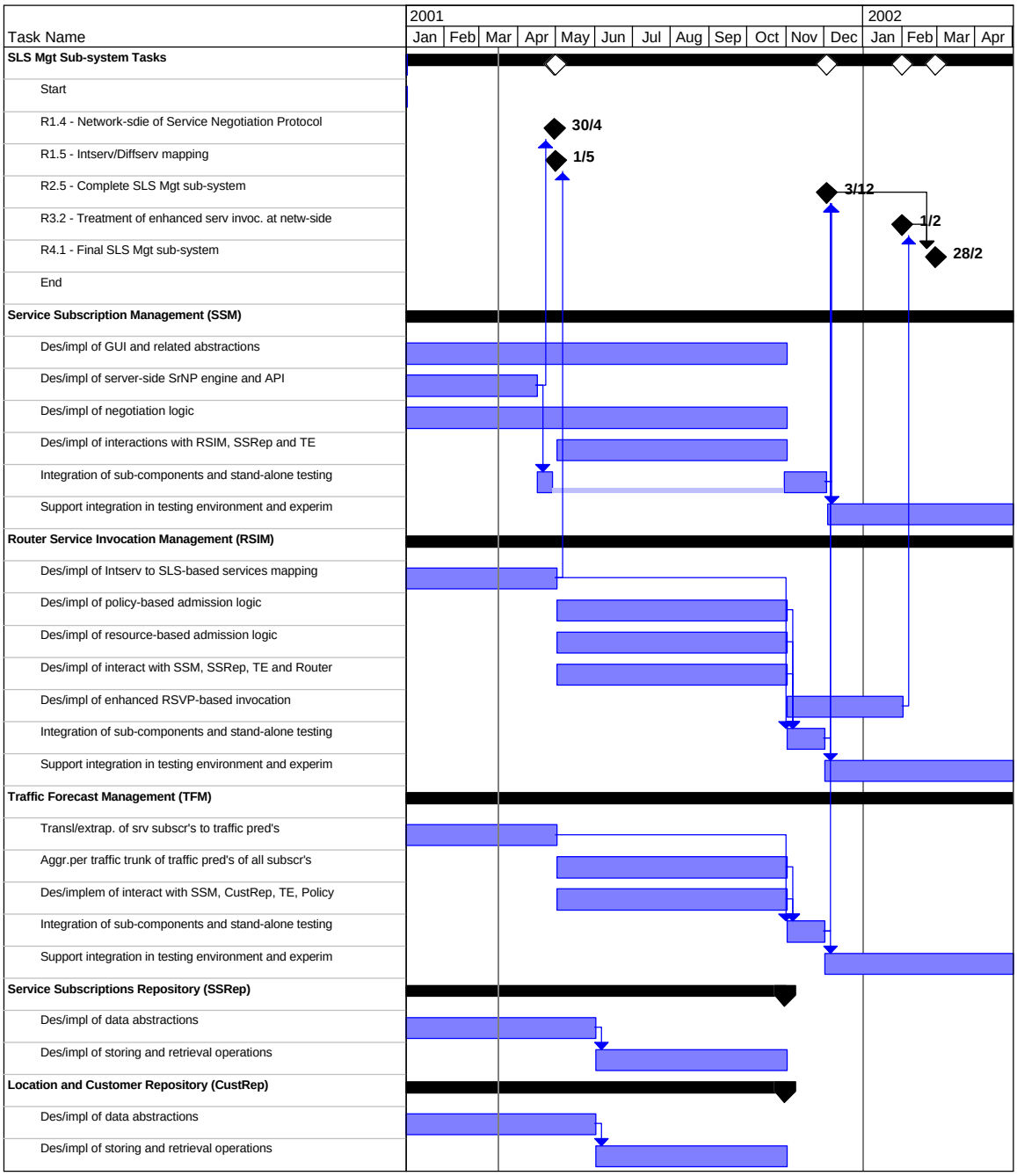

Figure 2: SLS Management sub-system plans.

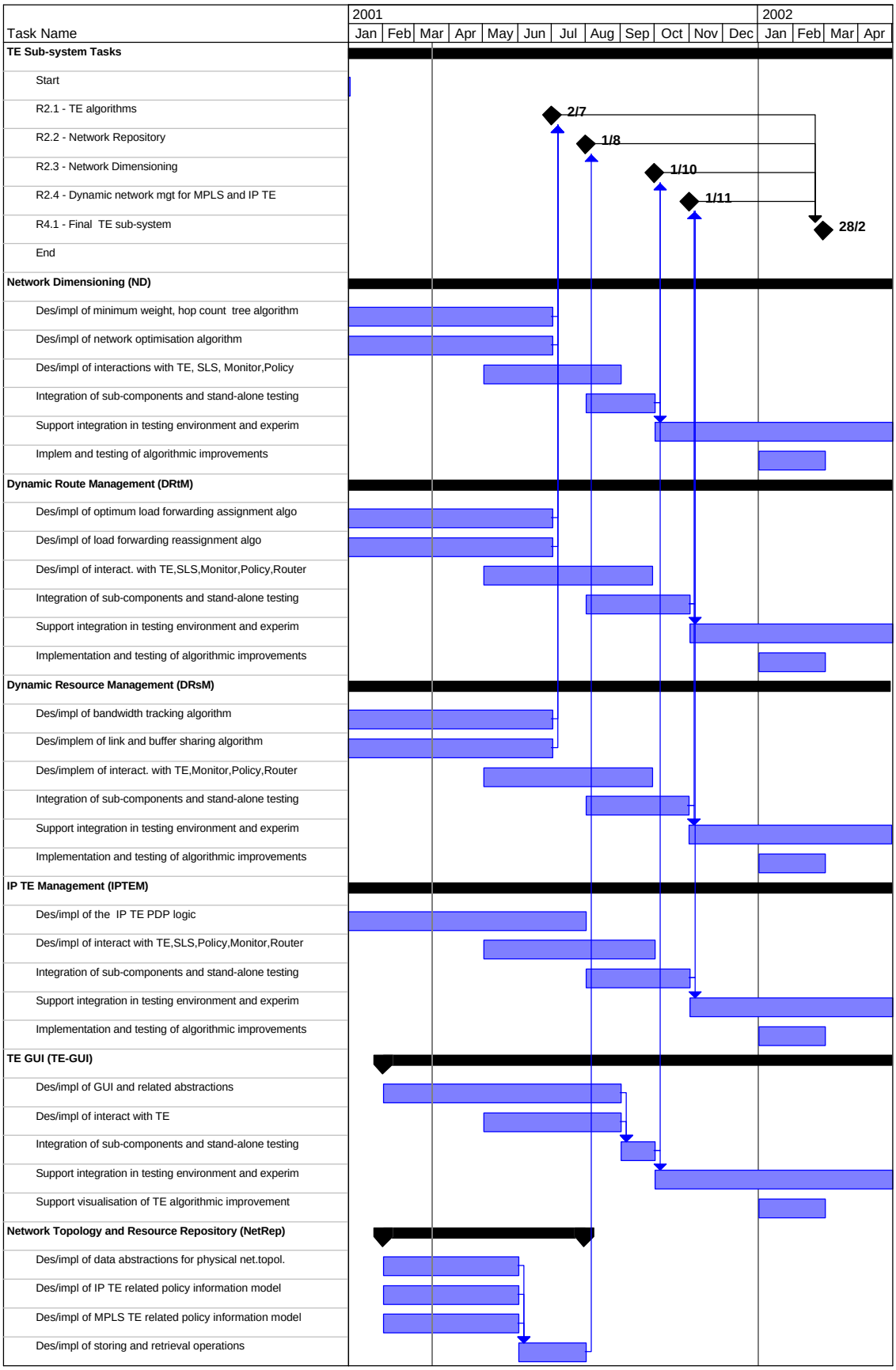

Figure 3: TE Sub-system plans.

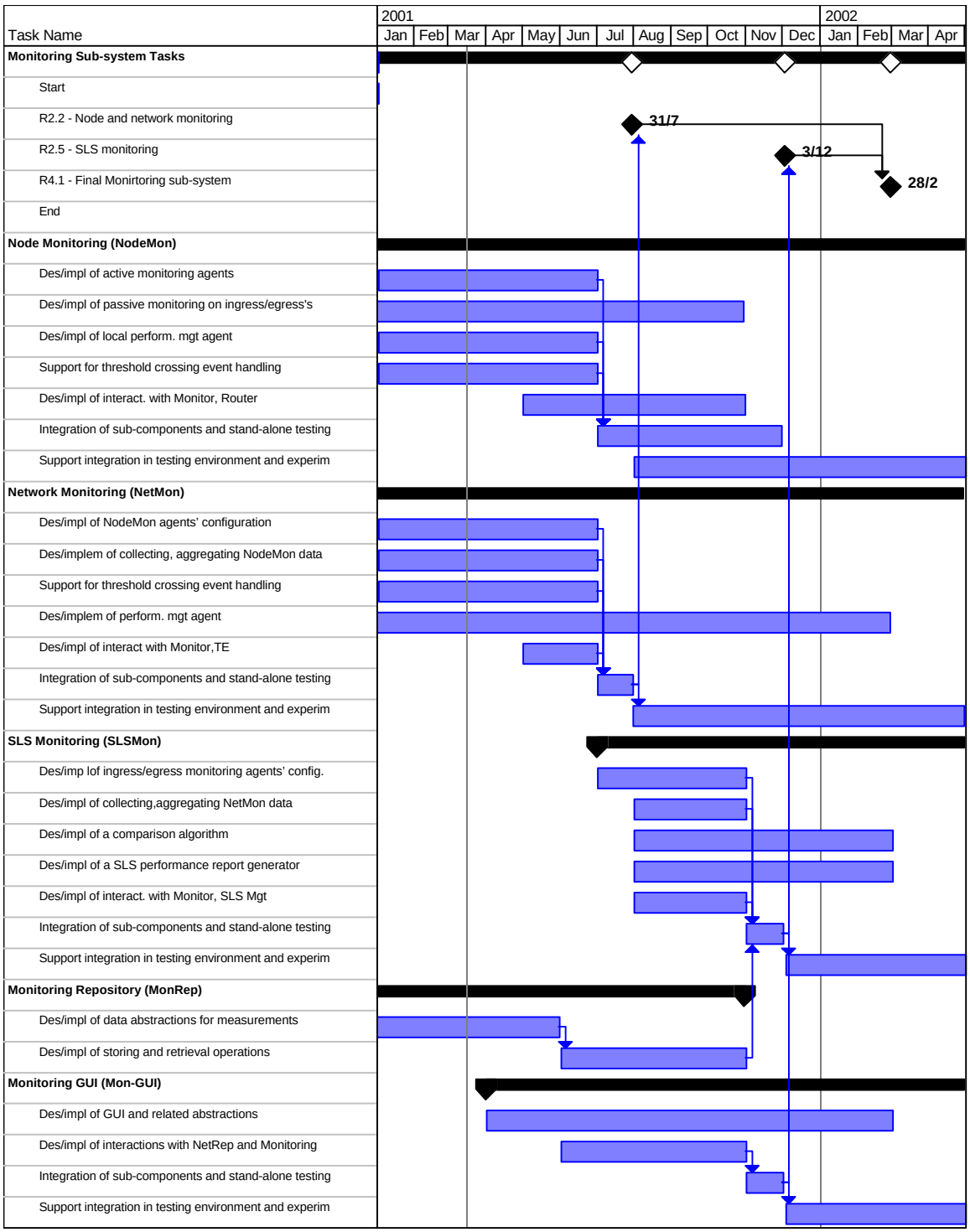

Figure 4: Monitoring sub-system plans.

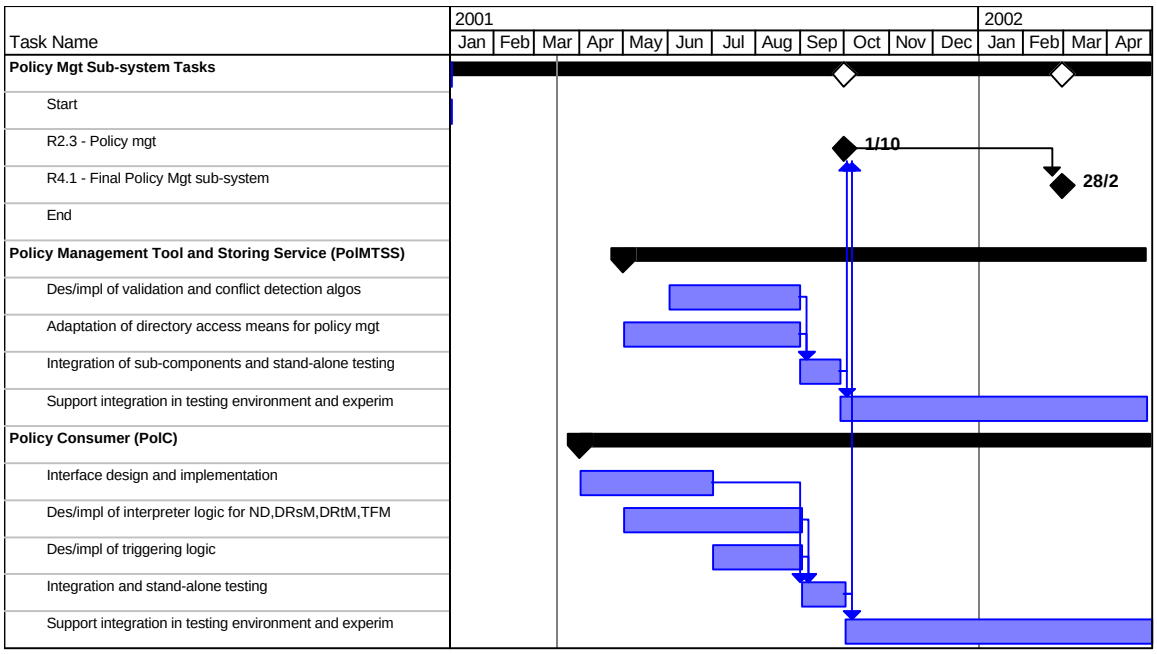

Figure 5: Policy Management sub-system tasks.

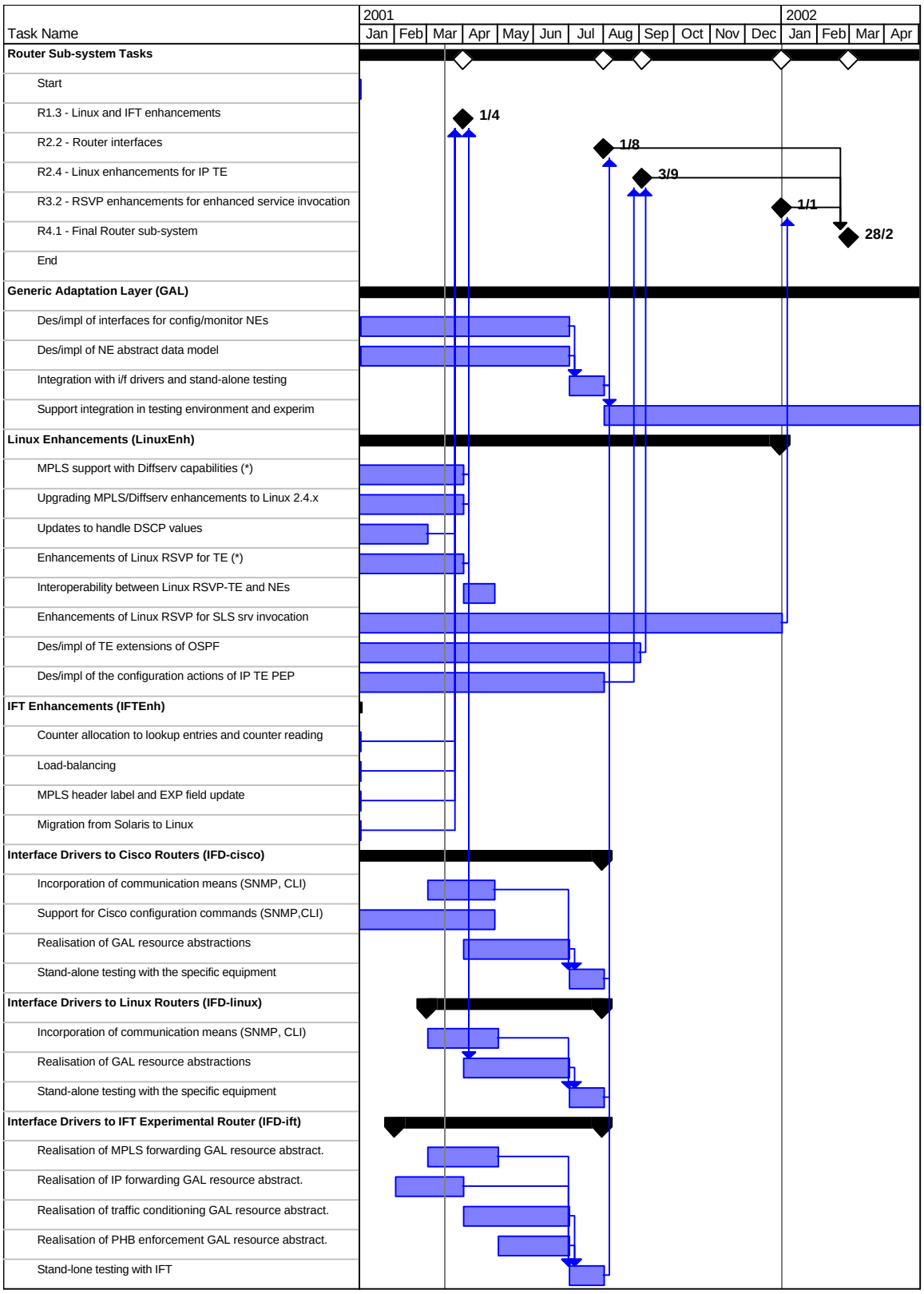

Figure 6: Router sub-system tasks.

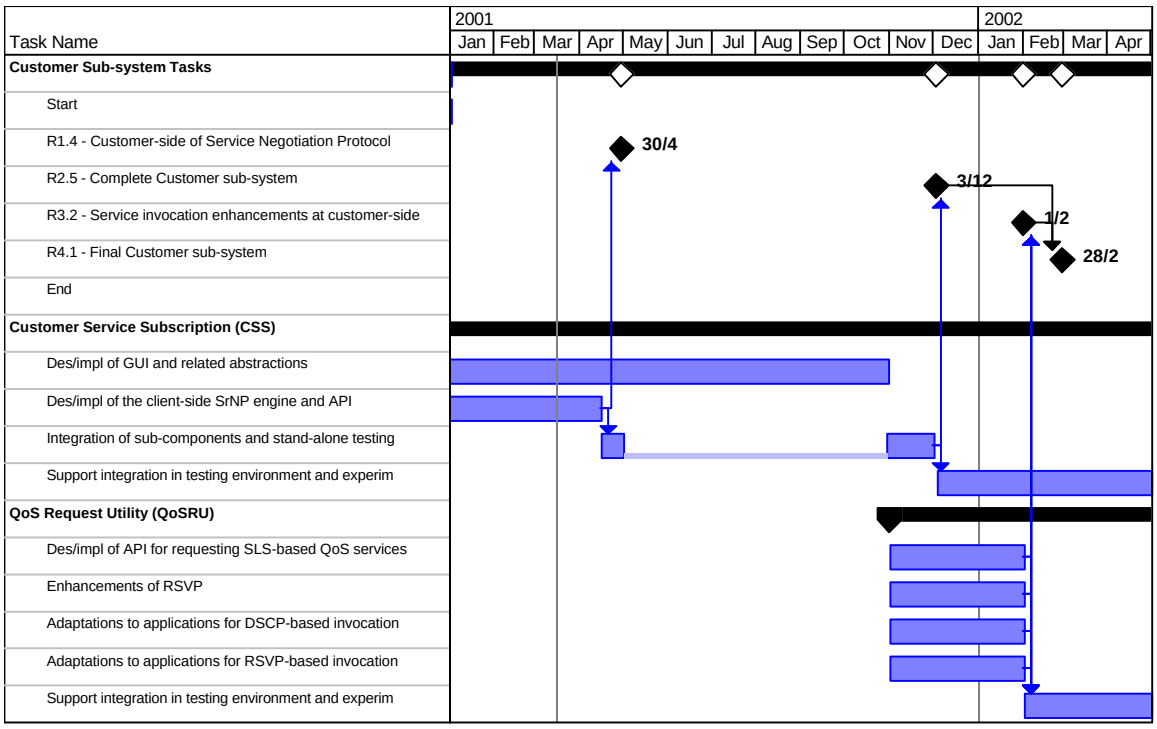

Figure 7: Customer sub-system tasks.

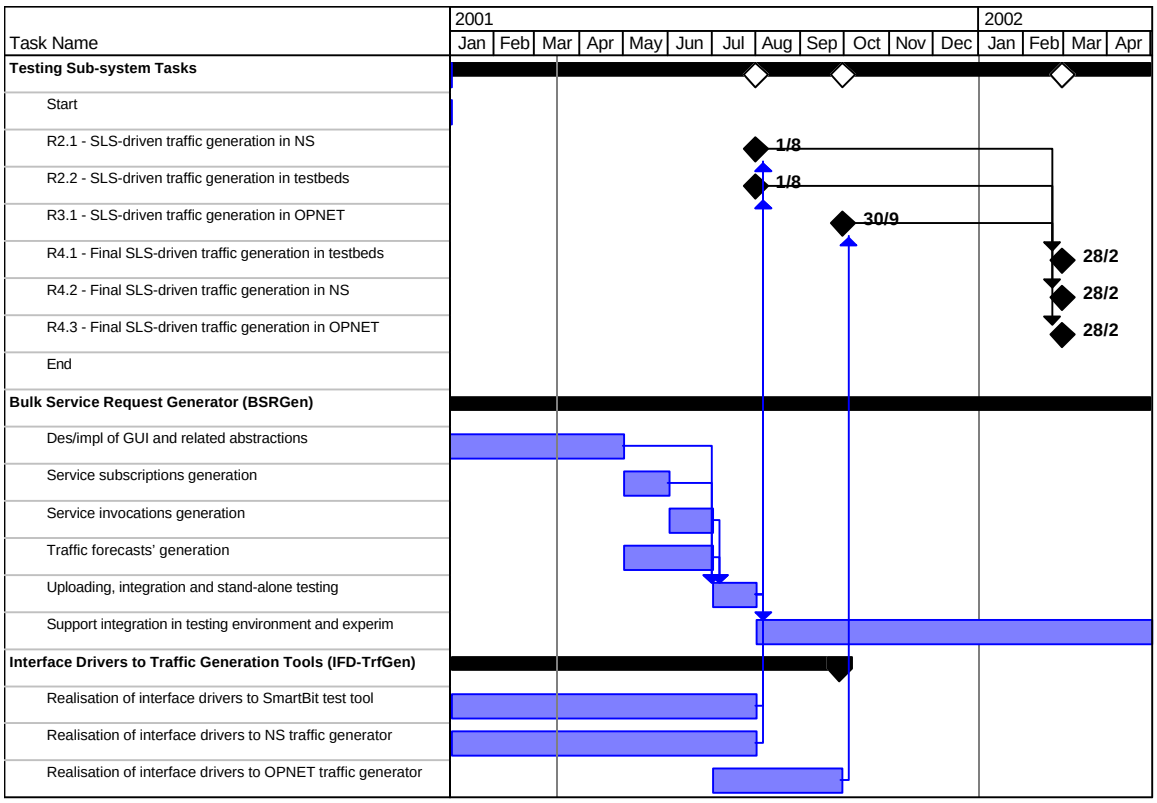

Figure 8: Testing sub-system tasks.

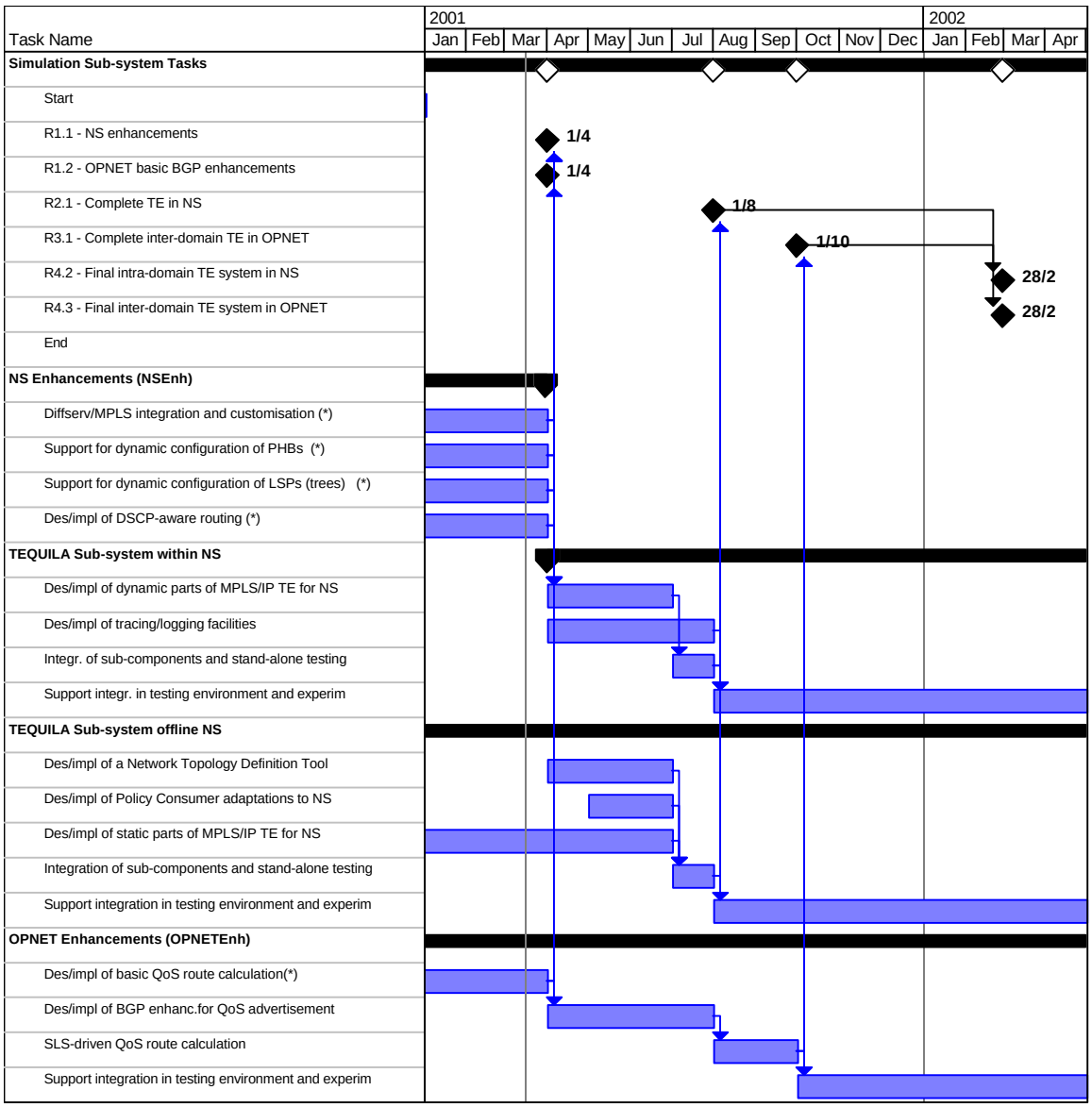

Figure 9: Simulation sub-system tasks.

5 RESOURCE PLAN

Table 4 depicts the required resources for accomplishing the implementation of the TEQUILA system per partner, per month.

	01/01	02/01	03/01	04/01	05/01	06/01	07/01	08/01	09/01	10/01	11/01	12/01	01/02	02/02	03/02	04/02	Total
ALCATEL	0,45	0,50	0,50	0,50	0,50	0,50	0,75	0,53	0,75	0,10	0,05	0,05	0,05	0,05	0,05	0,05	**5.38**
ALGO	2,00	2,00	2,00	2,00	2,30	2,35	2,35	1,85	2,35	2,30	1,50	1,00	1,63	1,53	0,42	0,42	**28.00**
FTR&D	0,00	0,50	5,20	5,30	4,90	4,10	4,00	1,70	0,70	0,50	0,25	0,25	0,25	0,25	0,05	0,05	**28.00**
IMEC	2,00	2,25	2,50	2,50	1,60	1,60	1,95	0,55	0,55	0,55	0,40	0,30	0,30	0,15	0,15	0,15	**17.50**
NTUA	1,82	1,92	2,27	2,81	2,56	2,26	2,41	1,02	1,30	1,40	1,47	1,35	1,23	0,58	0,30	0,30	**25.00**
GCX	1,50	1,50	1,50	1,50	1,50	1,75	1,75	1,50	1,75	1,75	1,75	1,65	1,65	1,50	0,60	0,60	**23.75**
UCL	1,20	1,30	1,30	1,50	1,40	1,50	1,00	0,50	0,40	0,40	0,30	0,20	0,60	0,60	0,20	0,20	**12.60**
TERENA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.00**
UniS	0,30	0,90	1,50	1,75	2,55	2,35	2,45	1,30	0,90	0,40	0,30	0,30	0,30	0,30	0,10	0,10	**15.80**
Total	**9,27**	**10,87**	**16,77**	**17,86**	**17,31**	**16,41**	**16,66**	**8,95**	**8,70**	**7,40**	**6,02**	**5,10**	**6,01**	**4,96**	**1,87**	**1,87**	**156.03**

Table 4: Resource plan.

Partners are committed to providing the effort specified in the above table, therefore guaranteeing the successful delivery of the implementation plan.

The effort required by partners according to the implementation plan is within bounds of the originally estimated (at time of proposal) effort for WP2 activities (Table 5). FTR&D, requiring an extra effort (15.5 MM), commit to providing the extra effort with no additional funding.

	WP2 planned effort	WP2 effort spent in PY1 (01/01/2000-31/12/2000)	Remaining planned WP2 effort	Required effort as from implementation plan
ALCATEL	19.00	13.62	5.38	5.38
ALGO	39.00	11.00	28.00	28.00
FTR&D	19.00	6.50	12.50	28.00
IMEC	25.00	7.50	17.50	17.50
NTUA	40.00	15.04	24.96	25.00
GCX	24.00	0.25	23.75	23.75
UCL	19.00	6.40	12.60	12.60
TERENA	0.00	0.00	0.00	0.00
UniS	20.00	6.20	13.80	15.80
Total	**205.00**	**66.51**	**138.49**	**156.03**

Table 5: WP2 planned and required effort per partner.

6 RISK ANALYSIS

Following the principles of risk management for software production [SOM01], this section presents the analysis of the risks associated with system implementation.

The risks are identified under the following headings:

- *technology risks*, which derive from the software and hardware technologies which are being used for developing the system,
- *people and organisational risks*, associated with the people and partner's organisations comprising the development team,
- *tools risks*, which derive from available software/hardware tools and external system components, which may be required for the development of the system,
- *requirements risks*, which derive from changes in the requirements that drove the objectives of the system to be developed and therefore of the project as a whole
- *estimation risks*, which derive from the specification of system functionality and the estimates of resources required to develop the system

Once the risks are identified, they are assessed in terms of their likelihood (subjective probability to occur) and their effect in system development. With respect to their likelihood, risks are qualified as:

- very low (occurrence probability less than 10%),
- low (occurrence probability between 10% and 25%)
- moderate (occurrence probability between 25% and 50%)
- high (occurrence probability between 50% and 75%)
- very high (occurrence probability greater than 75%)

With respect to their seriousness, risks are qualified as:

- catastrophic,
- serious,
- tolerable, or,
- insignificant.

Then, a suitable risk strategy is defined for avoiding and/or minimising the impact of the identified risks. Three types of strategies are sought for:

- avoidance strategies, targeting at reducing the likelihood of the risk,
- minimisation strategies, targeting at reducing the impact of the risk in system development, should the risk occurs,
- contingency strategies, targeting at finding a back-up solution should the worst happens.

Following the above lines, Table 6 depicts the risk analysis of the project implementation plan.

Risk	Likelihood	Effect	Strategy
Technology risks			
Software and hardware platforms	No risks.		System development is based upon software implementation technologies (CORBA, XML, C, C++, Java), hardware platforms (with Linux, Solaris, Windows/NT, Cisco IOS operating systems), which are professionally supported by their vendors and the people of the implementation team are familiar with.
People and organisational risks			
Recruitment	No risk.		Partners confirm they have the required resources according to the implementation plan (cf. Table 4)
Resource unavailability from a partner for a specific period	very low (partners are committed to the and they will exhaust the possibility of successful replacement)	tolerable	Avoidance strategy: N/A Minimisation strategy: Plan adjustment, which depending on the particular conditions may result in: Task reallocation amongst partners Later time delivery, provided that overall plan delivery is not seriously affected) Contingency strategy: (if overall plan delivery is seriously affected) Partner to seek sub-contractors Plan adjustment so that to Reallocate the task to other partners even at the expense of other tasks which are deemed less significant
Partner withdrawal	very low	Tolerable to serious, depending on partner	As previously
Tool's risks			
Non-availability of XML validators, SNMP agents, Lineo or Zebra implementation of OSPF in Linux	No risk.		There are implementations of the above tools available in the public domain.
Non-availability of Vovida (or other) implementation of COPS	moderate	tolerable	Avoidance strategy: An end-date (28/02/01) for surveying and deciding on the use of available implementations has been set in the plan. Task been allocated for providing a 'CORBA-rised' version of COPS in the case that an existing implementation cannot be found; if found, this task will be concerned with the adaptations required for using the implementations in the system Minimisation strategy: N/A Contingency strategy: N/A
Non-suitability of (the above) available tools.			Effort has been allocated in the tasks, which will be using the available tools in adapting them to the system environment. This risk entails the fact of finding the estimated effort to be less than the actual effort required for undertaking sufficiently the necessary adaptations. In this sense, this risk is considered as

			a special case of the risk 'Unrealistic effort estimates' of the 'Estimation risks' category, which is analysed below.
External system components	No risks.		The project does not rely on any component developed or to be developed by third parties, other than the tools generally available in the public, which presented above.
Requirements' risks			
Project objectives become obsolete	No risk.		The project deals with issues, which are widely recognised as open research topics and for which there is noted interest. The project is at the stage of initiating a WG (work group) in the IETF, which justifies the viability of project objectives.
Estimation risks			
Unforeseen complexity (in realising the specified system algorithms, protocols and interactions)	very low (system algorithms, protocols and interactions have been analysed and described in sufficient detail in D1.1, D1.2; work on system implementation is already under-way; system limitations and issues for further investigation have already been identified)	tolerable	Avoidance strategy: Project meetings (regular, ad-hoc) Progress report and review mechanisms already in place Minimisation strategy: Report complexity and analyse reasons (after all, considering the research nature of the project, this is regarded as a project result) Partner(s) to provide the extra effort required to ensure plans, however within contractual constraints Plan adjustment to realise the complexity, which depending on the particular conditions may result in: Task reallocation amongst partners Later time delivery, provided that overall plan delivery is not seriously affected) Drop realisation of the complexity, provided that overall plan delivery is not seriously affected Contingency strategy (if overall plan delivery is seriously affected) Plan adjustment, which depending on the particular conditions may result in: Task reallocation amongst partners even at the expense of other tasks which are deemed less significant Partner(s) to seek sub-contractors
Unrealistic effort estimates	very low (the implementation plan has been compiled by breaking down overall system development into a number of individual, well-defined sub-tasks, where the probability of effort miss-allocation is minimum, given partners' implementation experience)	tolerable	Avoidance strategy: Project meetings (regular, ad-hoc) Progress report and review mechanisms already in place Minimisation strategy: Partner(s) to provide the extra effort required to ensure plans, however within contractual constraints Plan adjustment, which depending on the particular conditions may result in: Task reallocation amongst partners Later time delivery, provided that overall plan delivery is not seriously affected) Contingency strategy (if overall plan delivery is seriously affected)

			Plan adjustment, which depending on the particular conditions may result in: Task reallocation amongst partners even at the expense of other tasks which are deemed less significant Partner(s) to seek sub-contractors

Table 6: Risk analysis.

It should be noted that based on the liaison, reporting and reviewing procedures already in place, the project will be regularly assessing each of the identified risks to decide whether or not they are being more or less probable and whether their effect has changed, rectifying accordingly the risk strategies.

7 REFERENCES

[D1.1] TEQUILA Project Deliverable D1.1, "*Functional Architecture Definition and Top Level Design*", July 2000

[D1.2] TEQUILA Project Deliverable D1.2, "*Protocol and Algorithm Specification*", January 2001

[D2.2v2] TEQUILA Project Deliverable D2.2, Version 2, "System Design and Implementation Plan – Version 2", to be released April 2001

[SOM01] I. Sommerville, "Software Engineering", 6th edition, 2001, Addison-Wesley, ISBN 020139815X

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