Managing e-Infrastructures successfully:
A strategic roadmap for federated service management
Document information:

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EXECUTIVE SUMMARY

The roadmap is the final and major output of the gSLM project, which has brought together experts from ITSM and e-Infrastructures to tackle some of the challenges in the management of e-Infrastructures. It is intended to assist all e-Infrastructure community members to make improvements to service management process and approaches. By introducing IT Service Management (ITSM) techniques, the impact of two decades of investment in e-Infrastructure can be consolidated and built upon.

Current e-Infrastructures face a number of challenges that threaten their ability to attract and retain users, make efficient use of resources, demonstrate value to funding bodies, compete with commercial computing services and adopt sustainable governance models and funding structures. We generalise a set of these issues into two challenges, that of user satisfaction (including reliability, quality of service guarantees, usability and user retention) and that of sustainability (including understanding impact and costs, integration and standards, extension to new communities and governance models).

We assert that ITSM can be effective in addressing the challenges in both these areas, specifically through the exploration and adoption of ideas, processes and approaches from traditional ITSM, frameworks such as ITIL and standards such as ISO/IEC 20000. Achieving this requires coordinated action by the many stakeholder groups involved, working in concert to bring about an overall change to how e-Infrastructures are managed.

At a policy level these actions can be seen as set of broad objectives, such as defined communication channels and cost awareness. How those objectives are achieved varies depending on the stakeholder is concerned. We provide specific recommendations for several main stakeholder groups, but these must be interpreted in light of specific situations.

At an operational level the same pattern applies. We propose a methodology based on traditional ITSM that can offer solutions to the challenges of e-Infrastructure service management. This methodology is fairly open since it must be applicable to a wide range of maturities and circumstances, but we provide links to supporting materials that will assist stakeholders in applying it. Using this approach we hope to improve the efficiency, attractiveness and sustainability of e-Infrastructures, and so contribute to the on-going revolution in digital science and research with all the benefits to society it brings.

The document has four core sections. Part 1 introduces the current challenges and proposes ITSM as a solution. Part 2 provides policy level recommendations aimed at introducing ITSM. Part 3 introduces the building blocks developed by gSLM to understand e-Infrastructure SLM maturity. Part 4 gives an outline plan that can be used by operational e-Infrastructures to introduce ITSM, and ends with a conclusion to the roadmap. Because the document addresses many different stakeholder groups, the table of contents is followed by a short explanation of how to use the document that indicates which sections will be of interest to which groups.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Summary</td>
<td>2</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>3</td>
</tr>
<tr>
<td>About this document</td>
<td>4</td>
</tr>
<tr>
<td>1. Context &amp; Introduction</td>
<td>5</td>
</tr>
<tr>
<td>1.1. Digital science and collaboration</td>
<td>5</td>
</tr>
<tr>
<td>1.2. e-Infrastructure today</td>
<td>6</td>
</tr>
<tr>
<td>1.3. Problems and challenges</td>
<td>7</td>
</tr>
<tr>
<td>1.4. IT Service Management and e-Infrastructure</td>
<td>9</td>
</tr>
<tr>
<td>1.5. Basis of recommendations</td>
<td>10</td>
</tr>
<tr>
<td>1.6. Expected impact of the roadmap</td>
<td>11</td>
</tr>
<tr>
<td>1.7. Conclusion</td>
<td>11</td>
</tr>
<tr>
<td>2. Policy Level Recommendations</td>
<td>12</td>
</tr>
<tr>
<td>2.1. Introduction</td>
<td>12</td>
</tr>
<tr>
<td>2.2. Actors and groups</td>
<td>12</td>
</tr>
<tr>
<td>2.3. Objectives in introducing service management</td>
<td>13</td>
</tr>
<tr>
<td>2.4. Recommendations for specific target groups</td>
<td>18</td>
</tr>
<tr>
<td>2.5. Conclusions</td>
<td>24</td>
</tr>
<tr>
<td>3. Building Blocks and methodology</td>
<td>25</td>
</tr>
<tr>
<td>3.1. Understanding and developing Grid and e-Infrastructure SLM and SDM</td>
<td>25</td>
</tr>
<tr>
<td>3.2. Matching infrastructure and SLM maturity</td>
<td>34</td>
</tr>
<tr>
<td>4. Guide for Federators and e-infrastructure providers</td>
<td>43</td>
</tr>
<tr>
<td>4.1. Introduction</td>
<td>43</td>
</tr>
<tr>
<td>4.2. Phase 1: Understand the baseline/current situation (Where are we now?)</td>
<td>44</td>
</tr>
<tr>
<td>4.3. Phase 2: Identify the need &amp; develop a vision (Where do we want to be?)</td>
<td>49</td>
</tr>
<tr>
<td>4.4. Phase 3: Define the progression stages (How do we get there?)</td>
<td>52</td>
</tr>
<tr>
<td>4.5. Phase 4: Develop and execute processes and procedures</td>
<td>53</td>
</tr>
<tr>
<td>4.6. Phase 5: Continual review and improvement (Did we achieve our goals?)</td>
<td>58</td>
</tr>
<tr>
<td>4.7. Summary: All phases and steps</td>
<td>61</td>
</tr>
<tr>
<td>5. Conclusions</td>
<td>62</td>
</tr>
<tr>
<td>6. References</td>
<td>65</td>
</tr>
</tbody>
</table>
ABOUT THIS DOCUMENT

This document aims to serve a range of different actors and stakeholder groups across a diverse community. In addition it is intended to be a practical document that can be read as a whole or used for guidance on specific topics by different groups. As a result it has a somewhat complex structure that bears explanation. Unless you have already dealt with the topics presented here we urge all groups to read the introduction, after which you may continue through the document or jump to the sections that apply to your individual case. Figure 1.1 summarises these sections.

Part 1: Context

Read this if you:
- Want context on e-infrastructure
- Want to understand why ITSM is of interest
- Want to understand our approach

Skip this if you:
- Understand e-infrastructure and know service management needs improvement

Content:
- Background on e-infrastructure
- Current challenges
- ITSM as a solution
- Expected impact
- Basis for recommendations

Primary Audiences:
All stakeholders

Part 2: Policy Level Recommendations

Read this if you:
- Work at a policy level
- Want to understand what strategies can improve service management in e-infrastructures
- Work in an operational role, but want context on why changes are needed

Skip this if you:
- Only want operational information

Content:
- How service management addresses e-infrastructure challenges
- Brief actor model
- Global objectives for improving service management in federated e-infrastructures
- Recommendations for all stakeholders to achieve these objectives

Primary Audiences:
- Policy makers
- Senior managers at e-infrastructures
- Directors at resource centres
- User representatives

Part 3: Building Blocks and methodology

Read this if you:
- Need to make operational changes to introduce ITSM to an e-infrastructure
- Need to simplify and understand complex e-infrastructure interactions
- Want to understand the methodology used in this document

Skip this if you:
- Are interested in policies but not a detailed approach for implementation
- Don’t need background and just want the guidance

Content:
- Defining Service Management
- A model for actors and a set of terminology
- A use case based model of ITSM processes
- General and per-use-case maturity levels
- Requirements for each use case maturity level
- Maturity assessment systems

Primary Audiences:
- Operations managers at e-infrastructures
- Operations managers at resource centres

Part 4: Guide for Federators and e-Infrastructure providers

Read this if you:
- Need to make operational changes to introduce ITSM to an e-infrastructure
- Need to apply ITSM concepts and approaches to your particular situation

Skip this if you:
- Are interested in policies but not a detailed approach for implementation

Content:
- Phase based approach to changing operational infrastructures
- Generic step-by-step approach that you can apply to your individual situation
- Links to guidance and support for the process from qSLM, external standards and ITSM frameworks

Primary Audiences:
- Operations managers at e-infrastructures
- Operations managers at resource centres

Figure 1.1: How to read this document – Overview
1. CONTEXT & INTRODUCTION

1.1. DIGITAL SCIENCE AND COLLABORATION

Over the last forty years, scientific and technical research has undergone a revolution in its community patterns and practices. While academia has long promoted collaboration and cooperation between specialists in different locations, modern technology and increasing specialism have lead to unprecedented growth in this remote collaboration. Communities of practice on new topics and ideas may be formed from researchers in dozens of countries, separated by language, culture and background but working toward common goals. This sort of interaction has been promoted by cultural, economic and scientific unions such as the European Union, as well as being supported by new kinds of technological platforms and services. As email brought instant communication to the research community over the last twenty years, online databases of information from genomes to biodiversity data and material properties are transforming how research is carried out. From a starting point of connecting researchers and providing them with common tools, technology is now enabling active, real-time collaboration across topics and time zones in a way that allows for a whole new research paradigm.

Contemporary science is increasingly organised into these large-scale collaborative projects or experiments, which include many hundreds or thousands of participants. These then require large international collaborations and imply engineering challenges for those supporting them. Such collaborations include the High Energy Physics collaboration around the Large Hadron Collider and its experiments, international genome sequencing efforts or large-scale astrophysics facilities such as the forthcoming Square Kilometre Array.

In parallel, increasing amounts of data that was previously paper-based is being digitised, while automated instruments are providing 24-hour streams of data on every imaginable subject. This ‘data deluge’ combined with changing practices has fed the phenomenal growth and success of digital science, and given rise to a new challenge: how best to capitalize on these new sources of information.

Supporting scientists have not been blind to these developments, and many efforts have been made to provide the structures over which these new patterns of research can operate, and the tools to help guide the deluge of data toward useful endpoints. Many technologies have been developed and tested, leading to a landscape of electronic infrastructure – e-Infrastructures – that seek in different ways to enable, facilitate and support
excellent digital science. These range from single-subject research infrastructures to large-scale multi-subject, geographically distributed computing infrastructures.

Many if not most e-Infrastructures are in some way federated – bringing together resources of some sort from multiple geographical locations and administrative domains, from disparate research groups, and integrating everything from computers owned by members of the public to national or regional computing systems. These are complex systems that serve demanding and diverse users, and their design and development has been a complex process.

1.2. E-INFRASTRUCTURE TODAY

Current e-Infrastructures and their precursors have made use of many different technologies, and gone through several evolutions to reach a relatively stable state. They have developed from both specialised, subject-specific systems and from very broad generic ones that are now meeting in a middle group, where there is a vision of interoperable services from many sources that can be integrated or blended to serve new purposes.

Basic, generic infrastructures include European networking systems like the GEANT research network, which connects the vast majority of Europe’s research sector. GEANT enabled more than 40 million researchers to connect to their counterparts worldwide. This network layer has been extended with a service layer built on top of it, through technologies like High Performance Computing (HPC) and Grid computing, which allow different kinds of resource aggregation and federation over the network layer. These developments have been largely academic, while the commercial sector builds generic solutions such as Cloud computing over commercial data networks. These generic systems are available to all but are not necessarily optimised for any specific use.

Subject-specific services have also been constructed, often starting from in-house or custom systems that are later modified to operate over more open systems. Many of these are now known as “Research Infrastructures” (RIs) and are, for instance, tied to specific large-scale instruments or experiments.

At present, these different approaches are attempting to integrate and interoperate with various levels of success. On a technical level, work is quite advanced in blending generic and specialist solutions, commercial and academic approaches. If not complete, solutions are at least understood and can be worked towards. Many of the remaining unresolved challenges are in the area of non-technical factors in e-Infrastructures. These include funding models, standards, management structures, legal issues and other ‘soft’ factors. Whatever the technical excellence of these systems, ignoring problems with these soft factors could result in a loss of potential or even in the failure of an otherwise successful set of services.

In the current landscape, the primary academic computing e-Infrastructures built over the GEANT network are the European HPC community, united by the PRACE project series and the European Grid community, coordinated by the European Grid. PRACE and EGI two cooperate, as well as working with peers in Asia and the Americas. They also support the development of e-Infrastructures in Africa. In comparison, the cloud computing community is led by commercial vendors, but efforts to integrate them into scientific e-Infrastructures are in process, from open source implementations such as OpenNebula and Eucalyptus through to the Helix Nebula science cloud initiative.

In parallel, various user communities have formed so-called Research Infrastructures (RIs) around specific subjects or instruments that have come together through ESFRI, the European Strategy Forum on Research Infrastructures. These drive the requirements of e-Infrastructure as they represent large, well-organised user communities. Some, such as the wLCG-computing Grid which supports the Large Hadron Collider, are closely tied to an existing e-Infrastructure, in this case EGI. Others are based on in-house technologies but all have large and complex requirements for services. Looking only at the volumes of data produced, the LOFAR radio
astronomy facility in the Netherlands predicts production of 20 petabytes (pb) of data in the next five years, wLCG deals with around 15pb per year, and the forthcoming Square Kilometre Array is expected to produce up to an Exabyte of raw data each day once in operation [1].

These various groups are loosely coordinated through bodies such as the European Commission, which contributes funding to many of these structures, but they remain disparate, both technologically and to a much greater degree in terms of ‘soft’ i.e. non-technical factors. As these many groups struggle to find an effective way to fit together into a pan-European e-Infrastructure landscape, and to work with new areas such as “Big Data” and data infrastructures, we appear to have reached a tipping point where technology is not the major barrier to integration and development. Rather, approaches to bringing management and funding structures together, to tackling legal issues and to achieving truly accepted standards are urgently needed. In many cases, the academic background of stakeholders has meant that there has been less focus on these ‘soft’ factors, and that there is now less institutional expertise than is needed. However, these situations are complex and what works for commercial providers cannot simply be adopted. New approaches are required to continue the evolution of e-Infrastructure from novel systems to the de-facto platform for European digital science.

1.3. PROBLEMS AND CHALLENGES

Notwithstanding their technical excellence and strong communities, European e-Infrastructures face a number of challenges and issues, notably involving the soft factors identified above that make e-Infrastructures available and attractive to users and contribute importantly to their long term viability. Soft factors were less obviously important during the earlier development process, but as the overall e-Infrastructure ecosystem has grown, so has their impact, to the point where a lack of solutions is inhibiting overall development.

A large number of these issues can be described in the context of a) a ‘user satisfaction challenge’ and b) a ‘sustainability challenge’, as illustrated in Figure 1.2.

We might generalize many of these soft factors as problems in providing a defined Quality of Service (QoS), a description which underlies many aspects of the user satisfaction challenge. While delivering computer capacity is quite achievable, delivering QoS remains a challenge. The current trend towards large-scale experiments as opposed to discrete research projects has put pressure on IT systems that were often built by the latter but must now support and allow access to much bigger and more complex scientific collaborations. It is no longer sufficient for scientists to wait an unknown amount of time to complete computations before analysing data and describing it in a scientific paper. Rather, data processing is increasingly aligned with tightly defined boundaries of experimental schedules, to provide results needed for subsequent stages of analysis or another experimental run. Results are also more tightly connected with the cost of each phase of the experiment.

Large-scale collaboration also means that the work of thousands of scientists can be involved in a single experiment, in such a way that the flow of data from an experiment and the mechanisms for publishing and organizing these data are key to the work and careers of thousands of people in numerous locations, as well as having great potential or actual economic impacts. These requirements cannot be satisfied by the current approach to operation of the infrastructures that serve to enable the research, which often provide only “best effort” Quality of Service.

The arrival of so-called ‘production Grids’ and ‘production Clouds,’ contrasted with test-beds or experimental systems, was the first step towards reliable federated systems, or at least systems explicitly constructed for daily use. However, the IT management and administration techniques currently used to ensure reliability and a level of QoS are not sufficient for large-scale, heterogeneous and geographically distributed resources.
Simply the fact that these resources often exist in different administrative domains is a challenge, since any approach that works for one company or one resource centre, can only improve the infrastructure functioning at the level of individual resources or, at most, at the level of a given domain. Federation brings management challenges – involving, for instance, different legal codes, different currencies or different management paradigms – that can impact users, whether or not they are aware of the complexity of the systems they are using. To improve the delivery of a federated service, one has to take into account all the aspects of federation at every step of designing a management solution for this infrastructure. Otherwise, the system as a whole will always be less reliable than its parts.

Reliability, which is a major driver of user satisfaction, was not initially regarded as a ‘must-have’ requirement. Even in some of the Grid Virtual Organizations’ Acceptable Usage Policies we find disclaimers such as: “There is no guarantee that the GRID will be available at any time or that it will suit any purpose”. Failure to define and maintain a set Quality of Service for federated e-Infrastructures was not a disincentive to use them at the outset, because the services were in pre-production mode and had committed early user communities. But the lack of defined and managed service quality is now having negative effects on services. As federated services such as Grids grow beyond initial user groups that have already bought into them, they must compete with alternative academic or commercial services, so must demonstrate so must demonstrate a genuinely competitive offering to potential users. Loose or vague promises about, say, availability and reliability will not be convincing. Federated services tend to be relatively complex, both in terms of a learning curve and barriers

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to entry (such as acquiring certificates to use services). While this is the case, adding that a service cannot
guarantee availability or other service parameters asks potential users to invest considerable time to adopt a
service that while powerful, may not be reliable or even available to them.

Equally, as services mature they must seek ways to move beyond development funding and become financially
sustainable, with all the challenges that brings. This requires defining the business model of the federated e-
Infrastructure, setting out who it benefits, what services it offers to users, and how it is funded. Without an
understood and managed level and quality of service, these are hard to define and it will remain difficult to
convince both users and funding bodies of the value of services. Combined with uncertainties about the real
costs of these systems, and resultant difficulties in showing their impact or cost efficiency, creating sustainable
models is challenging. However, without sustainable models it is hard to convince potential users to invest in a
service that may not exist in a year’s time.

The user satisfaction and sustainability challenges faced by e-Infrastructure are clearly intertwined. It is clear
that if these challenges are not met, then there is a chance that federated e-Infrastructures may fail, despite
their technical excellence and success to date. Ultimately, it may be that communities will adopt alternative
and possibly less effective technical solutions because they present clear service offerings with clear service
guarantees and parameters that federated e-Infrastructures do not currently provide. Such an outcome could
waste a decade of European investment and leadership in federated e-Infrastructure.

Given the risks outlined above, it is appropriate to look at bodies of knowledge that may have a positive impact
on the problems identified. A new approach is needed to managing these technically excellent services and
addressing ‘soft’ factors around them.

### 1.4. IT SERVICE MANAGEMENT AND E-INFRASTRUCTURE

IT Service Management (ITSM) is a management discipline that stresses a process-orientated approach to
managing IT services. It is extremely popular in the commercial and public sector, with several well-known
international frameworks such as ITIL and COBIT as well as international standards like ISO/IEC 20000.

Service management is concerned with how value is created for a customer by a provider, looking at both the
utility of a service and the warranty as the two crucial components in generating value. This sort of approach is
used by everyone from government departments like the US Internal Revenue Service [2] to global brands like
Disney [3], both of whom have adopted the ITIL framework.

ITSM is a mature field, and can provide useful input for managing federated infrastructures, but it cannot be
simply adopted, as it is based on assumptions, such as relatively hierarchical chains of responsibility, that are
rarely true for federated environments. However, knowledge from ITSM can be used to formulate related
strategies for federated environments, which recognise their unique features but bring tried and tested
approaches to the challenges they face.

Introducing ITSM to federated e-Infrastructures would help bring these services to a level of maturity that
would ensure their continued use, help justify investments in them and allow them to compete with
commercial computing services. A successful European market for federated e-Infrastructure would not only
contribute to existing research, but due to the heavy emphasis on collaboration in federated e-Infrastructures,
would also help to drive innovation in the European Research Area.

On a practical level, many of the key areas of work in ITSM lead to greater user satisfaction, through working
on the warranty of a service, which is the promise or guarantee that a service will meet its agreed
requirements. ITSM techniques alone will not make a technical service suddenly more reliable, but they will
give providers the tools to understand and tackle factors that affect reliability. In some cases ITSM techniques
will actually impact problems that appear to be technical but are in fact embedded in the management
surrounding the technology. Importantly, it will give users a much clearer idea of what they can expect in terms
of service quality, and a clear set of undertakings about what will happen when these service levels are not met.

ITSM processes also ask users to better express their specific needs, likes, dislikes and other parameters, which makes it easier for providers to see where technical effort is needed, increasing the efficiency of technical development work.

Sustainability challenges can also be met by ITSM. In the commercial sector it is necessary to have an understanding about costs, service portfolios and business models before one approaches service warranties. By adopting ITSM approaches, e-Infrastructures are forced to address these problems but are also given ways to think about them, and conceptual models for answering them.

To this end, we propose that the federated e-Infrastructure community should develop a shared understanding of what IT Service Management is, how it can tackle the challenges the community faces, and what is required to introduce it. This will involve a greater level of formalism in some processes and procedures than has been common before. However, change can be incremental, to make it organisationally and economically achievable. It also does not imply wholesale change. While new approaches will be needed at times, in many cases formalism will mean defining existing practices rather than inventing new ones.

Achieving this will require cooperation between a wide range of stakeholders, from European policy makers to national funding bodies, institute directors, operations managers, and crucially, users and user representatives. Each group will have to consider different elements of the overall challenge, but equally all will benefit from a positive outcome.

As a starting point, we propose that Service Level Management (SLM) is the first area of ITSM to be tackled. This sub-discipline deals with identifying, negotiating, agreeing and monitoring levels of service between providers and customers. It is one of the most important aspects of ITSM and, because it is related to the concept of Service Level Agreement already understood by the federated e-Infrastructure community, it can provide an entry point to the broader adoption of ITSM. Working through this area will also draw in elements of Service Delivery Management (SDM) and other elements of ITSM relevant to e-Infrastructure, allowing for a softer and more realistic introduction to a set of approaches that are quite alien to e-Infrastructures today.

1.5. BASIS OF RECOMMENDATIONS

The gSLM project was funded by the European Commission in order to develop recommendations and guidelines for federated infrastructures to improve their management processes and therefore provide more value to the users. We have examined this issue by bringing together experts on e-Infrastructure to interact with ITSM experts with broad commercial and public sector experience.

The ITSM experts come from a background of service provision in the commercial sector, based on well-defined standards and processes for management and measurement of service. They have experience of introducing ITSM to academic organisations and the particular problems this poses. The e-Infrastructure experts include those with experience of all areas of large-scale computing, from software development and infrastructure operations through to management policy, communication and exploitation. They also include teams connected to current e-Infrastructures like PRACE and EGI. The ability to mobilise knowledge and experience from both the e-infrastructure and ITSM communities, both within and external to the project through contact networks, gives gSLM the experience necessary to improve service level and quality management in the federated infrastructures domain.

The recommendations produced by the gSLM project were developed as a result of discussions between e-infrastructure and ITSM experts both within the consortium and including external advisers. They were carried out in person, through attendance at and organisation of events and workshops, as well as electronically
through mailing and discussion groups. The gSLM project reached out to user communities and user group managers by collecting their feedback on using e-infrastructures through a survey.

This consultation led to a complex process of creating a model of current e-infrastructure based on a blend of current practices and desirable but achievable new models. This allowed a very complex and diverse ecosystem to be simplified in such a way that it could be analysed and adapted. Relationships between actors were defined through use cases, defining relatively discrete management processes and based on understanding from systems like ITIL and ISO/IEC 20000. This was complemented by a maturity model based on the COBIT framework which allowed the team to see each use case at different levels of maturity, from very early beta stage maturity to highly optimised and controlled operation.

This led both to a detailed, concrete set of requirements and approaches that can be applied to operational infrastructures to effect change, and to a higher level set of policy recommendations for those involved in funding and managing federated e-Infrastructure.

In both cases, and much like the guidance found in ITIL, there is no single answer to the problems faced. Rather, we provide guidance that highlights common problems and solutions, but that should be interpreted in light of the individual goals and requirements of each group or e-Infrastructure.

1.6. EXPECTED IMPACT OF THE ROADMAP

This document is intended to catalyse discussion and improvement of a complex aspect of federated e-Infrastructures and one that is currently limiting the impact of good work carried out by groups across Europe over the past decade. As we will demonstrate, improving this situation requires action from a range of stakeholders with different needs, backgrounds and approaches. To this end we hope that this roadmap can achieve the following for its readers:

- Create an awareness that there is a general problem with real consequences in the area of federated e-Infrastructure Service Management;
- Demonstrate that there is understanding from the traditional IT Service Management sector that can be used to mitigate this problem;
- Highlight specific issues that a lack of ITSM, especially Service Level Management (SLM) gives rise to;
- Show how different actors must cooperate to tackle these issues and provide broad guidance as to the actions and strategies they should pursue;
- Provide a model for breaking down the complex relationships of federated e-Infrastructure into a set of actors, relationships and actions that allows structured assessment and improvement of service management;
- Provide concrete guidance for operational staff in federated e-Infrastructures to convert the broad improvements described here into real improvement in service quality and management.

1.7. CONCLUSION

Today, e-Infrastructures are impressive service structures supporting exciting digital science in Europe and beyond. However, primarily non-technical factors are increasingly limiting their ability to satisfy existing users, attract new communities and make long-term plans. We propose that solutions to many of these issues can be found within IT Service Management. This discipline, which has been validated in the commercial and public sectors, is not immediately compatible with academic environments but the ideas and approaches from it can be adapted and used to assist e-Infrastructures. Introducing these ideas is not simple but it will lead to more rational structures, better and clearer guarantees to users and will stimulate e-Infrastructures to make more concrete future plans for business models, service offerings and portfolios.
2. POLICY LEVEL RECOMMENDATIONS

Part 2: Policy Level Recommendations

Read this if you:
- Work at a policy level
- Want to understand what strategies can improve service management in e-Infrastructures
- Work in an operational role, but want context on why changes are needed

Skip this if you:
- Only want operational information

Content:
- How service management addresses e-Infrastructure challenges
- Brief actor model
- Global objectives for improving service management in federated e-Infrastructures
- Recommendations for all stakeholders to achieve these objectives

Primary Audiences:
- Policy makers
- Senior managers at e-Infrastructures
- Directors at resource centres
- User representatives

2.1. INTRODUCTION

Federated Infrastructures are large scale and complex structures, both in terms of their technical elements and the human and managerial structures that surround them. As a result, change can happen at a relatively slow pace. For instance, in the European Grid Infrastructure, roll-out of a new version of their Grid middleware can take many months while the hundreds of participating sites deploy the new software. Similarly, the formation of National Grid Infrastructures in Europe has been under way for several years but it is not yet complete.

Effecting change in such federated structures requires both time and the participation of many different stakeholder groups. Apart from simple distance and potential language barriers, differences in national legislation, funding sources, governance structures and culture give a complex picture. However, in order to capitalise on the European investment in e-Infrastructure of the past 15 years there is an urgent need for coordinated action. Such approaches are well recognised and have led to efforts like ESFRI, representing European scale research infrastructures, and the EGI.eu foundation to coordinate the European Grid infrastructure. These initiatives all aim to improve federated infrastructures, and to make them both sustainable and competitive.

Our approach is to build a shared understanding of the benefits of ITSM and the practicalities of its introduction. This will then lead to incremental change based on the joint action of different stakeholders, each acting in areas where they have influence to achieve community-wide benefits.

In this part of the document we present a way of thinking about the actors involved, and the common objectives they can seek to fulfil. We then show how, by each group taking different actions in concert, these objectives can be achieved.

2.2. ACTORS AND GROUPS
In order to analyse and explain the e-Infrastructure community we must consider the different groups within it. Later, in Part 3 we present an actor model of the organisations or bodies involved. We have also introduced several stakeholder groups in Part 1. Here, however, we briefly describe those stakeholder groups in order to assist in understanding the policy recommendations that follow.

### 2.2.1. POLICY MAKERS AND FUNDING BODIES

These may be national, European or global bodies tasked with guiding the broad actions of research communities, setting funding schemes and priorities, and seeking to tie together the disparate elements of the research community into more cohesive and effective units. Understandably they will be concerned with strategy, cost and the impact of e-Infrastructures. Obvious examples include the European Commission, governments in member states or national research bodies.

### 2.2.2. FEDERATED E-INFRASTRUCTURE OPERATORS

These will be organisations that seek to federate relatively large pools of resources that they do not necessarily own or directly control into cohesive wholes. They seek to provide high quality services to users, while hiding the complexity of their technical systems. Examples include the PRACE HPC system, the European Grid Infrastructure or various European National Grid Infrastructures.

### 2.2.3. RESOURCE OWNERS

These are organisations that own and directly manage resources. They are likely to be computing centres or departments at academic organisations, or may be regional or national data and computation centres. They are federated into e-Infrastructures but will almost always have other users who access them directly as well.

### 2.2.4. USER COMMUNITIES

These are scientists or researchers who group together around some common factor. Commonly this is research topic or discipline but it can also be geographical – a region or country – or any other factor. They come together to meet requirements such as a need for more computational resources, access to shared data sets or to benefit from platforms that allow remote research collaboration. They are generally not interested in the technical background of the systems they use but are very concerned with how easy it is to use and what guarantees it comes with.

### 2.3. OBJECTIVES IN INTRODUCING SERVICE MANAGEMENT

Achieving our vision of mature, well-managed e-Infrastructures in Europe requires the action of all stakeholders, from funding bodies and federation directors to resource owners and user groups. This requires building a sense of urgency around service management, a process started by gSLM and already having an impact on organisations such as EGI.eu. Initial efforts are concentrated on building interest and engagement in Service Level Management, as perhaps the most central aspect of ITSM in general. This focus can also help to answer emerging problems in making services guarantees that are being experienced by operational e-Infrastructures. Through improving SLM we are taking a first step towards bringing in ITSM in general and also introducing the terminology and conceptual structures that will make understanding and accepting other ITSM concepts much simpler.

While each stakeholder will contribute different things to the improvement of SLM and, later ITSM, they will all be tackling the same fundamental issues. However, exactly how these are addressed by each kind of stakeholder will depend on their circumstances. Each organisation and federation will need to engage the relevant people in a discussion on how to achieve these goals and make appropriate individual plans.
From our engagement with the federated e-infrastructure community we have identified a number of these global issues and needs that will impact all stakeholders, and must be addressed to allow services to become sustainable. In the following sections we present a series of actions that need to be undertaken by the community to improve SLM and ITSM.

2.3.1. OBJECTIVE 1: DEFINE SERVICES AND CUSTOMERS

In order to be both managed and sustainable, infrastructure and providers should clearly define their services and those paying for and using the services (one of which is normally the customer). While operating e-Infrastructures do serve real users and offer services, they often do not have a firm conceptual model and a clearly stated explanation of what broader value-generating services they aim to provide to which customer groups.

This problem is often seen in federated e-Infrastructures that have grown out of informal, academic environments. Often there is no clear consensus on what the service is and who the customers of it are, beyond simply saying that everyone provides computing services to users. While end users may be the ultimate beneficiaries of the whole e-Infrastructure ecosystem, they are not the direct customers of every portion of it. Such a general level description also makes it hard to build toward sustainability, as it makes forming business models and demonstrating value to funding bodies very complex.

The informality seen in the past means that in many cases stakeholders do not look at services in these terms, as they ‘just work somehow’ – albeit in a manner that might not be sustainable.

A first step in improving this is to define clearly what services are provided, in terms of services as a way to create value for a customer, rather than a technical service. While technical services may play a part, often a single technical service does not create value for a customer.

![Data store authentication: Customer view](image)

**Figure 2.1**: Using the data store from a user’s point of view

For instance an authentication service has no end user value outside of the context of providing the user access to, say, a store of scientific data. From the end users point of view the service they use is the data store, as seen in Figure 2.1.

However, the operator of the data store may be the customer of the authentication service, provided to them by a technology company they treat as a supplier. Hence the customer of the authentication service is someone with a facility they want to restrict access to, while the customer of the facility owner will be the user. An end user may use or access the authentication service but they are not the customers. Figure 2.2 shows this view.
If each stakeholder in a larger federated e-Infrastructure carefully defines what value-generating service they provide to whom, immediately we move from ill-defined cooperation to a network with a finite number of defined relationships that allows for management.

### 2.3.2. OBJECTIVE 2: USER-CENTRIC SERVICES

Federated infrastructures should seek to create user-centric services to both attract and retain user communities. Federated services are complex but powerful tools with specific features that can be of value to certain communities. In order to satisfy these user groups, which are often international and diverse, the services need to focus on addressing customer needs rather than providing solutions that are technologically unusual or trendy. We might call this a customer-centric approach to service development and provision.

This can be difficult, as some of these services have arisen from academic communities where there is a high level of technical literacy, or there is a strong group drive to try new ideas or adopt new technologies. Historically this has led to services that assume a lot of technical or specialist knowledge among potential users.

A user-centric approach should be visible in both the procedures and technical solutions provided. In looking at broadening a user base and becoming sustainable, federated e-Infrastructures must ensure that barriers to entry are as low as possible for users, and really suit the customer groups they seek to target. As most federated e-Infrastructures tend to target multiple scientific or technical communities, they should ensure that they do not simply follow the patterns and assumptions of either the initial community that adopted the technology, or the largest current user community.

### 2.3.3. OBJECTIVE 3: COST AWARENESS

It is important for both the current and future effectiveness of federated infrastructure services to have an awareness or estimate of the costs of providing them. In the commercial sector, understanding costs and setting prices is a fundamental activity that is built into or underpins most other activities. In the public and academic sectors, which have largely created current federated e-Infrastructures, this is not the case. State-funded organisations such as Universities obviously have budgets they must obey, but for computing resources they are rarely able to assign the use of each CPU hour to a certain budget line. This is exacerbated by the many ways in which such services are funded, often a mix of centrally and from slices of funding for varied end uses.

Cost awareness in federations is one step more complex. Not only is it difficult to track costs locally for participants, but the structures that connect them have been built on informal agreements and principles of
sharing rather than based on costs. This was a positive factor initially, as sharing between organisations in many countries was simplified by not making financial agreements and transactions. However, as these services seek to become more mature and sustainable, a lack of awareness of cost is problematic. Both to compete for users with alternative solutions (which may be less effective but more commercially orientated and clearly priced) and to demonstrate value to national and European funding sources, being able to at least estimate cost and relate it to achievement and impact is important.

While it is not necessary for all contracts or service agreements to involve finance, an appreciation of cost is important in agreeing how services will be provided. From the user perspective, being made aware that the service they are using, essentially for free, incurs a very high cost to provide will make it reasonable that there are limitations to how much or in what manner they are able to use it.

For service providers, being able to talk about even notional cost allows them to demonstrate that they provide value to their customers, and so justify themselves to the funding bodies that support them. This may be complex, since while usage is tracked, many academic organisations do not track cost in the way a commercial organisation would, but strategies to at least reach useful estimates of cost will make it easier to move toward financially sustainable business models and structures.

2.3.4. OBJECTIVE 4: BUSINESS MODELS AND SERVICE OFFERING

Each federated infrastructure should have an agreed-upon business model and a clear service offering to users. With their academic background, it is hard to imagine federated e-Infrastructures jumping directly to a commercial style business and revenue model. However, it is important to agree on at least broad business models and define what will be offered to potential users in order to move to self-supporting or sustainable models for operation. At a minimum, in asking potential users to choose their services over commercial alternatives they need to be shown what they get, how this will help, and what are the parameters under which a service is offered. Not having this means that attracting new users will be difficult and require extra effort in convincing and explaining a service to them, so much so that the cost of doing so may approach the cost of providing the service itself.

Previously, national and European funding and push from some large user communities have meant that potential users are essentially either paid to use services through projects, or are driven to use them by their community’s prior investment and engagement with them. In order to move forward and be sustainable, federated e-Infrastructure needs to be able to attract new users on its own merits and in a relatively open market that includes commercial services.

To do this, e-Infrastructures must build on a clear understanding of services and customers, which may be internal, and must make clear to users what they offer, and what they expect in return. This builds into a business model, which may be as simple as “what we do, for who and why” though ideally it should be developed to show what problems are solved for users, how, and why it is better than alternatives.

In terms of what is offered, service providers need to state clearly what they offer, as this may vary wildly. For instance a national e-Infrastructure may offer free resources to a certain limit for those working in the country, or equally may simply offer the federation layer to let users make better use of resources they already have access to. This should be clearly shown in a service offering to potential users.

It is also important to state what is expected in return from users. This might be finance in some form, but is equally likely to be a set of behaviours. It should be clear which actions must be carried out by users (for instance ensuring nobody else can use their credentials) and what behaviours are not permitted (perhaps running certain types of data or programs).
Clear service offerings and business models set up a clear and open relationship with a user community that makes them attractive and useful.

### 2.3.5. OBJECTIVE 5: SERVICE LEVEL MONITORING

Any service level expressed in an agreement signed with a customer needs to be monitored in some way, otherwise the compliance with the agreement cannot be verified. The services provided to users need to be monitored in all the aspects that are valid for customers or for providers.

While technical monitoring is not a new thing in federated e-Infrastructures, monitoring of agreements with users is not that common, even though it is essential for service delivery. Management can and should be monitored and reported on, especially with regard to the time frame of interactions with customers, in which deadlines should be specified for each step of the procedures.

Monitoring frameworks should be developed alongside service functionality and the deployment of each service must be aligned with enabling monitoring for this service. Even in cases where substantial effort is needed to enable such monitoring this should be done. While service agreements negotiation itself cannot be simply automated, if these agreements are well designed, they should be amenable to automatic monitoring of metrics and parameters.

Monitoring will allow management problems to be rapidly identified and addressed. It will also allow patterns to be noticed and predictions to be made that will help to improve overall service quality. Such an approach is useful in preventing problems in service management being accepted and circumvented, leading to inefficiencies.

### 2.3.6. OBJECTIVE 6: DEFINED COMMUNICATION CHANNELS

Channels for communication to the various stakeholders must be available, accessible and rational. Communications in the overall ecosystem around a service need to be structured to ensure people are provided with information or notified about problems or events in a timely and efficient manner. Coming from cooperative environments, federated e-Infrastructures often end up relying on informal or personal communication between participants as a way to get around problems in service management. While directly emailing or calling a person you know is able to solve a problem may be effective in the short term, in the long term it prevents more organised communication structures from developing.

Where possible, single points of contact or role-based communication systems (such as email lists and addresses tied to functions, not individuals) should be used. This has benefits, such as enabling traceability of communication or allowing individuals to delegate responsibility for a function to others when they know they will not be available. It also allows for monitoring of management.

### 2.3.7. OBJECTIVE 7: MEANINGFUL AND ACHIEVABLE USER GUARANTEES

The warranties or guarantees offered to users must be meaningful (non-trivial service levels) but realistically achievable by providers. When selecting new services, a sense of reliability and consistency is a very important aspect in deciding what to adopt. In many cases it is as important if not more important than functionality in the longer term.

An important part of a clear service offering to customers will be the warranty or guarantees that address factors such as the availability and capacity of a service, what support is available and when, and what will happen in case of failure. Even by simply stating what is already available, customers will be better informed and customer relationship management will be simplified. For customers it is usually not that important that quality levels are very high, but it is important that they are clearly and realistically defined.
From the provider point of view, defining guarantees also expresses the limitations of those guarantees, helping to effectively manage user expectations. Guarantees made to end-users should also be supported by and aligned with guarantees made between providers working together to provide the overall service.

Making these guarantees meaningful does not necessarily imply legal or financial contracts, but guarantees and the consequences of not meeting them should be scaled to the value of the services, and if appropriate to what is paid for them. Consequences may remain tied to community approbation or ‘name and shame’ tactics for failure, but should be clearly stated so that in case of failure, a customer can see that the agreed upon consequences occur.

2.4. RECOMMENDATIONS FOR SPECIFIC TARGET GROUPS

The issues and actions listed above are general ones that have an impact on the broad range of stakeholders in federated e-Infrastructure communities. As discussed, these need coordinated action, but different stakeholders will be able to advance solutions to these problems in different ways.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Stakeholder groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Define services and customers</td>
<td>Policy makers and funding bodies</td>
</tr>
<tr>
<td>2: User-centric services</td>
<td>P2: Ask funding proposals from research groups needing infrastructure services to define required service levels</td>
</tr>
<tr>
<td>3: Cost awareness</td>
<td>P4: Require funding proposals for service provision to supply an estimate of running costs</td>
</tr>
<tr>
<td>4: Business models and service offering</td>
<td>P5: Provide support for those seeking funding to understand business models, service management and costs</td>
</tr>
<tr>
<td>5: Service Level monitoring</td>
<td>P3: Require proposals to define quality of service as well as functionality</td>
</tr>
<tr>
<td>6: Defined communication channels</td>
<td>P1: Include SLM considerations in policies and funding calls for infrastructures</td>
</tr>
<tr>
<td>7: Meaningful and achievable user guarantees</td>
<td>P4: Support realistic and incremental improvement of SLM</td>
</tr>
</tbody>
</table>

Figure 2.3: Summary of stakeholder groups and policy level recommendations
Figure 2.3 provides a visual summary of the initial actions that major stakeholder groups can undertake to contribute to this global improvement. The subsequent sections explain these policy level recommendations in detail.

2.4.1. POLICY MAKERS AND FUNDING BODIES

Policy makers and funding bodies have, over the last two decades, been the groups that have funded and shaped priorities for federated infrastructure. While they do not often directly demand specific changes, they can and do have an influence on the broad direction of work and suggest topics to be addressed. In general, our recommendation to this group is to require that those requesting funding are aware of the issues this roadmap raises, and to provide support to help them meet the identified challenges. Specifically, we recommend the following:

**RECOMMENDATION P1: INCLUDE SLM CONSIDERATIONS IN POLICIES AND FUNDING CALLS FOR INFRASTRUCTURES.** Now that e-Infrastructures are relatively mature, it is reasonable to require that those seeking funding to develop new or extend and continue existing infrastructures and services pay attention to issues of service management. As such, service management should be included in the funding scheme, work programme and call guidance for future funding calls at national and European scales. Equally, in light of the modern service economy, it should be considered in setting policies that impact operational infrastructures, such as relevant trade legislation.

**RECOMMENDATION P2: ASK FUNDING PROPOSALS FROM RESEARCH GROUPS NEEDING INFRASTRUCTURE SERVICES TO DEFINE REQUIRED SERVICE LEVELS.** Researchers across Europe receive funding from Member States and the European Commission in support of their work. As part of a general move towards asking them to use European scale resources rather than building their own systems project by project, it is important to ask them to state what quality of service they require. Such information would help funding bodies assess the potential of research projects, give input on what funding bodies should demand from service providers and help matchmaking between users and infrastructures.

**RECOMMENDATION P3: REQUIRE PROPOSALS TO DEFINE QUALITY OF SERVICE AS WELL AS FUNCTIONALITY.** As well as asking users to state their needs, those seeking to build new service infrastructures or extend existing ones should be asked to state the quality of service they will provide as well as its utility. Clearly not all service providers will be asked to provide the same level of service. An innovative new service using cutting edge technology could state that they offered best effort service only, but a larger scale, developed and mature service infrastructure would be required to offer and maintain a considerable quality of service for the users they seek to serve.

**RECOMMENDATION P4: REQUIRE FUNDING PROPOSALS FOR SERVICE PROVISION TO SUPPLY AN ESTIMATE OF RUNNING COSTS.** At present, it is hard to track the costs incurred in the organisations that tend to contribute to many federated infrastructures, let alone the federated infrastructures themselves. This is complicated by the confidential nature of financial data for participants. However, if funding proposals are submitted for services, it is reasonable to request an estimate of their future running costs to see if they are viable and can be made sustainable. Entirely precise, line item accounting is too detailed to request, but funding bodies should ask for a realistic and useful estimate of how much would need to be charged or provided to break even if providing an envisioned service after the conclusion of a project.

**RECOMMENDATION P5: PROVIDE SUPPORT FOR THOSE SEEKING FUNDING TO UNDERSTAND BUSINESS MODELS, SERVICE MANAGEMENT AND COSTS.** It is clear that as we move forward, greater attention to business models, cost structures and service management is going to be required from federated e-Infrastructures. However, it is also clear that many of the stakeholders participating in these communities do not have the expertise internally to address these issues at present. As a result, policy makers and funding bodies need to support the development of these skills and the improvement of current e-Infrastructure.
This support could take many forms, from clear guidelines such as those provided for dissemination and outreach planning, to services comparable to the IPR Helpdesk, funded to give expert advice on IPR issues to projects, or the network of National Contact Points that give participants advice on Framework Programme funding and participation. By providing support it will make it easier for community members to improve these areas and show that funding bodies are committed to change in this area and prepared to provide the support needed to achieve it.

### 2.4.2. FEDERATED E-INFRASTRUCTURE PROVIDERS

In order for any change in service management to be successful, a strong and clear position from the management team involved is crucial. Directors need to embrace the idea of improving ITSM and convince their staff to face it. To prepare for the change, some strategic decisions must be made, and staff need to be provided with the necessary mandate and tools to efficiently effect an improvement.

**RECOMMENDATION F1: DETERMINE WHO YOUR CUSTOMERS ARE AND WHAT YOU OFFER THEM.**

Introducing SLM leads to better relations with your customers, but to achieve this it is crucial to decide who exactly the customers are and to which groups a service offering should be addressed. This means not just understanding who the primary customers of the service are, and which are the groups that benefit from it. It is then important to understand how mature the customers are in terms of their internal organization, ability to communicate and clearly express their requirements.

Having defined their customers, organisations need to define their offering, and develop a clear statement on what the added value of the federated infrastructure is and how customers benefit from using the federated infrastructure instead of one offered by a local resource provider. What are the benefits and overheads? Do they offer strong integration of provided services or is the customer left with federation complexity of their own?

By deciding on these factors early and at a management level, it makes it easier for your staff to effect the change in a smooth and efficient way.

**RECOMMENDATION F2: ASSESS YOUR CURRENT QUALITY OF SERVICE AND LEVEL OF IT MANAGEMENT MATURITY.**

Driving any change within an organization first requires understanding of the current situation. What do you do now in this area, whether or not you explicitly call it IT management? How successful is this effort? What do your users feel about the warranty and management of the services?

Understanding the current status helps to support the definition of realistic aims for improvement. Additionally, by using an assessment framework that is based on ITSM principles and expertise (such as that designed by the gSLM project), you are able to describe your organisation in a way compatible with ITSM standards and frameworks, which will later make introduction of elements of these standards and frameworks much easier.

**RECOMMENDATION F3: INFORM AND EDUCATE STAFF.**

Once the situation is understood, and a plan is being formulated, it is important to ensure that an organisation’s staff is both informed of the situation and has accepted and embraced it. Introduction of ITSM is considered a ‘technochange’ in traditional and commercial ITSM, and these have a very high failure rate when staff do not understand or resist them.

Staff members need training to understand why there is an issue, what solving it means, and how this will involve them and impact their daily work. This makes the change achievable and renders them a participant in a change rather than a victim of it.

**RECOMMENDATION F4: SUPPORT REALISTIC AND INCREMENTAL IMPROVEMENT OF SLM.** Once a problem is identified and members of staff are recruited to the process of tackling it, then management needs to define practical actions and goals that are incremental and realistic. While SLM and ITSM in general bring benefits,
their introduction incurs costs in time and effort. Staff cannot simply add the task of introducing service management to their existing roles.

Changes should be incremental so they can be broken down into manageable chunks, and effort should be assigned to them. This might be through a special team made up of staff who work only on this project for a period of time, or a percentage of the time of a larger group of staff. In either case, responsibilities should be well defined and someone with relevant experience and a clear mandate should be assigned to coordinate and manage the introduction.

RECOMMENDATION F5: DEVELOP CLEAR SLM POLICIES AND PROMOTE THEM TO RESOURCE PROVIDERS. Introducing SLM in a federated environment is complex. In order to have a positive impact, the change must be embraced by the resource providers that contribute to the services.

For the introduction of SLM to be successful and benefit customers, the resource providers must participate on some level. Resource owners will generally be separate organisations in a federated environment, so they cannot simply be told to conform to a new way of working. Instead, as with staff, they must be informed, convinced and supported in embracing new practices.

The easiest way to do this is to set out clear policies for organisations being federated that include the new elements needed to support SLM and ITSM as a whole. These need to be carefully explained to resource owners so that they understand both the content and the motivation for them, and see the benefits they bring.

RECOMMENDATION F6: MONITOR SERVICE QUALITY TO SUPPORT REACTION TO PROBLEMS AND STRATEGIC PLANNING. One key activity in managing a service is effectively monitoring its operation. Monitoring should not only give a general idea of the state of the service but should be aligned with attempts to carry out SLM. Hence, parameters related to SLM, and specifics in potential agreements like SLAs and OLAs should be monitored. Management should set out these parameters and periodically review both results and what is monitored. The goal should be that the monitoring allows problems to be noted early and addressed. It should also support strategic planning and decision-making, such as prioritising some areas over others, adding more resources to an area that is not performing, or recognising when adding more effort in SLM is no longer bringing benefits that justify the effort and expense. All of these issues require data, which should be provided by effective service monitoring.

2.4.3. RESOURCE OWNERS

Sites are the organizations that actually own the resources which allow services to operate. In most cases, reliability delivered at the site level will restrict if not limit the reliability and SLM possible on the federation level. In the federation, customers are often only available through a federator, so sites can only succeed or fail through their performance and contribution to the larger service.

RECOMMENDATION R1: DEFINE YOUR ROLE IN FEDERATION BUSINESS MODEL AND RELATIONSHIP WITH THE FEDERATOR. As federations need to define their customers and business model, so resource owners need to do the same. A resource owner needs to understand, for example, what importance the federation plays in the overall activities of the resource owner. Is it a crucial activity that justifies considerable effort, or a small sideline? Which staff work on the federated activities, and how are the needs of the federator and of other customers balanced?

The resource owner should also understand what business model the federator has adopted, such as are they simply matchmaking customers to resource owners, or at the other end of the scale are they providing a tightly coupled integrated service where sites are invisible. This will then determine how tightly the SLM of the site and federation need to be integrated.
RECOMMENDATION R2: UNDERSTAND YOUR EXISTING APPROACH TO SERVICE MANAGEMENT AND HOW IT CAN BE HARMONISED WITH FEDERATION SLM. Following on from understanding of the federation business model and how resource owners fit into it, the next step is to assess current service management and how it is related to federation SLM activity.

As with federations, assessing current SLM maturity is useful as it helps to see current activity through the point of view of SLM, and also to have a view on service management harmonised with the federation, which facilitates communication and agreement on what needs to be undertaken.

This can also lead into improvement in site SLM not related to activities as part of the federation – if effort needs to be expended to improve SLM then it may be wise to make it a global change rather than just a change to a part of the organisation.

RECOMMENDATION R3: UNDERSTAND THE OBLIGATIONS (TECHNICAL, MANAGERIAL) THAT FEDERATION MEMBERSHIP IMPLIES AND PLAN TO ACHIEVE THEM. For sites managers the motivation for participating in the federation must be clear, and it must be seen to compensate for the additional effort and structural changes it implies. Federation means operating across organizational boundaries, which means that many processes previously carried our intuitively need to be progressively formally defined, since “intuition” that works in one organisation might not be the same in another organization.

Equally there will be technical changes required at the site level, and both these and the management changes should be clearly discussed, documented and agreed. These together form the ‘price of admission’ to the federation and once agreed should be implemented and followed in order to reap benefits from participation in the federation.

RECOMMENDATION R4: NEGOTIATE LEVELS OF SERVICE THAT CAN BE REALISTICALLY OFFERED FOR SERVICE GUARANTEES. Service Level Management ultimately allows federations to agree levels of service with users, which helps improve customer relations, recruit new users and bring other benefits. This quality of service will be in some way limited by the service levels provided by sites. It is important, therefore, to set out clearly what service levels a resource owner can commit to.

Agreed levels should neither be trivially low nor so ambitious as to be unsustainable. They should give lower limits for service, which may well operate at higher levels in many cases. Introduction of SLM may also allow agreed levels to be raised as systems become more optimised.

RECOMMENDATION R5: ESTIMATE THE COSTS OF PROVIDING SERVICES. Providers should have an understanding of the costs of running their services that can be shared with the federated infrastructure. Even if customers are not charged directly for services, the costs of running services must be known and should be included into the process of managing your infrastructure. This is important for both the resource owner and federator. The resource provider should be aware how its model of operation scales in terms of costs when supporting new customers.

Federators require this data such that they can show the value of the service to those paying for it (directly or indirectly), compare themselves to purely commercial solutions and also understand how to optimise efficiency of the federated service infrastructure.

Components of the overall costs will include all the elements of infrastructure needed for providing services at the required level, such as hardware costs, cost of utilities like power and water, staff effort, staff training, financial administration, facility costs and any other contributing cost to the systems used to provide the service. Even if exact costs are too difficult to provide, estimates should be calculated that can be used for approximate comparisons etc.

2.4.4. USER COMMUNITIES
Users and their representatives, such as Virtual Organisations managers, clearly have a part to play in determining how federated e-infrastructures are operated and managed. Up to now, they have often played a somewhat subsidiary role, due to the development path of e-infrastructures. While some groups, notably High Energy Physics, have had systems built to serve their needs, others have been encouraged to use existing infrastructures, not always fitted to their needs. However, as services are often provided free to users (as they are often funded by national or European bodies) they are often provided on a best effort basis. As federated e-infrastructures mature they need to better serve a wide range of user groups. As a result, users need to change their interaction with service providers in various ways.

**RECOMMENDATION U1: HAVE A CLEARLY IDENTIFIED REPRESENTATIVE WITH A MANDATE TO SPEAK FOR YOUR COLLABORATION.** In order to interact with service providers, user groups (especially geographically distributed ones) need to have representatives who can engage with providers, raising issues, expressing requirements and negotiating agreements. Representatives need to understand not only the subject and working patterns of the group they represent, but also the essentials of the way the service is provided, such that they can reach realistic agreements that suit both users and providers. The representatives also need to have a clear mandate from users to negotiate agreements in order to allow for rapid and efficient service adoption. This may be complex, and at first the mandate may have to be quite narrow, but for a user group of some sort to be effective it must find a way to speak with a single voice, in order to guide service providers in being more effective suppliers.

**RECOMMENDATION U2: DECIDE AS A COMMUNITY WHAT YOU REQUIRE FROM SERVICES.** Once representatives have been identified, it is important they understand what their community requires from service providers. This means that user groups and virtual organisations must internally decide on their needs before engaging with potential service providers. This may be complicated by a wide variety of subject areas or working patterns within a community, but in order to operate as a virtual organisation a consensus set of requirements or service baseline should be agreed. While this will not be perfect for every user it should be sufficient for all.

**RECOMMENDATION U3: ACCEPT THAT THERE ARE RECIPROCAL REQUIREMENTS RELATED TO SERVICE GUARANTEES.** While, in general, service guarantees such as SLAs might be seen as defining what a provider must do for their users, it is important that user groups recognise that there are reciprocal responsibilities in service guarantees. While these will generally be simpler than requirements on providers, they remain important. In order to receive service guarantees that are useful for the user community, they must respect these requirements carefully, for instance not running types of application not authorised for the federated service or ensuring that access credentials are adequately protected.

**RECOMMENDATION U4: REQUIRE NON-TRIVIAL GUARANTEES FROM SERVICE PROVIDERS.** While some federated e-infrastructure services are still in a beta form, many are maturing rapidly. They need user communities to adopt their services, at least for financial compensation or to justify their funding from state and European sources. In either case, users are in a relatively strong position and should be sure to use this to insist on service guarantees from providers. For anything but clearly beta services, an SLA that supports the needs of the users should always be required. This SLA should represent a level of service that the provider can realistically achieve, but should also be one that supports day-to-day work by the user community.

**RECOMMENDATION U5: UNDERSTAND THAT GUARANTEES MEAN YOU KNOW WHAT IS HAPPENING, NOT THAT IT ALWAYS WORKS.** While service agreements are very important in determining a quality of service, it is also important that users, individually and in groups, understand that they represent a warranty rather than an unbreakable agreement. Service agreements will describe a level of service that is expected, such as percentage availability. When this is not met the service guarantee will specify what steps will be taken, whether this is penalties of some sort, or an escalation of issues to named parties. This means that an SLA will not guarantee that a service will always be perfect and available, rather that users will know what the results...
will be in the case that it fails. This should, over time, mean that service availability goes up, but also reduces the uncertainty caused in case of failure.

### 2.5. CONCLUSIONS

We propose that having identified the issues leading from the user satisfaction and sustainability challenges, IT service management offers a means of facing these issues and challenges. However we recognise that adoption of ITSM based solutions is complex as ITSM is not well used in the academic sector, and is based on assumptions that are not always true for e-Infrastructures.

To address this we have interpreted ITSM understanding for e-Infrastructures, and have formulated a set of practical objectives that should be comprehensible to all stakeholder groups. Such an approach is necessary because concerted action by these different groups is quite clearly required to effect meaningful change. As a result we suggest that each stakeholder group work on different but complementary activities that together, over time will bring effective service management to e-Infrastructures. We summarise these objectives and recommendations in Figure 2.3.

This process of change will not be quick or simple, but is a realistic way to effect improvements and address challenges based on well-validated approaches and ideas that are used by major public sector and commercial organisations. Having accepted this challenge, what follows should be planning actual improvements and providing those in the community with tasks that bring them about. This is not a trivial task – in the commercial sector, this stage, which includes educating community members about service management and gaining their support and commitment, is often the hardest stage in ITSM introduction. Resulting recognition of this, the following parts of this document present approaches that allow for incremental improvement, couched in terminology that is familiar to e-Infrastructure community members.

This material should be an aid to policy makers and those in management roles in helping the community understand the current challenges it faces, in helping those with operational roles to understand the recommendations presented here, and in helping them convert those recommendations into tasks they can achieve. Through this we can capitalise on e-Infrastructure investments and help these communities sustain success in the future.
3. BUILDING BLOCKS AND METHODOLOGY

3.1. UNDERSTANDING AND DEVELOPING GRID AND E-INFRASTRUCTURE SLM AND SDM

The efficient delivery of high-quality IT services – especially in a constantly changing environment with ever-growing customer and user demands – poses a major challenge for IT service providers. To address this challenge, more and more (commercial) providers are adopting IT service management (ITSM) processes as described by the IT Infrastructure Library (ITIL) [4] [5] [6] [7] [8], or ISO/IEC 20000 [9]. ITSM can be regarded as a set of organisational capabilities and processes required by an IT (service) provider to keep his utility and warranty promises / commitments. In this context, Service Level Management (SLM) and Service Delivery Management (SDM) are the most important sub-disciplines.
Service Level Management (SLM) comprises the tasks and related processes of:

- Defining and maintaining a catalogue of IT service offerings;
- Specifying services and service components, including their dependencies and available service level options;
- Negotiating, signing Service Level Agreements (SLAs) with customers, underpinning supportive agreements with other parties that are part of the same organisation or federation, referred to as Operational Level Agreements (OLAs), and suitable contracts with external suppliers, referred to as Underpinning Contracts (UCs);
- Monitoring and reporting on the fulfilment of SLAs as well as (early) notifications of SLA violations.

Service Delivery Management (SDM) deals with managing the delivery of SLA-aware IT services through their lifecycle including:

- Planning of details of the service delivery including required capacities, availability and continuity planning as well as information security issues;
- Monitoring and reporting on capacity, availability, continuity and information security;
- Managing changes and releases in a controlled manner;
- Maintaining accurate information on the infrastructure and its configuration;
- Handling incidents and user requests, and resolving and avoiding problems.

Following a process-oriented approach to the implementation of SLM and SDM means providing a clear definition of tasks, activities and procedures. This must be supported by unambiguous delegation of responsibilities and identification of all interfaces, as well as steps to ensure adequate documentation, traceability and repeatability of all processes.

The gSLM approach has given special relevance to SLM, since it forms the foundation for effective SDM. In general, SLM is a vital part of customer-oriented provision of high quality IT services. It is important for achieving an improved relationship between IT service providers and their customers, as well as for aligning “what the IT people do” to “what the business requires”. In the relationship management domain, SLM provides common understanding of expectations, mutual responsibilities and potential constraints between different domains. Various approaches for supporting effective SLM have evolved from research and practice, mostly focused on business IT, throughout the last decade. Still, it should be noted that SLM in general is evolving beyond the “traditional” IT service provisioning scenarios – hence, introducing it to such infrastructures as Grids can be seen as part of a natural progression.

Having presented the problem and highlighted some corresponding solutions (in terms of clear objectives and policies to seek compliance to) in the preceding parts, this part deals with the instruments that we have articulated as a means to reach our target goals. This is what we present as the building blocks of the gSLM roadmap illustrated in Figure 3.2.

The building blocks in Figure 3.2 are depicted in layers to emphasize the fact that they build on one another, much like in a protocol stack. This is also related to the sequence we adopted for their development, starting with the lower layers and ending with the upper ones. In the following subsections, we highlight the most relevant aspects of these components. This presentation will be bottom up as shown in figure 3.2. Here we conclude with a brief presentation of each one as well as a summary of how they were conceived and their mutual relationships.

The Common Terminology is a compendium of terms that have been used anywhere within the development of the gSLM roadmap. It was started in the early phases of the project and experienced continuous upgrades as a consequence of the evolution of the project. The Common Terminology supports all the other building blocks.
The Actors and Relationships block is part of the model we envisaged to frame the gSLM roadmap. It reflects our understanding of which roles have to be supported in managing and delivering services as well as the main interactions between these roles. This part was adapted from ITSM to the federated infrastructures domain and constitutes a key element to describe the use cases.

The Use Cases consist of the specification of management functionality that has to be executed atomically and that involves at least one of the actors of the "Actors and Relationships" building block. In other words, the Use Cases define what the actors have to do or how they react under specific conditions. Use cases were developed once the Actors and Relationships model was drafted and it is a complement to the model.

The General Maturity Model is an abstraction used to describe how close (or far away) an e-infrastructure will be in respect to given service management target goals. It describes six maturity levels, beginning with level zero that means no service management functionality at all. The General Maturity Model is technology and functionality agnostic but adapted to our problem domain.

As its name suggests, the Maturity Model per Use Case is the building block consisting of the instantiation of the General Maturity Model for each use case. It represents the convergence of the two previously presented building blocks and consists of a tool to analyse any e-infrastructure in a per use case basis.
Finally, the Requirements Catalogue is a building block representing the latest level of refinement that is put in place in the gSLM roadmap. It consists of specific checkpoints to go through to determine the maturity level of a given e-infrastructure.

Through the following sections, the reader will get the necessary background to understand the design rationale for each of the above mentioned elements, i.e. the choices that were analysed, which were adopted, and why.

3.1.1. ACTORS, RELATIONSHIPS AND TERMINOLOGY

The proposed model characterizes the actors intervening in the different management operations and their respective collaboration relationships. In particular we envisage three principal actors, namely Virtual Organization, Federated Infrastructure and Site.

Virtual Organisation (VO). A group of people (e.g. scientists, researchers) with common interests and requirements, that needs to work collaboratively and/or share resources (e.g. data software, expertise, CPU, storage space) regardless of geographical location. They access these resources with some set of guarantees ad users of a given service. The VO collectively represents this set of users in respect of their interactions with the entity that will provide the services. For that reason the VO adopts the role of customer of the service provider. To get the intended services the VO, through its contact point, will register with one or many Federated Infrastructures. The relationships between the users and the VO must be established in the appropriate way, but this is out of the scope of the present model (partly as the relationships may be so diverse).

Federated Infrastructure (FI). An approved body that provides e-infrastructure-based services in a region, country or group of countries. FIs may be organized in larger bodies, creating a hierarchical structure, with primary FIs federated in secondary FIs etc. For instance, in the Grid domain in Europe, the primary FIs are created at national level forming what is known as National Grid Infrastructures (NGIs), and are federated in the European Grid Infrastructure (EGI). The role of a FI in the value chain can range from a simple mediator between VO and Sites to more complex responsibility to ensure that services are provided with a pre-agreed quality, thus acting like a conventional service provider. In any case we will consider that VO is the customer of the FI, which is representing the e-infrastructure as a whole. The infrastructure and middleware supporting the FIs on all levels is totally or partially provided by its registered Sites.

Site. An administratively independent domain that brings the resources (computational) to be federated with resources provided by other Sites and offered as a service through the role of a FI. From the perspective of our model, Sites are then suppliers of FIs and therefore they are not directly dealing with VOs.

This document provides instantiations and examples of SLM and SDM in the Grid domain environment. Here, please note that we use the term Grid Initiative (GI) instead of the term Federated Infrastructure (FI).

According to the actor’s role descriptions in Figure 3.3, a given actor has commitments to fulfil in respect of the other actors. Specifically, a VO as customer and the FI as service provider have mutual obligations to fulfil that are specified in a Service Level Agreement (SLA). The SLA describes the e-infrastructure-based service, documents Service Level Targets, and specifies the responsibilities of the FI and the VO. On the other hand, FIs have to rely on other FIs (lower level FIs in the hierarchy) or directly on Sites to ensure the resources of the services they are committed to provide. To this end, they will negotiate and sign Operational Level Agreements that are conceptually equivalent to SLAs. The relationship between SLAs and OLAs in respect to the service they are supporting is not one to one. In fact we can have one SLA supporting just one or more than one service. Also, one OLA can be established for one or many supported SLAs.
Figure 3.3 presents a summary of the model with the previously described actors and their main relationships. At this point, it is worth mentioning that VOs, FIs and Sites may have other contractual relationships with entities not explicitly mentioned as actors in our model. This is the case, for instance, with a middleware supplier or an application software supplier whose products are key to allow the corresponding actors to carry out their roles. All these external entities are collectively named External Partner/Supplier and we understand that appropriate underpinning contracts would be established when necessary with any of our model’s actors.

The model is one of many possible alternatives to describe service delivery in e-infrastructure. Nevertheless we believe that it is one that is sufficiently compatible with reality while still bringing a much greater level of service management than we see today. It is worth mentioning that our model supports the fact that the role of the FI can be that of a simple aggregator of service offerings of the Sites, or act as a real integrator providing an added value, or be somewhere in between. Our actor model tries not preclude any of the arrangements of actors imagined today in the various porpoise e-Infrastructure business models. For instance considering the FI simply a conduit rather than an added value federator can accommodate direct delivery of services from Site to VO.

An example of a structure of providers presented here is the European Grid Infrastructure (EGI) that can be considered a secondary FI in some cases. EGI is a federation of primary FIs – National Grid Infrastructures (NGIs). NGIs in turn, federate Sites at national level. This is captured by the recursive “federates” relationship in Figure 3.3. Customers of those providers are VOs that can be of two kinds: global VOs for which EGI serves as a single contact point and national VOs that directly contact the NGIs.

The glossary of terms was built and modified as the project evolved. Our main sources of reference were ITIL [4] [5] [6] [7] [8] and eTOM [10]. Where appropriate we coined our own definitions. A complete list of the terminology used can be found in the companion document [11].

### 3.1.2. DEFINITIONS OF USE CASES

To model the functionality that has to be provided to manage e-infrastructure-based services we have adopted a use case based approach. In software engineering, a use case is a list of steps, typically defining actions and responsibilities of given actors in respect to a system, to achieve a goal. Since the objective of the gSLM project is not to characterize a specific system, the concept here is slightly different. We define actors (principal actors) and the activities they must achieve in sequence. Therefore, our use cases are instantiations of business processes in the specific context of federated e-infrastructures. In other words, a use case defines the smallest management activities that are executed as a workflow. A more complex service management function will then result from the logical union of more than one of the use cases. To identify the appropriate use cases we adopted ITIL [4] [5] [6] [7] [8] as background information. ITIL is a process-based framework. Therefore we
analysed the majority of such processes and carried out an instantiation of those processes in interrelated activities. This instantiation was inspired by the model described in the previous section. This methodology has the advantages of a modular design and is by process decomposition techniques from the eTOM framework [10].

These use cases are classified into two levels. Level 1 use cases concern Service Level Management, which is the provisioning of the service with service level guarantees. Level II use cases gather all the functionality in support of the former category and constitute the core of the Service Delivery Management. In addition each level is further categorized. Hence, Level I contains two categories or types: SLA-related and OLA-related. Level II is sub-classified into six types: Continuity/Availability-related, Capacity-related, Security-related, Configuration-related, Change/Release/Deployment-related and Incident/Problem-related use cases. Table 3.1 shows this structure with the names of all specified use cases as it is instantiatiated for the Grid domain environment. The name of each use case indicates its scope. The detailed specification of all these use cases can be found in companion document [11].

A clear challenge in that approach is in respect of the scope of the use cases to be developed (i.e. why these use cases and not others) and the level of granularity of each one. In both respects we were guided by our own experience in specifying management processes in other service domains. As mentioned in the previous paragraph, we gave priority to the establishment and maintenance of service levels, thus generating the set of SLA-related and OLA-related use cases and subsequently we considered their most relevant supporting management functions, resulting in the above mentioned Level II use cases. Indeed the solution is not unique. Other authors would likely have come out with a more or less different set of use cases. Nevertheless, the set selected is valid when understood as a starting point that is subject to potential modifications when additional constraints (e.g. implementation constraints, technology support constraints) are considered. In addition, exposing working infrastructures to the use case list has elicited positive responses, in that they see that their activities can be described using these processes and categories.

For each use case the most relevant information provided is its description in natural language, which is complemented with the detailed steps in sequence. The level of granularity is such that it could allow for a clear implementation independent of the supporting technology. We also consider possible variations in how these will be applied, shown as branching steps for the use case workflow. In addition we describe the preconditions that have to be fulfilled, the triggers (in most cases, other use cases) and complementary considerations that put the use case in context if necessary, specific examples, exceptions, etc.

<table>
<thead>
<tr>
<th>Level I: Service Level Management (SLM) related</th>
<th>Area</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Level Agreement (SLA) related</td>
<td>Register new VO as &quot;customer&quot; of a GI</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Request a new service</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Publish service / add service to service catalogue</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negotiate and sign SLA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor SLA fulfilment through the GI</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluate and report on SLA fulfilment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Notify VO of SLA violation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Early warning notification to GI</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level II: Service Level Management (OLM) related</th>
<th>Area</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Level Agreement (OLA) related</td>
<td>Register new Site as resource provider within a GI</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Register new GI as member of a higher level GI</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Register new service element / instance / component to GI</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negotiate and sign OLA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor OLA fulfilment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluate and report on OLA fulfilment</td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td>Service Delivery Management (SDM) related</td>
<td>Notify site or lower level GI on OLA violation</td>
</tr>
<tr>
<td>-------</td>
<td>------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Continuity/ Availability-related</td>
<td>GI creates, maintains and enforces a Grid-wide continuity and availability plan</td>
<td>GI monitors availability of Grid services</td>
</tr>
<tr>
<td></td>
<td>GI plans, implements and reviews disaster mitigation and contingency controls</td>
<td></td>
</tr>
<tr>
<td>Capacity-related</td>
<td>GI maintains a Grid-wide capacity plan</td>
<td>GI monitors performance and workload of Grid services and resources</td>
</tr>
<tr>
<td>Security-related</td>
<td>GI maintains and enforces a Grid-wide security policy</td>
<td>GI manages information security risks</td>
</tr>
<tr>
<td>Configuration-related</td>
<td>GI maintains configuration information</td>
<td></td>
</tr>
<tr>
<td>Change/ Release/ Deployment-related</td>
<td>GI maintains a Grid-wide change and release schedule (forward schedule of changes)</td>
<td>GI maintains a Grid-wide change and release policy</td>
</tr>
<tr>
<td></td>
<td>GI notifies relevant actors of a future or completed change or release</td>
<td></td>
</tr>
<tr>
<td>Incident/ Problem-related</td>
<td>Incident is reported to GI</td>
<td>GI agrees on standard incident handling procedures with relevant actors</td>
</tr>
<tr>
<td></td>
<td>GI coordinates non-standard incident resolution</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GI coordinates problem resolution</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1: The set of use cases defined within the gSLM project

As an example of how the use cases are been specified we show the “Negotiate and sign SLA” use case below.

<table>
<thead>
<tr>
<th>Use Case Identifier</th>
<th>Use Case name</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCs:SLM:SLA:NEG</td>
<td>Negotiate and sign SLA</td>
<td>Service Level Management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Service Level Agreement (SLA) related</td>
</tr>
</tbody>
</table>

A VO and the GI negotiate and, if the negotiations are successful, sign an SLA for a service from the GI’s service catalogue. The signing can be regarded as the successful end (outcome) of the negotiation. It will trigger (technical) some procedures of preparing and delivering the service (not in the scope of this use case). Usually, before the SLA is finally signed (and certainly before it takes effect) OLAs need to be agreed and established with the corresponding Sites in order to support the fulfilment of the service level targets agreed and specified in the SLA. (For the OLA-related activities, see the respective use cases.) Typically, the baseline for the negotiation of a new SLA is a service catalogue providing details of the services and their attributes/parameters as well as different packages that a VO may be interested in. This may also include different pre-defined service level packages. The negotiation usually starts with exploring the requirements of the VO and mapping these requirements to the pre-defined sets of service packages, service level packages and freely configurable parameters.
**Pre-conditions**
- A VO was registered with the GI (for example by means of the successful end of use case UCs:SLM:SLA:REG)
- The service for which the SLA is going to be negotiated and signed is publicly available through the service catalogue of the GI
- Existence of negotiation mechanism
- Agreement on SLA representation format

The SLA is defined in a formal (unambiguous) manner, either textual (text document) or machine processable (e.g. XML). The SLA document is signed by both parties with either a paper or electronic signature, binding both sides to the contract statements. Machine processable format would be preferable, as it would support automatic configuration of GI’s middleware components.

The GI and VO failed to agree on the terms of service. The reasons for that can include: lack of particular services or resources on the GI side, inability to guarantee particular QoS by the GI, insufficient priority of the VO with respect to its demands.

**Primary Actors**
- GI, VO

**Secondary Actors**
- Users, (Optional mediators) National Government Entities, European Commission (could be involved as mediators in case the GI and VO cannot reach agreement – for instance EC could increase the VO priority in order for the GI to respect the VO demands).

**Trigger**
The action is triggered by the VO which wants to gain or extend its access to particular resource or services provided by the GI.

**DESCRIPTION**

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>VO requests access to new resources/services or requests modification of QoS parameters on currently used resources/services.</td>
</tr>
<tr>
<td>02</td>
<td>VO submits to the GI a set of statements/requests specifying particular requirements.</td>
</tr>
<tr>
<td>03</td>
<td>GI responds to the VO with the offer they are willing to provide for the request.</td>
</tr>
<tr>
<td>04</td>
<td>VO submits a new set of statements/requests, more closely matching the GI offer.</td>
</tr>
<tr>
<td>05</td>
<td>GI responds to the VO with a modified offer they are willing to provide for the request.</td>
</tr>
<tr>
<td>06</td>
<td>LOOP: Steps 02-05 are repeated until the requests of the VO are within the constraints offered by the GI.</td>
</tr>
<tr>
<td>07</td>
<td>In case of success, the SLA is rendered into a formal representation (text document, XML, database entry).</td>
</tr>
<tr>
<td>08</td>
<td>The SLA is signed by the GI and the VO (if the VO is not a legal entity, member institutions or representative institution must sign the SLA).</td>
</tr>
<tr>
<td>09</td>
<td>The SLA is stored in a SLA repository, and can now be used to enforce the new agreement by the middleware infrastructure (security, monitoring, accounting).</td>
</tr>
<tr>
<td>10</td>
<td>The SLA is closed when the lifetime conditions become true or conditions for its invalidation emerge.</td>
</tr>
</tbody>
</table>

**EXTENSIONS**

<table>
<thead>
<tr>
<th>Step</th>
<th>Branching Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>06a</td>
<td>VO and GI cannot come to agreement In this case, VO can ask a mediator (National Government, European Commission) to influence the GI to improve its offer to the VO, e.g. by increasing the VO priority within the GI.</td>
</tr>
</tbody>
</table>

**Comments**

1. **SLA representation:** An important issue for this use case is the way the requests, offers and final SLA statements are encoded. The obvious requirement is that the
final SLA is stored in a formal and unambiguous way, i.e. all statements and resources/services/values to which it refers are precisely defined and understood by both parties. This could be one of the goals of the ontology developed within the WP4.

2. **Negotiation process**: As the use case is in theory agnostic from the actual implementation, it is important to at least have some suggestions and ideas on how the process can be performed. Obviously as long as the negotiation process results in the formal SLA representation, it can be conveyed through email or phone calls. It is probably wise to suggest development of tools and technologies allowing the negotiations to proceed in a formal manner which can be tracked.

3. **Scope of the SLA**: Another important aspect of discussing SLA use cases, is the actual scope of the SLA. Apart from the obvious QoS parameters related to resource/service usage, it is important to have some idea of other statements, for instance ISO/IEC 20000-2 [12] lists the following:
   - brief service description;
   - validity period and/or SLA change control mechanism;
   - authorization details;
   - brief description of communications, including reporting;
   - contact details of people authorized to act in emergencies, to participate in incidents and problem correction, recovery or workaround;
   - service hours, e.g. 09:00 h to 17:00 h, date exceptions (e.g. weekends, public holidays), critical business periods and out of hours cover;
   - scheduled and agreed interruptions, including notice to be given, number per period;
   - customer responsibilities, e.g. security;
   - service provider liability and obligations e.g. security;
   - impact and priority guidelines;
   - escalation and notification process;
   - complaints procedure;
   - service targets;
   - workload limits (upper and lower), e.g. the ability of the service to support the agreed number of users/volume of work, system throughput;
   - high level financial management details, e.g. charge codes etc;
   - action to be taken in the event of a service interruption;
   - housekeeping procedures;
   - glossary of terms;
   - supporting and related services;
   - any exceptions to the terms given in the SLA.

4. To make the set of use cases complete we should consider the renegotiation by any of the two parties

5. To make the set of use cases complete we should consider the cancellation of such SLA

### 3.1.3. SUMMARY

Federated e-Infrastructures are computing systems bringing together resources coming from different administrative domains to a single service offering that provides value to a set of users. Examples of federated e-Infrastructures include computational and data grids as well as emerging federated Clouds.

We have generated a simple model with three actors: The VO, Site and FI, representing the user, federator and supplier roles. Each actor has commitments to fulfil with respect to the other actors. Specifically VO as customer and the FI as service provider have mutual obligations to fulfil that are specified in a Service Level Agreement (SLA). To support SLAs the FI will negotiate and sign Operational Level Agreements with involved Sites.
Service Management requires specifying the management functionality to be provided. For that purpose we have adopted a use case based approach. A use case defines the smallest management activities that have to be carried out atomically. In practice each use case consists of a set of well-defined activities that are executed as a workflow. To identify the appropriate use cases we used ITIL as background information. A total of 16 SLM-related and 22 SDM-related use cases have been specified. All these use cases are presented in detail in this roadmap's companion document [11].

3.2. MATCHING INFRASTRUCTURE AND SLM MATURITY

The reasons for using a maturity model are twofold. First, rather than making the implementation of SLM a binary decision, a maturity model allows SLM development to be shown as a set of achievable steps from no SLM to commercial level SLM compliant with systems such as ITIL or ISO/IEC 20000. Second, a maturity model can demonstrate that not all infrastructures must immediately push for the most mature SLM level. Rather, as a service or infrastructure matures, it should adopt a matching level of SLM maturity. Such an approach makes SLM adoption a more reasonable approach for e-infrastructures and Grids in particular. Maturity models are widely used in the IT sector by many organisations and for many subject areas. However, the basics remain the same. A maturity model is an abstraction of a system, which stratifies the maturity of the system into an easily manageable set of levels. Each level is accompanied by a description of diagnostic features of that level of maturity. It helps build common understanding of maturity such that they can be improved, leading to the improvement of the overall system.

Maturity models offer useful tools for understanding, assessing, improving and optimising given systems. From the 1970s, models for the stages of maturity in IT models have been developed, such as Richard Nolan’s ‘Stages of Growth’ model [13]. Perhaps the best-known maturity model is the Capability Maturity Model (CMM) and the Capability Maturity Model Integration (CMMI) that superseded it. Designed by Carnegie Mellon University in the USA, it was originally developed at the behest of the US Department of Defence as a tool for evaluating contractors for software. It has since been applied in many areas and has been updated in CMMI, a fairly comprehensive process improvement approach, widely used in software development and organisational development. CMMI levels can be summarised as shown in Figure 3.4.

The IT Service Management (ITSM) domain has adopted this concept in many areas. One example is the COBIT framework [14], produced by ISACA (a non-profit association dealing with practices around IT and information systems).
3.2.1. GENERAL AND PER-USE-CASE MATURITY MODEL

As mentioned above, the gSLM consortium selected COBIT as a base for a maturity model as it is relatively simple and easy to grasp. However, our maturity model has been modified in various ways. Most obviously, we have adapted the generic and specific descriptions of service levels using a terminology that will be familiar to those in the e-Infrastructure domain. This is intended to make SLM less foreign than systems such as ITIL may appear, and to provide concrete examples related to elements of Grids and e-Infrastructures. In addition, this is necessary as while not perhaps revolutionary, there are elements of Grids and management challenges imposed by their organisation that are uncommon in the broader IT field. The consortium chose six levels, using 0-5 for maturity. The addition of a zero level, seen in some models but not standard, was necessary in order to describe services and systems where there was as yet no recognition of service provision needs at all. Such levels are typically seen in very early stage services or systems, yet to emerge from a research lab or group into use by any significant customer base. The other main adaptation from COBIT was that rather than applying maturity levels to processes, we have chosen to apply them to use cases. These are clearly less generic than processes, but since the model is intended for a specific area, making it more precisely tuned to that area makes sense. In the following paragraphs we elucidate the generic maturity levels.

Level 0 – Non-existent. There is no consideration of service management at all, with developers and future service providers concentrating on getting the services to work. Either through lack of awareness or choice, quality assurance is not addressed. This level of maturity is seen in and appropriate for alpha level lab technical development of services. At this stage the team behind the service is made up of individuals more concerned about non-functional code than considerations of service.

Level 1 – Initial / ad hoc. There is an awareness that service quality has to be addressed. This awareness may grow from internal factors (increased service management awareness of staff) or external factors such as demand from supervisors or early customers. Such early customers will have some expectation of service availability and function, but probably through informal relationships with developers and service providers. Users likely have direct contacts for developers (phone, email). Such personal relationships between members of the provider team and customer base are possible as the number of individuals on both sides is small enough to support this. The service runs but is explicit in not being robust or reliable - downtime and failures are frequent and there is no warranty or contract.

Level 2 – Repeatable But Intuitive. There is some formalism in the provision of the system. Semi-formal agreements may be in use, and in multi-organisational contexts, agreements start to be discussed between organisations on a handshake level. There is likely to be a helpdesk or support system of some sort, though simple. It may consist of shared mailing lists for bugs and updates. Expertise and procedures begin to be captured but are likely documented in inaccessible formats such as private document servers or meeting minutes. What documentation exists is likely to be in nonstandard formats, contain inconsistencies and be updated haphazardly. Rules for managing systems and process begin to be set, but may be carried out though paths such as emails to named individuals or shared addresses rather than any real automation. Decisions on the priority of rules or processes will be intuitive. It is unlikely that over the whole system both processes and responsibilities are well defined, though one of the two may be. Some small areas may be better managed through individual effort but such blocks are likely to exist in a flat, unconnected hierarchy.

Level 3 – Defined. Formal contracts exist, as does some sort of service catalogue. Users and providers understand off the shelf services that cover a reasonable number of cases. SLAs exist and are non-trivial (for instance more than simple uptime figures). Rules are provided and are generally followed. However, monitoring is poor and even when infractions are noticed penalties are weakly imposed if at all. The biggest consequence of failure may be loss of reputation even if financial or other penalties are defined. Management of customer relations involves buy-in by both parties and interactions begin to be automated as interactions rely on a standardised framework. Documentation is available and has become standardised. At this stage
companies can realistically have contracts with academically provided services. Such agreements, however, are likely to be in areas such as out-sourced R&D infrastructures rather than mission critical systems.

Level 4 – Managed And Measurable. Contracts are not only formalised but also effectively monitored by both the customer and provider and enforceable for both. Services are reliable enough for mid and long term resource planning. When considering costs, opportunity costs as well as direct costs can be reasonably quantified and considered. The service or system is reliable enough for use in day-to-day and mission critical services by both academic and commercial organisations. The system is well monitored and changes to the system are reactive to monitoring. A change management process is in place that can predict and plan for changes, downtimes and maintenance as well as providing steps to cope with unanticipated service failure.

Level 5 – Optimized / Integrated. The management of the system has gone beyond formalism and repeatability into optimisation. Changes to the system are generally proactive rather than reactive. The system is optimised and commoditized to the extent that you can optimise against other organisations, or even offload services to other providers, or to the extent that it is well understood enough to be insured at a reasonable economic cost. Organisations can quickly adapt business goals to new situations, as they understand the whole process sufficiently. Service provisioning is no longer the prime focus as it is so well understood that it is a given. Rather, issues become more people-centric, such as maximising customer satisfaction or retention. These are more nebulous and can’t be reduced to mechanical steps, but become more important as the service moves from considering reliability metrics and other quantitative data towards Business Driven IT Management (BDIM).

<table>
<thead>
<tr>
<th>Maturity level 3 – generic text</th>
<th>Maturity level 3 – instantiated for the use case ‘Negotiate and sign SLA’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal contracts exist, as does some sort of service catalogue. Users and providers understand off-the-shelf services that cover a reasonable number of cases. SLAs exist and are non-trivial (for instance more than simple uptime figures). Rules are provided and are generally followed. However, monitoring is poor, and even when infractions are noticed penalties are weakly imposed if at all. The biggest consequence of failure may be loss of reputation even if financial or other penalties are defined. Management of customer relations involves buy-in by both parties and interactions begin to be automated as interactions rely on a standardised framework. Documentation is available and has become standardised. At this stage companies can realistically have contracts with academically provided services. Such agreements, however, are likely to be in areas like out-sourced R&amp;D infrastructures rather than mission critical systems.</td>
<td>There is a defined and documented process for negotiating the SLA, which in particular specifies the required scope of the negotiated SLA, the output format in which the SLA must be stored, and details of the negotiation protocol. However the negotiation process can still be performed using email exchange or phone calls, as long as both parties know what to do and expect at each step.</td>
</tr>
</tbody>
</table>

Table 3.2: Maturity level 3 instantiated for the use case ‘Negotiate and sign SLA’
Having established the maturity levels, it was necessary to instantiate them on a per use case basis. In other words to put each maturity level in context. To explain this, we compare the generic text of the level 3 maturity with the corresponding one instantiated for the use case ‘Negotiate and sign SLA’, which are both shown in Table 3.2.

A key sentence in the left column of Table 3.2 in the context of this use case is “SLAs exist and are non-trivial (for instance more than simple uptime figures)”. Also there is mention of the existence of documentation in a subsequent sentence. These two sentences are then expanded and become the first sentence of the right side column. In addition, the second sentence of the right column throws light on the mechanism through which the negotiation will take place. On the other hand, the remaining sentences on the left column are not meaningful in the current context; therefore they are simply ignored in the instantiation. A similar reasoning could be applied to the other maturity levels of this or any other use case.

A complete description of each use case maturity level can be found in this roadmap’s companion document [11].

3.2.2. REQUIREMENTS FOR ALL PER-USE-CASE MATURITY LEVELS

Clear requirements are a vital input to the development of any information system. They are a part of the system development planning process, developing an understanding of the relationship between its parts.

In System Engineering requirements are divided into two types: functional and non-functional. Both have their significance in the process of requirements engineering and, later, implementation. Functional requirements are defined as “a statement of some function or feature that should be implemented in a system”, whereas non-functional requirements are “a statement of a constraint or expected behaviour that applies to a system”. A term coined for the process of requirements collection is "requirements elicitation", as the list of requirements is a product of the process that usually includes many steps, such as gathering, analysis, filtering, grouping, aligning, building dependencies, etc.

Requirements elicitation is an important step in the development of any requirements that would help to improve an information system. In the implementation of SLM, definition of requirements helps e-Infrastructure representatives and designers to...

- assess the current maturity level of the infrastructure;
- better realize what implementation of Service Level Management exactly means;
- provide sources of reference for those who want to improve their Service Level Management implementation.

The requirements should be associated with specific use-cases and maturity levels. This means that fulfilling all the requirements on a specific maturity level in the specific use-case can be confirmation of reaching this level. Each requirement should be atomic and easily verifiable, to test the existence of some functionality or specific features of the system in an objective way. Requirements should be clearly described in language that can be understood by the people that will implement the requirement. Dependencies between requirements is a very useful tool for keeping them short and it supports implementations with better understanding of what exactly is demanded to fulfil a specific requirement. Usually, not all requirements assigned to a lower maturity level are dependent, as requirements address specific aspects of use-case implementation. Useful additions to the descriptions are identifiers and short titles.

The process of requirements elicitation may lead to creation of a requirements catalogue. The added value of creating the catalogue is the following:
• The roles of the main stakeholders (Sites, Federated Infrastructures and Virtual Organizations) are clearly specified and their contributions to improving Service Level Management in an e-Infrastructure are made clear;
• Requirements not only lead on from maturity levels but also establish criteria and therefore a tool for assessing SLM in a given e-Infrastructure.

The requirements catalogue is intended to be a useful reference of requirements for implementing or improving Service Level Management in e-Infrastructures. Having specified target Use Cases and maturity levels that an e-Infrastructure is willing to achieve, its designers can straightforwardly obtain a set of requirements that need to be implemented to reach this goal. Going through the requirements dependencies would provide them with a wider view of related Use Cases and managerial processes, which would support them in prioritisation of the functionality implementation.

In the following paragraphs, we outline the methodology adopted to derive the use case based requirements.

3.2.2.1. DEFINITION OF USE CASE ASPECTS TO BE COVERED BY REQUIREMENTS

To achieve better consistency of requirements we have tried to define the common elements in how use case maturity relates to requirements. Table 3.3 shows different aspects of a process we might consider, and for each it suggests how requirements will change with increasing maturity. Selection of these aspects was based on principles from the COBIT [14] and ITIL [4] [5] [6] [7] [8] frameworks, and from our understanding of the core aspects of activities related to Grid and other federated infrastructures.

To give an example, for any use case, documentation should generally be available internally from maturity level 2 and externally from level 3 and beyond. In contrast, process quality assurance generally occurs further through the maturity of a process, starting only at level 4 and being optimised in level 5. While we may find exceptions to this general structure, it provides us with a solid baseline for considering the requirements we have gathered and matching them to our use case based maturity model.

3.2.2.2. ACTORS SUBJECT OF THE SET OF REQUIREMENTS

To stop the requirements being overly abstract, they have to be targeted to a specified actor responsible for fulfilling them. As mentioned above, in the SLM model for e-Infrastructures we defined three main actors participating in the infrastructure’s functioning, namely Virtual Organization, Federated Infrastructure (Grid Initiative) and Site, where the naming in parenthesis corresponds to the instantiation in the Grid domain.

We decided not to specify the requirements for VOs in the scope of this requirements catalogue, as here we focus only on the requirements that need to be implemented for building Grid services. However, it should be noted that it is important that a VO is on a maturity level similar to the one FI (GI) is implementing. Otherwise, the communication between these two entities may be poor. We decided to include both FI (GI) and Sites as subjects of the requirements since, in our model, they are both providers of services. To build a mature e-Infrastructure, cooperation on both sides is necessary.

3.2.2.3. REQUIREMENTS PRIORITIZATION

In such a large set of requirements – we initially expected the requirements catalogue to contain more than several hundred requirements – some kind of prioritisation is necessary to facilitate planning for their implementation. In our approach, the prioritisation comes from three sources:

• Maturity Model – the maturity model itself prioritises requirements within a Use Case, as the most important requirements have to be implemented for lower levels of maturity. Usually, requirements for higher maturity levels depend on implementing requirements from previous levels;
• Dependencies between requirements – some of the requirements demand others as prerequisites – in such cases prioritisation is inferred from these dependencies;
• Use Case prioritisation – each e-Infrastructure that implements Service Level Management would have different ideas on how important a specific functionality (Use Case) is for them and their users. Therefore, by prioritising the Use Cases, the infrastructure would automatically prioritise requirements.

Since the importance of a specific Use Case is left somewhat to the preference of the infrastructure implementing it, we cannot assign absolute priority to each requirement. Instead, we provide dependencies between them and association with Use Cases with respect to successive levels of maturity. Using these tools and knowing their preferences for Use Cases, the implementers can easily assign priorities to all requirements.

<table>
<thead>
<tr>
<th>Aspect and its mode of implementation</th>
<th>Maturity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Process identification</td>
<td></td>
</tr>
<tr>
<td>Identified</td>
<td>X</td>
</tr>
<tr>
<td>Relation with other processes defined</td>
<td>X</td>
</tr>
<tr>
<td>Documentation of the process</td>
<td></td>
</tr>
<tr>
<td>Not available</td>
<td>X</td>
</tr>
<tr>
<td>Internally available</td>
<td>X</td>
</tr>
<tr>
<td>Available to all actors involved</td>
<td>X</td>
</tr>
<tr>
<td>Communication channels</td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>X</td>
</tr>
<tr>
<td>Specified for the Use Case</td>
<td></td>
</tr>
<tr>
<td>Roles management</td>
<td></td>
</tr>
<tr>
<td>No specific roles assigned</td>
<td>X</td>
</tr>
<tr>
<td>Roles identified</td>
<td></td>
</tr>
<tr>
<td>Roles are properly managed, including trainings</td>
<td></td>
</tr>
<tr>
<td>Data format specification</td>
<td></td>
</tr>
<tr>
<td>Not specified</td>
<td>X</td>
</tr>
<tr>
<td>Internally known</td>
<td></td>
</tr>
<tr>
<td>Documented</td>
<td></td>
</tr>
<tr>
<td>Scope of process integration</td>
<td></td>
</tr>
<tr>
<td>Single actor</td>
<td>X</td>
</tr>
<tr>
<td>Integrated between actors</td>
<td></td>
</tr>
<tr>
<td>Standard catalogues and registries</td>
<td></td>
</tr>
<tr>
<td>Not defined</td>
<td>X</td>
</tr>
<tr>
<td>Used in the Use Case</td>
<td></td>
</tr>
<tr>
<td>Alignment with standards and best practices</td>
<td></td>
</tr>
<tr>
<td>Process not aligned with standards</td>
<td>X</td>
</tr>
<tr>
<td>Aligned with de-facto standard bodies or known frameworks</td>
<td></td>
</tr>
<tr>
<td>KPI of the process</td>
<td></td>
</tr>
<tr>
<td>Not defined</td>
<td>X</td>
</tr>
<tr>
<td>Defined and measured</td>
<td></td>
</tr>
<tr>
<td>Supporting tools and level of integration with other processes</td>
<td></td>
</tr>
<tr>
<td>Carried out with generic tools (e.g. spreadsheets), not integrated</td>
<td>X</td>
</tr>
<tr>
<td>Specific manual tools, not fully integrated</td>
<td></td>
</tr>
<tr>
<td>Specific semi-automated or automated tools, fully integrated</td>
<td></td>
</tr>
<tr>
<td>Process quality assurance</td>
<td></td>
</tr>
<tr>
<td>Not carried out</td>
<td>X</td>
</tr>
<tr>
<td>Monitoring carried out</td>
<td></td>
</tr>
<tr>
<td>Analysis of monitoring data</td>
<td></td>
</tr>
<tr>
<td>Optimisation loop</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.3: Aspects to be taken into account implementing maturity levels on a per-use-case basis
3.2.2.4. ELICITATION OF REQUIREMENTS

The process of preparing the set of requirements is called "requirements elicitation", which usually includes steps such as: gathering, analysis, filtering, grouping, aligning, building dependencies, etc. In the process of defining this requirements catalogue we also followed that pattern, using a procedure composed of the following steps:

1. **Definition of methodology** – the project gSLM team devised the methodology elements summarised in previous sections.

2. **Definition of general requirements** – based on general practice in ITSM, we defined general requirements that were related to the main processes described in ITIL [4] [5] [6] [7] [8] and ISO/IEC 20000 [9]. Some of these requirements were technical, others related to common concepts like helpdesk, configuration database, understanding of SLA, etc. This step was intended to limit duplication of requirements that we expected to be frequent.

3. **Gathering requirements for specific Use Cases and maturity levels** – for each Use Case, experts within the gSLM project staff were asked to propose requirements at each maturity level, according to the agreed methodology. They were also asked to define dependencies both to general requirements and to other requirements within the same Use Case.

4. **Identification of common requirements** – the team responsible for this deliverable, in collaboration with the Use Case requirements authors, reviewed all the requirements and improved the clarity of expression and overall consistency. Similar Use Cases were then identified and merged, keeping the initial reference to the Use Case and maturity model.

5. **Dependency building** – all the requirements were again reviewed and dependencies between requirements for different Use Cases, as well as relations to the general requirements, were identified and checked. Lastly, the general requirements that were not identified as prerequisites to any other requirement in Use Cases were removed from the list.

6. **Building the catalogue** – finally, the requirements catalogue was built based on the data prepared within previous steps.

We assume that this catalogue will be used to verify or implement specific functionalities – i.e. Use Cases – therefore we present all the requirements that are needed to achieve a specific maturity level in a specific Use Case. The relation between requirements from different Use Cases can be tracked in the detailed description of each requirement, where dependencies and references to all Use Cases and maturity levels can be found. Illustrating the outcome of the methodology above, Table 3.4 shows the requirements associated with the use case "Negotiate and sign SLA". The full set of requirements for all use cases is contained in this roadmap’s companion document [11].

3.2.3. THE GSLM E-INFRASTRUCTURE MATURITY ASSESSMENT TOOL

As a directly related application of all the above building blocks, the consortium developed a tool to help in the maturity analysis of real e-infrastructures. In fact, the gSLM e-Infrastructure maturity assessment tool is based on requirements-based analysis using the gSLM derived use cases and maturity levels. It works essentially in reverse with respect to the way in which the use cases, maturity levels and requirements were created.

Participants are asked several hundred yes/no questions in order to ascertain whether they have passed each of the requirements the project has derived. By analysing this data it is possible to see which use case maturity levels they achieved (where they pass all related requirements). This produces a table for each use case, which identifies the corresponding maturity level.
At a basic level this provides an idea of the state of maturity of the infrastructure’s service management, but can also provide material for further analysis. Apart from average maturity, by looking at where a respondent is more or less mature it is possible to see which areas they have worked more on and which areas they have not developed. The data also assist in planning for improvement. Respondents can see use cases where they have partially achieved a higher level, and see exactly which requirements must be passed to improve their maturity level. This allows for the planning of relatively ‘quick wins’ — where a small amount of effort can have a large impact on overall maturity. It can also allow for longer term strategic planning to make sure that efforts around management have the greatest impact possible on service management, and in appropriate areas. For instance if the major concern of an infrastructure is user relations while relations with suppliers are already strong, more effort can be channelled into use cases involving user interaction.

<table>
<thead>
<tr>
<th>MATURITY LEVEL 1: INITIAL/AD HOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>R01: Contact data to GI is available</td>
</tr>
<tr>
<td>R10: GI has a rudimentary Service Catalogue</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MATURITY LEVEL 2: REPEATABLE (BUT INTUITIVE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R25: An informal SLA negotiation process is present in GI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MATURITY LEVEL 3: DEFINED</th>
</tr>
</thead>
<tbody>
<tr>
<td>R26: GI defined the scope of SLA</td>
</tr>
<tr>
<td>R27: GI defined the format of SLA</td>
</tr>
<tr>
<td>R28: GI specified a contact for SLA requests</td>
</tr>
<tr>
<td>R29: GI defined the SLA negotiation protocol</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MATURITY LEVEL 4: MANAGED AND MEASURABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R30: GI has an SLA negotiation management system</td>
</tr>
<tr>
<td>R31: GI is able to perform SLA verification</td>
</tr>
<tr>
<td>R32: GI is able to perform SLA negotiation rollback</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MATURITY LEVEL 5: OPTIMISED</th>
</tr>
</thead>
<tbody>
<tr>
<td>R33: GI is able to automate the SLA negotiation process</td>
</tr>
<tr>
<td>R34: GI is able to automatically optimise the SLA</td>
</tr>
</tbody>
</table>

Table 3.4: Requirements for the use case ‘Negotiate and sign SLA’

Overall the maturity analyser gives immediate and quite simple feedback on overall maturity, but its real value is as a basis for deeper analysis. This might be through members of an infrastructure staff analysing the data or through using it as a basis for consultancy with service management experts. Its major advantage is that because it is requirements- based, broader strategic goals can be traced back to specific changes or improvements which can be realistically made, meaning that it is of practical use.

3.2.4. SUMMARY

A major challenge inherent in bringing these ideas to e-Infrastructures is driving adoption – a problem also seen in traditional ITSM introduction. To deal with this, an attractive approach is to look at incremental change plans, based on concrete entities or steps that can be taken to improve service management. Incremental improvements increase the likelihood of uptake. Through them it can be demonstrated that service
management can be improved, leading to overall improvements of the service in an achievable and less daunting manner. Additionally, by making incremental improvements very concrete and couched in the terms of the federated e-Infrastructure community, they should sit more comfortably with the community where they are instigated.

In practice we have adopted a maturity model approach. A maturity model is an abstraction of a system which stratifies the maturity of the system into an easily manageable set of levels. With the goal of building a common understanding of SLM/SDM maturity in Grids and e-Infrastructures we develop a domain specific maturity model. We selected COBIT as a basis, because it is relatively simple and easy to adapt. Our maturity model consists of two parts:

- A descriptive model, generally describing maturity levels;
- Descriptions of the maturities of individual use cases.

We use our generic maturity levels as a schema for deriving maturities of specific use cases and operational areas of SLM and SDM. The overall result is a complete model that allows community members to quantify an e-Infrastructure’s current maturity. Furthermore, this fine granularity of maturity levels can also be used as a basis to determine the next steps in improving an infrastructure’s SLM/SDM.

Last but not least, the maturity model allows us to develop the requirements that a given e-Infrastructure has to fulfil to reach a given maturity level. Our requirements elicitation process was based on six steps, namely, 1) Definition of methodology; 2) Definition of general requirements; 3) Gathering requirements for specific Use Cases and maturity levels; 4) Identification of common requirements; 5) Dependency building and 6) Building the catalogue.
4. GUIDE FOR FEDERATORS AND E-INFRASTRUCTURE PROVIDERS

Part 4: Guide for Federators and e-Infrastructure providers

Read this if you:
- Need to make operational changes to introduce ITSM to an e-infrastructure
- Need to apply ITSM concepts and approaches to your particular situation

Skip this if you:
- Are interested in policies but not a detailed approach for implementation

Content:
- Phase based approach to changing operational infrastructures
- Generic step-by-step approach that you can apply to your individual situation
- Links to guidance and support for the process from gSLM, external standards and ITSM frameworks

Primary Audiences:
- Operations managers at e-Infrastructures
- Operations managers at resource centres

4.1. INTRODUCTION

This part of the strategic roadmap describes a generic approach to be applied to federated e-Infrastructures, aiming at improving their IT Service Management (ITSM).

Part 4 is divided into phases to provide optimal guidance. Each phase is described in the following way:

- First, the “key idea” of the phase is defined in order to give the reader a notion and impression of the motivation for the actions in the phase.
- Secondly, the “inputs and outputs” of the phase are specified.
- Following this, a general procedure for the phase is given (“How to proceed”). This section is intended to provide a basic understanding of the phase, and to show what aspects need to be considered. The steps to be performed are listed and explained. For each step, concrete examples and additional explanations/comments are given.
- Finally, the useful concepts and supporting material for this phase and its related aspects are introduced and referenced. The concepts are pieces of much more concrete guidance or supporting methods (“tools”) that are publicly available or provided by the gSLM project.

Figure 4.1 shows in a generic way how each phase is structured, how different phases are connected to each other, and how supporting concepts may be applied in different phases.

This Part of the roadmap can be regarded as a “good practice”-based guideline for implementing SDM and SLM in federated infrastructures, based on experience, findings and outcomes from the gSLM project. In this context, SLM and SDM are regarded here as the two major sub-disciplines of IT Service Management (ITSM), as explained in section 3.1.
4.2. PHASE 1: UNDERSTAND THE BASELINE/CURRENT SITUATION (WHERE ARE WE NOW?)

4.2.1. KEY IDEA

In a federated environment, the current implementation status of SLM and SDM should be realistically assessed.

4.2.2. INPUT AND OUTPUT

- Input: No specific input.
- Output: A solid qualitative and quantitative assessment of the current situation (including organizational maturity, effectiveness and compliance considerations) of Service Level Management (SLM) and Service Delivery Management (SDM) in the regarded scenario/context.

4.2.3. HOW TO PROCEED

Question: How should we proceed to understand the current situation (baseline) of our SLM and SDM?

The following steps may form a solid approach to achieve the desired output of this phase:
STEP 1.1 SET THE SCOPE (E-INFRASTRUCTURE, FI, SITE, VO, SERVICE, ETC.)

- Instructions:
  o Scope setting means to identify the area(s), for which SLM/SDM considerations shall be made.
  o Consequently, scope setting also means to identify any area(s), for which SLM/SDM is not considered to be relevant at the current point in time (exclusions from the scope).
  o Please refer to building block 1.A for more information on scope parameters.

- Examples:
  o Example for a “full scope” statement: The scope considered for the baseline is a specific FI/GI (e.g., PLGRID) and includes all (Grid) services provided through/by this FI (i.e. the entire service catalogue). No exclusions are made.
  o Example for a “partial scope” statement: The scope considered for the baseline is a specific FI/GI, but does not include all services provided through/by this FI. The service ... is excluded from the scope. That means that any SLM/SDM considerations are independent of this service and will not cover this service. For example, SLAs and OLAs are not intended for this service, and defined incident reporting procedures are not intended to be applied to incidents related to this service.
  o Second example for a “partial scope” statement: The scope considered for the baseline is a specific FI/GI, but only includes the Sites X and Y. That means that any SLM/SDM considerations are only related to these Sites and no other Sites in the context of the FI.

- Comments: None

STEP 1.2: DEFINE THE TOPICS TO BE ADDRESSED TO DESCRIBE THE CURRENT SITUATION IN A QUALITATIVE WAY

- Instructions:
  o Since SLM and SDM are quite abstract terms, a clear understanding of the specific topics that are relevant for the baseline assessment need to be in place.
  o A promising way of understanding the relevant topics to be considered is to look at the use cases connected to managing service levels and service delivery.
  o Each use case represents a specific task or challenge that is part of SLM/SDM and needs to be performed to achieve a certain goal or output.
  o Please refer to building block 1.B for more information on use cases.

- Examples:
  o Service level agreements (SLAs) and the way they are managed and monitored.
  o Reporting and managing incidents across the federation.

- Comments:
  o Looking at the use cases is also helpful for (at a later point in time) defining organisational processes.

STEP 1.3: DEFINE THE METRICS REQUIRED TO DESCRIBE THE CURRENT SITUATION IN A QUANTITATIVE WAY

- Instructions:
  o Now that the specific topics to be considered have been identified, specific metrics need to be identified for these topics, which – altogether – shall serve as a quantitative basis for the baseline assessment.
  o Please refer to building block 1.C for more information on metrics and key performance indicators (KPIs).
• Examples:
  o Exemplary metrics for the topic “Service level agreements (SLAs) and the way they are managed and monitored”:
    ▪ Number of SLAs (at a specified point in time)
    ▪ Amount of services covered by live SLAs (in per cent)
  o Exemplary metrics for the topic “Reporting and managing incidents across the federation”:
    ▪ Number of incidents (over a specified period of time)
    ▪ Average resolution time for incidents, grouped by different categories/priorities

  • Comments: None

**STEP 1.4: DESCRIBE THE QUALITATIVE AND QUANTITATIVE BASELINE BASED ON THE RESULTS FROM STEPS 1.2 AND 1.3**

• Instructions:
  o For the topics identified in step 1.2, perform a qualitative assessment of the current degree of maturity taking into account all relevant sources of information in the given scope.
  o For the metrics and KPIs defined in step 1.3, perform a quantitative assessment of the degree of effectiveness and efficiency.
  o Please refer to building block 1.D for more information on maturity assessment using the gSLM maturity model.
  o Please refer to building block 1.E for more information on maturity assessment using the gSLM assessment tool.

• Examples:
  o Qualitative baseline for the topic “Service level agreements (SLAs) and the way they are managed and monitored”:
    ▪ Some SLAs are in place between Sites and VOs, but many of the (federated) services provided are not covered by clear SLAs
    ▪ There is no formal/defined approach to defining, agreeing or monitoring service levels
    ▪ There is no uniform template in place which that is used consistently when SLAs are defined
    ▪ The monitoring infrastructure is able to provide some information relevant for SLA monitoring (e.g. simple data aggregation, tagging logs for specific VOs). But most monitoring activities are focused on default system logs
  o Qualitative baseline for the topic “Reporting and managing incidents across the federation”:
    ▪ There is awareness of the need for an incident management process
    ▪ Assistance is available on an informal basis through a network of knowledgeable individuals
    ▪ These individuals have some common tools available to assist in incident resolution, and most users know how to report their incidents to the most suitable individual at the FI

• Comments:
  o An important beginning point for highlighting improvement is to establish baselines as markers or starting points for later comparison. Baselines are also used to establish an initial data point to determine if a service or process needs to be improved. As a result, it is important that baselines are documented, recognized and accepted throughout the organization. Baselines must be established at each level: strategic goals and objectives, tactical process maturity, and operational metrics and KPIs.
The baseline describes the current state/situation of SLM and SDM in a qualitative and quantitative way, including the supporting processes and tools as well as the current level of performance.

4.2.4. USEFUL CONCEPTS AND SUPPORTING MATERIAL

Background: As part of the gSLM project, different methodologies and tools have been developed to provide assistance in performing or supporting the different steps of this phase. These methods and concepts are also referred to as the “gSLM building blocks” and have been described in Part 3 of this document. (Figure 3.2 gives an overview of the most important building blocks such as the actors and relationships model, the definitions of use cases, the general maturity model, the per-use-case maturity model and the requirements catalogue.)

In addition, various frameworks and standards, mainly from the ITSM domain, provide (good practice-based) guidance in different situations.

Questions:

- What are the most important things we have to know (and know how to use) to perform steps 1.1 to 1.4?
- Where do we get further guidance on these topics?
- Which gSLM building blocks may be applied?
- Which other sources may be helpful in addition?

**CONCEPT 1.A: SCOPE PARAMETERS**

When defining the scope (of a management system), the following parameters may be considered:

- Organisations or organisational units involved in the federation
- (Federated) services offered
- Geographical locations
- Customers (including VOs) and their locations
- Technology used to provide services

Practical guidance on scoping (scope definition) and scope parameters can be found here:

- ISO/IEC 20000-1, clause 4.5.1 [9]
- ISO/IEC 20000-2, clause 4.5.1 [12]
- ISO/IEC 20000-3 [15]

This concept may be applied in Step ...

| 1.1                  | Setting the scope for SLM/SDM considerations in an organization or Federated Infrastructure (initiative) |

**CONCEPT 1.B: GSLM USE CASES DEFINITIONS FOR SLM/SDM**

This concept is a gSLM building block. Please refer to Section 3.1.2, Definitions of use cases, for detailed information.
<table>
<thead>
<tr>
<th>CONCEPT 1.C: GSLM ACTORS AND RELATIONSHIPS MODEL FOR SLM/SDM</th>
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<tbody>
<tr>
<td>This concept is a gSLM building block. Please refer to Section 3.1.1, <em>Actors, relationships and terminology</em>, Definitions of use cases, for detailed information.</td>
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<thead>
<tr>
<th>CONCEPT 1.D: METRICS AND KPIS</th>
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<tr>
<td>Metrics should be (SMART):</td>
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<tr>
<td>• Specific</td>
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<tr>
<td>• Measurable</td>
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<tr>
<td>• Achievable</td>
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<tr>
<td>• Related to each other</td>
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<tr>
<td>• Time-bounded</td>
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<tr>
<td>Practical guidance on metrics and KPIs can be found here:</td>
</tr>
<tr>
<td>• COBIT [14]</td>
</tr>
<tr>
<td>• ITIL Continual Service Improvement [8]</td>
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<thead>
<tr>
<th>CONCEPT 1.E: GSLM MATURITY MODEL</th>
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<tr>
<td>This concept is a gSLM building block. Please refer to Section 3.2.1, General and per-use-case maturity model, for detailed information.</td>
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</table>
This concept may be applied in Step ...

| 1.4 | Qualitative maturity baseline assessment on a manual basis |

CONCEPT 1.F: MATURITY ASSESSMENT TOOLS

The gSLM online maturity assessment tool is based on the gSLM maturity model (see building block 1.E). This concept is a gSLM building block. Please refer to Section 3.2.3, The gSLM e-Infrastructure maturity assessment tool, for detailed information.

This concept may be applied in Step ...

| 1.4 | Qualitative maturity baseline assessment on a semi-automated basis |

4.3. PHASE 2: IDENTIFY THE NEED & DEVELOP A VISION (WHERE DO WE WANT TO BE?)

4.3.1. KEY IDEA

In a federated environment, a common understanding of the desired state of SLM and SDM, and overall awareness of the need for improvements should be in place.

4.3.2. INPUT AND OUTPUT

- **Input:** A solid qualitative and quantitative assessment of the current situation (including organizational maturity, effectiveness and compliance considerations) of Service Level Management (SLM) and Service Delivery Management (SDM) in the regarded scenario/context.
- **Output:** A statement (approved by relevant authorities) on the need for improvements in SLM and SDM, including clear policies and requirements as well as an overall vision and a summary of the most important goals to be achieved.

4.3.3. HOW TO PROCEED

Question: How should we proceed to develop a vision and identify the need for improvements?

STEP 2.1: DEFINE THE VISION

- **Instructions:**
  - Formulate an overall vision for developing SLM/SDM.
- **Examples:**
  - Example for a vision focused on customer alignment and value: "Our vision is to offer services aligned to the needs of our users (customers), creating a clear and outstanding value, and to be recognized by our users (customers) as a reliable partner, effectively supporting them in their goals and dynamically responding to their needs and demand."
Example for a vision focused on technology leadership: "Our vision is to provide the most innovative technology solutions in the area of ... to our users (customers) and to be regarded as the most progressive adopter of new technologies in our area."

Example for a vision focused on economic goals: "Our vision is to be the market leader in the area of ... and to achieve an average return on investment of ..."

- **Comments:**
  - A vision usually describes a desirable state, situation or condition in the future, usually from a high-level perspective, and aligned to even higher-level goals.
  - From the perspective of a traditional service provider, the service provider's vision will be aligned to the business objectives of the (main) customer(s) of this service provider.
  - In analogy, in federated environments, where services are offered on the basis of a federation of different organizations, technologies and processes, the vision should reflect the overall goal of supporting the users of the services in a way that they experience a real value from the services.
  - Sometimes, in practice, a distinction is made between the vision and the mission statement of an organization/enterprise. While in this case the vision describes a desired state in the future, the mission should express how and in which primary role the organization/enterprise sees itself. The mission statement is often less connected to strategic goals, but tells people something about the core purpose of the organization/enterprise. Mission statements may be used for marketing and advertisement, which is usually not the case for the (strategic) vision. Examples of mission statements:
    - "We connect the world!" (telecom provider)
    - "Enabling European research" (e-Infrastructure provider)

### STEP 2.2: DEFINE AND PRIORITIZE (MEASURABLE) GOALS

- **Instructions:**
  - Based on the topics and metrics/KPIs used for the baseline assessment (see phase 1, steps 1.2 and 1.3), define the qualitative and quantitative (i.e., measurable) short-, medium- and long-term goals that need to be achieved.
  - Prioritize the goals according to their importance and impact as well as time-criticality (urgency).

- **Examples:**
  - First priority: Service Level Agreements (SLAs) are in place with all customers covering at least 80 per cent of the services provided (metric: coverage of services/customers by SLAs in percent; target value: 80%).
  - Second priority: Incidents are reported via pre-defined channels and handled by a standardized process (metric: amount of incidents that are under the control of the formal process vs. amount of incidents not handled according to the process; target values: 80%/20%).

- **Comments:**
  - Measurable goals are typically derived from the overall vision. They reflect short-, medium- and long-term objectives. Smart metrics should be defined for each single goal to ensure that the achievement of goals can be evaluated.
  - A schedule including deadlines for achieving the goals may be defined at this stage. However, the concrete schedule for implementation stages and activities is part of phase 3.

### STEP 2.3: DESCRIBE THE MAIN GAPS BETWEEN THE CURRENT BASELINE AND THE GOALS/VISION
• Instructions:
  o Identify the gaps between the goals (step 2.2) and the current situation (steps 1.3 and 1.4).

• Examples:
  o Currently, only few SLAs are in place. Many services are provided to customers without a clear definition and understanding of the mutual duties and responsibilities, and without clearly defined and measurable warranty parameters. The coverage of services/customers by SLAs is only 15%. This is 65% below the target value.
  o Currently, incidents are not managed in a standardized way. A formal incident management process covering all relevant sites is not in place. Thus, the number of incidents that are under the control of a formal process is 0%.

• Comments: This step is directly related to the steps 1.3 and 1.4. Now, it not only defines the baseline (current situation), but in particular the delta between this baseline and the goals defined in step 2.2.

STEP 2.4: COMMIT TO THE NECESSARY IMPROVEMENTS AND RELEASE CLEAR OVERALL POLICIES

• Instructions:
  o The gaps identified in the previous step lead more or less directly to the necessary improvements.
  o In this step, a definitive commitment to the necessary improvements by authorized decision-makers through the federation is required.
  o Policies are formulated to express this commitment and serve as guidelines for subsequent actions.

• Examples:
  o SLAs need to be developed and agreed with, ideally, all customers.
  o The design of SLAs shall be standardized, as well as the process of negotiating, monitoring and reporting on service levels.
  o A formal incident management process needs to be developed and agreed between all relevant stakeholders.

• Comments:
  o Obviously, improvements can be directly derived from the main gaps identified in the previous step (2.3).
  o However, this step is not only about identifying reasonable areas for improvement, but primarily about achieving a commitment to these improvements by all relevant (involved, interested) parties.
  o This step must be performed by responsible senior authorities.

4.3.4. USEFUL CONCEPTS AND SUPPORTING MATERIAL

CONCEPT 2.A: POLICIES

A policy is a means of expressing a commitment to certain goals and directions. It should be adequate for its purpose (i.e. not too generic, and not too specific) and communicated to all relevant stakeholders. Policies are a mechanism used for governance. Concrete (operational) processes and procedures (including processes and procedures in the areas of SLM and SDM) should be developed on the basis of clear policies.

Practical guidance on policies can be found here:
  • COBIT [14]
This concept may be applied in Step ...

| 2.4 | Defining clear overall policies and committing to the necessary improvements |

4.4. PHASE 3: DEFINE THE PROGRESSION STAGES (HOW DO WE GET THERE?)

4.4.1. KEY IDEA

While previous stages have addressed the current situation and goals, this section describes how to elaborate a course of actions to be implemented in order to initiate the transition from the given baseline to achieving the specified goals.

4.4.2. INPUT AND OUTPUT

- Input: A statement (approved by relevant authorities) on the need for improvements in SLM and SDM, including clear policies and requirements as well as an overall vision and a summary of the most important goals to be achieved.
- Output: A plan (typically in the form of a project plan) specifying the schedule of necessary actions and connected milestones, including planning of resources.

4.4.3. HOW TO PROCEED

Question: How should we proceed to develop a plan of necessary actions, milestones and deliverables?

STEP 3.1: IDENTIFY OPTIONS FOR IMPROVEMENT ACTIVITIES

- Instructions:
  - Based on the improvements identified as necessary (see phase 2, step 2.4), the related improvement activities are identified.
- Examples:
  - Develop and agree a generic SLA template.
  - Define and agree an SLA negotiation process.
  - Develop and agree a generic OLA template.
  - Define and agree an OLA negotiation process.
  - Develop and agree a generic SLA and OLA monitoring plan.
  - Define and agree procedures for incident reporting.
  - Define and agree an overall incident management process.
  - Define the requirements for common supporting technology/tools for managing incidents (including recording, escalation, and tracking).
  - ...
Prioritize the activities identified in step 3.1 according to their importance and impact as well as time-criticality (urgency) and based on the priorities of the related goals (see phase 2, step 2.2).

- Example:
  - Highest priority (to be completed within 6 months): Establishing SLAs.
  - High priority (to be completed within 12 months): Establishing OLAs, installing a standardized incident reporting process.
  - Medium priority (to be completed within 24 months): Extending the incident reporting process to a complete incident management process.
  - Low priority (to be decided on at a later point in time, not subject to current planning).

### STEP 3.3: SPECIFY AND SCHEDULE THE MILESTONES

- Instructions:
  - Specify and schedule clear and unambiguous milestones that reflect the outputs of the improvement activities.
- Examples:
  - M+1: Generic SLA template defined and agreed.
  - M+2: SLA negotiation process defined and agreed.
  - M+6: SLAs in place, covering at least 80% of all services provided.
  - ...

### 4.4.3.1. STEP 3.4: IDENTIFY THE REQUIRED RESOURCES

- Instructions:
  - Create and agree an overall plan of the required resources, clearly connected to goals, activities, deliverables and/or milestones.
  - Resource planning should consider the following types of resources:
    - Human
    - Technical
    - Financial
    - Informational
- Examples:
  - Resources required for establishing SLAs through the federation:
    - Human: Required manpower
    - Technical: SLA management tool
    - Financial: Monetary impact of the required manpower and technology to be acquired
    - Informational: Access to different sources of information that may be relevant when establishing SLAs

### 4.4.4. USEFUL CONCEPTS AND SUPPORTING MATERIAL

There is no specific supporting material referenced for this phase.

### 4.5. PHASE 4: DEVELOP AND EXECUTE PROCESSES AND PROCEDURES

### 4.5.1. KEY IDEA
Based on a clear understanding of the current situation (phase 1), clear policies and directions, an overall vision, defined goals and commitment from senior authorities (phase 2), and a concrete plan of prioritized and scheduled improvements to be realized (phase 3), this phase deals with a number of generic tasks to be performed to set up an effective service management system (enabling effective SLM and SDM).

In this context, three critical success factors need to be considered:

1. **PEOPLE**: Roles, responsibilities, competencies and skills, awareness;
2. ** PROCESSES**: Clearly defined organizational processes, process-specific policies and procedures and their interfaces and dependencies;
3. **TOOLS**: Supporting tools and technology.

### 4.5.2. INPUT AND OUTPUT

- **Input**: A plan (typically in the form of a project plan) specifying the schedule of necessary actions and connected milestones including planning of resources.
- **Output**: Defined and assigned roles and responsibilities, defined processes and procedures to be implemented, successful communication and adequate training and awareness for all relevant people involved, adequate tool support.

### 4.5.3. HOW TO PROCEED

Question(s): How should we proceed to actually implement the improvements and achieve our goals? What aspects do we have to think about, and then put into practice?

Basically, this phase is about setting up a so-called (service) management system as shown in **Figure 4.2**.

---

**Figure 4.2: Aspects of developing a management system for SLM and SDM**

---

### STEP 4.1: DEFINE AND ASSIGN AUTHORITIES AND RESPONSIBILITIES (PEOPLE ASPECT)

- **Instructions**:
  - Define the roles that are part of the management system.
For each role, define the connected tasks and required skills.

Establish, assign and communicate the roles and related tasks.

Please refer to building block 4.A for more information on assigning responsibilities using the RACI concept.

Please refer to building block 4.B for more information on communication and communication planning.

**Examples:**

- **Role:** Senior responsible owner for SLM and SDM (overall accountability for the entire management system).
- **Role:** FI-wide Service Level Manager (overall responsibility for the process).
- **Role:** FI-wide Incident Manager (overall responsibility for the process).
- **Role:** Service Owner (to be defined for each service in the service catalogue, responsibility for the service in general, the information stored about this service in the service catalogue, quality and improvement of the service).
- **Role:** SLA Owner (to be defined for each SLA, responsible for regular reviews, reporting, etc.).

**Comments:**

- When identifying the necessary SLM/SDM-related roles, the gSLM use cases may be helpful (see building block 1.B).

---

**STEP 4.2: DEFINE AND IMPLEMENT PROCESSES AND PROCESS-SPECIFIC POLICIES AND PROCEDURES (PROCESS ASPECT)**

**Instructions:**

- Define the processes that are part of the management system.
- Define the procedures that are required to define, how processes and process-specific activities shall be carried out.
- Install and communicate the processes and procedures.
- Please refer to building block 4.C for more information on designing and defining processes.
- Please refer to building block 4.B for more information on communication and communication planning.

**Examples:**

- **Process:** SLA Management.
  - Procedures in the context of SLA Management:
    - Identification and recording of service level requirements
    - Negotiation and recording of SLAs
    - Negotiation and recording of OLAs
    - Activation of SLAs and OLAs
    - SLA and OLA monitoring
    - Regular SLA reporting (including creation and distribution of reports)
    - Early-warning notification of potential SLA violation
    - ...
  - **Process:** Incident Management:
    - Incident identification and logging/recording
    - Incident classification
    - Incident prioritization
    - Incident functional escalation
    - Incident hierarchical escalation
    - Incident resolution
    - Incident closure
    - ...

• Comments:
  o When identifying the necessary SLM/SDM-related processes, the gSLM use cases may be helpful (see building block 1.B) since they show which tasks and activities need to be carried out. Often, the activities of one or more use cases can be regarded as activities in a specific process.

STEP 4.3: PLAN AND REALIZE ADEQUATE TOOL SUPPORT (TOOLS ASPECT)

• Instructions:
  o Identify the requirements for adequate tool support.
  o Acquire and/or implement suitable tools.

• Examples:
  o Tools required for managing SLAs:
    ▪ SLA and OLA administration tool or database
    ▪ Monitoring tool(s)
    ▪ Reporting tool(s)
  o Tools required for managing incidents:
    ▪ Trouble ticket tool or similar

STEP 4.4: OFFER TRAINING, DEVELOP SKILLS AND CREATE AWARENESS (PEOPLE ASPECT)

• Instructions:
  o Identify the topics for creating awareness.
  o Develop and implement an awareness campaign and measures for continual review and improvement of awareness.
  o Identify education and training needs.
  o Develop and implement an education and training program

• Examples:
  o General awareness required for the processes of SLA Management and Incident Management.
  o Role-/task-specific trainings.

4.5.4. USEFUL CONCEPTS AND SUPPORTING MATERIAL

CONCEPT 4.A: RACI

The RACI model will be beneficial in assigning responsibilities. RACI is an acronym for:

▪ Responsible
▪ Accountable
▪ Consulted
▪ Informed

Exemplary simplified RACI matrix:
### Concept 4. B: Communication Plans

A communication plan should consider the following:

1. Who is communicating?
2. What is the message
3. Who is the addressee of the message?
4. How will the message be communicated? (channels, media)
5. When and how often will the message be communicated?
6. How will the success of the communication be evaluated?

Practical guidance on communication plans can be found here:

- ITIL Service Transition [6]
- COBIT [14]
This concept may be applied in Step ...

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<tr>
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<tbody>
<tr>
<td>4.1</td>
<td>Communicating roles and responsibilities</td>
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<tr>
<td>4.4</td>
<td>Creating awareness</td>
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</table>
  
(a) Plans and necessary actions need to be communicated to relevant parties. By means of effective communication (e.g. of processes, procedures and specific skills), people shall be enabled to fulfil their role in the SLM/SDM context.

CONCEPT 4.C: PROCESS DEFINITIONS

A process definition should at least cover:

1. Overall goal and objectives of the process
2. Input(s) to the process
3. Output(s) to be generated through the process
4. Triggers for the process, if the process is event-triggered
5. Activities to be performed
6. Roles to be involved
7. Metrics and KPIs to measure the effectiveness and efficiency of the process
8. Interfaces to other processes

Practical guidance on process design/definition can be found here:

- ITIL Service Design [5]
- COBIT [14]
- Microsoft Operations Framework (MOF) [16]

This concept may be applied in Step ...

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<td>4.2</td>
<td>Defining and designing processes for SLM and SDM</td>
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</table>

4.6. PHASE 5: CONTINUAL REVIEW AND IMPROVEMENT (DID WE ACHIEVE OUR GOALS?)

4.6.1. KEY IDEA

The implemented processes and procedures, established roles and the use of tools/technology in this context should be subject to continual monitoring and reviews for their suitability and effectiveness. If the SLM/SDM practices implemented do not lead to the desired outcomes, further improvements need to be identified and then implemented.

4.6.2. INPUT AND OUTPUT
• Output: Defined and assigned roles and responsibilities, defined processes and procedures to be implemented, successful communication and adequate training and awareness for all relevant people involved, adequate tool support.

• Output: Reports and results from reviews indicating the degree of compliance, effectiveness and efficiency of the measures taken.

### 4.6.3. HOW TO PROCEED

#### STEP 5.1: REPORT ON ACHIEVEMENT OF SERVICE LEVEL TARGETS AND PROCESS PERFORMANCE

- **Instructions:**
  - Identify the areas, where regular reporting is needed.
  - For reporting area, define the reports to be created. Create a list or database of report specifications, and for each report specify at least:
    - Purpose
    - Audience
    - Frequency
    - Content
    - Data sources
    - Person, group or role responsible for creating and distributing the report

- **Examples:**
  - By default, monthly SLA reporting for all SLAs.
  - Quarterly reporting on the process of SLA Management (effectiveness, efficiency).
  - Quarterly reporting on the process of Incident Management (effectiveness, efficiency).

#### STEP 5.2: PERFORM REVIEWS AND AUDITS ON MANAGEMENT SYSTEM COMPLIANCE, EFFECTIVENESS AND EFFICIENCY

- **Instructions:**
  - Define reviews and, if required, audits to be conducted.
  - Ensure that review and audit results serve as input for continual improvement.

- **Examples:**
  - Annual service review for each SLA.
  - Annual review of every process.

### 4.6.4. USEFUL CONCEPTS AND SUPPORTING MATERIAL

#### CONCEPT 5.A: AUDITS

An audit is a systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which the audit criteria are fulfilled.

- **Audit criteria:** set of policies, procedures or requirements used as a reference against which audit evidence is compared
- **Audit evidence:** records, statements of fact or other information which are relevant to the audit criteria and verifiable

Internal audits, sometimes called first party audits, are conducted by the organization itself, or on its behalf,
for management review and other internal purposes (e.g. to confirm the effectiveness of the management system or to obtain information for the improvement of the management system). Internal audits can form the basis for an organization’s self-declaration of conformity. In many cases, particularly in small organizations, independence can be demonstrated by the freedom from responsibility for the activity being audited or freedom from bias and conflict of interest.

External audits include second and third party audits. Second party audits are conducted by parties having an interest in the organization, such as customers, or by other persons on their behalf. Third party audits are conducted by independent auditing organizations, such as regulators or those providing certification.

Practical guidance on management system audits can be found here:

- ISO 19011: Guidelines for auditing management systems [17]

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<th>This concept may be applied in Step ...</th>
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<td>5.2</td>
<td>Planning and conducting audits</td>
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4.7. SUMMARY: ALL PHASES AND STEPS

**Phase 1: Understand the baseline/current situation (Where are we now?)**

1.1 - Set the scope (e-infrastructure, Fl, site, VO, service, etc.)
1.2 - Define the topics to be addressed to describe the current situation in a qualitative way
1.3 - Define the metrics required to describe the current situation in a quantitative way
1.4 - Describe the qualitative and quantitative baseline based results from steps 1.2 and 1.3

**Phase 2: Identify the need & develop a vision (Where do we want to be?)**

2.1 - Define the vision
2.2 - Define and prioritize (measurable) goals
2.3 - Describe the main gaps between the current baseline and the goals/vision
2.4 - Commit to the necessary improvements and release clear overall policies

**Phase 3: define the progression stages (how do we get there?)**

3.1 - Identify options for improvement activities
3.2 - Prioritize actions for improvement (based on the priorities of the goals)
3.3 - Specify and schedule the milestones
3.4 - Identify the required resources

**Phase 4: develop and execute processes and procedures**

4.1 - Define and assign authorities and responsibilities (people aspect)
4.2 - Define and implement processes and process-specific policies and procedures (process aspect)
4.3 - Plan and realize adequate tool support (tools aspect)
4.4 - Offer trainings, develop skills and create awareness (people aspect)

**Phase 5: continual review and improvement (did we achieve our goals?)**

5.1 - Report on achievement of service level targets and process performance
5.2 - Perform reviews and audits on management system compliance, effectiveness and efficiency

*Figure 4.3: Guide for Federators and e-Infrastructure providers, summary of all phases and steps*
5. CONCLUSIONS

The past decade has seen major shifts in the way research is carried out. From predominantly lab-based development, computing has played an increasingly crucial role in a broad range of technical and scientific developments. From automating processes through to modelling complex systems and investigating them ‘in silico’, this shift has been accompanied by parallel shifts in the broader European economy, notably a movement from a product-based economy to a service based economy. This has altered the relationship between the research and academic sectors, notably in the way that commerce supports research. Previously, the commercial sector provided tools needed by the academic sector. Researchers may have developed prototypes, but they were refined and brought to market by commercial organisations, as the research sector represented a profitable market for commercial organisations.

While this relationship persists, a new dynamic is observable around the growth of the service economy. Now, the research sector invents and consumes a range of services, which facilitate their work. However, this has altered the path from idea to prototype to a tool in use by a wide range of researchers. Where before researchers created technical prototypes that could not be widely adopted without a manufacturer, with the creation of IT-based services, it is now possible for a prototype to be seamlessly developed into an operational service, and as the service is only software and can be rapidly shared and deployed elsewhere, the relationship between researchers and commercial organisations that support them has changed.

The rise of e-Infrastructure has accelerated this shift. By investing in relatively affordable commodity computing equipment, research organisations can provide their own tools and provision their own services in a way they had never been able to previously. However, while researchers typically understand the technical or theoretical aspects of the tools they use, there are other bodies of knowledge associated with service provision that they lack, notably service management expertise. Operating and providing a complex, large-scale service to a large audience is a non-trivial task, and one that the commercial service provision sector has been developing over several decades. From their experience it is apparent that the warranty and reliability aspects of a service can be as important as its functionality in deciding what service to adopt – a more technically capable service may not be a good option if it is provided only on a best effort basis that cannot be relied upon for daily work.

Federated e-Infrastructures such as Grids and data infrastructures arose from academic needs and were driven by requirements specific to certain communities, but as they developed and needed to scale to larger user communities, they also received funding and support to extend themselves into multi-community services. While these services are in general technically excellent, this scaling asked them to adopt a service provision model unusual in the academic research sector. In parallel, the commercial sector has offered up alternative services that they try to market to the research sector, such as single-provider commercial clouds. While in many cases these commercial services may not be as technologically appropriate as those developed by academia, among other factors they are more clearly priced and come with stronger and more clearly stated guarantees about the services.

This problem has been brought into focus as federated e-Infrastructures seek to shift from development and research funding sources to more sustainable operational models that are likely to be based on payment for services, either directly or through long term national or European funding scaled to the services provided. In either case these services need to show that they can be managed in an efficient and cost effective way that is broadly comparable to the service management seen in fully commercial services. These skills must be demonstrated to funding bodies, to ensure value for money if they consider continued funding of service infrastructures, or they must be demonstrated to users, to encourage service uptake and persuade them to provide support (whether it is financial or endorsement).

Having identified the problem area, it is important to further analyse the scale and precise nature of the problem. For e-infrastructures, this has two main aspects. The first is to ensure that the community
A Strategic Roadmap for Federated Service Management

acknowledges the problem. This is complex because to many in the academic sector, lack of formal management technique is not seen as a problem. Through the gSLM project and other initiatives, awareness of these issues has been raised, and in parallel, the drive to new sustainable structures has highlighted and clearly demonstrated that change is needed in order grow and maintain e-Infrastructures. The other factor is to quantify the problem in a way that is clearly apparent and comprehensible for community members. As described in this roadmap, gSLM has developed an analysis framework and methodology that uses requirements-based assessment as a basis for consultative intervention in e-Infrastructure operation involving e-Infrastructures and IT Service Management experts. This approach allows e-Infrastructures to look in detail at their operations, identify their current level of maturity and receive guidance on what specific factors and situations can be improved to enhance overall maturity and effectiveness. Here we generalise these issues into two challenges, the user satisfaction challenge and the sustainability challenge. These reflect problems frequently seen by community members, but that have thus far proved difficult to address using the tools and concepts currently available.

With a clearer understanding of the problem, the next step is to see how it can be addressed. Clearly there are many different stakeholders involved in the federated e-Infrastructure community, and all will have to act in some sort of concert in order to effect a change in this complex ecosystem. In this roadmap we have outlined the broad, high-level issues within the service management area. Examples include making services user-centric, defining communications channels and agreeing business models.

Many of these are common sense steps, but nevertheless need to be approached in a rational, sequential manner. In many cases the seemingly simple questions, such as what precise services are provided and for whom, were automatically answered during the development of services but need to be reassessed in the new sustainability-focused environment that e-Infrastructures find themselves in. We provide some of the higher priority actions for each stakeholder group, though the lists are not exhaustive. These recommendations should combine to achieve the objectives proposed. For instance, achieving meaningful user guarantees requires funding bodies to ask service providers to consider service guarantees, requires service providers to accept this, requires resource owners to state what guarantees they can fulfil, and lastly requires users to clearly state their requirements. No single stakeholder group alone can achieve this objective, but together they can. This form of guidance should help shape high level and strategic plans for community members and support plans for more concrete activities.

We complement this broad, strategy and policy-level guidance with more specific and technical guidance for assessing and planning operational changes. This is based on the conceptual model of e-Infrastructure service provision that we have constructed. The model is based on a simplified model of the actors and processes needed to manage a federated service. These processes are divided into various levels of maturity and requirements matched to them, to allow for both requirements-based assessment and concrete planning for improvement. Having described this model we have also provided a methodology for operational managers and others involved in the details of service provision to assess, reflect, plan and improve the management of a service.

This model, however, remains quite general, since it needs to be applicable to the many kinds of operational e-Infrastructures varying in purpose, maturity, funding and resources. Exactly as seen in commercial frameworks such as ITIL, this is best practice guidance that must be interpreted in light of individual situations, rather than a single solution that can be universally applied. To assist this we provide links to external resources that will help community members implement the model.

While the effort required to effect these changes is far from trivial, we believe that it is not only advisable but also increasingly crucial for the continued success and growth of federated e-Infrastructures. Better managed services will be more attractive to users, their costs and benefits will be more transparent to those funding them, they will be easier to operate and more likely to succeed in competition with services offered by the commercial sector. We believe the work presented here can offer a firm basis for such changes, though the
actual change will have to be planned by the many stakeholders contributing to the overall ecosystem, and will require the participation of experts in both the federated e-Infrastructures and those with an understanding of commercial and traditional approaches to IT Service Management.

It is difficult to summarise the guidance provided here, since it is a framework rather than a prescription, but we might say that the following principles need to be accepted and adopted by all community members and stakeholders:

- Current management of services represents hard work over the past decades but cannot scale to deal with the current situation and imagined future scenarios.
- Services need to be managed in a more formal way to solve challenges such as user satisfaction and sustainability.
- There is a cost to introducing new management paradigms, but it is both necessary and will improve efficiency and effectiveness over time.
- Introduction of new ideas requires concerted action by all stakeholders and is not the problem of any one group.
- There are concepts from areas such as IT Service Management that can be used to address these issues but they require careful interpretation to be of use in e-Infrastructure.
- The effort needed to convince stakeholders of the need for IT Service Management may be equal to any cost in implementing technical aspects of service management.
- It is crucial to define exactly what services are offered and who are the primary beneficiaries, who we might call customers. Services should be aligned to these direct beneficiaries.
- The community should agree business models based on an understanding of who the customers for services are.
- Services may not be charged for, but must be able to offer estimates of their cost in order for them to be assessed, demonstrate their impact and compete with commercial alternatives.
- Guarantees must be offered to users that support their requirements, are realistic and have some form of consequence in case of failure.
- Users must clearly state their needs so guarantees can be matched to them, and must not accept services without guarantees.
- Effective monitoring of the fulfilment of guarantees is required.
- Implementation of IT Service Management should be incremental in order to make it attractive and realistic.
- Introduction of IT Service Management is not a one-off process, and once in place must be continually monitored, optimised and extended to meet the needs of providers and users.

The work presented here is an attempt to assist the community in understanding and implementing these principles. We hope that this work will be continued by members of the federated e-Infrastructure community, both through action within infrastructures and through new projects and initiatives providing further support. We also hope that coordinating bodies, such as standards organisations, European scale infrastructure coordinators, funding bodies and policy bodies will adopt some of the ideas and approaches suggested here, and help catalyse broader acceptance of the service management problem and better attempts to solve it.
6. REFERENCES


