How to Do SOA Right?

An SOA Governance Framework for the ESA Space Situational Awareness Preparatory Programme

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Service Orientation is a software design paradigm, which promises increased return on IT investments and organisational agility towards business changes. In the past years, the SOA design paradigm has been adopted by a large number of new software development projects. Many organisations are however facing difficulties in demonstrating the value of their SOA projects. This has been mainly because most of early SOA initiatives have been technology driven. This setback has led to a shift in the SOA paradigm, moving the focus from technology to SOA as a design paradigm. Organisations have in the recent years come to realise that the promised benefits of SOA, come unavoidably with the need for more coordination across the traditional boundaries of individual projects and across business lines. This need is typically addressed by establishing some level of governance in an SOA environment. Without an appropriate level of governance the SOA projects can quickly spiral to chaos and end in the undesirable state of "Wild West SOA". An SOA governance is typically defined using a set of "precepts", "processes", "roles" and "metrics", which together establish the framework for making the right decisions when doing SOA. SOA adoption impacts many aspects of funding, planning, implementation and operation of software systems. A successful SOA Governance framework must accordingly cover the complete service life-cycle as well as the service portfolio management aspects; The example of the ESA’s Space Situational Awareness Preparatory Programme (SSA-PP) demonstrates how SOA and SOA Governance can be successfully applied in the context of a space programme. One of the objectives of the SSA-PP has been provision of services based on federation of assets, which are owned and governed by different participants. SOA has therefore been adopted as a suitable architectural choice for realising SSA-PP software systems. The SSA services are currently being developed in multiple parallel software development projects with European industry throughout Europe. This setup represents some challenges at system level, as each project reuses services of other projects while providing in turn its own services for reuse to others. Moreover the system level SSA capabilities can only be realised through orchestration of the services of multiple projects. The interdependency of the service development projects is typical for a mature SOA and gives rise to the need to more strict coordination when it comes to introduction of new services vs service reuse, standardisation of service contracts, use of common data models, governance of service reuse, service ownership and service change management. In order to address this eminent need for coordination, The SSA Preparatory Programme SOA Governance Framework has been developed in 2011 in a joint effort by the European Space Agency (ESA) and industrial experts.

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I. Introduction

SERVICE oriented computing as a software design paradigm and the associated architecture, the Service Oriented Architecture (SOA), have moved through the typical phases of IT hype cycle since their emergence more than a decade ago. The Gartner\(^4\) 2011 Hype Cycle for Application Architecture [1], shown in figure 1 illustrates clearly how SOA has evolved from being a technology and middleware-tooling driven initiative to become a mature software development methodology. It is remarkable to acknowledge that Gartner places the maturity of today’s SOA (in 2011) at the same level of Object Oriented computing as a software methodology and at the maturity level of XML as a technology.

SOA has however become an ambiguous buzzword in the past years, since many tool vendors have used it to brand their products. It is therefore worth revisiting briefly the goals of service oriented computing as a software design paradigm. Service orientation aims ultimately at increasing the agility of an organisation in responding to changes, by aligning its IT to its business needs. It also aims at increasing the overall IT Return on Investment (ROI) and at reducing the burden of specifying, developing, deploying, validating and maintaining an ever-growing number of independent silo-based applications for each new or modified set of business requirements. At more technical level the main objectives of service orientation are to increase the interoperability of services, facilitating the federation of services from independent domains (and owners). In other words in an ideal SOA, services which have been developed independently and were never meant to work together can participate in multiple service compositions to provide completely new solutions in response to new business requirements or to changes of existing ones [2].

In order to achieve these objectives, services, which are pieces of software logic to which service orientated design principles have been applied, must exhibit certain characteristics such as reusability, abstraction, statelessness, autonomy, loose coupling, discoverability and composability [3].

At design level the principles of service orientation translate to a set of design patterns, which can be applied at different, service oriented architectural levels: the service architecture, the service composition architecture and the service inventory architecture. Examples for these design patterns are “service normalisation”, “service contract centralisation”, “schema centralisation”, “process abstraction”, “process centralisation”, “business rules centralisation”, “service broker”, “legacy wrapper”, “service façade”, “concurrent service contracts” and many other design patterns. A detailed overview of SOA design patterns is provided in [4].

But - as with many things in life - there is no great benefits without new challenges! The promised benefits of SOA come unavoidably with the need for more coordination among projects, which reuse the same services. “In fact, current IT practices, which focus on individual projects, time-to-market, and cost containment, actively discourage good SOA behaviour.” [5] The need for cross-project coordination is typically addressed by establishing some level of governance in an SOA environment. Without an appropriate level of governance the SOA projects can quickly spiral to chaos and end in the undesirable state of "Wild West SOA".

II. Measuring the value of SOA

Evidence gained from a number of scientific researches and industry surveys [5],[6] shows that many SOA initiatives have failed to deliver on the premised values of the service orientation. This has initially led to a decline

\(^4\) Gartner is one of the most recognised independent IT benchmarking organisations (www.gartner.com)
in the number of new SOA initiatives and to a general disillusionment about the highly inflated expectations, promised by the SOA hype. After this initial setback and with no better architectural design paradigm on hand, organisations have come to realise the weaknesses of their initial, mainly technology driven, approach towards SOA adoption. This has resulted in a change in the SOA paradigm, which is sometimes referred to as the “second generation SOA” or SOA 2.0. Many organisations have come to appreciate SOA more and more as a design paradigm rather than a technology and to realise that SOA adoption is much harder than simply adopting a set of new middleware tooling, as usually propagated by vendors.

To get “measurable” benefit from SOA, some fundamental changes are necessary in how the IT projects are planned, funded, organised, managed and executed. SOA Adoption can impact significantly the interaction between the business and IT and the relationship between independent software projects. In order to implement these changes, new organisational entities and roles, such as the SOA Centre of Excellence (CoE) or the SOA Governance are often introduced, which oversee the coordination of the changes related to SOA adoption. This shift in the roles and responsibilities of clearly separated traditional IT projects towards more cross-project and domain-wide coordination, requires a cultural change which often represents an obstacle not lesser than the technical challenges of successful SOA adoption.

The topic of SOA governance has accordingly gained in the recent years increased attention, since its importance and role in achieving the SOA objectives have been realised by more and more organisations that have executed SOA projects.

### III. What is SOA Governance and Why Is It Needed

The terms “Governance” and “Management” are very confused. Governance is about providing guidance for decision-making, while management is concerned with execution of those decisions. In other words governance defines the principles for taking decisions when executing SOA. Management reviews and approves these principles and executes them. Some of the typical decisions to be taken in each SOA initiative are [7], [8]:

1) Which Services are needed?
2) Which Services shall implement first?
3) Is this really a new, reusable service?
4) Who pays for the development and maintenance of the service?
5) Who owns this Service?
6) Who approves changes to existing services?
7) How do the proposed/approved changes to existing services impact its current consumers?

SOA Governance frameworks typically attempt to answer the above questions by defining a combination of following elements [9], [10]

- **Precepts** define the SOA Governance Rules, which must be followed by all involved stakeholders in an SOA initiative. They define which entities have the authority to make which decisions; define the condition and the criteria for each decision and specify the consequences of non-compliance to the rules. The main objective of precepts is to define the SOA rules of conduct, hence limiting the decision-taking ability of each individual;

- **Principles, policies** and design **standards** translate the mandatory precepts in concrete formats, e.g. through providing templates, or making the application of a certain design pattern mandatory. While the precepts may remain at conceptual level, these artefacts define concretely where and how to apply each mandatory precept, how to validate its correct application and which concrete actions to take to enforce compliance and to escalate in case of non-compliance;

- **Guidelines** and **best practices** are exactly the same as principles, policies and standards, except that they cover the optional precepts;

- **Roles** are a means for assigning responsibilities to human actors and organisational entities which take the decisions when doing SOA in accordance to the rules laid down by precepts;
• **Processes** specify formally the series of activities and events, which describe concretely when and how SOA Governance shall be executed each role;

• **Metrics** are the means for measuring the success of the SOA Governance, i.e. evaluating to the compliance level to the precepts. Some metrics can be used at the same time to measure the effectiveness of a SOA Governance framework itself. For instance a high number of non-compliances to a certain precept, often escalations in a Governance process or high number of waivers as part of a process are good indicators that the subject precept may require a review and some level of adjustment;

An important aspect about SOA Governance is that effective SOA Governance is based on a hierarchical competency structure. It is therefore essential that the SOA Governance team is delegated the required authority by the organization for definition of Governance precepts and roles as well as for the execution of the processes and measurement of compliance.

### IV. The European Space Situational Awareness (SSA) SOA initiative

#### A. European Space Situational Awareness Preparatory Programme

“The Space Situational Awareness Preparatory Programme (SSA-PP) was authorised at the November 2008 ESA Ministerial Council and formally launched 1 January 2009. After an initial three-year period to 2011, full operational services will be implemented in 2012-19 upon approval. The objective of the SSA programme is to support Europe's independent utilisation of, and access to, space through the provision of timely and accurate information, data and services regarding the space environment, and particularly regarding hazards to infrastructure in orbit and on the ground. In general, these hazards stem from possible collisions between objects in orbit, harmful space weather and potential strikes by natural objects that cross Earth's orbit. The SSA programme will, ultimately, enable Europe to autonomously detect, predict and assess the risk to life and property due to remnant man-made space objects, re-entries, in-orbit explosions and release events, in-orbit collisions, disruption of missions and satellite-based service capabilities, potential impacts of Near Earth Objects, and the effects of space weather phenomena on space- and ground-based infrastructure.

To achieve this, ESA's SSA programme is focusing on three main areas:

- **SST - Space surveillance and tracking of objects in Earth orbit**  
  Watching for active and inactive satellites, discarded launch stages and fragmentation debris that orbit the Earth.

- **SWE - Space weather**  
  Monitoring conditions at the Sun and in the solar wind, and in Earth's magnetosphere, ionosphere and thermosphere, that can affect space-borne and ground-based infrastructure or endanger human life or health.

- **NEO - Near-Earth objects**  
  Detecting natural objects that can potentially impact Earth and cause damage.

Each of these is being implemented as a 'segment', analogous to the dedicated 'ground segment' - computers and other resources on the ground - that traditionally support each ESA satellite in space.” [11]

From an IT perspective the SSA Preparatory Programme represents a federated and highly distributed system of systems which composes four geographically distributed data and service provision centres at Germany, Spain, Italy and Belgium. These centres receive the data from a network of ground based and space-borne sensors; process and archive the data and provide higher level SSA products and services to SSA user community as shown in Figure 1.
B. The SSA SOA Initiative

The federation of existing and new assets, which are owned and governed by different participants to the SSA programme and provision of services based on these federation to the user community in each of the three SSA domains is one of the main objectives of the SSA Preparatory Programme. The SSA services are very diverse and will cover a wide spectrum from pure data provision to more advance capabilities such as satellite conjunction analysis and warning, manoeuvre analysis, re-entry analysis, fragmentation analysis and various space weather and NEO services.

SOA has therefore been identified as the most suitable architectural choice for realising SSA software systems. As the first step towards adopting SOA, a Common SSA SOA Infrastructure, in short COSIF has been designed and deployed. COSIF builds on commercial SOA middleware, extending it with a layer of vendor independent generic utility services, with the purpose of avoiding undesired future vendor lock-in. Oracle Fusion Middleware has been selected as the underlying SOA suite, based on an elaborate and systematic evaluation and assessment activity which was performed in 2010 and described in [12]. The SSA specific services are currently being developed and deployed on the COSIF in a number of parallel software development projects with European industry throughout Europe.

V. The SSA-PP SOA Governance Framework

The development of the SSA capabilities in multiple parallel projects by independent European industrial suppliers represents a number of challenges at system level during SSA preparatory programme, as each project reuses services of other projects while providing in turn its own services for reuse to others. Moreover the system level SSA capabilities can only be realised through orchestration of the services of multiple projects.

The interdependency of the service development projects is typical for a mature SOA and gives raise to the need to more strict coordination when it comes to introduction of new services vs service reuse, standardisation of service contracts and service meta data at design time and run-time (messages), use of common data models, governance of service reuse, service ownership and service change management. In order to address this eminent need for coordination, The SSA Preparatory Programme SOA Governance Framework has been developed in 2011 in a joint effort by the European Space Agency (ESA) and industrial experts. At its core it includes the SSA-PP SOA Governance Model (SSGM), which has been specified as a tailoring of The Open Group SOA Governance Model [13] to accommodate the SSA Preparatory Programme specifics and needs. The SSA SOA Governance framework comprises currently the following elements:

- The SSA-PP SOA Governance Model which specifies the applicable SOA governance precepts, roles, processes and metrics
- The SSA Reference Service and Data Meta Model, which specifies in compliance to the OMG Model Driven Approach (MDA) Computational Independent, Platform Independent and Platform Specific Reference
Models (CIM, PIM and PSM reference models) for all SSA Services. The reference Model is defined in form of a set of design time meta-data to be provided for each SSA service and in forma of a generic SSA Message Header for all exchanged messages at run-time. This reference model builds the basis for intrinsic interoperability of SSA services and is elaborated on in [14];

- A set of Templates for SOA Governance Artefacts defined in SSGM, e.g. Service Candidate Proposal, Solution Candidate Proposal, Service Change Proposal, Service Reuse Proposal. Figure-3 shows as an example the Service Candidate Proposal Template

- The SSA-PP SOA Governance Requirements which specify the concrete policies and design standards to be applied at each process step;

- The customised SSA Service Registry and Repository

- The Reference COSIF Architecture for SSA Preparatory Programme

- And a reference SOA Governance cookbook which servers as a tutorial for how to comply to the SSA-PP SOA Governance Model;

The following chapters of our paper will elaborate on the details of the SSGM governance processes.

<table>
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<th>Description</th>
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<tr>
<td>Requester (requester ID):</td>
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<td>Requester Governance Role: SDT</td>
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<tr>
<td>Requester Governance Process: Service Candidate Specification</td>
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| Service Owner (i.e. department, contact): |
| Programme name SSA |
| Segment Name ☐ SST ☐ NEO ☐ SWE ☐ GEN |

| Submitted Appendices: |
| Service Name: |
| Parent Solution: |

| Service Purpose (Textual Description of the capability for which the new service is proposed): |
| Service Domain |
| Service Version x.y |
| Composition Level ☐ Business Process ☐ Composite Service ☐ Basic Service |
| Business Logic Changes at Runtime? ☐ Yes ☐ No |

| Operations |
| Name / Interaction / Tags | Input Parameters | Output Parameters |
| Impl. Platform | Protocol Binding |
| Asynchronous ☐ Yes ☐ No |
| Data Size ☐ Small ☐ Medium ☐ Large ☐ Bulk |
| QoS ☐ RT ☐ NRT ☐ GT ☐ BE |
| Priority ☐ Low ☐ Medium ☐ High |

| Security (Optional) |
| Confidentiality ☐ None ☐ SSL/X.509 |
| Integrity ☐ None ☐ SSL/X.509 |

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VI. SOA Governed Processes

The SSGM processes are grouped in the following four categories as shown in Figure 4:

- Solution Portfolio Management Processes
- Solution lifecycle Management Processes
- Service Portfolio Management Processes
- Service Lifecycle Management Processes

Figure 4 - SSGM SOA Governed Processes

The Service and Solution lifecycle management processes are very similar and resemble the traditional waterfall software development processes. The only new process is the initial service and solution candidate specification. All other processes are extension and customisation of standard software development processes with focus on SOA

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specific aspects. The result of the solution candidate specification is the so-called SOA blueprint, as part of which the business processes which compose the solution are conceptually outlined and their composing service capabilities are identified in a top-down approach. This leads to the identification of services reuse candidates, service change proposals and new service candidates. For each identified new service need, an instance of a service lifecycle processes is triggered. It is important to appreciate the decoupled nature of the solution and services lifecycles as they can be individually phased with regard to each other.

The portfolio management processes govern the aspects of ownership, reuse and change management of services and solutions. Each of the SSGM processes is currently specified in detail in a tabular format as well as in form of a process work-flow in BPMN notation as shown in 6 for the example of the service change management process. The table format of specifies for each process:

- The Process Name
- Textual description of the process
- A detailed mapping of the subject process to processes and sub-processes of the ECSS-E-ST-40C standard [15] applicable to all software development for ESA ground data systems
- Process Objectives and Applicable Precepts
- All Events which trigger the start of the subject process
- All Input Artefacts to the process
- All Event which can result in the flow of the subject process
- The reference process, which are further triggered by the events resulting in this process
- All output artefacts
- The involved Roles in the process
- The list and order of the tasks to be executed by each Role

The following example provides an extract of the Service Change Request specification:

| Objectives | - Ensure that proposed service change is in compliance to SSA SOA Governance principles  
- Minimise the overall impact of the service change on the SSA SOA Solution portfolio  
- Ensure the appropriate service granularity level, i.e. avoid ever growing new capabilities being added through this process to an existing service (propose rather creation of new services);  
- Assess service quality (too many service change requests for an existing service may be a sign of bad design or low quality implementation, hence creation of a new service rather than endless service changes might be more efficient);  
- Avoid any unforeseen impact on current service consumers  
- Facilitate a seamless service transition |
| Triggering Event(s) | “Service Change Need Identified” |
| Triggered in Processes | “Solution Candidate Specification”, “Service Monitoring and Maintenance”, “Service Acceptance” |
| Input Artefacts | Service Change Request  
- Delta user/sw requirements  
- Modified specification of existing Service CIM  
- Parent business Processes  
- Modified Service Data Model |
| Tasks | SDT:  
- Justify the change  
  o In the context of re-use in a new solution, depict how the modified service would provide the required capability in the business process or service composition;  
  o Provide a mapping of user/sw requirements to the SRS of the existing service and high-light the delta requirements;  
  o In the context of service enhancement either provide reference |
to the defect report (SPR) or justify why adding new capability to the existing service is better than creating a new service;
- Compile and submit a Service Change request to CoE for approval

CoE:
- Ensure information provided in Service Change Proposal has the appropriate level of detail in compliance to the SSGM guidelines and principles;
- Ensure that service change is technically justified
  - In the context of service reuse (after enhancement) this means existing service can not be reused as-is and changing the existing service is more adequate than creating a new service (avoid adding too many new capabilities to an existing service and creating too large services with an ever-growing set of capabilities);
  - In the context of defect fixing this means to verify that the SPR is approved and valid. Special attention must be paid to service quality (too many service change requests for an existing service may be a sign of bad design or low quality implementation, hence creation of a new service rather than endless service changes might be more efficient);
- Perform a service change impact assessment, if the impact is not acceptable reject the change proposal and propose new service development
- Work out a service migration plan in form of a service roadmap and inform all current service consumers
- Ensure that multiple versions of the service are maintained in compliance to service roadmap.
- Initiate service retirements for old versions of changed services according to the service roadmap

The discussion of the individual tasks and Roles specified by the SSGM and elaboration on each SSGM process would explode the scope this paper. What is important is however to note how the same schema can be applied to address the core aspects of service and solution lifecycle.
Figure 5 - SSGM SOA Governed Processes
VII. Relation of the SOA Governance to Existing Software Engineering Standards

SOA projects for developing ground data systems must comply to the ECSS standards, which are applicable to all ESA software developments in particular the ECSS-EST-40C [15] (in short E40C) software engineering standard specifies the software lifecycle processes. Any ambiguity in relationship between the SOA Governance processes and other applicable software lifecycle processes can be a source of confusion and iteration at project execution time. The SSGM process have therefore been developed in full compliance to E40C processes. This compliance is demonstrated in a direct mapping of each SSGM process to the corresponding E40C process and tasks as shown in figure 6.

Moreover any newly introduced SOA Governance artifact is mapped to a relevant E40C document and the Governance Process events are mapped where applicable to joint reviews, as specified by E40C. In order to avoid duplication of work, the SSGM has tailored the E40C document templates, the DRDs, to incorporate the SOA aspects rather than defining new templates.

VIII. Conclusion

Adopting SOA is not an easy task. Demonstrating the value of SOA and achieving the SOA strategic goals of increased return on IT investment and increased organisational agility towards change are even more difficult undertakings. SOA can only deliver on its promises if it is approached by IT and Business as a new design paradigm and not purely as a technology. This requires that the related organisational changes introduced by SOA design paradigm are appreciated at both IT and business level.

SOA adoption impacts many aspects of funding, planning, implementation and operation of software systems. It requires therefore more coordination across the traditional boarders of individual projects and business lines. “In fact, current IT practices, which focus on individual projects, time-to-market, and cost containment, actively discourage good SOA behaviour.” [5]. The required coordination need is typically addressed by establishing some level of governance in an SOA environment.

A successful SOA Governance framework must cover the complete service life-cycle process from identification of the service need, to its specification, design, implementation, deployment, validation, operation and eventual
retirement. It must also address the aspects of service portfolio management, such as service reuse, ownership and change management as well as solution (service compositions) lifecycle and portfolio management;
The Example of the SOA Governance framework for the SSA Preparatory Programme demonstrates how SOA Governance can practically be implemented in the context of a space programme of the European Space Agency.
## Acronym List

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<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>COSIF</td>
<td>Common SSA SOA Infrastructure</td>
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<tr>
<td>DRD</td>
<td>Document Requirements Definition</td>
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<tr>
<td>ECSS</td>
<td>European Cooperation for Space Standardisation</td>
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<td>ESA</td>
<td>European Space Agency</td>
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<td>IT</td>
<td>Information Technology</td>
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<td>PP</td>
<td>Preparatory Programme</td>
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<td>SOA</td>
<td>Service Oriented Architecture</td>
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<td>SSA</td>
<td>Space Situational Awareness</td>
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References

7. Malinverno, P. "SOA Governance in a nutshell: Sample Governance Mechanisms for a Service-Oriented-Architecture.”, Gartner Research Note ID Number: G00139465, April 2006